Guide for Developing Integrated Aquatic Vegetation Management Plans in Oregon

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Preface

The ecological relationships in our lakes, ponds and streams have resulted from of a long, continuous process of geologic change and biological evolution. As systems have evolved, communities of aquatic plants and animals developed that are uniquely adapted to environmental conditions of each system. The native aquatic plant communities that are integral to aquatic ecosystems provide food, shelter, and nesting sites for many kinds of fish, waterfowl and smaller animals. Rooted aquatic plants help secure and stabilize shorelines and play a major role in the cycling of nutrients, particularly nitrogen and phosphorus, in aquatic ecosystems. In some cases, large aquatic plants help improve lake water clarity by competing for nutrients with small (typically microscopic) aquatic plants, called algae, which can form nuisance "blooms" when excessive nutrients are present. Invasion of a system by a non-native aquatic plant species, however, can quickly destroy the lake community that took so many years to develop.

Aquatic weeds such as Eurasian watermilfoil, Parrotfeather, and Brazilian elodea, have invaded many of Oregon's lakes, reservoirs and streams. These invasive plants have spread quickly in the absence of diseases, insects, and other environmental constraints that serve as natural controls in their native regions. Aquatic weeds have damaged the function and health of our aquatic ecosystems and degraded beneficial uses (recreational, aesthetic enjoyment, fishery, irrigation, water supply, wildlife habitat, etc.). They raise pH when they photosynthesize, deplete dissolved oxygen when they die, and alter the structure of the aquatic ecosystem. They slow water movement, increase sedimentation rates, and accelerate filling-in of lakes and reservoirs. Aquatic weeds often interfere with human use and enjoyment of a waterbody as well. They clog propellers, snag fishing lines, and are a danger to swimmers and skiers who become entangled in dense vegetation. Aquatic weeds block flow in irrigation and drainage systems and clog water intake screens used for agriculture.

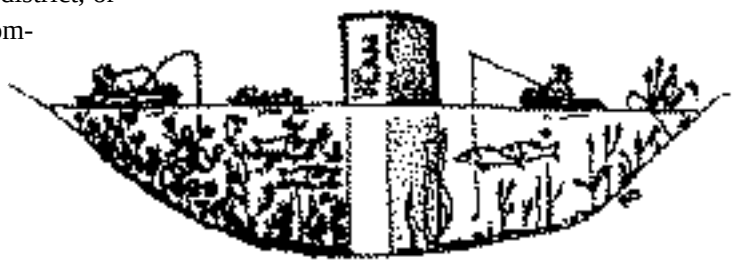
Aquatic weeds often form thick, single-species stands that can seriously damage the spawning and rearing habitat of salmon and other fish. Since preservation and restoration of salmon habitat is a critical issue in Oregon, invasive aquatic plants that affect their habitat must be responsibly managed (See Appendix C-Watershed and Limnological Background Information).

Nuisance Native Aquatic Vegetation

This planning document focuses on management of non-native plant species in Oregon waters. Under certain conditions, however, native aquatic plants can become a problem too. Causes of abundant growth of native vegetation can be complex. Luxuriant growth often signals excessive nutrient concentrations in the lake. High nutrient concentrations may originate in the lake itself (internal loading), or from around the lake or elsewhere in the watershed (external loading). Such water quality problems require intensive management approaches that may differ from those needed to eliminate non-native plant invaders from a waterbody. Furthermore, management goals for nuisance native plants emphasize reduction of problem growth, not elimination of the species from the system, as may be required for non-native weed control.

Invasive aquatic vegetation can be managed, and in some cases native vegetation can be restored, with a well-planned management program that balances biological, social, environmental and site constraints. Finding a remedy to nuisance aquatic plants that is effective, environmentally sensitive, and economically feasible is the goal of integrated aquatic vegetation management.

This manual is a guide to the steps needed to produce an *integrated aquatic vegetation management plan* (hereafter called the Plan). Using an integrated management approach, citizens and organizations can work together with a watershed council, special district, or other group to produce a management plan to combat a weed infestation in a lake or reservoir. The process described in this manual thus represents a major step toward *holistic* (lake and watershed) management of aquatic plants in freshwaters of Oregon.



Material Covered In This Manual

By definition, integrated aquatic vegetation management requires incorporating information on many aspects of a waterbody and its watershed into a unique planning document. The challenge in preparing this manual was in condensing a wealth of critical information on the topic into a comprehensive but simple format. It is a step-by-step guide, as the process of planning is broken down into separate but interrelated steps. This manual is designed to cover a wide range of situations that might be encountered while managing aquatic plants in Oregon's public lakes, although the principles and procedures can also be applied to private waters. While the document does refer to scientific principles when needed, it is not a primer on limnology or lake management. Appropriate references, resources, and a contact list for technical assistance from local, state and federal agencies are provided.

This manual does the following:

- describes how to identify six invasive, non-native aquatic plants found in Oregon waters
- provides an understanding of aquatic vegetation functions in aquatic ecosystems
- explains methodology and appropriate use of various aquatic vegetation management techniques
- identifies constraints affecting application of aquatic vegetation management activities (e.g., salmon habitat, use as a drinking water supply)
- offers guidance on mapping vegetation and collecting water samples
- defines and explains technical terms
- provides step by step guidelines on how to prepare a plan

Terminology

Many descriptive terms have been used for problem aquatic plants. They have been called invasive, nuisance, noxious, exotic, alien, non-native, and non-indigenous. More colorful colloquialisms include grass, sea weeds, moss, and frog moss. This manual deals primarily with aquatic plants that degrade beneficial uses of aquatic systems, and which have been introduced to Oregon by human activities. Throughout the manual, these plants will be referred to simply as aquatic weeds.

A Quick Walk Through The Manual

This manual is divided into four parts:

PART I: Introduction To Aquatic Plant Management

- Chapter 1, Introduction. This chapter defines the Plan and presents the purpose and objectives of these Plans.

PART II: Developing A Plan

- Chapters 2-12, Steps in the Planning Process. Using flow diagrams and illustrations, these chapters give step-by-step instructions for putting together a Plan.

PART III: Implementing A Plan

- Chapter 13, I Have a Plan—What's Next? In this chapter, the reader is offered guidance on how to use a Plan.

PART IV: Technical References

- Appendix A– Glossary of Terms–defines technical terms used in aquatic plant management.
- Appendix B– Invasive, Non-native Aquatic Plant Fact Sheets–provides drawings, and features of non-native (exotic) aquatic plant species that are or could be a threat in Oregon waters.
- Appendix C– Watershed and Limnological Background Information–briefly describes physical, chemical and biological features of a water body and its watershed.
- Appendix D– Aquatic Plant Control Methods–summarizes aquatic plant control methods available for Oregon waters.
- Appendix E– Resources and References–presents a list of resource agencies and organizations that can provide technical information and assistance on aquatic plant management in Oregon. It also lists technical reference materials that provide more detailed coverage of topics discussed in this manual.

Throughout the manual, you will also find the following special notations:

RED FLAG: These alert the reader to the presence of a serious situation in the waterbody requiring immediate or special action as part of the planning process.

TIP: These give extra information on important points or directions for particular tasks.

√! These point out areas where you may need to revisit steps already taken after gathering new information.

References and Resources:

- These appear at the end of each chapter and list names of agencies, organizations, and titles of literature that can provide more information on topics just discussed. Citations in the quick reference sections and text are numbered to correspond to the references, or lettered to correspond with the resources, appearing in Appendix E.

NOTES:

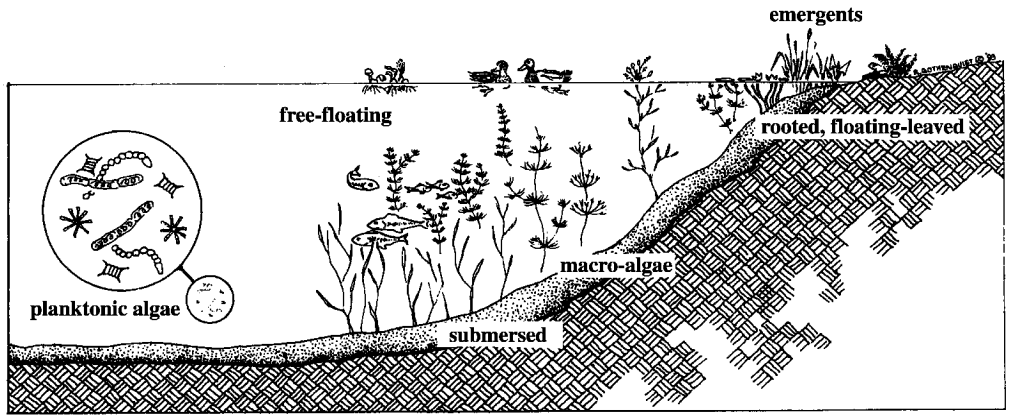
CHAPTER 1

INTRODUCTION

Does Your Waterbody Have An Invasive Aquatic Plant Or An Algae Problem?

This manual focuses on controlling nuisance aquatic plants, occurring in Oregon lakes. To use this manual, it is necessary to distinguish between an aquatic plant problem, and a water quality beneficial uses. The biology and ecology of weeds allows them to fluorish under a wide range of conditions. Nutrient enrichment is not a prerequisite for aquatic weed problems. Often, all that is needed is to introduce an invasive species to a system.

Invasive weed species–Eurasian watermilfoil, and Brazilian elodea for example–are listed as Noxious Aquatic Plants by the State of Oregon (See Box next page). Managinßg aquatic plant problems, particularly those resulting from non-native species infestations, should follow the integrated aquatic vegetation planning route described by this manual.



Aquatic Plants and Algae

Aquatic plants are large vascular plants that live in wet conditions. Aquatic plants (also called macrophytes) usually possess true roots, stems and leaves, and look like plants in your yard. They can be grouped into four types: emergent plants, rooted floating-leafed plants, submersed plants, and free-floating plants.
Emergent plants have a large portion of stems and leaves growing above (emerging from) the water surface; they are found in shallow water (less than 2 feet deep) or along the shoreline.
Rooted floating-leafed plants have leaves that float on or just above the surface but are connected to the bottom by long, tough stalks.
Submersed plants have most of their leaves and stems below the water surface, often with flowering parts projecting above surface. They may be securely or loosely rooted in the bottom.
Free-floating plants float near the water surface with root systems dangling in the water, but not connected to the sediment.
Algae are simple, primitive plants that do not have true roots, stems or leaves. Many algal species are microscopic forms that float in the water (called phytoplankton). Some appear as large, easily seen upright forms, and are called macro-algae. Certain types of green algae can form stringy colonies 3 feet or more in length. Nuisance algal growth commonly associated with nutrient problems often appears in the form of surface scums that are greenish or brownish in color.
Algae and free–floating plants get their nutrients from the water while rooted plants get their nutrients from the sediment. Reducing excess nutrient inputs will have minimal impacts on rooted vegetation and may increase the growth of light-limited rooted plants.

When Is A Plan Required?

An integrated aquatic vegetation management plan (IAVMP) is necessary to deal with nuisance (especially noxious, non-native) aquatic plants in lakes, ponds, or rivers. This is particularly important given the multiple uses of our lakes and streams and the potential widespread negative impacts these invaders can have on health and usage of an aquatic system.

Plans may be required before certain aquatic plant control activities may be initiated. For example, in sensitive salmonid-bearing waters described in the Oregon Plan for Salmon and Watersheds, a plan should be completed that addresses the multiple objectives of controlling nuisance plants and protecting other aquatic species

Balancing Act
Consideration of site-specific factors is necessary when choosing management methods for a specific waterbody. There is no magic bullet. For example, no method exists that can completely remove an exotic species infestation and at the same time be inexpensive and have no effect on the local ecology. Thus, the planning process should carefully balance all these concerns to develop a plan that meets the needs of the community while preserving the health of the ecosystem.

Adaptive Document
The Plan should be flexible and allow for change. An adaptive document provides for modification of the Plan in response to new information or changing circumstances. Factors that could affect the Plan include changes in the aquatic plant problem, water use priorities, and watershed activities that influence aquatic plant growth. Also, plant control technologies as well as government policies and regulations may change over time and affect the Plan.

Taking the Long View
Aquatic plant management is a long-term venture; achieving management goals for a waterbody can take many years. Even after main goals are attained, some form of management, if only minimal, may be necessary to maintain desired aquatic plant conditions, or to prevent re-occurrence of non-native weed species.

A Look At The Oregon Plan for Salmon and Watersheds

Initiated in 1995, Oregon's salmon restoration initiative is designed to restore salmon to a level at which they can once again be a part of people's lives. While the Oregon Plan focuses on the needs of salmon and steelhead, it will conserve and restore crucial elements of natural systems that support fish, wildlife and people.

Government alone cannot conserve and restore salmon and steelhead, so the plan recognizes that conservation efforts must be worked out by communities and landowners in the form of watershed councils, soil and water conservation districts and other grassroots efforts.

In brief, the Oregon Plan involves the following: (1) coordination of effort by all agencies, (2) development of action plans with relevance and ownership at the local level, (3) monitoring progress of conservation and restoration efforts, (4) making appropriate corrective changes in the future and (5) implementing measures focused on salmon recovery and watershed health.

See: www.oregon-plan.org

TIP: Aquatic vegetation management plans for other lakes may be available to use as models while you write your own plan. Please contact Mark Sytsma, PSU Center for Lakes and Reservoirs[J]. For a listing of Oregon lake asscations, contact Oregon Lakes Association (OLA) [H]

NOTES:

CHAPTER 2

GETTING STARTED

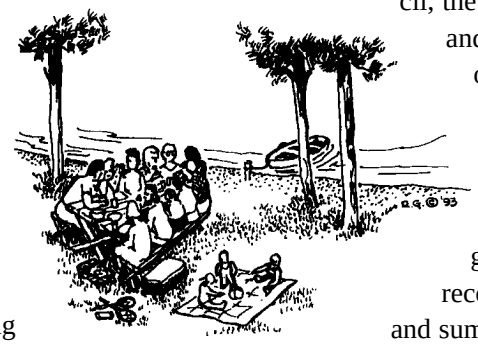
Organization Is Key

You are probably reading this manual because you are concerned about an invasive or nuisance aquatic plant problem in your favorite lake or river. Others may share your concern. The first step in managing aquatic plants is to get organized. Begin by talking with your neighbors to determine if they have similar concerns about your waterbody.

The next step is to gather together a core group to talk more about the problem. The gathering might be an informal one, such as a potluck picnic or barbecue, where concerns about aquatic plant problems can be discussed at more length. Important questions that will need to be considered include:

- Is there an aquatic plant problem?
- What is the problem?
- Should anything be done about it?
- Should a community group be formed to address the problem?
- Who will participate in the planning process?

The core group can then plan to meet with the larger lake community to share their concerns in a more formal setting. The local watershed council can be key to any aquatic weed control program that may be implemented. The watershed council has representatives of various user groups in the watershed that need to be involved in the decision making process. Posting a notice on the community bulletin-board or in a newsletter, or sending out a one-page flier are simple ways to notify the neighborhood of the location and intent of such a gathering. Often, newspapers are willing to publish a short article for folks organizing neighborhood meetings.



The Steering Committee

The local watershed council can establish a special steering committee headed by one or two key individuals. Throughout the planning process, the steering committee should represent the larger community of lake residents, as well as those with management responsibilities and interests in the lake. This group will be responsible for completing the steps in this manual to produce a plan that will utimately be presented for approval to the watershed council or other relevent body. Thus, it will be important for the steering committee to remain in touch with the lake community and watershed council to share information and allow for participation of all interested individuals in the planning process. This contact can occur through newsletters or scheduled committee meetings or general meetings open to the public.

To begin the process of “learning more about it,” the steering committee should identify the problem and start to assemble available background information on the topic of aquatic plant management.

A first point of contact for existing lake information should be with the local watershed council, the Oregon Departments of Fish and Wildlife, and the Department of Environmental Quality, which may have watershed or lake data reports available. Past studies or reports can be useful, such as diagnostic investigations called “Phase I” studies, reconnaissance lake data reports, and summaries such as found in the Atlas of Oregon Lakes. These reports usually include an aerial photo and depth contour map of the waterbody.

Planning Steps Summarized

Supplied with background information, the steering committee should begin to assess the aquatic plant problem and the need for action by completing the steps described in Chapters 3-12 of this manual.

The diagram on the following page illustrates the steps needed to complete the Plan. The diagram begins at the upper left-hand corner with the Lake Steering Committee. The planning process consists of two phases:

- Phase I (Problem/Site characterization)
- Phase II (Control Strategies Development)

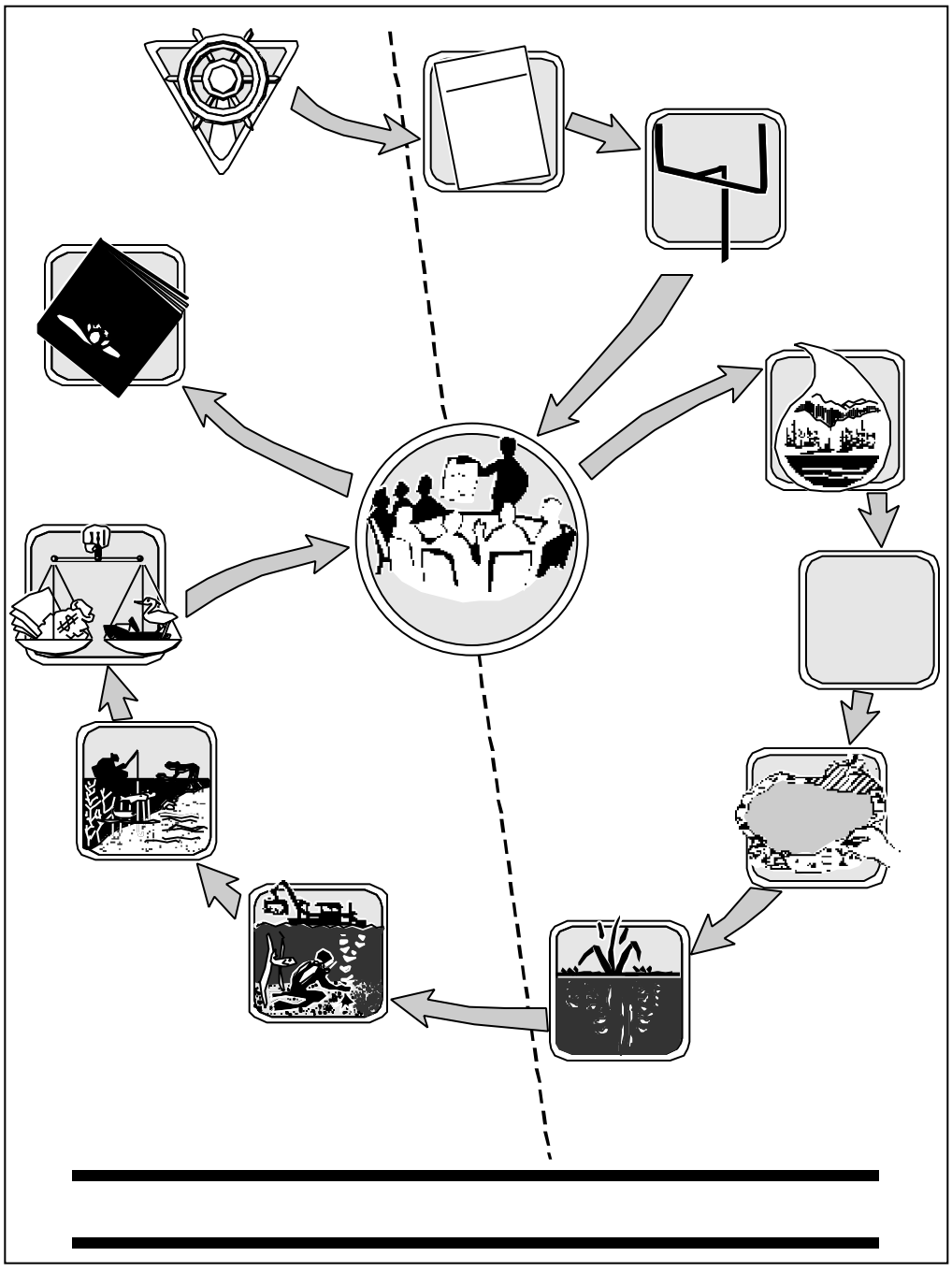
Phase I involves collecting information about aquatic plants and other features of your project area. The right side of the diagram presents the steps of Phase I:

- **Develop Problem Statement (STEPA)**
  This step involves developing a realistic problem statement describing limitations on beneficial uses of the waterbody.
- **Identify Management Goals (STEPB)**
  This step identifies reasonable aquatic plant management goals that maximize beneficial uses yet are compatible with the waterbody's capacity to sustain the uses.
- **Involve the Public (STEP C)**
  This step offers guidance in bringing the community into the planning process.
- **Identify Waterbody/Watershed Features (STEP D)**
  This step investigates background features of the waterbody and watershed to understand the whole system.
- **Identify Beneficial Use Areas (STEP E)**
  This step focuses on identifying beneficial use areas of the waterbody in a waterbody Use Map.
- **Map and Characterize Aquatic Plants (STEP F)**
  This step outlines how to perform an aquatic plant survey to identify and map general plant types in a waterbody. This step also includes translating survey data into a description of beneficial and problem plant zones in a water body.

The left side of the diagram depicts Phase II, which investigates aquatic plant control strategies and applies Phase I results to fine-tune a specific plan through the following steps:

- **Investigate Control Alternatives (STEP G)**
  This step investigates available control options in terms of effectiveness, advantages, draw backs, costs, permits and site specific factors.
- **Specify Control Intensity (STEP H)**
  This step matches control intensity with appropriate plant zones in a waterbody, producing a Control Intensity Map.
- **Choose Integrated Treatment Scenario (STEP I)**
  This step identifies critical factors for choosing a combination of controls that best meet long-term management goals with the least environmental impacts.
- **Develop an Action Program (STEP J)**
  The final step applies information from preceeding steps to formulate a unique, long-term action plan for management of nuisance aquatic plants in the waterbody.

For simplicity, the steps are presented in a recommended order. For some waterbodies, having pertinent information from prior investigations might provide shortcuts through a few of the steps. Certain steps can be covered more generally for water bodies with simpler problems (e.g., early stage pioneering infestations of non-native weed species) compared to those with more complex matters (e.g., large-scale, establishment of non-native plant populations). Also, as you move through the planning process and more complete information becomes available on your water body, you may need to revisit earlier steps. For instance, you may find it necessary to redefine the original problem statement (Step A) or your initial management goals (Step B). Points in the planning process where such movements may be needed are marked "√!" At the end of this chapter, a checklist is provided to help you track your progress through the planning process.



PLAN CHECKLIST

(check here)

( ) **Step A**- Develop Problem Statement (Chapter 3)

( ) **Step B**- Identify Management Goals (Chapter 4)

( ) **Step C**- Involve The Public (Chapter 5)

( ) **Step D**- Identify Waterbody/Watershed Features (Chapter 6)

( ) **Step E**- Identify Beneficial Use Areas (Chapter 7)

( ) **Step F**- Map and Characterize Aquatic Plants (Chapter 8)

√! Checkpoint

After gathering this new information do you need to redefine the problem statement and/or management goals?

Yes Repeat steps A (if necessary), B, and C.
Proceed to step G

No Continue to step G

( ) **Step G**- Investigate Control Alternatives (Chapter 9)

( ) **Step H**- Specify Control Intensity (Chapter 10)

( ) **Step I**- Choose Integrated Treatment Scenario (Chapter 11)

√! Checkpoint

Update watershed council/community on recommended treatment scenario.

( ) **Step J**- Develop Action Program (Chapter 12)

( ) Submit draft Plan to watershed council for approval

Notes:

CHAPTER 3

DEVELOP A PROBLEM STATEMENT (STEP A)

What Is The Problem?

Before a group of interested people can make good decisions about managing aquatic weeds, they have to agree on the problem. Preparing a problem statement is the first step for the steering committee. The problem statement should describe the important uses of the waterbody that are being impacted by aquatic weeds.

The committee's first-draft of the problem statement should be presented to the rest of the community for further discussion and refinement. The problem statement might be modified several times before the Plan is complete.

How To Write A Clear Problem Statement

The following steps can help you develop a realistic problem statement:

1. Make a list of users of the waterbody.
2. Find out how users identify the problem.
3. Group the problems into categories.
4. Condense the main categories into a problem statement.

Let's examine each of these tasks in more detail.

1. Make a list of users of the waterbody
It is important to identify everyone who has an interest in the waterbody. The steering committee itself may represent a variety of users and can start with its own membership for ideas on who uses or has an interest in the waterbody. Efforts should be made to include as many different users as possible. (Read more about how to reach out to other concerned users of the waterbody in Chapter 5-Involve the Public.)

When is a Plant a Weed?

Determining whether a plant is a problem is not always easy. In some cases, the reason for desiring to eliminate a species is ecological, as when a species, such as the non-native, noxious invader Eurasian watermilfoil, threatens the health of a lake. Sometimes a plant is considered a weed for aesthetic (it's considered unsightly or smelly), or economic (it reduces property value) reasons . An individual's attitude toward certain plants in the waterbody can vary depending on human usage and safety issues. For instance, surface mats of shoreline water lilies may be pleasing to some who might never venture into the water, but not to those who swim in the area. Dense growth of submersed vegetation may be a problem to the angler using a motor-boat, but not to the pilot of a float plane that skims the surface of the water. It is important to recognize these factors about aquatic plants when determining if a nuisance condition exists in a waterbody.

2. Find out how users identify the problem
Different users will have different points of view about the waterbody's problem. Therefore, it is important to get a broad section of the public involved; only then can you consider the full variety of perspectives and see to it that they are included in the problem statement.

3. Group the problems into categories
This task involves grouping problem descriptions according to what uses they affect. Some uses of a waterbody that can be affected by nuisance aquatic plant growth are:

- fishing
- wildlife habitat
- motorboat access
- visual enjoyment
- swimming
- ecosystem function

Problems are often associated with the amount of vegetation as well as its location in the waterbody. Thick stands of submersed or floating plants in beach or shoreline areas may pose a serious safety risk to swimmers or waders. Dense, surfacing plants can be a hazard to those using non-motorized craft (rowers, rafters, sailboarders). Launch, marina and dock areas clogged by weeds can hinder motorboat access. Most importantly, the presence of **invasive, non-native plant species** in a waterbody is a serious situation (See box). Left unchecked, non-native weed species such as Eurasian watermilfoil are aggressive competitors. They can rapidly crowd out native vegetation, creating serious nuisance conditions affecting many beneficial uses.

4. Condense main categories into a problem statement

The final task in Step A is to shorten the major categories into a brief description of the main problems posed by aquatic plants in the waterbody. Describe the specific locations of problem plant communities. Use numbers, if available, to describe how the problems affect beneficial uses of the waterbody. For example, "The number of serious swimming accidents caused this year by problem plants near the swimming beach was X," or "The community lost Y dollars in revenue this year because the annual rowing event had to be called off due to excessive aquatic plant growth." Statements like these make the problem statement specific for your waterbody and your community.

Example Of A Problem Statement

After completing Step A, you will end up with a problem statement that might sound something like this: "In 1994, Eurasian watermilfoil was found in Lake Serene. In the following three years, milfoil spread throughout the boat launch area of the 100-acre lake, forming dense shoreline stands out to 12 feet deep. In addition, dense stands of water lilies choke the swimming area at the opposite end of the lake.

Swimming, boating, fishing and other recreational uses have been severely impacted. Local residents are afraid to swim in the lake and are very concerned about the safety of their children. A special rowing tournament held annually since 1975 on the lake in mid-summer can no longer be conducted due to surfacing plant growth. Cancellation of this event resulted in an estimated loss of revenue of X dollars annually. In addition, the average number of fishing days in Lake Serene declined from Y days in 1994 to Z days in 1997."

References on Problem Statement Development

- The Lake and Reservoir Restoration Guidance Manual[4]
- Management Guide for Lakes and Reservoirs[5]

Aquatic Weeds: How Did They Get Here?

Your lake is weed choked. How did it happen? A common means of introduction of aquatic weeds is through stem fragments that are transported from lake-to-lake on boats, trailers, and fishing gear. Non-native, invasive aquatic plants can be spread from one waterbody to another if "infected" boating equipment is not properly inspected and all stem fragments removed. Sometimes, invasive aquatic weeds can be purchased from aquatic nurseries for water gardens and home aquaria. These plants are adapted to grow well, and fast, under a variety of environmental conditions. Just like terrestrial weeds they can cause problems when they escape to natural systems. Preventing the introduction and spread of non-native and invasive species is critical to preserving the health of Oregon's aquatic resources.

CHAPTER 4

IDENTIFY MANAGEMENT GOALS (STEP B)

Setting Aquatic-Plant Management Goals

Once a problem statement has been drafted for your waterbody, the next step is to come up with specific management goals. Management goals define what the community wants to achieve in response to the aquatic plant problems. Defining goals helps in selecting the best methods, which form the heart of the Plan.

Goals vs. Methods

It is important to understand the difference between management goals and management methods. The goals are conditions in the waterbody that the community wants to achieve, and the methods are the means of attaining those conditions. A goal, for example, might be to reduce aquatic plant growth near a swimming beach so that it is no longer a safety hazard. Mechanical harvesting of the plants or a herbicide treatment might be methods eventually selected to achieve that goal. But the method cannot be chosen before the community establishes its goals and examines other critical aspects of the problem.

Goal-Setting Criteria

Goal-setting begins by identifying an initial set of goals that is reasonable and realistic for the community and the waterbody. These initial goals must address specific uses and be both practical and attainable.

It may be useful early on to set specific criteria to aid in goal-making decisions, such as:

- If a noxious, non-native weed is present, give highest priority to reducing or eliminating its populations, if feasible.
- Give priority to keeping a particular area clear of weeds, especially where human safety is at risk.
- Limit community outlay to less than X dollars.
- Reduce costs by using volunteer labor where possible.

Matching What's Desirable With What's Practical

Setting goals involves balancing user desires with the natural limitations of the waterbody and the financial limits of the community. A goal of removing all native plants in a lake is, under most circumstances, a bad choice. A lake is an active, living system, not a sterile swimming pool. Native aquatic plants play many important roles in the aquatic ecosystem (See Preface). Lakes with deep, rich sediments will likely continue to support nuisance plant populations unless aggressive measures are taken in the waterbody. Furthermore, some control measures are very effective, but may also be very costly.

If the community chooses not to do anything to manage nuisance aquatic plants, it is critical to understand the possible consequences. Will there be impacts on human safety, recreational uses, or aquatic life and habitat if problem conditions in the lake are allowed to continue? Consequences of the no action management goal become particularly important when a waterbody is infested with an invasive, non-native weed. In a shallow lake, these invaders can wreak havoc on the local environment, recreational use, fish survival, and finances. The establishment of desirable and acceptable management goals results from conducting, from the start, well-planned community meetings backed by strong efforts to present all information and gain broad based support.

Example Of Aquatic-Plant Management Goals

Here is an example of management goals for our imaginary Lake Serene: “The management goals are to maintain recreational uses and improve fish habitat in the lake by removing milfoil from known locations, and to keep swimming areas clear of weeds for safety reasons. Additional goals are to choose appropriate plant control methods that are environmentally sensitive, and reduce overall control costs by using volunteer labor when possible.

The Importance Of Public Involvement

TIP: As you move through the planning process, you will continue to learn more about your waterbody and plant problem. With new or more complete information available, you may need to revisit the goal-setting step to refine your management goals. An appropriate time for reviewing initial goals would be after presenting the initial problem statement and goals at a public meeting of the lake community. Another time is after determining beneficial use areas in the waterbody.

CHAPTER 5

INVOLVE THE PUBLIC (STEP C)

The Importance of Public Involvement

Once an aquatic plant problem has been recognized, it is crucial to bring all interested and affected parties together early on to participate in planning. Identifying people who have an interest in the waterbody often requires a bit of searching early in the process; although they have a tendency to make themselves more apparent later on, most often after all the planning has been completed. In addition to local residents or property owners, the waterbody may serve a variety of stakeholder groups with sometimes conflicting interests. Several state, county, local, and federal agencies may be involved. Private businesses or other interest groups may have concerns about the waterbody as well. Fortunately, the local watershed council includes representation of a broad range of stakeholders, and thus provides an opportunity for identifying and bringing interested parties into the aquatic plant management planning process.

Pulling all these parties together is like weaving a piece of fabric; each group interested in the waterbody is like a different strand of thread. As the strands are woven into the cloth, it becomes stronger. The end product—achieving consensus among the parties—is like strongly interwoven cloth. The objective is to encourage cooperation and gather support for the management program, but the benefits of community participation go beyond this.

Informed citizens, agencies and other groups who become involved in a waterbody management project learn about:

- The ecology of the aquatic system
- The management options for the system
- Different government agencies
- Special organizations with an interest in fresh-water management
- Leadership, organization, and cooperation.

What is a Watershed Council?

A watershed council is a locally organized, voluntary, non-regulatory group established to assess the condition of a watershed and build a work plan to implement enhancement and protection activities. Watershed councils offer local residents the opportunity to be involved in making decisions that affect their watershed. Each watershed council is as unique as the watershed they represent.

A watershed council becomes an official entity when it is recognized by a local government, usually the County Board of Commissioners. This official recognition makes the councils better candidates for Federal and State grants. Watershed councils should be representative of a broad range of stakeholder interests including conservation, recreation, timber, agriculture, and other interests within their basin. The state encourages councils to be as inclusive as possible of the various stakeholder groups within a watershed.

For more information on forming a watershed council call or write to the Oregon Watershed Enhancement Board (see contacts).

Public Involvement Steps

Public involvement means participation of the entire community. Important elements in the Public Involvement Process are:

1. Work with the local watershed council
2. Identify interested groups
3. Conduct public meetings
4. Keep the community informed

It is the role of the steering committee to do the initial leg work—gathering information to educate the community, as well as working closely with the watershed council to develop a draft management plan for public comment and input.

1. Work with the local watershed council
The local watershed council is concerned with protecting resources within the bounds of its watershed. Thus, a management plan for a specific waterbody should coordinate with the watershed council. It is critical that the steering committee maintain continuous links with the watershed council and the larger community throughout the planning process.

2. Identify interested groups
The steering committee identifies interested groups and compiles a list of appropriate contacts. The committee should already have a good handle on potential user and interest groups, having considered this topic in Step A. Some groups that may have an interest in management of an aquatic system are:

- Residents or property owners around the water body
- Special user groups (e.g., anglers, Trout Unlimited, Oregon Trout)
- Local government
- State and federal agencies (e.g., DEQ, ODFW)
- Native American tribes
- Water-related businesses (e.g., resorts, tackle & bait shops, dive shops)
- Elected officials
- Environmental groups (e.g., various fish groups, Nature Conservancy, Oregon Lakes Association)

3. Conduct public meetings
One of the best ways to reach the public is a meeting sponsored by an existing lake association or community club. These are usually made up of property owners around the waterbody. If no lake association exists, it is worthwhile to form one. Public meetings are a good way to attract individuals from within and outside the association. Local government officials, state agency personnel, local tribes, business people, and environmental and other user groups should all be invited to participate in these meetings.

Notes on Consensus Building

Consensus building in a diverse group can be a most challenging task. It may be difficult to get people with different interests to agree 100 percent on an issue. But it is critical to bring all groups together in the planning process to constructively discuss the issues and work toward achieving a consensus. To lead the effort, it will be helpful to identify individuals with strong, steadying leadership qualities. The following are some practical suggestions for achieving a common goal in a group:

1. Acknowledge that each person's opinion is important.
2. Emphasize that this is a group endeavor.
3. Use expert advice to clarify misconceptions.
4. Emphasize the community benefits of management actions.

TIP: Many of the identified groups consist of volunteers who may have limited time to participate in public meetings. It is a good idea to contact these people well in advance of the event so they can plan their time accordingly. Meetings will most likely need to be scheduled for evenings or weekends.

Timing is critical. Public meetings should be conducted at strategic stages in the planning process. Critical points are:

1. At the formative stages, following completion of Steps A and B
2. When possible plant control alternatives have been identified by the steering committee (after Step H)
3. After a control scenario has been selected, but before it is carried out (after Step J)
4. During implementation of the control scenario
5. During post-treatment evaluation

Widespread support is needed for implementing any action in a public waterbody. It is crucial that the interested parties support and accept proposed aquatic plant management actions. It is a good idea to collect written documentation of this support to have on record. Later on, the supportive documentation can be useful for purposes of clarification or emphasis.

4. Keep the community informed

Newsletters sent to association members and other interest groups and agencies are a good way to keep the public informed.

The organization initiating the planning process needs to stay in personal contact with these other interest groups. Members of the steering committee or other association members, for example, could accept invitations to participate in meetings of groups interested in the lake and present information on aquatic-plant management.

References on Public Involvement/Lake Management Organizations

- Starting and Building an Effective Lake Association[26]
- The Lake and Reservoir Restoration Guidance Manual (Appendix 3A)[4]
- Management Guide for Lakes and Reservoirs, Chapter 3[15]
- Oregon Lakes Association[H]
- North American Lake Management Society[I]

NOTES:

CHAPTER 6

IDENTIFY WATERBODY/ WATERSHED FEATURES (STEP D)

Waterbody-Watershed Connection

A lake or river is a dynamic, living system, teeming with physical, chemical and biological activity. The system extends beyond its shores to include the surrounding land (the watershed) that drains into the waterbody. A waterbody and its watershed are inseparable. In fact, waterbody conditions are very much influenced by what occurs in the watershed.

A watershed contributes nutrients to a waterbody that are necessary for aquatic plant growth. These nutrients—especially phosphorus and nitrogen—flow to the lake from all parts of the watershed by way of streams, ground water, and stormwater runoff. In addition, activities in the watershed, such as agriculture and forestry, road maintenance and construction can all contribute silt, debris, chemicals, and other non-point pollutants to the waterbody.

Nonpoint pollution sources arise from more widespread, dispersed sources (Technically, some nonpoint sources can enter a waterbody through a point source, but that is generally not the case.), in contrast to point sources such as pipes or outfalls that dump directly into the waterbody. Because of these important land-water connections, integrated aquatic plant management has to take a look at the entire picture. A waterbody can't be managed without understanding what makes the whole system work. Learning about the features of both the watershed and waterbody aids in understanding problems in the waterbody and in designing an effective management program.

A Plan should consider watershed problems and identify long-term measures to reduce them. Controlling watershed inputs from these sources can enhance the effectiveness of primary in-lake control measures targeting aquatic plant problems.

In addition, since aquatic plants are integral to the functioning of aquatic ecosystems, management activities that influence aquatic plant abundance and species present in a system can also impact nutrient cycling in a lake and exacerbate existing nutrient-related problems. So, understanding the way an aquatic system functions as part of a watershed is necessary for development of a truly integrated management plan. It must be understood, however, that managing nuisance growth of aquatic weeds typically requires more than implementing best management practices in the watershed.

How To Describe The Watershed And waterbody

This planning step is composed of two tasks:

1. Describe the watershed
2. Describe the waterbody

This step is really a fact-finding endeavor, which is conducted by the steering committee. The committee may have already uncovered some of the background information recommended below in its preliminary search for data (See Getting Started, Chapter 1). In fact, the local watershed council may already have some background data in its files on the particular waterbody.

1. Describe the watershed

To understand a waterbody's problem, you first need to identify features of the watershed. If the waterbody is in a watershed with federal land in the basin, there may be a federal watershed analysis that includes the area of interest. Contact the local office of the Forest Service of BLM. The Watershed Council may also have conducted a watershed assessment using the Oregon Watershed Assessment Manual. These documents may have information that can help your group understand the watershed functions that affect the waterbody.

It is important to note characteristics of the watershed such as:

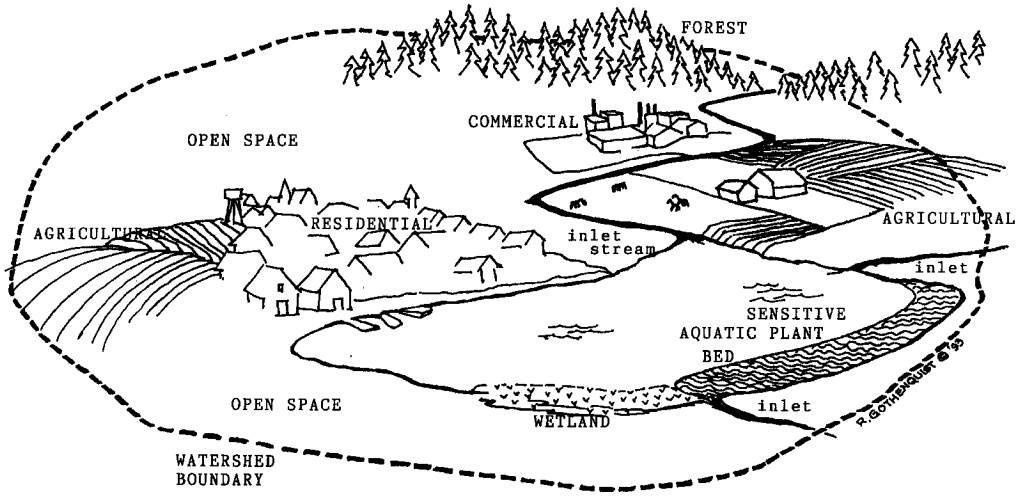
- Size and boundaries of the watershed
- Tributaries, wetlands and sensitive areas
- Land use activities in the watershed
- Nonpoint pollutant sources
- Existing watershed management, monitoring or enhancement programs
- The presence of rare, endangered or sensitive animals and plants

Much of this information is readily available as documents, maps or data that can be obtained from the local watershed council, local planning or public works departments and state agencies. Appendix C–Watershed and Limnological Background Information–offers a more detailed discussion on these topics and how and where to collect information on your watershed.

2. Describe the waterbody

You probably know more about your lake than just about anyone else. You can probably easily describe your lake in general terms–you know where the weeds are thickest, where the snags are that can snap your prop or tangle your fishing line, and where the big, hungry fish like to hang out. The description of your lake that is required for a Plan is really no different from how you would describe your lake to a friend. However, where your description to a friend might include observations and information on how to avoid obstacles and where to catch fish, the observations required for a Plan describe what it is about the waterbody that can affect the growth of plants. Understanding the factors that influence weed growth is an important step in controlling a nuisance weed situation. Important waterbody features are:

- Location
- Lake basin morphology (size, shape, and depth)
- Water sources
- Physical and chemical characteristics (water quality)
- Biological characteristics (animals and plants)
- Shoreline uses
- Outlet control and water rights.
- Size of littoral area potentially available to aquatic plants



"WATERSHED SNAPSHOT"

Because Oregon has such diverse climates, ranging from inland desert to coastal plains to high elevation mountains, the location of your waterbody can explain unique aspects of the problem and what might work best in your situation. The size, shape and depth of a waterbody determines where aquatic plants can grow, and other biological and chemical processes occurring in the waters. These factors are especially crucial to salmon and steelhead utilization of your lake and watershed. A waterbody is influenced by types and quantity of inflowing and outflowing water sources. In addition, understanding water quality characteristics, such as temperature, light, dissolved oxygen levels and nutrient concentrations in the water, helps explain the overall health and limitations of the system. From a fisheries habitat perspective, temperature and dissolved oxygen levels are critically important to fish survival and reproduction. Finally, there are important cultural factors on the shoreline (land use, regulating flow through the outlet) that further define the waterbody. These physical, chemical, and biological features of freshwater ecosystems are described in more detail in Appendix C–Watershed and Limnological Background Information.

Getting Started In Your Search Of The Waterbody

A number of inventories of Oregon lakes have been conducted by various agencies in the past several decades. Over 200 lakes in Oregon were mapped by Portland State University and the Oregon Department of Environmental Quality (DEQ) during the early 1980's. The results were published in the *Atlas of Oregon Lakes*. Earlier lake reconnaissance surveys were also performed in the 1970's, led by Robert McHugh of DEQ. In addition, the U.S. Geological Survey, Water Resources Division, conducted an extensive statewide survey of lakes during 1973 to 1979, publishing results in a six volume set entitled *Lakes of Oregon*. The information in the earlier surveys may be out of date, especially with respect to land use, but they can provide much of the basic background information required for planning.

Sampling/Monitoring To Fill Data Gaps

Some of the information you need to describe your waterbody and develop a Plan may not be available. In that case, an organized information gathering program might be necessary to fill in background data gaps. Much information can be collected by lake-area residents. Special sampling equipment is often necessary to obtain some information. In these cases, seeking the technical assistance of lake management professionals may be a prudent decision.

Also, certain types of water samples require analyses by approved analytical or biological laboratories. Refer to *Water Quality Monitoring Technical Guide Book*[32] from the 1999 Oregon Plan for Salmon and Watershed monitoring team.

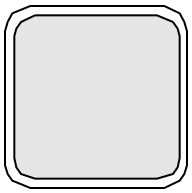
State or local lake monitoring programs may be sources of training and assistance in setting up a sampling program for your waterbody. The Center for Lakes and Reservoirs at Portland State University can provide information on measurement of basic water quality characteristics in Oregon's lakes and reservoirs.

References and Resources on Lake, River and Reservoir Monitoring and Ecology

- Appendix C–Watershed and Limnological Background Information
- Water Quality Monitoring Technical Guide Book[32]
- Atlas of Oregon Lakes[28]
- Lakes of Oregon[7]
- Center for Lakes and Reservoirs[E]
- The Lake and Reservoir Restoration Guidance Manual[14]
- Volunteer Lake Monitoring: A Methods Manual[9]
- Limnology[23]
- Oregon Dept. of Environmental Quality staff
- Watershed council
- Local governments
- Freshwater limnologists/chemists

NOTES:

CHAPTER 7



IDENTIFY BENEFICIAL USE AREAS (STEP E)

In terms of human enjoyment, freshwater systems are popular outdoor recreational places for swimming, boating, and fishing. They also offer a variety of economic benefits such as tourism, food supply, and transportation. Their capacity to provide aesthetic enjoyment can be immeasurable. Freshwater bodies perform vital functions such as flood protection, providing drinking water, and generating electricity. More importantly, freshwater systems provide habitat and food for aquatic life, including fish, waterfowl and other animals.

Beneficial Uses are Protected
Lakes have multiple beneficial uses, but foremost among them is the preservation of salmon habitat as described in the Oregon Plan for Salmon and Watersheds. Any management activities occurring in freshwater systems in Oregon must be compatible with this statewide salmon conservation and restoration program.

Beneficial uses of water bodies are protected by Oregon State statutes. Under the State Surface Water Quality Standards, protected beneficial uses include fish and shellfish rearing, spawning and harvesting, swimming, boating, navigation, irrigation, wildlife habitat, and domestic, industrial, and agricultural water supply.

Balancing Multiple Uses
Desired uses of a waterbody must be compatible with it's capacity to sustain those uses, both human and natural. Unfortunately, a single waterbody often supports many different desirable uses, which sometimes conflict with each other. The management challenge involves identifying and agreeing on uses that complement each other, and realistically managing for these uses.

How To Determine Beneficial Use Areas Of Your waterbody

This step focuses on identifying zones for each beneficial use on a map of the lake. Often, the process of defining these areas reveals the potential for conflict. Step E consists of two tasks:

1. Identify present waterbody use areas
2. Produce a waterbody usage map

1. Identify present waterbody use areas

The first task is to identify the areas of your waterbody presently employed for beneficial uses. You can begin this identification with the list of uses compiled by the steering committee in Chapter 3. For each use from that list, identify the areas where it is most common in the waterbody. Additional information about use areas might be available in the zoning, wetland, or resource inventory maps you created in Chapter 5. Common use areas include:

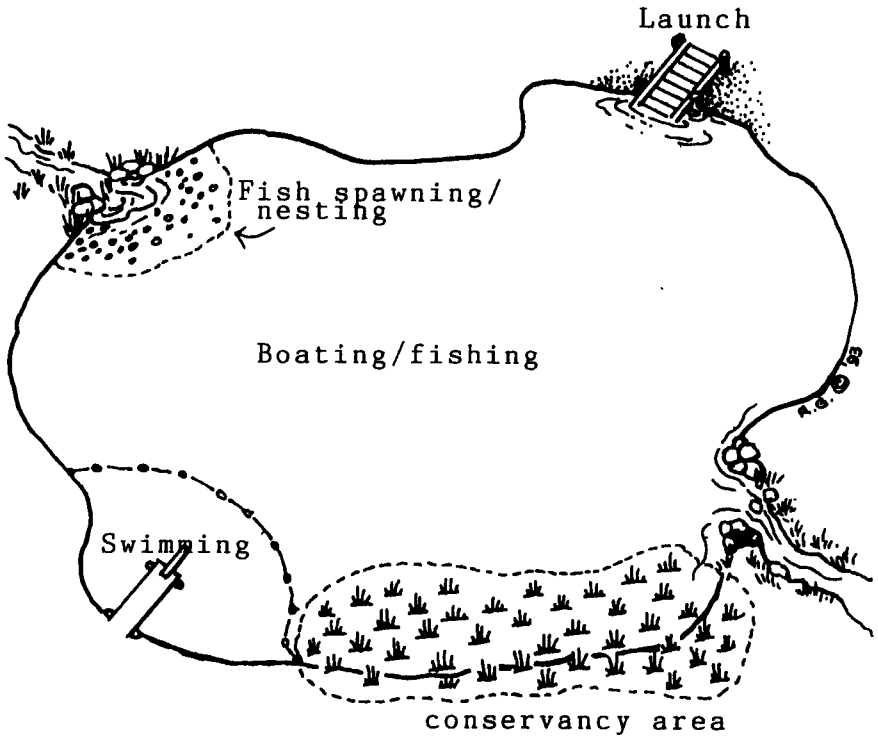
- Conservancy areas, including habitats that are integral to the lake ecosystem, such as nesting sites, fish rearing or spawning areas, or locations of rare plant communities
- Boating and boat access areas (launches, ramps)
- Water skiing zones
- Beaches and swimming areas (public, private)
- Fishing areas
- Areas for special aquatic events (e.g., sailing, rowing, mini hydroplane races)
- Parks, picnic areas, nature trails, scenic over looks
- Irrigation/water supply intakes
- Other shoreline uses (e.g., residential, commercial)

2. Develop a waterbody usage map

The next task is to draw the current waterbody use areas on a map of the lake. This waterbody usage map shows primary human uses, as well as habitat areas for fish, waterfowl, and other wildlife utilizing the waterbody. As you develop this map, look for potential conflicts in use, such as a water-skiing zone coinciding with a fishing area.

Example of a Waterbody Usage Map

The following is a waterbody usage map drawn for the imaginary Lake Serene.



BENEFICIAL USE AREA MAP

CHAPTER 8

MAP AND CHARACTERIZE AQUATIC PLANTS (STEP F)

What Is An Aquatic Plant Survey?

Depending on a waterbody's size, depth, and other characteristics, aquatic plants can cover extensive areas or occur in small, localized areas. In order to design an effective management program specific to your waterbody, the types of aquatic plants, their location, and abundance must first be determined. This can be accomplished by performing an aquatic plant survey. A survey involves systematically traveling around the waterbody and shoreline and noting aquatic plant presence and abundance. An important part of the survey is collecting samples of aquatic plants to verify the species.

How To Map Aquatic Plants

Mapping aquatic plants in your waterbody involves the following tasks:
1.Conduct a systematic survey of the waterbody
2.Produce an aquatic plant survey map
3.Describe beneficial and problem plant zones

1. Conduct a survey of the waterbody

Aquatic plant surveys are usually conducted at critical stages in the growth cycle of plants. Ideally, surveys should be performed early in the growth season (spring), at mid-season (summer), and late in the growth season (fall). But this often can't be done because of time and financial limitations. A survey at the height of the growth season (August), when plants are most obvious, provides a practical and valid alternative. A simple aquatic plant survey consists of:

A. Identifying major types of aquatic plants
B. Drawing a map of aquatic plant types and locations in the waterbody
C. Estimating relative abundance of aquatic plant types
D. Collecting samples of plant species
E. Identifying substrate types

A. Identifying major types of aquatic plants
Before you start your survey, you will need to become familiar with various types of aquatic plants. There are generally four kinds of aquatic plants that inhabit freshwater (See Box pg. 8.2). The types are categorized according to how they are attached to the sediments. The four groups are emergent (such as cattails), freely-floating (not rooted to the sediment, such as duckweed, coontail), rooted floating-leaved (such as water lilies), and submersed forms (such as milfoil). The four plant types may occupy different regions of the lake, with emergents and floating-leaved plants confined to shoreline margins, while submersed and free-floating plants can extend to deeper, open water areas. Species representing the different plant types may also occur together in mixed communities at a specific site (e.g., rooted, floating-leaved lilies with rooted milfoil). In general, aquatic plants tend to inhabit shallow, near-shore areas of the waterbody. In shallow water bodies, profuse aquatic plant growth may occur throughout the system.

B. Drawing a map of aquatic plant types and locations in the waterbody
You will need the following basic supplies and equipment for your survey:

√ a map of your waterbody
√ a rope marked off in feet to measure water depth
√ a weighted rake with rope attached for collecting samples
√ a notebook, pencils, and waterproof marker
√ labeled plastic bags for samples
√ an anchor

Keeping the four basic plant types in mind, tour the entire waterbody by boat, noting where plants are near or at the water surface. You may also find it helpful to walk around the shoreline, especially if near-shore areas are clogged by weeds and make boat passage difficult. Sketch the locations of plant growth for the four types on a large-scale map of the lake, preferably one that indicates water depth intervals and includes major landmarks for reference.

An aerial photograph of the lake may be helpful in determining the distribution and cover of emergent and floating-leaved aquatic plants. Aerial photos used for vegetation mapping should be taken during mid- to late-summer when plants are at their maximum biomass. You will probably need to check on the identity of plants you see on aerial photos by checking the area from the ground–called "ground-truthing" in the remote sensing lexicon. Aerial photos may not be very useful for submersed aquatic vegetation mapping because turbidity in the water may obscure the plants.

C. Estimating relative abundance of aquatic plant types

The relative abundance or prominence of the aquatic plants types often indicates the overall health of the system. A healthy aquatic system usually has a variety of types and species of plants. The presence of only a few species of plants in a waterbody may occur where shoreline areas have been disturbed (by an influx of sediments or other contaminants) or have been invaded by exotic species.

In order to determine relative amounts of aquatic plants, you will need to look at the plant beds at representative points within the waterbody. Before leaving shore, establish survey lines, called *transects,* at appropriate points along the shoreline. For a small lake, you can mark off transects, say every 300 feet, all the way around the shoreline. Draw

How to Recognize the Four Types of Aquatic Plants

Emergent aquatic plants grow rooted in saturated soils around the shoreline or in water up to about 3 feet deep. Mature emergents' stems, leaves, and flowers extend well above the water surface. Many look like terrestrial plants. Soft rushes, bulrushes, cattails, and iris are typical emergent species.

Free-floating aquatic plants float on or under the water surface. Their root systems, if present, generally hang beneath the plant and are not attached to the bottom. This diverse group ranges from large plants like coontail and water hyacinth to very small surface-floating plants like duckweed. They are usually found in protected areas or where water currents are very slow. Since they absorb nutrients entirely from the water column, these aquatic plants are frequently found where nutrient content is high.

Rooted floating-leaved aquatic plants grow attached to the sediments in water depths from 1.5 to 10 feet. They are recognized by oval or circular leaves that float on or project just above the water surface.The floating leaves are connected to the bottom by long, flexible, fairly rigid stems. Water lilies are common floating-leaved plants.

Rooted submersed aquatic plants grow at water depths where light is sufficient. Submersed plants grow with stems and leaves underwater, although some forms also have differently-shaped floating leaves (e.g., broad-leafed pondweed). Submersed species usually have long, thin, flexible stems that are supported by the water. Submersed plants show a variety of leaf forms, from long ribbons (long-leaf pondweed) to feathery whorls (milfoil). Most submersed aquatic plants produce flowers above the water surface.

these lines on the lake map extending them perpendicularly from shore out to where the water is about 20 feet deep (typically the outer limit of growth), or its greatest depth if the lake is less than 20 feet deep.

In a boat, follow each of these lines looking at the submersed plants through an underwater viewer. These can be obtained at diving shops or recreational supply stores or built. At regular points along the transect (e.g., at increments of 3 feet of water depth), make an estimate of plant abundance by counting the number of visible plants per unit area of lake bottom. Estimate plant abundance as sparse (a few plants per square yard), moderate (5-10 plants/square yard), or dense (more than 10 plants per square yard). Where lake water clarity is poor, or an underwater viewer is not available, a more general characterization of plant beds can be obtained by deploying the sampling rake at regular intervals and depths around the lakeshore, and noting plant species brought up on the rake.

D. Collecting samples of plant species

Identifying aquatic plant species is important for several reasons. For one thing, different species often respond differently to the same control techniques. A management technique that is very effective on one species may not work at all on another species. It is also important to determine whether any rare or sensitive plants are present. These species are protected and some control techniques may damage them.

It is crucial to find out whether any invasive, non-native plants are present so a timely, aggressive control program can be started. A small population of an exotic aquatic plant species should be eliminated to prevent habitat destruction, particularly if a plant or animal species listed under the Endangered Species Act occurs in the waterbody. To help acquaint you with some non-native plant invaders, Appendix B includes illustrated plant identification factsheets of six exotic species of concern in Oregon waters.

RED FLAG–**If an invasive, exotic (non-native) species is present in your waterbody,** notify staff at Department of Agriculture, Noxious Weed Program. A more intensive survey should be conducted to determine the precise locations of the exotic plant populations. In addition, special measurements should be taken to determine status of infestation regardless of whether it is in a beginning or an advanced stage

RED FLAG–**If an endangered, rare or sensitive aquatic plant is present in your waterbody,** a more intensive survey is recommended to determine the precise locations. See discussion on the Oregon Natural Heritage Program in Appendix C page C4.

Samples of aquatic plants should be collected at points along the survey transects. From the boat or shoreline you can cast a weighted rake to the lake bottom and pull up aquatic plants. Be sure to note the transect line number, the location on the transect, and depth from which the sample was taken (use your calibrated rope). Specimens collected in this manner can be bagged and sealed for later shipment to a specialist for identification. The box on the following page describes how to collect and prepare an aquatic plant sample for verification.

It is also advisable that you preserve a sample of important plant species in your waterbody for a permanent record. Oregon Lake Watch staff or the Department of Agriculture can help you with ideas on preserving plant specimens.

TIP: Many problem plant species can reproduce and spread by fragments. Be sure to remove all plant fragments from the boat and trailer when leaving the water. Dispose of the fragments in a garbage can to avoid creating new colonies of nuisance plants within the lake or transporting the plants to another lake.

E. Identify sediment types

Sediment types are generally classified as:

– mucky, organic
– sandy
– compact, clayey
– gravely

Sediments in the waterbody can be identified by either collecting a bottom sample with a small sampling dredge, by pushing a PVC pipe into the bottom, or by examining sediment brought up with an aquatic plant sample.

2. Produce an aquatic plant survey map of the waterbody

Using field notes and maps from the aquatic plant survey, construct an aquatic plant map of the waterbody. The aquatic plant map should show:

- Water depth contours, in feet or meters (this type of data is presented on bathymetric maps)
- Approximate location(s) for each of the four types of macrophytes
  – emergents
  – free-floating
  – rooted, floating-leaved
  – submersed
- Highlighted locations of non-native invasive aquatic plant species, if present
- Highlighted locations of rare, sensitive, or endangered aquatic plant species, if present
- Locations of wetlands/conservancy areas
- General sediment types
- Tributaries/outlet(s)
- Open areas

3. Describe beneficial and problem plant zones

Once you have mapped the aquatic plants in your waterbody, the next step is to use that information to write a description of beneficial and problem plant zones. Characterizing the aquatic plant zones allows you to determine where special control actions are required. Task 3 consists of the following steps:

A. Describe plant types
B. Determine problem areas and beneficial plant zones
C. Determine need for special action

A. Describe general plant types

The purpose of this step is to write a description of the main types of aquatic plants occurring in the

How To Collect And Prepare An Aquatic Plant Sample For Verification

Step 1. Obtain an aquatic plant sample by dropping a weighted rake to the lake bottom and pulling up the vegetation snagged by the rake. Remove the plants from the rake, sorting out the different plant types. To keep the plants from drying out, sort them in a shallow pan filled with water.

Step 2. Rinse a few healthy specimens of the plant types of concern with water from the lake. Carefully lay the plant specimens between two pieces of dry paper towel, place them in a plastic bag and seal the bag securely. Label the bag clearly with the date, name of waterbody, location and depth of sample, and your name and telephone number.

Step 3. Mail the samples to a recognized aquatic botanist** for identification as soon as possible. Dry plant specimens in a plastic bag can be easily mailed in a regular envelope.

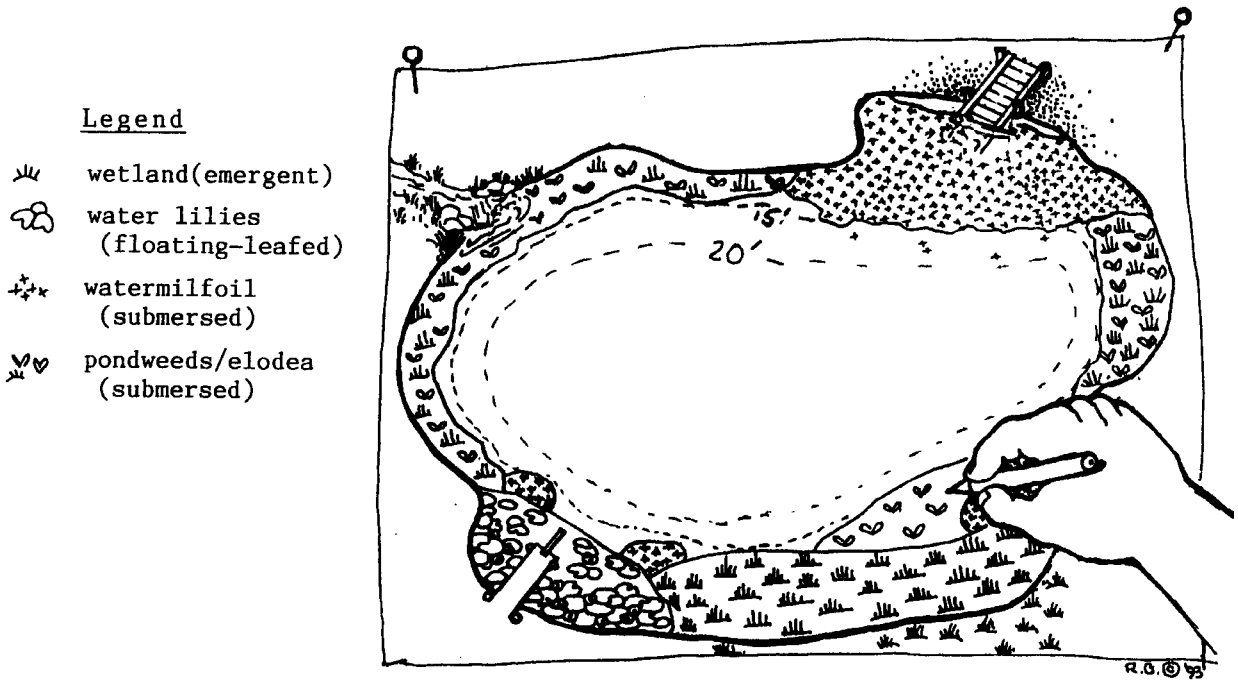
Step 4. If delivering a fresh (wet) sample in person, store it in a plastic jar filled with lake water in the refrigerator in the interim, and then transfer it to a small cooler with an ice pack for transport to an aquatic plant expert**. Plant samples can usually be kept fresh in this way for up to five days.

*****To whom do I send an aquatic plant sample for identification?***

It is critical that the plant sample be accurately identified by an aquatic botanist or a trained freshwater management professional. Contact the Department of Agriculture, Noxious Weed Program (503-986-4621) or the PSU Center for Lakes and Reservoirs (503-725-3833) for assistance in plant identification.

Example Of Aquatic Plant Map

The following is an example of an aquatic plant survey map produced for Lake Serene.



waterbody. Give the general locations of plant beds and the maximum depth of growth. Also estimate how much of the surface area is occupied by plants.

B. Determine problem areas and beneficial plant zones

Identify the parts of the waterbody affected by the following problems:

- The presence of invasive exotic species
- Excessive native plant growth that interferes with important waterbody uses as swimming or boating.

Beneficial plant zones

Identify conservation areas, fish-rearing habitat (especially salmon) or native vegetation considered beneficial to fish, waterfowl, and other wildlife. Non-native and invasive aquatic weeds are not considered beneficial habitat for fish. A lake littoral area (aquatic plant zone) with a diverse native plant community providing complex, multi-level underwater structure makes ideal habitat for salmon. Aquatic weed-infested lakes are often dominated by one, canopy-forming species. The high biomass and reduced light levels under an an aquatic weed canopy may result in oxygen concentrations and pH levels that degrade habitat quality.

Rare, endangered, or sensitive plants may be present in some lakes. Zones containing these plants should be protected. These special habitat areas may limit use of certain aquatic plant control methods in or near the waterbody.

C. Determine special need for action in the waterbody

The presence of a pioneer population of non-native, aquatic plant species signals an urgent situation. Because of the nuisance potential posed by these weedy invaders, and detrimental impacts on critical habitat, immediate action may be necessary.

Example Of Written Description Characterizing Aquatic Plants

A description of the aquatic plants in Lake Serene might read like this: "Aquatic plant growth in this lake is confined to a narrow band around most of the shoreline, extending out to 12 feet in depth. The total area of the lake occupied by aquatic plants is estimated to be about 40 acres (or 40% of the entire lake area). Some isolated patches of emergent plants, such as iris, cattails, and other reeds and rushes occur along the shoreline. A large water lily bed occupies the end of the lake where the swim beach is located. The submersed plant community is composed of sparse stands of naiad, common elodea and small-leaf pondweed in the shallows, and moderately-dense beds of big-leaf pondweed occurring throughout the deeper water areas. A large, surfacing stand of (non-native) Eurasian watermilfoil also occurs near the boat launch. In addition, a few scattered stands of non-native milfoil plants are present at the opposite end of the lake (near the swim beach), intermingled with the other submersed plants.

The entire bay with the boat launch as well as the near-shore region at the opposite end of the lake are highest priority **problem zones** because of the presence of the noxious, non-native weed milfoil. These milfoil areas require special control action. Another problem zone is the swim beach area which is heavily populated with water lilies; these surfacing beds make shoreline access as well as actual swimming most difficult and dangerous. Lake Serene supports a planted trout fishery and nesting blue herons. The native beds of pondweed, elodea, and naiad form an important source of food and refuge for these and other aquatic wildlife. Also, the wetland near the swim beach is classified as a conservation area while recognized as a beneficial zone, and protected in the overall aquatic-plant management plan."

√! In completing the planning steps to this point, you may have uncovered new and critical information on the nature and type of aquatic weed problems in your waterbody. This new information may affect some of your initial objectives. For instance, you may have discovered the existence of noxious, non-native plants or sensitive plants in your waterbody. These conditions will affect your choice of management goals and control options. If this information wasn't available to you as you started the planning process, it may be necessary to revisit STEP A and STEP B and refine the Problem Statement and Management Goals. Once the necessary revisions are made, they should be presented to the larger community for approval through the public process. Now it is time to look at available control options.

References and Resources on Aquatic Plant Identification

- Oregon Natural Heritage Program[F]
- Department of Agriculture, Noxious Weed Program[A]
- Aquatic Plant Identification and Herbicide Use Guide[10]
- Wetland Plants of the Pacific Northwest[11]
- Wetland Plants of Oregon and Washington[30]
- Common Marsh, Underwater & Floating-leaved Plants[2]

CHAPTER 9

INVESTIGATE CONTROL ALTERNATIVES (STEP G)

Control Alternatives Available in Oregon

A variety of methods are currently being used for controlling nuisance aquatic plants. The following is a list of aquatic plant control alternatives available for use in Oregon:

Physical Methods
- Hand-pulling/cutting
- Bottom barrier application/sediment covers
- Water-level drawdown
- Watershed controls
- Water column dyes

Mechanical Methods
- Harvesting and cutting
- Bottom tillage (rotovation)
- Diver-operated dredging
- Weed Rolling

Biological Methods
- Grass Carp (irrigation and drainage canals only)
- Milfoil weevil

Chemical Methods
- Fluridone
- Diquat
- Copper compounds
- Glyphosate
- Endothall
- 2,4-d

Control Alternatives Summarized

With so many techniques to choose from, how do you sort out the options? First, you'll have to become familiar with the advantages and disadvantages of each control alternative. Table 9-1 summarizes important economic, environmental, and logistical factors for the management techniques. Having a basic understanding of the capabilities of each option will help you choose the best combination of treatment methods.

More complete and in-depth information on these control methods is available from other sources. Appendix D of this manual describes each option's mode of action, effectiveness and duration of control, advantages, drawbacks, costs, required permits, and provides other comments. Aquatic Plant Management in Lakes and Reservoirs, prepared by the North American Lake Management Society and Aquatic Plant Management Society is a useful resource for both the layperson and professional on control methods as well as other aquatic plant management topics. The manual provides a thorough, concise, and up-to-date summary of the current science and practice of aquatic plant management in North America. Other references and resources are listed at the end of this chapter.

No action alternative

Aquatic plant management usually involves "doing something" in the waterbody to correct the problem. Sometimes, however, control options may not be as appealing as simply "doing nothing." It is important to consider possible consequences to the waterbody if no action is taken against problem aquatic plants. The choice of no action may have serious impacts on the aquatic ecosystem and related human uses when problem infestations are due to non-native, invasive species.

It's important to consider the potential for nuisance non-native plants to impact fish and wildlife. Aquatic weeds affect fish and wildlife by altering the structure of the underwater habitat. These effects are difficult to observe, but are none-the-less important. Dense weed beds can also produce changes in the water's dissolved oxygen concentration, temperature, and pH that can be harmful to aquatic life.

Continued on page 9-6

Table 9-1
SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN OREGON

Method	Appropriate Scale (Area or Extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit(s)/ Regulatory Agency
Physical							
Hand Pulling Raking	Small Scale	Season or Longer	Moderate to High (with complete removal)	$0 with volunteer labor, $500 to $2400/day contract divers	• Site specific • Species specific • Mimimum impact on native plants • Use near obstructions	• Slow, labor intensive expensive • Short-term turbidity increase • Diver visibility can restrict effectiveness	None
Hand Cutting	Small Scale	<One season	Moderate	$100 to $1000 for equipment + labor Vounteer labor would reduce costs	• Immediate plant removal	• Fragments generated • Short-term increase in turbidity	None
Bottom Barriers	Small-scale	2 to 3 years	High	$0.15 to $0.75/sq.ft for material $0.15 to $0.75/sq ft for installation	• Immediate plant removal • Materials reusable • Site Specific • Useful around obstructions	• Not species specific • Benthic organism impacts • Material costs • Maintenance required • Decay causes low DO	None
Drawdown	Large scale	None	Low	Variable	• Useful for repair/ maintenance of shorelines and structures • May enhance growth of emergents (water fowl habitat)	• Not species specific • May impact wetlands • Loss of recreation • Dissolved osygen decrease • Benthic invertebrate impacts	Yes Dept. of Water Resources
Watershed Controls	Small-scale	None-long term	Low	Low	• Long-term improve-ment in water quality • May encourage rooted and discourage non-rooted species	• Does not address all nutrient sources used by most aquatic plants	No

Table 9-1
SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN OREGON

Method	Appropriate Scale (Area or Extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit(s)/ Regulatory Agency
Physical							
Water column dye (Dyes are regi tered as herbicides)	Large-scale	Weeks to months	Low	$12.50/acre-ft.	• Non-toxic • No special equipment needed	• Shallow, closed systems only • Not effective when plants near surface • No use in potable, flowing, or clorinated water •Not species specific •DO decreases when plants decay	No For info contact: ODA
Mechanical Harvesting	Large-scale	Less than one season	Low-Moderate	$600/acre (May vary with transport costs	• Immediate plant removal to cutting depths (4-8 ft) • Minimal bottom disturbance • Materials may be composted • Reduces internal loading of nutrients	• Plant disposal • Fragments formed • Fish and invertebrate impacts • Slow • High initial capital $ • Operating depth limited • Operatioins depend on weather • Not species specific	No
Rotovation/ Cultivation	Large-scale	2 to 3 years	Moderate - High	$1000 to $1750/acre (depends on plant density and area of treatment)	• Winter treatment minimizes summer season recreation impacts • May increase species diversity	• Bottom disturbance/ increased turbidity • Fragments formed • Decay causes low DO • Bottom obstructions limit use • Not species specific	Yes Contact ODSL/COE
Hydraulic dredge	Large-scale	Potentially long	High	Variable, average $2-$7/m^3	• Removal of entire plant, including roots •Additional benefits of deepening lake, removal of enriched or toxic sediments	• Very costly • Temporary bottom disturbance and increased turbidity in water column • Not species specific in mixed community	Yes Contact ODSL/COE

Table 9-1
SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN OREGON

Method	Appropriate Scale (Area or Extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit(s)/ Regulatory Agency
Mechanical							
Diver-operated dredge	Small-scale	Potentially long (Depends on availability of propagules for recolonization	Moderate-High	$1200-2400/day (coverage depends on plant density)	• Site specific • Species specific • No depth constraints • Used near obstacles	• Labor intensive, slow • Potential fragmentation • Temporary bottom disturbance and increased turbidity	No permits for disturbing less than 50 yd^3 contact: ODSL/COE
Weed rolling	Small-scale	Long-term The life of the roller	Moderate	Purchase $2000 minimal operating cost	• Low operating cost • Supresses plant growth over time	• Not species specific • Impacts benthic organisms • May fragment plants • Bottom obstructions can limit use	None
Biological							
Grass carp	Large-scale	Potentially long	Low-High	$50 to $200/acre (depends on stocking density)	• Low maintenance • Large area covered	• Stocking densities not well established • Difficult to fine-tune control • Preference for native species over exotics • Ecological impacts unknown • Not site specific • Recapture problems • Susceptable to predation by wildlife or humans • Eradication potential high	Yes ODFW For use in irrigation and drainage canals only Not for use in natural systems
Milfoil Weevil	Large scale	Potentially long	Low-Moderate	Minimum $1000 plus monitoring and site suitability assessment	• Native to N. America • M. spicatum specific	• Will not completely eliminate weeds • M. spicatum specific	Yes ODA Form 526
Chemical							
Fluridone	Large-scale	> 1 year (depends on availability of propagules for recolonization)	High	$900 to$1400/acre	• Systemic herbicides, kills roots/shoots • Some species specificity with correct application rates • Non-toxic	• Requires long contact time • Off-site movement possible • Nutrient release and decreased dissolved oxygen	No For info. contact: ODA

Table 9-1
SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN OREGON

Method	Appropriate Scale (Area or Extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit(s)/ Regulatory Agency
Chemical							
Glyphosate	Large-scale	> 1 year (depends on availability of propagules for recolonization)	High	$250/acre	• Systemic herbicide kills roots/shoots • Non-toxic • No label restrictions on swimming, fishing • Low cost	• Non-selective herbicide • Emergent plants only	No For info. contact: ODA
Endothall	Large-scale	Weeks to months	Moderate	$500 to $700/acre	• Short contact time required • Low toxicity • Fast dissipation	• Contact herbicide • Temporary effect • Label restrictions on fish comsumption, irrigation and domestic water use	No For info. contact: ODA
2,4-d (amine and esther)	Large-scale	>1 year (depends on availability of propagules for recolonization)	High	$700 to $1000/acre	• Systemic herbicide • Some species specificity with correct application rates • Low toxicity of amine formulation	• Use restrictions for irrigation, livestock domestic water • Off-site movement possible • Esther formulations more toxic to fish	No For info. contact: ODA
Diquat	Large-scale	Weeks to months	Moderate	$600 to $1000/acre	• Short contact time required • Low toxicity • Fast dissipation from water	• Contact herbicide • Short-term efficacy • Effectiveness reduced in turbid water or muddy vegetation • Use restrictions for irrigating, spraying domestic, lifestock water use	No For info. contact: ODA
Copper chelates	Large-scale	Weeks to months	Moderate to high (depends on species)	$120 to $340/acre (depends on species)	• No use restrictions • Short contact time required • Low cost	• Toxicity on fish greater in low pH water • Persistent in environment • Species susceptibility varies • Non-target species effected	No For info. contact: ODA

Economic impacts should also be considered. Weeds can negatively affect tourism and commercial activities associated with use of the waterbody.

In summary, before a decision is made to "do nothing" to control nuisance plants, the potential consequences of that decision on beneficial uses of a waterbody must be carefully considered.

References and Resources on Aquatic Plant Control Alternatives

- Noxious Weed Program Coordinator, Oregon Department of Agriculture[A]
- Aquatic Plant Management in Lakes and Reservoirs[7]
- Aquatic Plant Identification and Herbicide Use Guide, Vol II[10]
- Aquatic Plant Management Program, FSEIS[1]
- Restoration and Management of Lakes and Reservoirs[13]
- Lake and Reservoir Restoration Guidance Manual[l4]

CHAPTER 10

SPECIFY CONTROL INTENSITY (STEP H)

This step of the Plan development involves determining how much control is needed for particular plant problems. Are there plant zones around the lake that should be left alone (no control)? Where should a low level of control be applied to preserve some intermediate level of plant growth? And under what circumstances would a high level of control be necessary, such as where a minimal amount of nuisance plants can be tolerated?

What Are The Different Levels of Control?

No Control
It is best to leave special habitat areas containing native aquatic plants untouched. In areas such as sensitive salmonid-bearing waters described in the Oregon Plan for Salmon and Watersheds and shoreline wildlife conservancy areas that serve as nesting and forage sites for waterfowl and other animals, management actions may cause more harm than good. Native plant beds that function as fish spawning sites are best left alone or subjected to minimal treatment. In some cases, the presence of native plants may have aesthetic value to the surrounding community. When noxious weeds are present, however, some management action can be taken that will benefit the aquatic system.

Low Level of Control
Low levels of control or partial removal of vegetation might be all that is needed to attain your management goals. For instance, in lakes where a warm-water fishery is important, using mechanical methods to develop fish lanes through vegetation can be valuable. Low-intensity control efforts are also important in shoreline treatments where emergent vegetation is to be protected. Low-level control maximizes enjoyment of a waterbody while minimizing plant removal. A benefit of low-level control using mechanical means is the low treatment cost per acre because less plant material is removed.

High Level of Control
The occurrence of certain aquatic plants may require aggressive control. The presence of invasive non-native plants may justify aggressive measures to remove plants, especially where critical salmonid habitat may be degraded.

For safety reasons it may be necessary to clear all vegetation from swimming or wading areas. Other areas requiring intensive removal may include areas around docks or boat ramps. It is important to note that the latter two examples describe small-scale, localized treatments. Lake-wide control efforts affecting 100 percent of aquatic plants are seldom appropriate, except perhaps in lakes where invasive, non-native plants are widespread and can be selectively removed with appropriate whole-lake methods.

How to Determine Levels of Control in a Waterbody

To determine appropriate levels of plant control in your waterbody, refer to the waterbody usage map and the aquatic plant map. The following tasks describe how to use these maps to produce a control intensity map.

TIP: If the maps are the same size and scale, they can be overlaid. A blank map of the waterbody showing just the shoreline outline can be placed over these to produce the control intensity map.

Task 1. On the usage map, identify use areas of the waterbody that are not impacted by existing aquatic vegetation growth. Make a list of these use areas under the heading NO CONTROL.

Task 2. Next, locate areas around the waterbody that are or have the potential to be designated conservancy zones, or are confirmed sites inhabited by rare, endangered, threatened or state listed sensitive plant or wildlife species, particularly salmon. Add these areas to the NO CONTROL list.

Task 3. On the usage map, identify use areas of the waterbody that require some control of existing aquatic vegetation growth. Make a list of these use areas under the heading LOW CONTROL.

Task 4. Referring to the aquatic plant map, recheck that low control areas do not contain endangered, rare, or sensitive plant populations. If they do, remove from low control list.

Task 5. On the usage map, identify use areas that require maximal removal of aquatic plant growth. Make a list of these areas under the heading HIGH CONTROL.

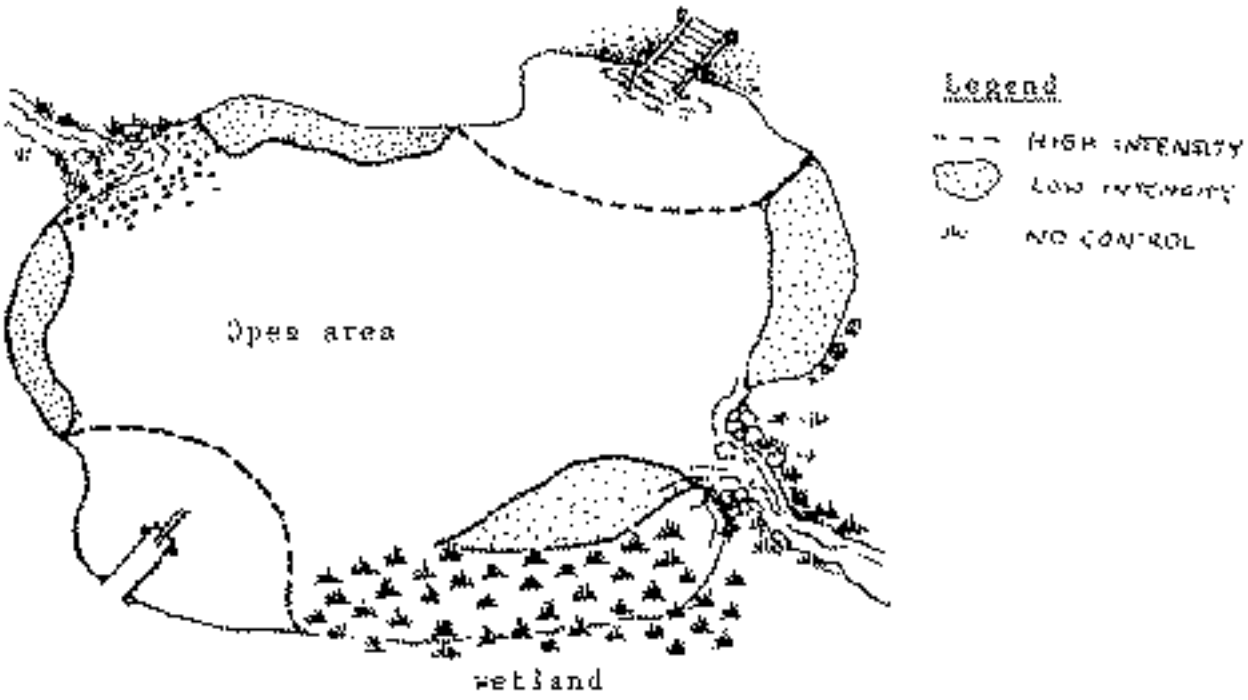
Task 6. Referring to the aquatic plant map, locate areas with invasive, non-native plant populations (like Eurasian watermilfoil or Brazilian elodea). Include these areas on the list of HIGH CONTROL.

References and Resources on Sensitive Plants and Animals

- Oregon Plan for Salmon and Watersheds[D]
- National Heritage Program[F]

Example of a Control Intensity Map

The end product is a map clearly showing zones of all three control intensities. Construction of a control intensity map will aid in choosing appropriate treatment options for each area of the lake (Chapter 11).



Chapter 11

CHOOSE INTEGRATED TREATMENT SCENARIO (STEP I)

The Integrated Approach—A Juggling Act

This step involves choosing a combination of control efforts that best meet the management goals and financial resources of waterbody users, and produces the least impact on the environment. The procedure consists of evaluating each control option listed in Chapter 9 using an integrated vegetation management approach. This approach examines the alternatives with regard to such factors as:

- The extent of problem plant(s) infestation
- Scale, intensity, and timing of treatment
- Effectiveness against target plant(s)
- Duration of control (short-term vs. long-term)
- Human health concerns
- Endangered or threatened species impacts
- Other environmental impacts and the associated mitigation, if needed
- Program costs
- Permit requirements (Federal, State, local)

Reviewing control alternatives in light of these and other site-specific factors provides a means of narrowing down the options into an appropriate management package. No management program, however, is without impacts or consequences. No management program is inexpensive, 100% effective and 100% environmentally friendly. Choosing a management program requires a careful weighing of all the factors. The trick in deciding a course of action is to achieve a balance between expected management goals and cost, that results in a net environmental benefit.

A Procedure For Choosing An Appropriate Treatment Scenario

Using the Control Intensity Map, match each control zone (no control, low control, high control) with an appropriate control method. The following considerations are important:

- **The type and extent of plant growth and timing of treatment.**
  In reviewing control options, it is important to understand both the extent and the life cycle of the problem plant species. What is the area of problem growth? If the infested area is small (say, 0.25 acre), then large-scale methods, like mechanical harvesting, may not be appropriate. The same logic applies for large-scale problems treated with small-scale methods. What is the plant's typical life cycle? Some plant species with early-season growth are more susceptible to treatment in the springtime. In other situations, winter treatment may be most effective.

- **Probable duration of control.**
  How long will the plant be controlled? Is duration of control short-term (a month, a growing season) or longer term (1 year, 2 years, more)?

- **Site-specific constraints that might affect use of control method.**
  Does the site have a lot of submerged logs, bottom debris, or water intake pipes that would hamper bottom treatments like rotovation or bottom barrier application? Are there many surface obstacles such as docks or buoyed areas that could interfere with surface operations of mechanical cutting or harvesting?

- **Capital costs and operation/maintenance costs.**
  If specialized equipment is to be purchased for the control project, determine the cost of buying, operating and maintaining it, including staff wages and replacement costs.

- **Human safety and health concerns.**
  Will the control option restrict use of the water body after treatment by banning water contact or ingestion (swimming, fishing, drinking or irrigation use)? Does the operation of large machinery or equipment occur at a peak time of recreational use? Does this control option represent a severe safety hazard or interfere significantly with normal use?

- **Fisheries, waterfowl or wildlife status and general ecology of waterbody.**
  Does the aquatic system have important fish spawning sites? If so, control activities that disturb the bottom would be prohibited during certain critical life cycle periods. Furthermore, the presence of endangered, rare, or sensitive plants or animals, especially salmon species, that may utilize aquatic plant beds could prevent or limit the use of certain control methods.The life cycles of the desirable plant and animal species have to be considered and the timing of control activities adjusted to minimize impact.

- **Balancing enhancement of beneficial human uses with environmental protection.**
  What are the projected short-term and long-term impacts on the local environment? Is there a risk that control for the sake of maximizing human use could seriously jeopardize an important segment of the native aquatic plant or animal community?

- **Possible *mitigation* techniques and costs, including replacement of untargeted plants that are removed.**
  Some aquatic plant control techniques pose higher risks of removing non-target organisms, particularly emergent vegetation along the shore line. Estimates should be made of the types and areas of plant species that may be affected by the control techniques. Lost areas can be mitigated by replanting with nursery stock plants or plants harvested from local areas (check on local harvesting restrictions). Volunteers can often help with revegetation efforts.

- **Local, county, state or Federal permit requirements.**
  Find out what permits are necessary, whether a fee is required, and the expected time it takes to process the permit application(s). The length of time involved in processing different permit applications can vary enormously (See Table 11-1). While most permits for aquatic plant control work in freshwater are free, some have an assessed fee.

- **Obtain permission of owners.**
  Many small lakebeds are privately owned. Larger ones may have public ownership due to their “navagability.,” The Division of State Lands is the management agency responsible for publicly owned waterways.

Example Of Recommended Treatment Scenario

The following is an example of a recommended treatment scenario produced for Lake Serene:

LAKE SERENE RECOMMENDED TREATMENT SCENARIO

- Whole-lake diver surveillance for milfoil locations (Spring).
- In-lake treatment
  - –First-year milfoil treatment: Systemic herbicide application in boat launch embayment with bottom barrier application in swimming areas (Spring).
  - –Second-year milfoil treatment: Diver hand removal/bottom barrier application on residual populations (Spring).
  - –Water lily treatment: Systemic herbicide/bottom barrier (Spring).
- Watershed controls.

√! You have come a long way in gathering critical information and evaluating plant control options with regard to the specifics of your waterbody and user needs. Now is a good time to update the community on the status of the emerging plan. The information can be presented to the community for discussion and approval through the public process. After obtaining group consensus on a treatment scenario, the steering committee can finalize the long-term action program.

Table 11-1. Who Permits What?
Permits / Documents Required Aquatic Weed Control Acitvities in Oregon

Permit / Document	Agency	Description	Control Activities	Mimimum Process Time
Remove and Fill	Division of State Lands	Permit required if more than 50 cu. yds of sediment are disturbed.	dredging, rotovating	45 Days
Natural Heritage Program Letter confirming search of data for critical plant or animal species	The Nature Conservancy	Natural Heritage Program is a State repository of data on endangered, threatened, & sensitive plant species, native wetland plant communities, aquatic & non-vegetation wetland systems.	search should be conducted for any control activity.	3-7 Days
Fish Planting Permits	Dept. of Fish & Wildlife	A permit is required for stocking of triploid (sterile) grass carp in Oregon waters for control of aquatic vegetation. Currently only approved for irrigation districts.	grass carp stocking	60 Days
Local Permits	Local jurisdictions	Permits may be required on the local level for various activities, such as shoreline management or Growth Management Act/Sensitive Area ordinance.	variable	variable
NPDESPermit 402 / 401	Oregon Dept. of Env. Quality	Permit/certification may be required for return water from hydraulic dredging disposal site.	dredge material disposal	Call ODEQ
Section 10 Permit	Army Corps of Engineers	Dredging in navigable waters in the US.	dredging	Call COE
Section 404 Permit	Army Corps of Engineers	Disposal of dredged or fill material in waters of US.	dredging, boat ramps, shoreline armoring	Call COE
APHIS Form 526	Oregon Dept. of Agriculture	Application and permit to move live plant pests or noxious weeds.	importing milfoil weevils	Call ODA

NOTES:

CHAPTER 12

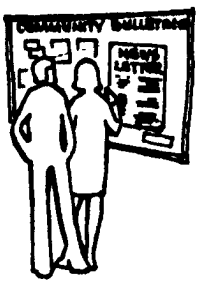
DEVELOP AN ACTION PROGRAM (STEP J)

Putting All The Pieces Together

The final task is to take all the information and formulate a long-term action program (plan) for aquatic plant management. This Plan provides the community with guidance and direction for aquatic plant management in their particular waterbody. The decision to proceed with aquatic plant control in a waterbody is just the beginning. Follow-through is critical. Aquatic plant control is an ongoing concern that requires long-term commitment. This is particularly true of water bodies with exotic plant infestations or with nuisance plant growth that has developed over many years. In these situations, achieving management goals could take many years. The Plan should be flexible and evolving. It should provide for regular checking of how well the actions are working and allow for modification as conditions change.

Components Of The Action Plan

While the integrated treatment scenario forms the heart of the Plan, there are other activities that are also essential components of the management program. These include program budgeting, evaluating program effectiveness, organizing public outreach and exotic weed prevention programs, developing funding strategies, and identifying short-term and long-term actions. These components are all linked together by the critical element of time. Appropriate start-up time and duration of each of these activities can vary widely. For these reasons, it is important to divide the action plan into short-term and long-term program elements.



1.Review and recheck the recommended integrated treatment scenario. The following factors need to be determined:

- Costs
- Permit requirements
- Human safety/health
- Environmental impacts, particularly if critical salmon habitat exists within the project site
- Mitigation, if needed
- Acceptability to waterbody property owners, users and other interested parties

2.Compute costs and a budget to implement the overall program.

In particular, identify:

- Planning costs
- Contracted treatment costs
- Capital costs (for equipment or materials)
- Operation and maintenance costs
- Equipment replacement costs
- Program monitoring/evaluation costs
- Mitigation costs
- Permit costs

3.Determine monitoring and evaluation strategies to evaluate the program's success.

In particular, you will need to:

a.Determine methods to track short- and long-term nuisance plant growth trends.

b.Evaluate the effectiveness of your annual program with respect to meeting management goals.

4.Plan a public outreach program.

Educational information about the aquatic plant management program can be disseminated through:

- Public meetings
- Newsletters and media coverage
- Posted signs around the waterbody
- Special events highlighting management

activities on the waterbody such as workshops or lake fairs.

5.Plan an exotic weed prevention program.

The old adage "an ounce of prevention saves a pound of cure" really holds true when it comes to exotic weed invaders. The Plan should contain an exotic (non-native) weed prevention component to limit introduction of non-native weeds to the waterbody and to provide a means of quick response if exotic weeds are sighted. Exotic weed invaders such as Eurasian watermilfoil, Brazilian elodea and hydrilla spread primarily by frag mentation (breaking off of stem pieces) and transport on boating equipment. Efforts to halt the spread through educational means, by a citizen watch for these invaders in the water body, and by visual inspection of boats entering and leaving the waterbody are recommended.

6.Develop funding strategies.

a.Identify community groups with an interest in the waterbody.

b.Identify the level and duration of needed funding.

c.Assess all funding options, including:

- Voluntary donations for aquatic plant control
- Formation of a lake or property owner association with the ability to collect revenue
- Establishment of a weed control or water improvement district or other taxing district
- Grants or loans from public agencies or other outside sources:
  - Oregon Watershed Enhancement Board
  - Oregon Department of Agriculture Weed Program
  - Oregon Department of Environmental Quality 319 grant program

d.Identify an action plan based on optimal short and long-term funding sources to accomplish the plan. Incorporate into points 7 and 8.

7.Construct a short-term action plan.

Some elements of the Plan may be initiated immediately. Control methods like handpulling are usually small scale and have no permit requirements, so they can be implemented as soon as plants begin to show growth in early spring. Mechanical harvesting is usually performed later in the season when plant growth is at its peak so it is important to contact a harvester the winter before to schedule a treatment.

Volunteer efforts can be used for some activities. Many home or property owner watershed controls can be implemented right away. Public out reach programs on scheduled management activities can be started immediately with little or no cost.

8.Construct a long-term action plan.

Other elements of the Plan may require more time for completion, to procure funding, or to obtain permits. Certain techniques require repeat treatments over several years for optimal effectiveness (e.g., diver dredging, rotovation). The timeframe for processing permits may be extended if multiple permits are required or several agencies are involved in the review process. It may take time to advertise for specialized contract services such as diver dredging.

√! The planning process results in a written Plan that summarizes all the information that you have gathered. The written document provides the basis for annual review of short-term and long-term elements of the Plan. It is recommended that a three ring binder with tabs for each planning step be used to organize your planning document. In this way, any new information, monitoring results and necessary changes in the program can be easily documented for future use. Your plan should have the following written components:

√ Problem statement

√ Management goals

√ A list of waterbody and watershed characteristics from previous studies or current sampling work

- √ A map showing beneficial and recreational use areas of the waterbody
- √ A map showing types and locations of aquatic plants
- √ A written description of aquatic plants
- √ A discussion of aquatic plant controls, examining pros and cons of use in the waterbody (results can be presented in a matrix format)
- √ A control intensity map showing proposed control areas in the waterbody
- √ Description of public involvement program, including specific examples
- √ A list of action strategies, both short and long-term, and time frames
- √ A description of the monitoring and evaluation process to be used
- √ A description of the long-term action plan, periodically modified to changing conditions as indicated by the monitoring/evaluation program
- √ A budget outlining how any potential funding will be used

A written plan containing these elements will serve you well in overall management of aquatic plants, as well as in meeting requirements of certain public funding sources. This dynamic plan is your guide to adaptive management, fine-tuned over the years as conditions in or affecting your waterbody change with time.

The Road Well Traveled

Congratulations on completing your Plan! Throughout the planning process, you have learned about the workings of the waterbody and its watershed, as well as aquatic plant management in Oregon and its applicability to your waterbody. You have learned how to organize and work together, and most of all, how to compromise. Now you can begin the process of initiating the aquatic plant management program uniquely created for your waterbody.

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CHAPTER 13

I HAVE A PLAN - WHAT'S NEXT?

The period between development of an integrated aquatic plant management plan and implementation of the plan is a time for excitement, paperwork and patience! It involves scheduling, public outreach, securing permits and funding, and arranging for volunteer and contracted services. The duration of this period largely depends on the scale, intensity and complexity of the plant control program. Once these necessary items have been taken care of, you are indeed off and running!

Permits And Other Requirements

After the Plan has been approved and adopted, steps can be taken to secure required permits for control measures. The role of the permit process in the protection and management of our State's freshwater resources is a necessary and important one (See Box). The permits, fees, and notification procedures depend on the control methods to be used and the size, type or other special features of the waterbody. (See Chapter 11 for summary information on permits necessary for certain control activities conducted in Oregon.) Often, several jurisdictions may be involved in the permitting process for a project. As a result, you may need to make a few phone calls to secure information and application forms.

Why Are Permits Needed?

Anyone planning aquatic plant management activities in their waterbody should be aware of the various State and local regulations protecting freshwater resources and aquatic life. There is no single regulation governing aquatic resources in our State, nor a single agency wholly responsible for overseeing freshwater activities. However, there are a number of laws regarding water quality, fisheries, wildlife, and habitat, and many different agencies responsible for administering these laws. In most cases, authorities overlap on both the local and State levels, and sometimes the Federal level, especially if critical salmon habitat areas or navigable waters are affected. You should check with local and county public works or planning departments on what permits are required for a particular control activity in your lake or stream. Personnel with Oregon Departments of Environmental Quality, Agriculture, and Fish and Wildlife can assist you with information on permits required by State agencies.

Funding

Finding the right mechanisms for collecting funds is important. If major costs of the program are being funded by private contributions, outline a schedule for collecting committed donations. Local funds may be provided by financing through special community club or lake association assessments. It is best to start such an assessment process well in advance of the need for initial outlay of funds. Forming a water improvement district is a way to procure funds through special tax assessments. Timely completion of grant applications is critical if funding has to be secured through competitive, cost-sharing grant programs such as those administered by OWEB (Oregon Watershed Enhancement Board) or DEQ's 319 program.

Implementation Needs Management

Once the plan is approved by the planning committee and larger community, start lining up volunteers for parts of the program where citizen labor can be used. It may be beneficial for your association or club to expand the functions of the steering committee or establish a special aquatic plant management committee to oversee the long-term management program. Whether the project is large and complex or small and simple, each facet of the program will need to be managed.

Monitoring Program Effectiveness

A carefully designed aquatic plant management program can be successful and satisfying. But it also requires long-term commitment and flexibility. Depending on the severity of problems in the waterbody, it can take many years to achieve specific management goals. Furthermore, conditions in the waterbody or community needs may change over time. As a result, an aquatic plant management program must include a monitoring element to regularly evaluate treatment effectiveness and recommend program adjustments as needed. The effectiveness of the overall program should be assessed on an annual basis at a minimum. Progress in meeting management goals can be quantitatively tracked by directly sampling/measuring problem plant populations at strategic times during the year. Your local watershed council can provide assistance in planning a monitoring project for your waterbody.

On a more informal note, it may also be helpful to conduct periodic surveys of the community to gain their impressions of effectiveness of the program. During the implementation phase, it's important to be patient, be realistic in your expectations, and keep the lines of communication open!

Keeping Everyone Informed

It is critical to keep the community informed about the progress of the control project. In particular, give advance notice of any inconveniences that might be experienced by users of the waterbody as a consequence of in-lake activities. The community will want to know about the findings of post-treatment monitoring and evaluation of the control effectiveness. In going through the planning process described in this manual, you have already started the educational ball rolling. Through public meetings, newsletters, barbecues, and local media coverage, you've gotten word out that a problem exists in your waterbody but there's a way to tackle it. Continue to use informational avenues that have worked for you to update the community on important aspects or results of the control program.

In following the planning steps in this Manual, you have created a unique document—your PLAN! The Plan describes the best path to integrated aquatic plant management in your waterbody. Good luck in your aquatic plant management efforts!

APPENDIX A

Glossary of Terms

GLOSSARY OF TERMS

Algae — Small aquatic plants containing chlorophyll and without roots that occur as single cells or multi-celled colonies. Algae form the base of the food chain in aquatic environments.

Algal bloom — Heavy growth of algae in and on a body of water as a result of high nutrient concentrations.

Alkalinity — The acid combining capacity of a (carbonate) solution, also describes its buffering capacity.

Aquatic plant survey — A systematic mapping of types and location of aquatic plants in a waterbody, usually conducted by means of a boat. Survey information is presented on an aquatic plant map.

BMPs (Best Management Practices) — Practices or methods used to prevent or reduce amounts of nutrients, sediments, chemicals or other pollutants from entering water bodies from human activities. BMPs have been developed for agricultural, silvacultural, construction, and urban activities.

Bathymetric map — A map showing depth contours in a waterbody. Bottom contours are usually presented as lines of equal depth, in meters or feet.

Benthal — Bottom area of the lake (Gr. benthos depth).

Biocontrol — Management using biological organisms, such as fish, insects or micro-organisms like fungus.

Biomass — The total organic matter present (Gr. bios life).

Bottom barriers — Synthetic or natural fiber sheets of material used to cover and kill plants growing on the bottom of a waterbody; also called sediment covers.

Chlorophyll — The green pigments of plants (Gr. chloros green, phyllon leaf).

Consumers — Organisms that nourish themselves on particulate organic matter (Lat. consumere to take wholly).

Contact herbicide -— An herbicide that causes localized injury or death to plant tissues with which it contacts. Contact herbicides do not kill the entire plant. Aquathol® and diquat are contact type herbicides.

Control intensity map -— A map of a waterbody showing areas requiring no, low or high levels of aquatic plant control. See Chapter 10.

Decomposers — Organisms, mostly bacteria or fungi, that break down complex organic material into its inorganic constituents.

Detritus — Settleable material suspended in the water: organic detritus, from the decomposition of the broken down remains of organisms; inorganic detritus, settleable mineral materials.

2,4-d (2-4-dichlorophenoxy acetic acid) —The active chemical ingredient of the aquatic systemic herbicides Aqua-Kleen® and Weedar 64®.

Diquat — The active chemical ingredient of the aquatic contact herbicide Ortho Diquat®.

Dissolved oxygen — A measure of the amount of oxygen gas dissolved in water and available for use by microorganisms and fish.

Drainage basin — The area drained by, or contributing to, a stream, lake, or other waterbody (see watershed).

Drawdown — Decreasing the level of standing water in a waterbody to expose bottom sediments and rooted plants. Water level drawdown can be accomplished by physically releasing a volume of water through a controlled outlet structure or by preventing recharge of a system from a primary external source.

Dredging — Physical methods of digging into the bottom of a waterbody to remove sediment, plants

or other material. Dredging can be performed using mechanical or hydraulic equipment.

Ecology — Scientific study of relationships between organisms and their surroundings (environment).

Ecosystems — Any complex of living organisms together with all the other biotic and abiotic (nonliving) factors which affect them.

Emergent plants — Aquatic plants that are rooted or anchored in the sediment around shorelines, but have stems and leaves extending well above the water surface. Cattails and bulrushes are examples of emergent plants.

Endothall — The active chemical ingredient of the aquatic contact herbicide Aquathol®.

Epilimnion — The uppermost, warm, well-mixed layer of a lake (Gr. epi on, limne lake).

Eradication — Complete removal of a specific organism from a specified location, usually refers to a noxious, invasive species. Under most circumstances, eradication of a population from a site is very difficult to achieve.

Euphotic zone — That part of a waterbody where light penetration is sufficient to maintain photosynthesis.

Eutrophic — Waters with an ample supply of nutrients and hence a rich organic production (Gr. eu well, trophein to nourish).

Exotic — Refers to species of plants or animals that are not native to a particular region into which they have moved or invaded. Eurasian watermilfoil, Brazilian elodea, and hydrilla are exotic plant invaders in Oregon.

Floating-leafed plant — Plants with oval or circular leaves floating on the water surface, but are rooted or attached to sediments by long, flexible stems. Waterlilies are examples of rooted floating-leafed plants.

Fluridone — The active chemical ingredient of the systemic aquatic herbicide SONAR®.

Flushing rate — Term describing rate of water volume replacement of a waterbody, usually expressed as basin volume per unit time needed to replace the waterbody volume with inflowing water. The inverse of the flushing rate is the (hydraulic) detention time. A lake with a flushing rate of 1 lake volume per year has a detention time of 1 year.

Free-floating plants — Plants that float on or under the water surface, unattached by roots to the bottom. Some have small root systems that simply hang beneath the plant. Water hyacinth and tiny duckweed are examples of free-floating plants.

Glyphosate — The active chemical ingredient of the systemic herbicide RODEO®.

Grass carp — Also known as white amur, grass carp (*Ctenopharyngodon idella*) is a large, vegetation-eating member of the minnow family (*Cyprinidae*). Originally from Russia and China, these plant grazers are sometimes used as biological agents to control growth of certain aquatic plants. Oregon permits grass carp in irrigation canals and in lakes and reservoirs less than 10 acres in size.

Herbicide — A chemical used to suppress the growth of or kill plants.

Habitat — The physical place where an organism lives.

Hydraulic detention time — The period of detention of water in a basin. The inverse of detention time is flushing rate. A lake with a detention time of one year has a flushing rate of 1 lake volume per year.

Hypolimnion — The cold, deepest layer of a lake that is removed from surface influences (Gr. hypo under, limne lake).

Integrated aquatic plant management — Management using the best combination of plant

control methods that optimizes target weed species control, maximizes beneficial uses, minimizes environmental impacts and optimizes overall costs.

Limiting nutrient — Essential nutrient needed for growth of plant organism which is the most scarce in the environment. Oftentimes, in freshwater systems, either phosphorus or nitrogen may be the limiting nutrient for plant growth.

Limnology — The study of inland waters (Gr. limne lake).

Littoral — The region of a body of water extending from shoreline outward to the greatest depth occupied by rooted aquatic plants.

Macro-algae — Large, easily seen (macroscopic) algae. The macro-algae Nitella sp. sometimes forms dense plant beds and can be a conspicuous member of the aquatic plant community.

Macrophyte — Large, rooted or floating aquatic plants that may bear flowers and seeds. Some plants, like duckweed and coontail, are free-floating and are not attached to the bottom. Occasionally, filamentous algae like Nitella sp. can form large, extensive populations and be an important member of the aquatic macrophyte community.

Mitigation — Actions taken to replace or restore animals or plants that may have been damaged or removed by certain prior activities.

Morphology — Study of shape, configuration or form (Gr. morphe form, logos discourse).

Niche — The position or role of an organism within its community and ecosystem.

Nitrogen — A chemical constituent (nutrient) essential for life. Nitrogen is a primary nutrient necessary for plant growth.

Non point (pollutant) source — A diffuse source of water pollution that does not discharge through a pipe or other readily identifiable structure. Non point pollution typically originates from activities on land and the water. Examples of non point sources are agricultural, forest, and construction sites, marinas, urban streets and properties.

Non-target species — A species not intentionally targeted for control by a pesticide or herbicide.

Noxious weed — Non-native plant species that, because of aggressive growth habits, can threaten native plant communities, wetlands or agricultural lands. The Oregon State Department of Agriculture, Noxious Weed Control Program has the authority to designate certain plants as "noxious" in the state. Eurasian watermilfoil (*Myriophyllum spicatum*) is a designated noxious weed in Oregon.

Nutrient — Any chemical element, ion, or compound required by an organism for the continuation of growth, reproduction, and other life processes.

Oligotrophic — Waters that are nutrient poor and have little organic production (Gr. oligos small, trophein to nourish).

Oregon Plan for Salmon and Watersheds — Oregon initiative that focuses on increasing salmon and steelhead populations, restoring habitat, and improving water quality through cooperative efforts of local communities, watershed councils, and agencies and other groups with management interest in salmonid fisheries.

Oxidation — A chemical process that can occur in the uptake of oxygen.

pH — The negative logarithm of the hydrogen ion activity.

Phosphorus — A chemical constituent (nutrient) essential for life. Phosphorus is a primary nutrient necessary for plant growth.

Photosynthesis — Production of organic matter (carbohydrate) from inorganic carbon and water in the presence of light (Gr. phos, photos light, synthesis placing together).

Phytoplankton — Free floating microscopic plants (algae) (Gr. phyton plant).

Point (pollutant) source — A source of pollutants or contaminants that discharges through a pipe or culvert. Point sources, such as an industrial or sewage outfall, are usually readily identified.

Pollutant — A contaminant, a substance that is not naturally present in water or occurs in unnatural amounts that can degrade the physical, chemical, or biological properties of the water. Pollutants can be chemicals, disease-producing organisms, silt, toxic metals, oxygen-demanding materials, to name a few.

Primary production — The rate of formation of organic matter or sugars in plant cells from light, water and carbon dioxide (Lat. primus first, producere to bring forward). Algae are primary producers.

Problem statement — A written description of important uses of a waterbody that are being affected by the presence of problem aquatic plants. See Chapter 3.

Producers — Organisms that are able to build up their body substance from inorganic materials (Lat. producere to bring forward).

Public Awareness/Outreach — Programs designed to share technical information and data on a particular topic, usually associated with activities (such as management) on or around a waterbody.

Residence time — The average length of time that water or a chemical constituent remains in a lake.

Rotovation — A mechanical control method of tilling lake or river sediments to physically dislodge rooted plants. Also known as bottom tillage or derooting.

Secchi disc — Typically a 20-cm (8-inch) diameter disc painted white and black in alternating quadrants. It is used to measure light transparency in lakes.

Sediment — Solid material deposited in the bottom of a basin.

Sensitive areas — Critical areas in the landscape, such as wetlands, aquifer recharge areas, and fish and wildlife habitat conservation areas.

Standing crop — The biomass present in a body of water at a particular time.

Steering committee — A small group of people organized to represent the larger community of individuals, businesses, agencies and organizations who have an interest in management of a particular waterbody. The steering committee is responsible for following the planning steps outlined in this manual.

Stratification — See thermal stratification.

Submersed plant — An aquatic plant that grows with all or most of its stems and leaves below the water surface. Submersed plants usually grow rooted in the bottom and have thin, flexible stems supported by the water. Common submersed plants are milfoils and pondweeds.

Susceptibility — The sensitivity or level of injury demonstrated by a plant to effects of an herbicide.

Systemic herbicide — An herbicide in which the active chemicals are absorbed and translocated within the entire plant system, including roots. Depending on the active ingredient, systemic herbicides affect certain biochemical reactions in the plant that can cause plant death. SONAR® and RODEO® and Aqua-Kleen® (2,4-d) are systemic herbicides.

Thermal stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density) and hypolimnion (lowest, cool, least mixed layer).

Thermocline — (Gr. therme heat, klinein to slope.) Zone (horizontal layer) in waterbody in which there is a rapid rate of temperature decrease with depth. Also called metalimnion, it lies below the epilimnion.

Topographic map — A map showing elevation of the landscape in contours of equal height (elevation) above sea level. This can be used to identify boundaries of a watershed.

Transect lines — Straight lines extending across an area to be surveyed.

Tributaries — Rivers, streams or other channels that flow into a waterbody.

Triclopyr — The active ingredient of a systemic herbicide being evaluated in Washington for aquatic plant control.

Triploid — A genetic term referring to non-reproducing (sterile) forms of grass carp induced by manipulating reproductive genes. Reproducing grass carp have two pairs of chromosomes and are termed diploid. Triploid fish have three sets of chromosomes.

Trophic state — Term used to describe the productivity of the lake ecosystem and classify it as oligotrophic (low productivity, "good" water quality), mesotrophic (moderate productivity), or eutrophic (high productivity; "poor" water quality).

Vascular plant— A vascular plant possesses specialized cells that conduct fluids and nutrients throughout the plant. The xylem conducts water and the phloem transports food.

Waterbody usage map — A map of a waterbody showing important human use areas or zones (such as swimming, boating, fishing) and habitat areas for fish, wildlife and waterfowl. See Chapter 7.

Watershed — The entire surface landscape that contributes water to a lake or river. See drainage basin.

Watershed council — This council of individuals is a locally organized, voluntary, non-regulatory group established to assess conditions of their local watershed and build a work plan to implement enhancement and protection activities within their watershed.

Watershed management — The management of the natural resources of a drainage basin for the production and protection of water supplies and water-based resources.

Watershed snapshot — A simple drawing of a waterbody and its watershed showing important identifying features such as watershed boundary lines, inlet and outlet streams, wetlands, landuse zones and other site-specific characteristics. This is a simple way of condensing background data and information on a project area and displaying slected features in a picture.

Wetland — A generalized term for a broad group of wet habitats. Wetlands are areas of vegetation that are transitional between land and water bodies and range from being permanently wet to intermittently water covered.
The regulatory definition of a wetland used by EPA, COE, and ODSL is as follows:

> *"Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."*

Zooplankton — Microscopic animal plankton in water. Daphnia sp. or water fleas are freshwater zooplankton.

APPENDIX B

Invasive, Non-native Aquatic Plant Fact Sheets

INVASIVE, NON-NATIVE AQUATIC PLANT FACT SHEETS

Introduction

Correct identification of aquatic plants is important, especially with regard to invasive, non-native species. The presence of an exotic species in a system signals a serious potential threat to the local ecology and aggressive action is usually warranted to control invasive weed populations. Also, control strategies that are effective on one of these species may not be effective on another. The following factsheets are presented to aid in identification of six non-native aquatic species of concern in Oregon freshwater systems. The six invader plant species are:

- Eurasian watermilfoil (*Myriophyllum spicatum*)
- parrotfeather (*Myriophyllum aquaticum*)
- Brazilian elodea (*Egeria densa*)
- hydrilla (*Hydrilla verticillata*)
- fanwort (*Cabomba caroliniana*)
- water hyacinth *(Eichhornia crassipes*)

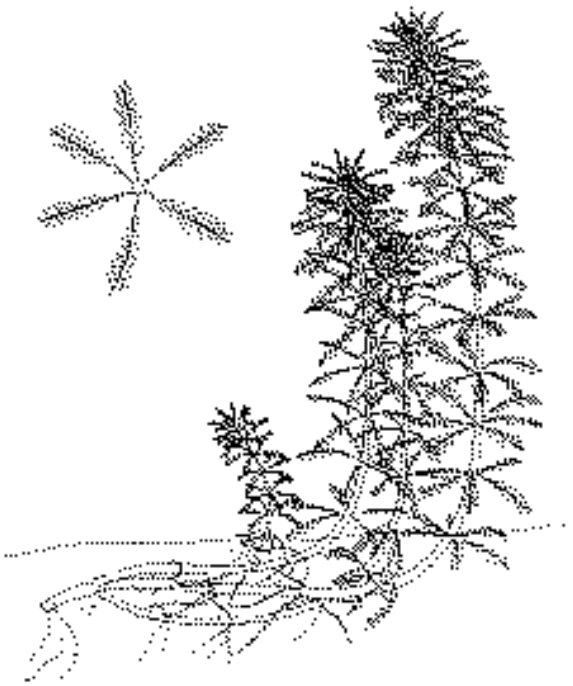
Usually there are key features that easily differentiate aquatic plant species, but in some cases plants require careful scrutiny for correct identification. Hydrilla, and Brazilian elodea, which are designated “noxious weeds” in Oregon, and native *Elodea canadensis* are perhaps the most difficult species to correctly identify. The importance of accurate identification is aptly illustrated by this trio of plants. Hydrilla is one of the most damaging of the non-native aquatic plants. While hydrilla has not been documented in Oregon waters to date, in 1995 a pioneering infestation of this invasive weed was confirmed in Pipe and Lucerne Lakes (King County) in western Washington State. Care must be taken not to mistake hydrilla for one of the other plants in the trio because it requires special, rapid action to control its spread. A comparison of these three plants is included in this section (see figure, A Comparison). If in doubt–call an expert!

Myriophyllum (milfoil) species may also require careful observation for correct identification. There are two weedy milfoils in Oregon: Eurasian watermilfoil, a State noxious weed designate, and parrotfeather, a species of concern. Parrotfeather has distinctive emergent leaves, while Eurasian watermilfoil and the two native milfoils are mostly submersed (except for the flower stalks). In addition to the native milfoils, several other aquatic plants are commonly mistaken for Eurasian watermilfoil. The milfoils of Oregon are compared in this section and some widespread, native aquatic plants that you may find in your lake are illustrated.

Plants are amazingly adaptable organisms. Since they are usually rooted and can’t move around to search out hospitable environments like animals do, plants adjust their growth to match the environment that they find themselves in. The form of an aquatic plant, like all plants, is determined by an intricate interaction between its environment and biology. Photos and drawings cannot convey the rich variation possible as individual plants respond to their unique environment. The illustrations shown here represent the general features of the plant. The plants you find in your lake should be compared to the illustrations with special consideration of the key features mentioned in the text. If identification is in doubt contact an expert (see Appendix F for a list of people who can answer your questions).

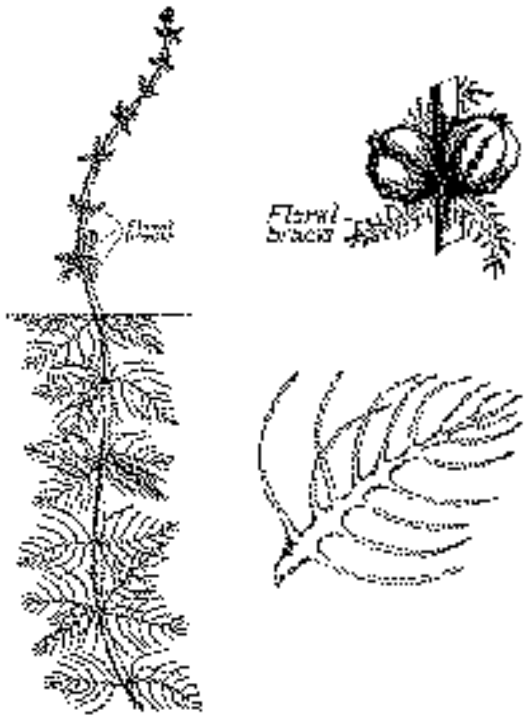
The Myriophyllums

Eurasian watermilfoil (*Myriophyllum spicatum*)
a common submersed aquatic weed



Parrotfeather (*Myriophyllum aquaticum*)
an emergent aquatic weed

Northern watermilfoil (*Myriophyllum sibiricum*)
a native aquatic plant



Whorled watermilfoil (*Myriophyllum verticillatum*)
a native aquatic plant

Eurasian watermilfoil

(Myriophyllum spicatum L.)

Description

Milfoil has finely dissected leaves that form in whorls of 4 on the stem. Milfoil leaves fall off as they age, so occasionally you may find less than four leaves in a whorl, especially near the bottom of the plant. Leaves near the surface are often a reddish or brown color. Eurasian watermilfoil generally has 12-16 pairs of leaflets on each leaf. It's often difficult to separate Eurasian watermilfoil from its native cousins: northern watermilfoil and whorled watermilfoil. Calling an expert at Department of Agriculture, Noxious Weed Control Program may be the best way to positively identify your milfoil.

Growth Habit

Eurasian watermilfoil is the culprit in many nuisance aquatic plant cases in Oregon. It has been the subject of much research, and its growth habits are well known. Milfoil overwinters as short bright green stems from a few inches to a few feet long-rooted in the sediments. Milfoil stores energy and nutrients in its roots over the winter. In early spring, plants grow rapidly to the surface where they can form a mat or canopy of branches. Rapid spring growth and canopy formation allows milfoil to outgrow and shade out other, more desirable native plants.

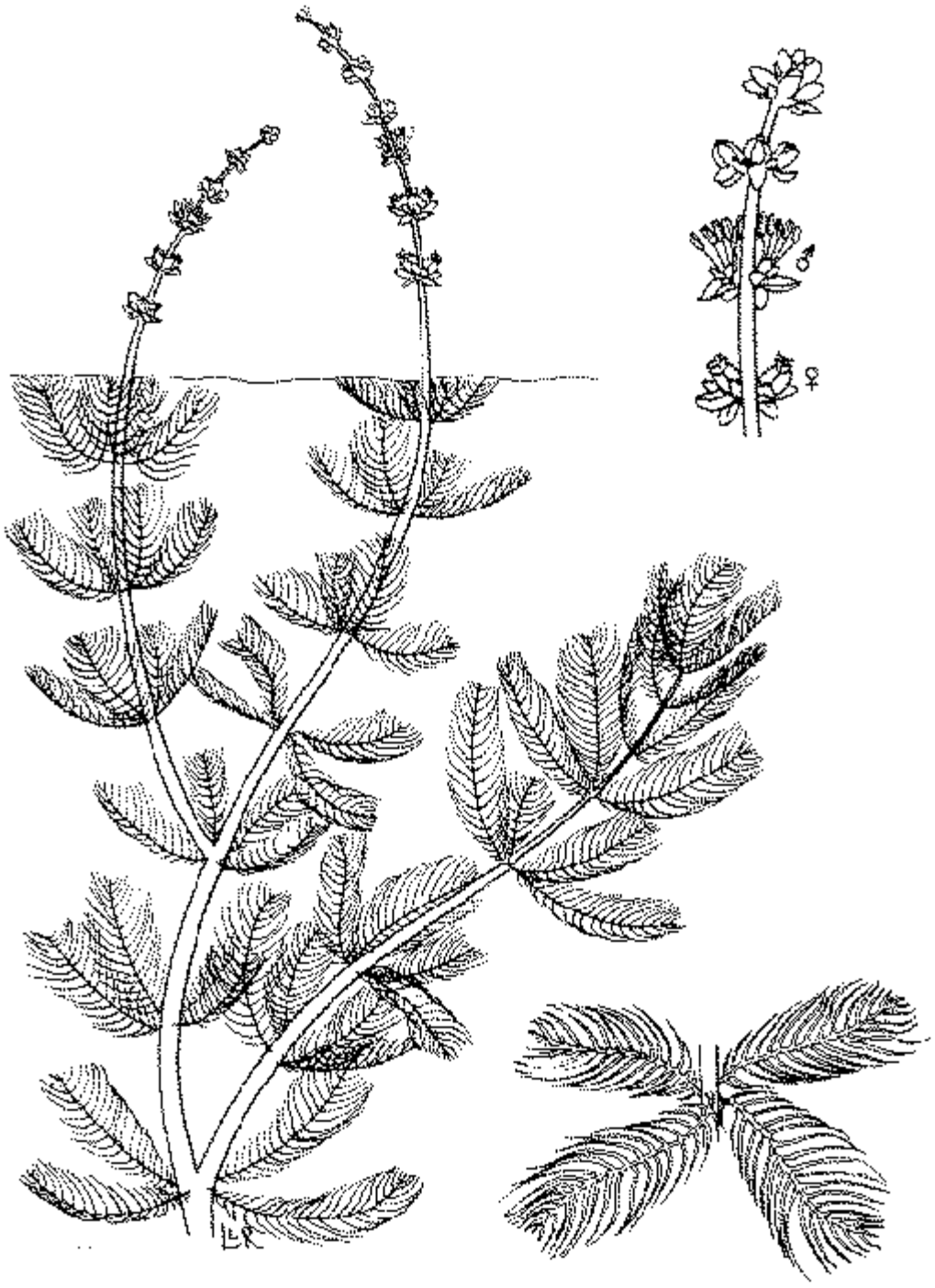
Propagation

Milfoil is spread primarily by stem fragments. Fragments are formed when pieces of the plant are cut off of the main plant body, such as by a boat propeller or during harvesting operations. These stems fragments can root and produce new plants. Milfoil also fragments naturally. In the late summer, the stems of milfoil become quite brittle and roots begin to form on the stem. Wave action or a duck paddling though a milfoil bed can cause stems to break.

Control

Prevention of Eurasian watermilfoil invasion requires control of fragment spread. Some management techniques, harvesting for example, can create fragments and contribute to the spread of milfoil. Milfoil is susceptible to several herbicides, including 2,4-d, endothall and fluridone. With the proper herbicide and application rate, milfoil can be selectively removed from an aquatic system, leaving more desirable aquatic plant species. Other intensive methods, such as bottom barrier placement and diver-dredging are effective against small-scale infestations of milfoil. Milfoil is relatively unpalatable and is low on the grass carp preference scale, especially if other more palatable species are present. Other biological controls of milfoil are under intensive investigation, although none are likely to be available soon.

Eurasian watermilfoil
(*Myriophyllum spicatum L.)*



Key features:

- 12 to 16 leaflets on each leaf
- Leaves near surface may be reddish or brown
- Emergent flower stalks sometimes during the summer
- No emergent leaves
- Milfoil leaflets look like “feathers”

Parrotfeather

(*Myriophyllum aquaticum* (Vell.) Verdc.)

Description

Parrotfeather has both emergent and submersed leaves. The submersed leaves are finely-dissected, and feathery, often with a reddish color. The submersed growth form of parrotfeather is easily mistaken for Eurasian watermilfoil (*Myriophyllum spicatum* L.). The emergent stems can be from a few inches to over a foot high and are the most distinctive feature of parrotfeather. Emergent leaves form in whorls on the stem. Leaves are bright green and finely divided. In spring, very small, white, tuft-like flowers form where the emergent leaves attach to the stem.

Growth Habit

Parrotfeather grows best when rooted in shallow water. In nutrient-enriched lakes parrotfeather can grow as a floating plant in deep water. The emergent stems can survive on wet banks of rivers and lake shores, so it is well adapted to moderate water level fluctuations. Parrotfeather's distribution in Oregon is thought to be limited to coastal lakes and streams and the Columbia River system in southwest Oregon. Parrotfeather invasion of lakes and streams severely changes the physical and chemical characteristics of the aquatic ecosystem. The emergent stems shade the water column eliminating algae growth, which is the basis of the aquatic food web. Parrotfeather is also excellent habitat for mosquito larvae.

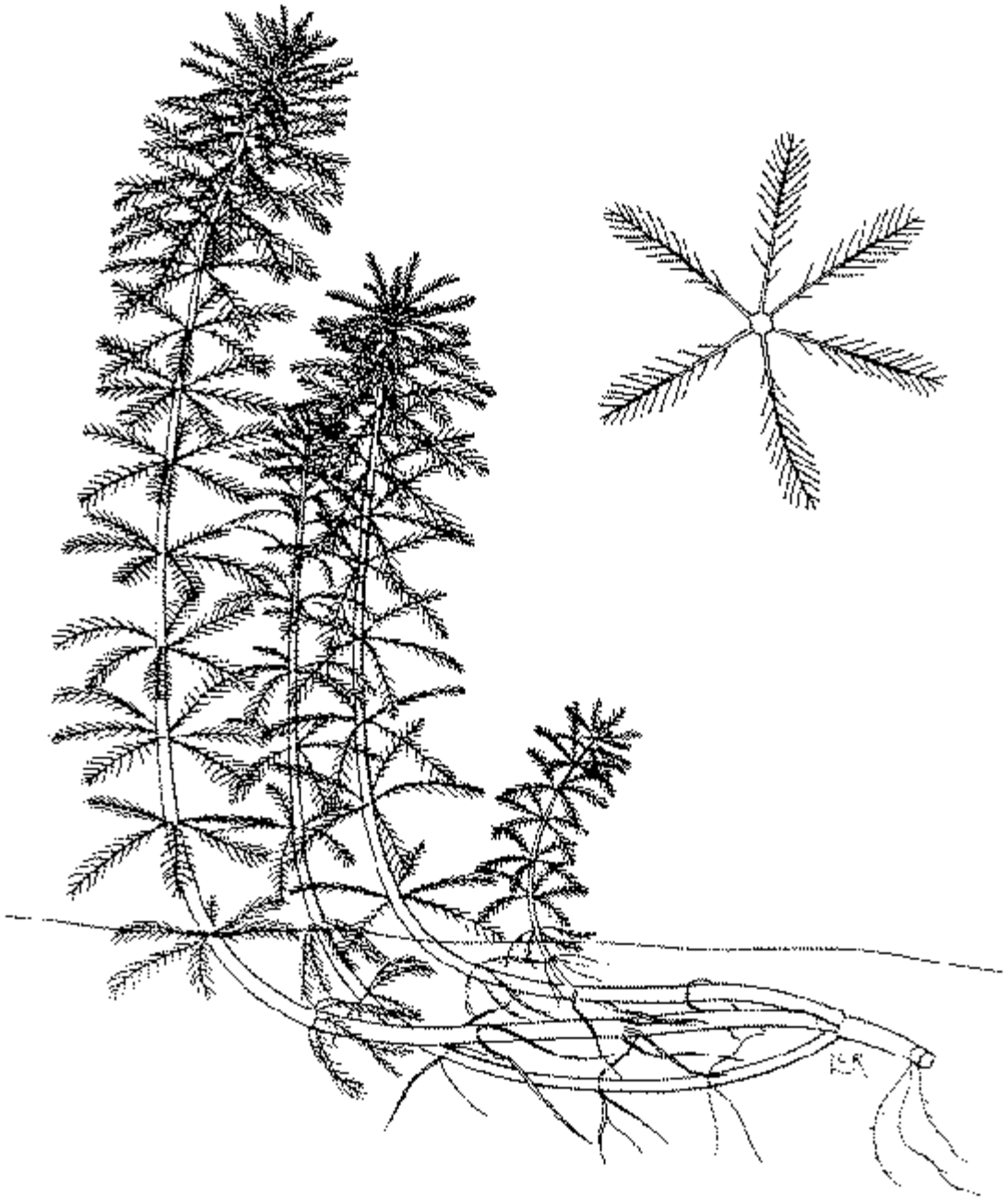
Propagation

Parrotfeather spreads only by plant fragments. All the parrotfeather plants in Oregon are female. In fact, there are no male plants anywhere outside of its native range in South America. Consequently, there is no sexual reproduction and no seeds are formed. Parrotfeather rhizomes are quite tough and can be transported long distances on boat trailers. Parrotfeather's attractive green foliage make it a popular aquascaping plant, which has contributed to its spread.

Control

Parrotfeather has a high tannin content, which makes it unpalatable for most grazers, including grass carp. Parrotfeather is sensitive to many herbicides, but a thick cuticle, which forms a waxy cover on the emergent leaves, hampers aerial application of herbicides. Research has shown that parrotfeather growing in water deeper than about 20 inches may be particularly sensitive to reduction in phosphorus concentrations in the water column.

Parrotfeather
(*Miriophyllum aquaticum* (Vell.) Verdc.)



Key features:

- Bright green, christmas-tree like emergent stems
- Dense mat of intertwined rhizomes in the water with abundant, long roots
- Reddish feathery-leaved, very limp submersed leaves may be present

Brazilian elodea

(*Egeria densa* Planch.)

Description

Brazilian elodea is often confused with Hydrilla and Common elodea. Since Common elodea is a native species and Hydrilla an extremely aggressive invader, it is important that the plants be correctly identified. Common elodea has three leaves per whorl, Brazilian elodea four (sometimes eight) leaves per whorl, and Hydrilla five leaves per whorl. Common elodea leaves are usually less than 1/2 inch long and about 1/4 inch wide. Brazilian elodea leaves are greater than 1/2 inch long and less than 1/4 inch wide. Hydrilla has small “prickle hairs” on the leaf edges and spines on the midvein of the leaf that gives the plants a rough feeling. Hydrilla also forms small (1/4 to 1/2 inch long) tubers in the sediment, which are not formed by the other two species. Brazilian elodea has three-petaled, white flowers, less than an inch in diameter, that float on the water surface.

Growth Habit

Brazilian elodea is rooted in the sediment and grows rapidly in the spring, forming a canopy of intertwined stems at the surface that shades out native aquatic plants. It is a popular aquarium plant, commonly sold in tropical fish stores. The characteristics that make Brazilian elodea a popular aquarium plant: rapid growth under low light levels, easy propagation, and tolerance of a wide range of water and sediment types, also makes it a nuisance aquatic plant when it escapes and grows in lakes and streams.

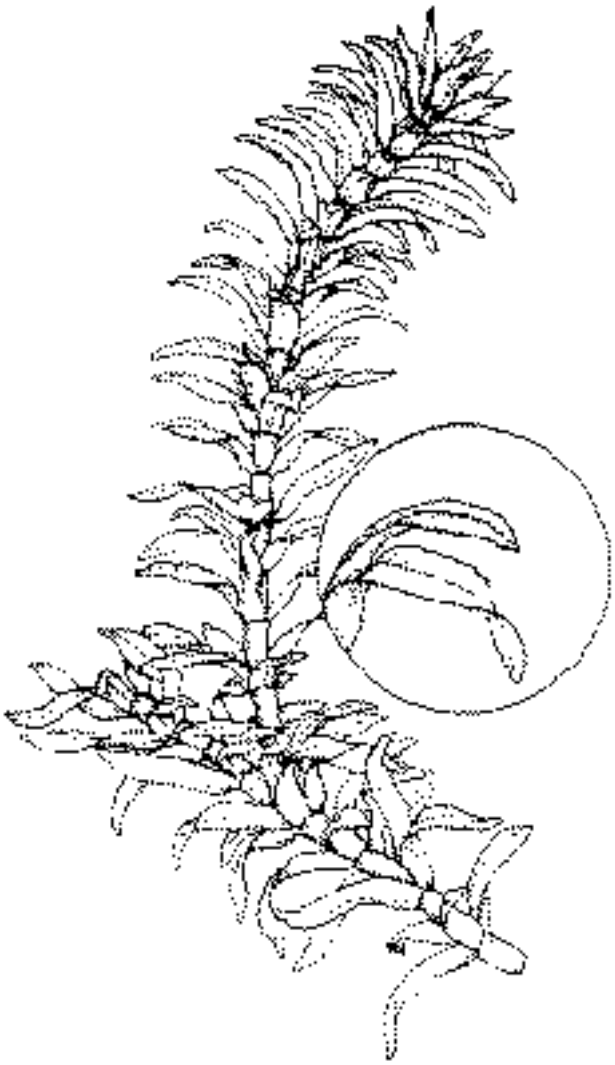
Propagation

Plant fragments are the primary mode of spread of Brazilian elodea. Fragments are formed when pieces of the plant are cut off of the main plant body, such as by a boat propeller or during harvesting operations. These stems fragments can root and produce new plants.

Control

As with other aquatic plants that are spread by stem fragments, prevention of Brazilian elodea fragment spread is critical to preventing the invasion of new lakes. Some management techniques, harvesting for example, can create fragments and contribute to the spread of Brazilian elodea. Once established, Brazilian elodea is susceptible to several herbicides and appears to be a preferred species grazed by grass carp. Other methods, such as bottom barrier placement and diver-dredging are effective against small-scale infestations of Brazilian elodea.

Brazillian Elodea
(*Egeria densa* Planch.)



Key features:

- Submersed, sometimes with floating white flowers
- Leaves in whorls of four or eight
- Leaves greater than one-half inch long and less than one-quarter inch wide
- **No tubers** attached to roots in sediment

Hydrilla

(*Hydrilla verticillata* (L.F.) Royle)

Description

Hydrilla closely resembles its cousins Brazilian elodea (*Egeria densa*) and common elodea (*Elodea canadensis*), both widespread in Oregon. The primary distinguishing feature of Hydrilla is the presence of tubers that form on the roots. Tubers are small potato-like structures 1/4 to 1/2 inch long. Hydrilla also has small prickles on its leaves that give the plant a rough feel. Hydrilla typically has 3 to 8 leaves in a whorl around the stem that are 1/10 to 1/8 inch wide and 1/4 to 3/4 inches long. Hydrilla also forms turions (small, hard buds) on the stem and has small (1/2 inch diameter) white, floating flowers.

Growth habit

Hydrilla is a submersed plant that is rooted in the sediment. Hydrilla is probably the most troublesome submersed aquatic plant in North America. It grows rapidly under very low light levels, in a variety of aquatic habitats from static to flowing water and at depths from an inch to 50 feet. The stem branches in the upper parts of the water column, forming a canopy that inhibits growth of native species and interferes with recreational use of lakes.

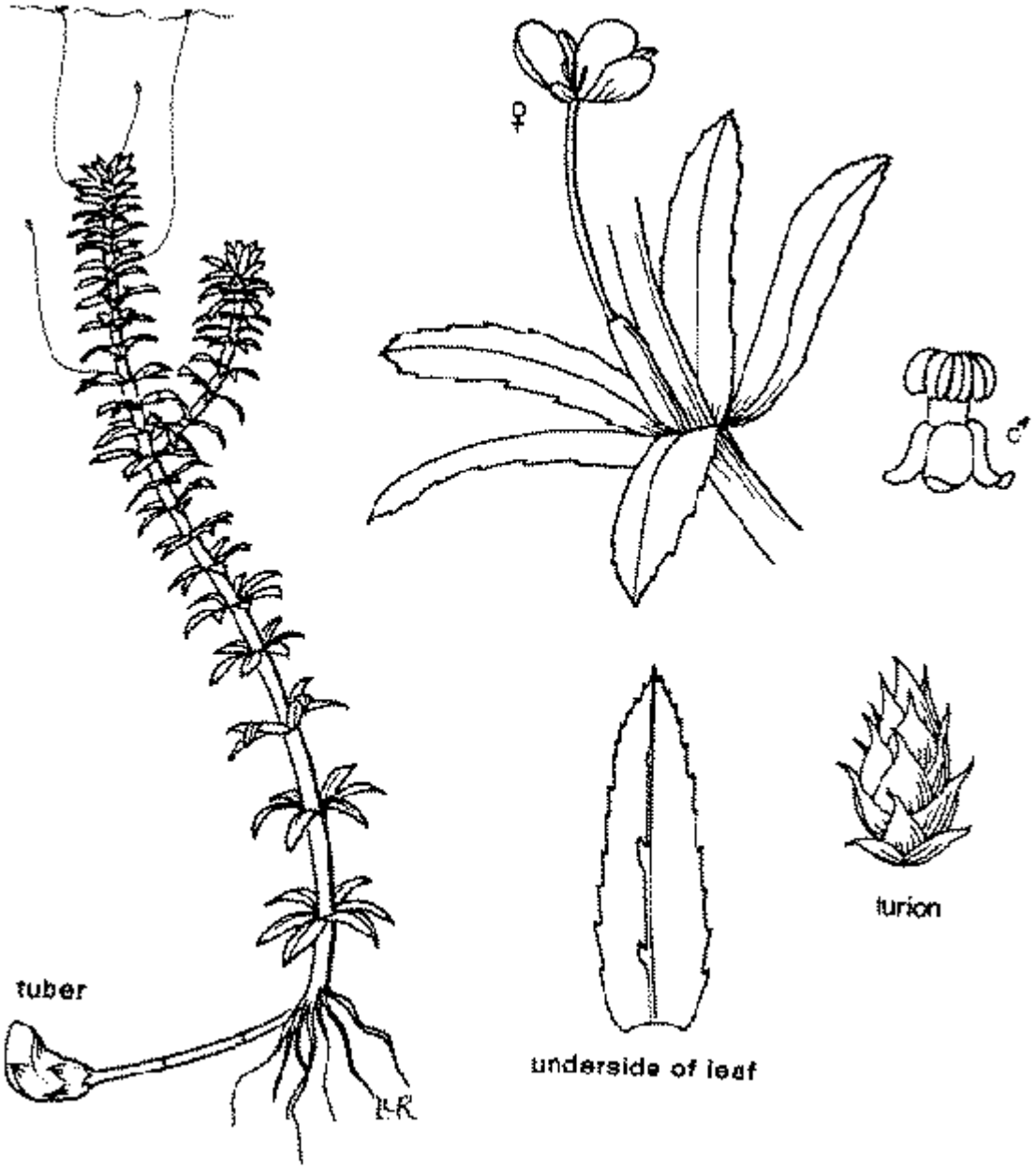
Propagation

Hydrilla has three primary means of spread: stem fragments, tubers, and turions. Stem fragments are formed by harvesting operations and by boat props. Each stem piece can root and form a new plant. Tubers form on the roots in the sediment, and turions form on the stem in the water column. Tubers are produced in the sediment by the thousands, and sprout in the spring. Turions are smaller and are easily carried by water currents, providing a mechanism for long distance transport. Some strains of Hydrilla can set very small seeds.

Control

Hydrilla hasn’t been found in Oregon yet. It is such a troublesome plant in other parts of the country, however, that it would be dangerous if a small, pioneer colony were over-looked or missidentfied. Nearby, California has been battling outbreaks of this weed for many years. In 1996 a pioneering infestation of hydrilla was confirmed in Pipe Lake, King County in western Washington State, and is now undergoing aggressive treatment. Tubers and turions complicate control strategies. There is currently no technique, short of dredging, to remove tubers from the sediment once they are formed. Herbicide treatments can kill vegetative parts of the plant but do not affect the tubers. Grass carp will readily eat leaves and stems of Hydrilla, but do not eat the tubers. No biocontrol agent has been found that can effectively attack tubers in areas with even mild winters.

Hydrilla
(*Hydrilla verticillata* (L.F.) Royle)



Key features:

- Tubers (one-quarter to one-half inch long potato-like propagules) attached to roots in the sediment
- Tiny spines and “prickle hairs” on the leaves give hydrilla a rough feel

Fanwort

(*Cabomba caroliniana* Gray)

Description

Fanwort has distinctive fan-shaped submersed leaves arranged in pairs on the stem. In the water, fanwort has a “tubular” look because leaves are quite dense on the stem and there is little branching. Submersed leaves resemble those of water buttercup (*Ranunculus aquatilus*). Buttercup leaves, however, are arranged alternately (one per node) on the stem. Distinctive, but small, floating leaves may also be present. Floating leaves are long (less than one-half inch) and narrow (less than one-quarter inch). The stem attaches to the floating leaf blade at the center where there is a slight constriction. Small (less than one-half inch diameter), white flowers float on the water surface.

Growth Habit

Fanwort is a rooted aquatic plant with a limited distribution in the Northwest. In Oregon fanwort has infested several coastal lowland lakes and is present in side-channels of the Columbia River. Fanwort has been in Cullaby Lake, on the north coast of Oregon, for at least 10 years where it creates severe nuisance conditions. However, no extensive surveys have been conducted to determine its real extent. In contrast to other rooted aquatic plants, fanwort is reported to obtain nutrients important for growth from the water column rather than the sediment. Fanwort is a serious aquatic weed as far north as upstate New York and Michigan. It clearly has the ability to grow and create serious weed problems in Oregon.

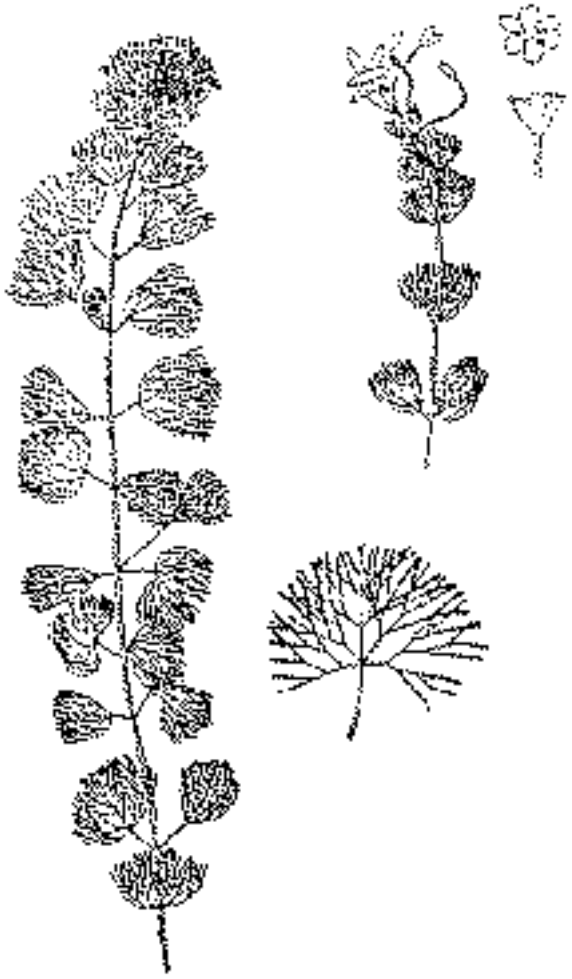
Propagation

Like many problem aquatic plants, fanwort can regenerate from small stem fragments. Fanwort stems become brittle in late summer, which causes the plant to break apart, facilitating distribution and invasion of new water bodies. Fanwort is self-pollinating in the South and seeds readily germinate. Yet, seeds collected in New Jersey failed to germinate. There is no information on seed viability in the Northwest.

Control

There has been little research on fanwort biology or management. Fanwort shows varying susceptibility to the herbicides available for management in Oregon. Fanwort has greater sensitivity to the contact herbicides diquat and endothall used in conjunction with complexed copper. Drawdown has been used to reduce fanwort growth in the South, however, extreme drying is necessary to prevent regrowth from seeds. Grass carp eat fanwort but there has been no research on other biocontrol agents. Because it may obtain most of its important nutrients from the water, fanwort may be sensitive to reduction in nutrients in the water. At the least, prompt action and vigilant monitoring of our lakes may prevent further spread of fanwort and increased management costs in the future.

Fanwort
(*Cabomba caroliniana* Gray)



Key features:

- Fan-shaped leaves in pairs on the submersed stem
- Submersed stems have a “tubular” appearance
- Small (less than one inch long), oval floating leaves with stem attached in the center

Water hyacinth

(*Eichhornia crassipes* (Mart.) Solms)

Description

Water hyacinth is a floating plant with round to oval leaves up to 10 inches in diameter, although smaller leaves are common. Leaves are bright green and shiny and held upright so they act like sails, which facilitates distribution of the plant. The leaf stalk is spongy and thick and helps to keep the plant bouyant. A mass of fine roots hang in the water column. Flowers are large (2-3 inches) and attractive. They are blueish purple or lilac colored with a yellow spot. Water hyacinth can be purchased in nurseries throughout Oregon, however, it has not become established in natural systems.

Growth Habit

Water hyacinth can form impenetrable mats of floating vegetation. Water hyacinth has not been found in the wild in Oregon but it is sold as an ornamental plant in garden stores in the state. Although it is thought that water hyacinth cannot survive Oregon's winters, its presence as an ornamental makes it possible for escape and growth in the wild under the right conditions.

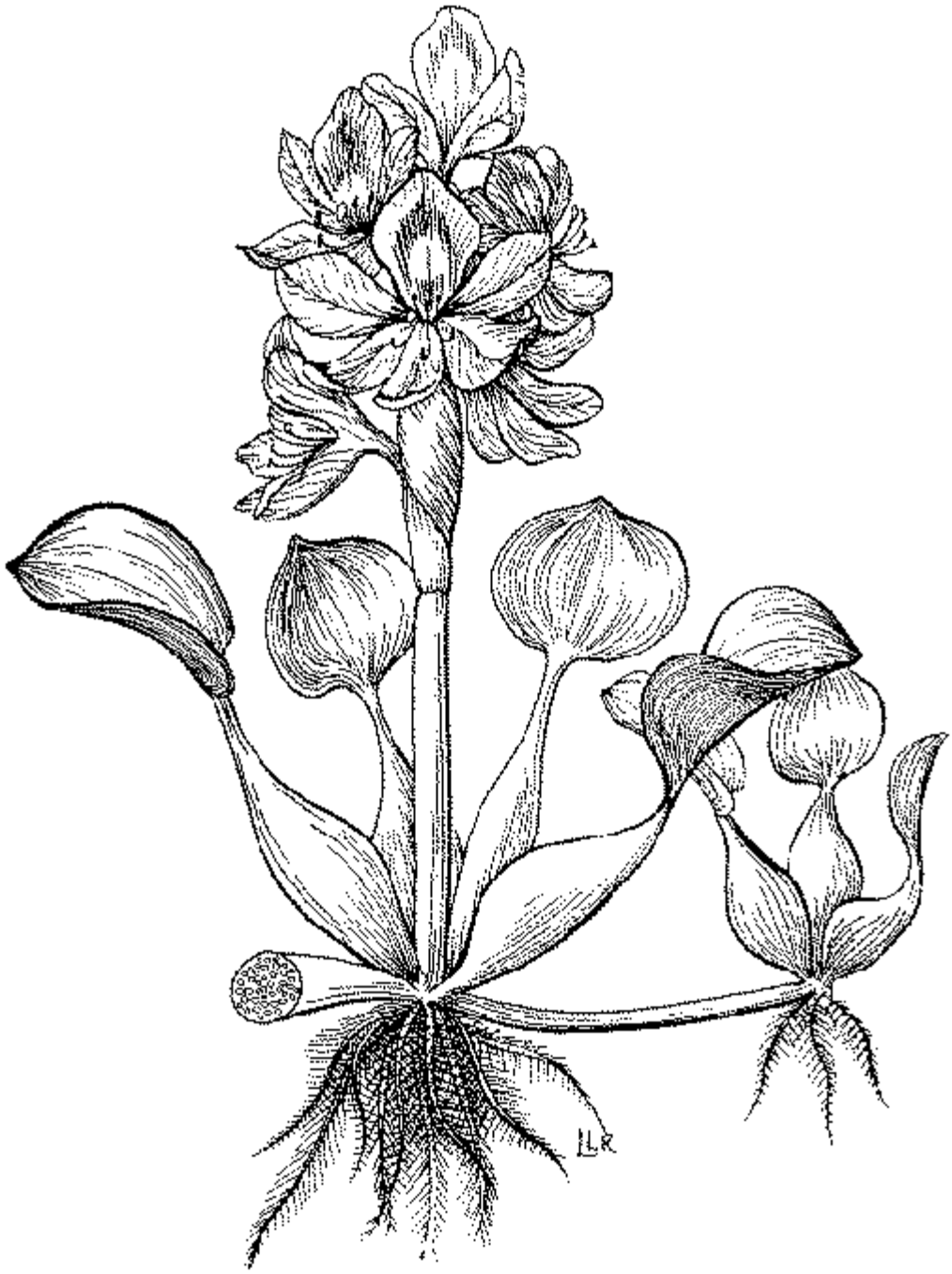
Propagation

Water hyacinth reproduces by seeds and vegetatively. Daughter plants form on rhizomes forming dense beds of water hyacinth. In one study, two plants produced 1200 daughter plants in four months. Individual plants break off of the mat and are dispersed by water currents. As many as 5000 seeds can be produced by a single plant. Seeds are eaten and transported by water fowl. The seeds sink to the bottom and may remain viable for 15 years. Seedlings are common on mud banks exposed by low water levels.

Control

The best way to manage water hyacinth is to keep it from becoming established in Oregon. One important means of controlling the introduction of water hyacinth is to keep them from escaping from ornamental ponds and backyard pools. Grass carp will eat water hyacinth and the plant can be managed with herbicides. All management options are very expensive and require an ongoing commitment. Be aware of the threat of water hyacinth and report any sitings to your local weed board and/or the Oregon Department of Agriculture, Noxious Weed Control Program!

Water hyacinth
(*Eichhornia crassipes* (Mart.) Solms)



Key features:

- Floating bunches of oval leaves that form a dense surface mat
- Long roots dangling in the water
- Attractive, hyacinth-colored (purplish) flowers

APPENDIX C

Watershed and Limnological Background Information

I. Watershed Features

Watershed Size/Boundaries

The size and topography of the watershed can significantly influence the waterbody. Watershed boundaries are marked by ridges and hilltops. The most obvious sources of drainage to a waterbody are inflowing rivers and streams (called tributaries). Other sources of inflow include surface flow or overland wash (often evident as water running over the ground, such as after a rainstorm). Water inflow below the surface of the ground to a lake or river is called groundwater. In cases where no streams flow into the waterbody, the watershed is the area from which groundwater is captured to supply the waterbody along with rainfall runoff.

Tributaries, Wetlands and Sensitive Areas

Tributaries

Identifying tributaries (rivers, streams, creeks) flowing into your waterbody can help you locate major sources of incoming waters. Land uses near these streams may also be important in controlling long-term water quality. Streams are effective at sculpting the land by cutting into and scouring channels which creates sediment along the way. They also transport sediment, nutrients, and other materials downstream where they are eventually deposited. Streams are shown on USGS quad maps and other general maps. The best source for stream mapping is your watershed council.

Wetlands and Sensitive Areas

It is important to determine if there are any wetlands or sensitive areas adjacent to the problem waterbody. Certain aquatic plant control actions could impact these special, often fragile areas of vegetation. National Wetland Inventory Maps (based on USGS quad series) are good sources and can be obtained from Division of State Lands. Local bookstores or map supply stores often stock or will special order these maps for you. Check with your local or county Planning Department for a map of sensitive areas as defined by local Sensitive Areas Ordinances.

How to Determine Boundaries of a Watershed

A map showing the watershed boundaries (usually the area from which surface water flows toward the waterbody) is a very useful tool. Often a watershed map already exists for your lake or river. Watershed maps are sometimes available from your local watershed council or Public Works or Planning Department of your county or city.

If a watershed map does not exist for your particular waterbody, you can construct one by using a topographic map. A topographic map shows a series of concentric circles called contour lines. Each contour line represents points on the surface that are the same elevation. The scale on topographic maps usually is presented in feet (or meters) above mean sea level (MSL). USGS quad maps also show contours, usually in 20 foot increments. Topographic or USGS quad maps can be obtained from local Public Works or Planning Departments, National Wetlands Inventory (US Fish & Wildlife), map stores or outdoor recreation stores. U.S. Geological Survey sometimes has regional groundwater maps, which would be useful for seepage lakes (groundwater-fed).

To find the watershed boundaries, read from the waterbody shoreline (the low point) outward on all sides to the highest elevation. Stop at the point before elevation readings begin to decrease. Once you have an initial boundary, check again to see you didn't stop too soon at a dip on the map. For guidance see "Watershed Fundamentals" in the Oregon Watershed Assessment Manual. Local or county staff can also assist you in checking watershed boundaries.

Land Use Activities In the Watershed

Human activities around a waterbody can have a significant influence on the aquatic system. Reducing pollutant inputs from livestock, croplands, forestry, residential properties and other sources can help protect the quality of the waterbody in the long term. These pollution sources, left unchecked, could make the water quality worse over time. Yet, while controlling these inputs helps reduce contamination, control of these sources alone is unlikely to provide a short-term solution to aquatic-plant problems. In most cases, in-lake management efforts form the primary means of dealing with the immediate problem of nuisance plants.

You can view recent aerial photos, if available, to get "the big picture" of the area around the waterbody. These may be obtained from your local or county Public Works or Planning Departments. The Division of State Lands and Regional Corps of Engineers Office also has aerial photos in black and white and sometimes in color. Aerial photos give an important bird's-eye view of the watershed, but it may not be enough. For more detail on land uses, zoning maps and land use maps can help define the now as well as what the future may bring. Contact your local Planning Department for zoning maps and information on development trends in the region.

Point And Nonpoint Pollutant Source Locations

The watershed not only contributes water to maintain the waterbody, but also sediment, nutrients, organic matter and contaminants that can wash into the lake or river. Pollutants can originate from two types of sources: point and nonpoint. Point sources arise from a distinct source that can be easily traced; they typically discharge through a pipe, conduit or outfall structure. Sources of nutrients and contaminants that do not originate from a pipe are commonly referred to as nonpoint sources. These sources are more diffuse in nature and may not be as obvious as piped discharges. Nonpoint sources include runoff from agricultural areas, forests, urban runoff (lawns, driveways, roadways), construction sites, seepage from septic tanks, discharges from marina and recreational boating and other widespread sources.

Since seeping or failing septic systems are often found to be sources of nonpoint pollution, areas with on-site waste treatment/disposal systems should be identified. A quick means of identifying potential nonpoint sources of pollution from septic systems around a waterbody can be accomplished by reviewing zoning maps from the Planning Department or as-built plans of developed communities. You can also contact local Public Health Department for more information.

303(d) List of Water Quality Limited Waterbodies

Currently about 100 lakes and reservoirs in Oregon are listed by the Department of Environmental Quality (DEQ) as water quality limited, or "303(d) listed" waterbodies, or "waterbodies of potential concern". The 303(d) list, which is a list of streams, rivers, lakes and reservoirs that fail to meet water quality standards, is required of all states as part of the 1972 federal Clean Water Act. The list only identifies the water quality problems of the waterbody (e.g., high chlorophyll *a* concentrations, turbidity, algae, weeds), not the causes. Causes of water quality problems are investigated and corrective actions are proposed later on as management plans are developed. Oregon Departments of Agriculture and Environmental Quality are charged with developing management plans for all the waterbodies on the 303(d) list. Copies of the 303(d) list and associated documents are available at public libraries throughout Oregon and all DEQ offices and on the web at http://waterquality.deq.state.or.us/wq/. For more information, you can call DEQ's water quality division at (503) 229-5279 or toll free in Oregon at 1-(800) 452-4011.

While nonpoint source loadings can originate from anywhere in the watershed, certain land use practices such as agriculture, construction, and city streets contribute greater inputs than other land uses such as forests and well-vegetated areas. Small quantities of pollutants from many sources in a watershed can have a cumulative effect, and can severely impact the quality of the receiving waters. Water quality can become so degraded that the waterbody fails to meet critical protective water quality standards (See Box on 303(d) listed waterbodies).

Existing Watershed Management, Monitoring, Or Enhancement Programs

Integrated aquatic plant management takes the holistic view, working in cooperation with other management efforts in the watershed. Of primary importance is the recent efforts embodied in the Oregon Plan for Salmon and Watersheds (See Box), which focuses on water quality improvement and native fish habitat restoration. The steering committee will need to work closely with its local watershed council and conservation team to develop a plan compatible with salmon enhancement efforts in the watershed.

If any management activites in critical habitat for federally listed threatened or endangered salmon species are being proposed, the steering committee should coordinate with the appropriate federal management agency (National Marine Fisheries Service or U. S. Fish and Wildlife Service) and ODFW to ensure that detrimental impacts to listed species do not occur.

There are things that everyone can do in the watershed to limit point and nonpoint inputs to lakes, rivers and streams. Best Management Practices (BMPs) in agriculture, construction, home and yard practices are methods designed to prevent or reduce loadings of nutrients, sediments, pesticides, and other contaminants to receiving waters. In addition to zoning (information supplied

The Oregon Plan for Salmon and Watersheds.

Initiated in 1997, Oregon's Salmon and Watershed Plan is designed to restore salmon to a level at which they can once again be a part of people's lives. Development of this program was instigated by the threat of federal endangered species listing of coastal coho salmon. While the Oregon Plan focuses on the needs of salmon and steelhead, it will conserve and restore crucial elements of natural systems that support fish, wildlife and people. The Oregon Plan has four key elements:

1. Coordinated Agency Programs
A number of state and federal agencies administer laws, policies, and management programs that affect all life cycle stages of salmon and steelhead. Under this plan, governmental agencies that impact salmon are accountable for coordinated programs consistent with conservation and restoration efforts.

2. Community Based Action
Government alone cannot conserve and restore salmon and steelhead. With agencies providing technical and regulatory support, restoration activities are performed at the local level.

3. Monitoring
Annual monitoring will be conducted to determine levels of response of salmon habitats and populations to conservation and restoration efforts.

4. Appropriate Corrective Actions
The Oregon Plan calls for making appropriate changes to current programs as needed and improving compliance with existing laws without introduction of new ordinances.

You can view the Oregon Plan on the web at: http://www.oregon-plan.org/

by your local Planning Department), there may be watershed management programs such as agricultural BMP activities through your Conservation District or septic tank maintenance programs through your local Health Department or County Cooperative Extension Service.

II. Waterbody Features

The Presence Of Rare, Endangered, Or Sensitive Animals And Plants

Oregon's Natural Heritage Program maintains a database on endangered or high quality native plant and animal species. The Natural Heritage Program, administered by the Division of State Lands and the Nature Conservancy, is responsible for information on the state's endangered, threatened, and sensitive plants as well as high quality native plant communities and wetlands. Similarly, the Oregon Department of Fish and Wildlife manages and interprets data on wildlife species of concern in the state. Although the Natural Heritage Program does not contain a complete inventory of all natural features in Oregon, the database is continually updated.

The presence of rare, endangered or other state sensitive animal or plants species in the immediate area being considered for aquatic plant treatment may pose certain limitations on those activities. This is particularly true for use of certain aquatic plant control techniques, such as aquatic herbicides.

Location, Size, Depth, and Shape

Location

A thorough description of where your lake is located is an important element in a Plan. A complete description should include the County, Township, Range, Section, and coordinates of your lake. This information can be obtained from topographic maps published by the U.S. Geological Survey, or from soils maps consulted in your characterization of the watershed.

Size

The size, depth, and shape of a lake determines the area colonizable by aquatic plants and also influences the mixing that occurs in the lake. The timing and degree of mixing of lake water is a characteristic feature for each lake and is a key determinant of the productivity of the ecosystem. Size can vary from less than an acre to thousands of acres. Aquatic plants can typically cover a larger percentage of the lake area in small lakes and consequently play a larger role in the overall functioning of the ecosystem in small lakes than in large lakes.

Depth

The depth of a lake tells us much about the biology and productivity of the lake. In deep lakes, surface waters warm during the summer while bottom waters remain cool. This thermal stratification in deep lakes affects mixing of water in the lake. Deep waters do not mix with the surface waters. This can have profound impacts on the amount of nutrients entering the lake, the growth of algae, water clarity, and the area colonizable by nuisance aquatic plants. Shallow water bodies typically support more aquatic plants than deeper, steeper-sided basins.

Basin Shape

The measurement of the shape of the lake basin is called bathymetry. Bathymetric lake maps are based on a series of depth measurements. Depth is usually measured at intervals along transects. These measurements are plotted on a map of the lake and contours drawn to provide a topographic map of the basin. The depth and size (area) of a lake determine the lake volume, which, in turn, determines the hydrology of the system.

Shoreline Shape
The shape of the shoreline can also provide information about the lake's biology and physical/chemical characteristics. Lakes with many embayments and an irregular shoreline have more shallow areas, and are consequently more susceptible to nuisance plant growth. Similarly, a long narrow lake has a greater shoreline length, i.e., more shallow areas, than a more circular lake with the same area.

Water Sources (Tributaries, Groundwater) And Hydrology

A waterbody is defined by characteristics of water flow. As water is impounded in a basin, a stream or river becomes a reservoir or lake. The period of detention of water in a basin is called the hydraulic detention time. The detention time can vary from days to years, depending upon the volume and flow through a particular waterbody. The inverse of detention time is the flushing rate, which is how fast the water in a lake is replaced. A lake with a detention time of 1 year has a water replacement, or flushing rate, of 1 lake volume/year. A lake with a 1/2 year detention time has a flushing rate of 2 lake volumes/year, a 2 year detention time gives a flushing rate of 1/2 lake volumes/year, etc. A short detention time (high water flow rates and low lake volume) results in a flushing rate that is so high that algal cells produced in the water column are washed out of the system faster than they can be replaced. Consequently, high flushing rates lead to low algal biomass, clear water, better and deeper light penetration into the lake, and better aquatic plant growth conditions.

Since water flow defines a waterbody and also influences its biological characteristics, it is important to consider the sources and volumes of water entering and leaving your lake. Are streams flowing in and out of the lake? Do they flow all year or seasonally? Is more water entering the lake than is flowing out? If so, the lake may be recharging the groundwater. If more is flowing out than is flowing in groundwater may be moving into the lake. Streams are also important in terms of fisheries support as well as possibly contributing to downstream movement of aquatic plant problems.

Physical, Chemical And Biological Characteristics Of The Waterbody And Tributaries

Rooted aquatic plants compete with algae for light and nutrients in the water column. Removal of the aquatic plants may increase light availability and result in enhanced algae growth. If water column nutrient levels are high enough nuisance algae blooms may occur. Therefore, in order to prevent exchanging a nuisance aquatic plant problem for a nuisance algae problem you must consider whether the light, temperature, and nutrient environment of the lake and its tributaries may support nuisance algae growth. Some of the required information may be available from the sources listed at the beginning of this section. If the data are incomplete or inadequate, a sampling program may be required to fill the gaps.

Physical/Chemical (Water Quality) Characteristics

Transparency
Water transparency is one of the oldest and easiest methods for describing a lake. Over the years the method of measuring transparency has been standardized to allow comparisons of measurements taken by different people in different lakes. The standard method utilizes a Secchi disk to measure transparency. A Secchi disk is a large diameter, black and white plate that can be lowered into the water on a rope. The depth at which the disk disappears from view (the Secchi depth) is related to the amount of materials (algae, sediment, and dissolved organic material) suspended in the water column. The Secchi depth has been correlated with a number of indices that indicate the overall productivity of the lake, including the maximum depth at which aquatic plants can grow.

Temperature
Temperature profiles are important descriptive information because of the effect of temperature on

biology and water density. Most biochemical reactions occur more rapidly at higher temperatures. Water temperature is an important determinant of photosynthesis rate in plants and respiration rates of plants and animals. Temperature determines the rate of growth of aquatic plants, and triggers the onset of growth in the spring and the fall dieback. Temperature also influences the density of water. Surface warming can lead to thermal stratification, as mentioned above, which can have significant impacts on nutrient availability, distribution and concentrations in lakes. In addition, extensive shallow areas (which typically have high aquatic plant densities) may undergo larger night/day temperature fluctuations than deeper, off-shore waters, which can lead to onshore-offshore water currents that can shorten herbicide contact times and effectiveness.

Dissolved Oxygen

Measurement of dissolved oxygen profiles in the lake can provide much information about the overall functioning and productivity of the lake. All of the organisms that are commonly observed in lakes require oxygen to survive. In stratified lakes, oxygen in the cool, dark bottom waters can be used up by the bacteria that decay and decompose the dead algae cells that rain down from the warmer and more well-lit surface waters. Loss of dissolved oxygen in the bottom waters makes those waters inhospitable for fish and many other aquatic organisms. Loss of oxygen also causes chemical changes in the sediment that result in the release of nutrients that can fuel growth of algae and rootless aquatic plants, like coontail (Ceratophyllum demersum), in the lake.

Alkalinity

Alkalinity is a measure of the ability of water to resist changes in pH (a measure of acidity). Large fluctuations in pH can occur on a daily basis in lakes with low alkalinity and dense aquatic plant growth because of the chemical reactions of photosynthesis. Plant photosynthesis uses the energy of sunlight to convert the carbon in carbon dioxide and bicarbonate ions into plant tissue. The removal of carbon dioxide from the water causes pH to increase. During the night, respiration of plant tissues releases carbon dioxide into the water, causing pH to decrease. Extreme high and low pH can influence a number of chemical reactions that determine the availability of nutrients in the lake, and can lead to chemical toxicity problems for fish and insects.

Phosphorus

In many lakes the concentration of phosphorus in the water determines the growth rate of algae. Therefore, measurement of the concentration of phosphorus in the water is an indication of the potential productivity of algae in the lake. Two forms of phosphorus are generally measured in lakes. Dissolved, inorganic phosphorus is readily available for plant and algae uptake. Total phosphorus includes dissolved phosphorus and the phosphorus that is associated with algae, zooplankton, and particles in the water.

Phosphorus concentrations can vary considerably with depth in stratified lakes. Low dissolved oxygen concentrations in bottom waters of stratified lakes can result in a chemical reaction that causes phosphorus to be released from the sediment to the water. As a consequence, bottom waters can have much higher phosphorus concentrations than surface waters.

Nitrogen

Nitrogen often limits aquatic plant growth and can occasionally limit algae growth. As with phosphorus, there are inorganic and organic forms of nitrogen. Inorganic nitrogen can exist in three forms in lakes: nitrite, nitrate, and ammonia. Nitrite is usually present in only very small amounts. As with many other chemical constituents, the distribution of inorganic nitrogen varies with depth in stratified lakes. Nitrate is generally most abundant in the surface waters, and ammonia dominates the bottom waters. Presence of nitrates in the bottom waters may indicate that groundwater is entering the lake. High concentrations of ammonia and/or nitrates in the surface waters may suggest that there is septic pollution present.

Biological Characteristics

Your lake is a complex community made up of a variety of interacting plants and animals. Aquatic weeds and algae make up the plant community. Fish, zooplankton, insects, and wildlife interact with each other and the plant community to make a functioning aquatic ecosystem. The aquatic plant community is discussed in greater detail in Chapter 8-Map Aquatic Plants. This section describes other characteristics of the biological community that must be considered in developing a Plan.

Algae
The algae, or phytoplankton, community forms the foundation of the aquatic ecosystem and are the first link in the aquatic food chain. The algae in your lake can be used as indicators of the overall nutrient status of your lake and the likelihood of nuisance algae blooms. Certain algae, such as the blue-green algae (a.k.a. cyanobacteria), are characteristic of nutrient enrichment. Since algae and some aquatic plants both compete for dissolved nutrients, in certain cases, algae problems may increase if aquatic plants are removed. In other words, fewer weeds allow the algae to have a bigger share of the nutrient pie. As a result, the algae may flourish and create their own problems.

It is important to note that management for nuisance algae and management for nuisance aquatic plants in a waterbody require different tactics. The dominance of algae generally indicates a problem with excessive nutrients in the water column that could come from a variety of in-lake or offshore sources. Algae control usually necessitates both internal and external controls. Aquatic plant control is primarily concerned with in-lake treatment for long-term effectiveness. It may also be supplemented by watershed controls as a secondary aid.

The concentration of chlorophyll *a* in the water column is an index of algae abundance. Chlorophyll *a* is one of a family of pigments that make green plants green. It is the molecule that captures the energy in light and transfers it to a chemical form that provides the fuel for the entire ecosystem. High chlorophyll *a* concentrations in lake water indicate high algae densities, which influences the light available for aquatic plant growth.

Zooplankton
The zooplankton are microscopic aquatic animals that graze on the algae present in the water. Zooplankton graze algae like cows eat grass. High zooplankton densities can reduce algae abundance and result in high water clarity that permits aquatic weeds to proliferate. The efficiency of zooplankton grazing is dependent upon the relative size of the algae and zooplankton. Large zooplankton are the most efficient grazers, but they also look like big juicy steaks to hungry fish.

Fish
There is a fine balance between the algae, zooplankton and fish in your lake. Many small fish depend upon zooplankton for food. If zooplankton populations are reduced by the fish, algae can grow unchecked. Using the cow/grass analogy, if wolves (fish) eat the cows (zooplankton), the grass (algae) grows tall. If the wolves are eliminated by hunting (big fish eat little fish), the cow population increases, and the grass is short. Since algae determines light penetration of the water, changes in the fish community can affect aquatic weed growth in your lake.

Many lakes in Oregon are stocked with catchable-size trout. Introduction of many large fish into your lake can have a ripple effect all the way down the food chain, and can affect aquatic weed distribution and growth. The reverse is also true; changes in the aquatic plant community due to your control and management activities, can affect the fish population. Information on the native and stocked fish in your lake can be obtained from the Department of Fish and Wildlife.

Wildlife
Your lake may serve as a resource for a variety of waterfowl and wildlife. Some waterfowl feed on aquatic plants, while birds of prey, like eagles and osprey, may fish in a lake or river. Muskrats,

beavers, otters, deer, and other animals may be residents or visitors. Your management activities may alter the habitat quantity or quality available for wildlife. A seasonal census of wildlife utilization of the lake should be included in a Plan. Local residents and the Department of Fish and Wildlife are good sources of information on the kinds and numbers of wildlife that depend upon your lake.

Shoreline Use

Your examination and characterization of the watershed will provide some information on land use along the shoreline. A more detailed look at the shoreline is necessary to evaluate the feasibility of some aquatic-plant management techniques. Some herbicides cannot be used near drinking water intakes; others require a waiting period before the water can be used for irrigation purposes. In addition, you may identify areas that could be a source of nutrients to the lake (e.g., failing septic systems and heavily-fertilized lawns) and contribute to water quality problems (see previous section on Point and Nonpoint Pollutant Sources).

Outlet Control And Water Rights

What you do in your lake may effect water users downstream and you must consider their water rights. Lake drawdown and subsequent refilling would affect flow below the outlet. Would altering flow affect someone's water rights or fish habitat downstream? Would herbicide use affect downstream uses? Water level manipulation requires some type of outlet structure. Who controls the outlet structure and lake water level? Are they willing to cooperate in your efforts to manage aquatic vegetation?

It is important to note that certain water rights and established in-stream flow rates are legally protected and must be maintained.

Salmon species within the project watershed require special consideration, especially with the recent passage of the Oregon Plan for Salmon and Watersheds (See Box at beginning of appendix). If salmonids migrate through your lake, the management plan must accommodate their movements and spawning and rearing activities. The Oregon Division of State Lands can provide information about outlet control. Information regarding salmon use and movement into and out of your lake can be obtained from the ODFW.

References and Resources on Lake, River and Reservoir Monitoring and Ecology

- Nonpoint Source Pollution Assessment and Management Program[7]
- The Lake and Reservoir Restoration Guidance Manual
- Citizen Lake Watch Program
- Volunteer Lake Monitoring: A Methods Manual
- A Citizen's Guide to Understanding and Monitoring Lakes and Streams

APPENDIX D

Aquatic Plant Control Methods

Physical Control Methods

Physical methods of aquatic plant control include:

- Hand-pulling
- Hand cutting
- Bottom barrier application (sediment covers)
- Water level drawdown
- Implementing watershed controls to reduce nutrient inputs
- Water column dyes

Each method will be briefly discussed in terms of mode of action, effectiveness and duration of control, advantages, drawbacks, costs, and required permits.

Hand Pulling

Principle

Hand-digging and removal of rooted, submerged plants is an intensive treatment option. This method involves digging out the entire plant (stem and roots) with a spade or long knife and disposing of plant residue on shore. In shallow waters less than 3 feet, no specialized gear is required. In deeper waters, hand removal can best be accomplished by divers using scuba or snorkeling equipment and carrying collection bags for disposal of plants.

Control Effectiveness And Duration

Efficacy of plant removal depends on sediment type, visibility, and thoroughness in removing the entire plant, particularly the roots. A high degree of control over more than one season is possible where complete removal of the entire plant has been achieved.

Advantages

The technique results in immediate clearing of the water column of nuisance plants. The technique is very selective in that individual plants are removed. It is most useful in sensitive areas where disruption must be kept to a minimum. Because the technique is highly labor-intensive, it is most appropriate for small-area, low plant density treatments. In these cases, the technique is very useful for aggressive control of sparse or small pockets of Eurasian watermilfoil. This method can also be useful for clearing pondweeds or very small patches of water lilies from areas around docks and beaches.

Drawbacks

The technique is time-consuming and costly, especially where contract divers may be used. Diver visibility may become obscured by turbidity generated by swimming and digging activities. Also, it may be difficult for the laborer to see and dig out all plant roots. Environmental impacts are limited to mostly short-term and localized turbidity increases in the overlying water and some bottom disruption.

Costs

Costs will vary depending on whether contract divers or laborers are used, or if removal activities are the result of volunteer efforts. In the case of contract divers and dive tenders, expenses can run upward of $500 to $2400/day with area covered dependent on density of plants.

Permits

No permits are currently required for hand-pulling aquatic plants. However, be sure to check with your local jurisdiction or watershed council before beginning any aquatic plant management activities in a water body.

Hand Cutting

Principle

This technique is also a manual method, but differs from hand-pulling in that plants are cut below the water surface (roots generally are not removed). Implements used include scythes, rakes, or other specialized devices that can be pulled through the weed beds by boat or several people. Mechanized weed cutters are also available that can be operated from the surface for small-scale control.

Control Effectiveness and Duration

Root systems and lower stems are often left intact. As a result, effectiveness is usually short-term as regrowth is possible from the uncut root masses.

Duration of control is limited to the time it takes the plant to grow to the surface from remnant root systems.

Advantages
The technique results in immediate removal of nuisance submerged plant growth. Costs are minimal.

Drawbacks
Like hand-pulling, the technique is time-consuming. Visibility may become obscured by turbidity generated by cutting activities. Also, since the entire plant is usually not removed, this technique does not result in long-term reductions in growth. Environmental impacts are limited to mostly short-term and localized turbidity increases in the overlying water and some bottom disruption. Cut plants must be removed from the water.

Costs
Where volunteer efforts are employed, costs are mostly limited to purchase of a cutting implement. This can vary from under $100 for the Aqua Weed Cutter (Sunrise Corp.) to over $1000 for the mechanized Swordfish (Redwing Products).

Permits
No permits are required for hand-cutting or raking of aquatic plants. However, be sure to check with your local jurisdiction or watershed council before beginning any aquatic plant management activities in a waterbody.

Bottom Barrier Application (Sediment Covers)

Principle
Barrier material is applied over the lake bottom to prevent plants from growing, leaving the water clear of rooted plants. Bottom covering materials such as sand-gravel, polyethylene, polypropylene, synthetic rubber, burlap, fiberglass screens, woven polyester, and nylon film have all been used with varying degrees of success. Applications can be made up to any depth, with divers often utilized for deeper water treatments. Usually bottom conditions (presence of rocks or debris) do not impede most barrier applications, although pre-treatment clearing of the site is often useful.

Control Effectiveness and Duration
Bottom barriers can provide immediate removal of nuisance plant conditions upon placement. Duration of control is dependent on a variety of factors, including type of material used, application techniques, and sediment composition. Elimination of nuisance plant conditions for at least the season of application has been demonstrated by synthetic materials like Aquascreen and Texel. Where short-term control is desired for the least expense, burlap has been found to provide up to 2-3 years of relief from problematic growth before eventually decomposing (Truelson14, 15). After satisfactory control has been achieved (usually several months), some synthetic barrier materials can be relocated to other areas to increase benefits.

Advantages
Bottom barriers can usually be easily applied to small, confined areas such as around docks, moorages or beaches. They are hidden from view and do not interfere with shoreline use. Bottom barriers do not result in significant production of plant fragments (critical for milfoil treatment). Bottom barriers are most appropriately used for localized, small-scale control where exclusion of all plants is desirable; where other control technologies cannot be used; and where intensive control is required regardless of cost.

Drawbacks
Depending on the material, major drawbacks to the application of benthic barriers include some or all of the following: high materials cost, labor-intensive installation, limited material durability, possible suspension due to water movements or gas accumulation beneath covers, or regrowth of plants from above or below the material. Periodic maintenance of bottom barrier materials is required to remove accumulations of silt and any rooting fragments. In some situations, removal and relocation of barriers may not be possible (e.g., natural fiber burlap does decompose over time). Sediment covers can also produce localized reduction in populations of bottom-dwelling organisms like aquatic insects.

Costs
Costs vary from approximately $0.30/sq. ft (Texel) to $0.35/sq. ft (Aquascreen) for materials with an additional $0.25-0.50/sq. ft for installation. Locally, prices for rolled burlap material (available in fabric stores, outlets) average from $0.15 to $0.25/sq. ft for materials only.

Permits
Currently no permits are required by State agencies for bottom barrier applications in freshwater systems. However, be sure to check with your local jurisdiction or watershed council before beginning any aquatic plant management activities in a waterbody.

Water Level Drawdown

Principle
Water level drawdown used for management of aquatic plants involves exposing plants and root systems to prolonged freezing and drying, or hot, dry conditions to kill the plants. Drawdown for plant control is usually performed during winter months, although summertime drawdowns are sometimes conducted.[13] It's use has been more common in management of reservoirs and ponds than in natural lakes.

Control Effectiveness and Duration
Aquatic plants vary in terms of susceptibility to drawdown. Some aquatic plants can be permanently damaged after sufficient exposure, while others are unaffected or even enhanced. Therefore, accurate identification of target species is critical before considering this method. A summary of responses of common aquatic plants to water level drawdown is presented in Restoration and Management of Lakes and Reservoirs.[13] For Eurasian watermilfoil, effects have been variable, partly because of the species'ability to withstand low temperatures for short periods of time as well as its resiliency and tenacity. The mild, wet winters typical of Western Oregon may not provide adequate freezing/drying conditions to kill certain plants.

Advantages
In addition to controlling aquatic plant biomass, drawing down the water level makes it possible to use several other management procedures for restoration or improvement. For instance, it can be used for fish management, to repair structures such as docks or dams, to facilitate localized dredging or bottom barrier placement or to remove stumps or debris. This technique can result in compaction of certain types of sediments, such as mucky substrates and thus improve shoreline use. Decreasing nearshore vegetation through drawdown can reduce potential inputs of nutrients to the water from seasonal dying of aquatic plants. Drawdown can be used to attract waterfowl by enhancing growth of certain emergent plants such as cattails and bulrushes.[13]

Drawbacks
This technique is not species-selective; removal of beneficial plant species may occur. Wetlands adjacent to the waterbody can be exposed with possible negative impacts on both plant and associated animal communities. Prolonged drying and freezing can decrease bottom-dwelling invertebrates that could be important food sources for fish. Dissolved oxygen levels may decline as a result of lowering the water level with possible negative impacts on fish and other aquatic organism. Recreational use of the waterbody may be limited or unavailable during the period of drawdown. Drawdown has not proven effective in the coastal lowlands of the Pacific Northwest. If summer or winter drawdown is implemented for plant control, sediments must become completely dry for a prolonged period of time to kill plant roots.

Costs
If an outlet structure is located on the waterbody, expenses should be minimal. Other costs would include recreational losses (perhaps loss in tourism revenue).

Permits
Most water level drawdown projects that release through regulated outlet structures require approval from Oregon Division of State Lands. In addition,

if the project area is within a federal navigable waterways system, it will be necessary to obtain a permit from the U.S. Army Corps of Engineers.

Watershed Controls

Principle
The principle involves reducing sources of external (outside) nutrient and sediment inputs by implementing watershed best management practices (BMP's). The idea is to shut off entry of growth-stimulating nutrients (phosphorus and nitrogen) to the waterbody by using prudent household and yard care practices, as well as employing agricultural, forestry, construction and road maintenance practices that minimize pollutant loadings in the watershed. Common examples of homeowner BMP's include: maintaining septic systems, using prudent lawn and garden fertilizing practices, and disposing of yard litter by shredding or composting well away from water's edge. Use of watershed controls is often implemented as part of a whole lake/watershed management effort, which may involve other in-lake aquatic weed control and/or nutrient control measures. For a more complete discussion on BMP's, see The Lake and Reservoir Restoration Guidance Manual.[4]

Control Effectiveness and Duration
If it has been demonstrated that excessive rooted macrophyte growth is due to siltation and external nutrient inputs and not to historically-enriched sediments, then appropriate watershed controls could provide long-term control of nuisance aquatic plant growth. But it will take many years to achieve this because siltation has created suitable habitat for plants to flourish, with an adequate supply of nutrients already contained in sediments.

Advantages
Watershed best management practices are wide-ranging and usually easy to perform. Since the watershed and waterbody are interconnected, any reduction in contaminant loading to a waterbody as a result of BMP's can maintain or extend effectiveness of separate in-lake controls.

Drawbacks
Employing BMP's to correct nuisance aquatic plant growth will not result in immediate, substantial growth reduction because habitat has already been created that supports aquatic plant growth. Consultation with lake management experts as to underlying causes of poor water quality (nuisance aquatic plant growth is often symptomatic of a larger problem) can aid in avoiding such a mistake.

Costs
Initiation of most homeowner BMP's involves very little expense to get started. Most of the effort involves voluntary changes in behavior, such as modifying product buying practices (go for less packaging, more environmentally friendly products), conserving water, energy, and composting where possible.

Permits
Permits are not usually required for initiation of best management practices around shorelines. This is especially true for property owners utilizing prudent household and yard management practices.

Water Column Dyes

Principle
The theory behind this technique is to suppress aquatic plant growth by shading the plants from sunlight needed for photosynthetic growth. Dark-colored dyes are applied to the water, which reduces the amount of light reaching the submersed plants.

Control Effectiveness And Duration
Aquashade (Applied Biochemists, Inc.) is a commercial dye product available for applications in closed systems (water bodies with no outflow). According to the manufacturer, Aquashade is apparently effective against Eurasian watermilfoil, Hydrilla, Elodea, and various pond weeds, as well as macroalgae Chara sp. and filamentous green algae like Spirogyra spp. There are a number of other pond dyes on the market that mimic Aquashade in their shading effects. These products are probably more effective in shallower water

bodies where dye concentrations can be kept up and the loss of dye through dilution would be less. Best results are obtained when the product is used early in the growth season.

Advantages
Aquashade is reported to be non-toxic to humans, livestock, and aquatic organisms. No special equipment is needed for application; it can be poured into the water by hand from shoreline or boat. It imparts a blue color to the water.

Drawbacks
Its use is limited to shallow water bodies with no outflow. According to the manufacturer, Aquashade is less effective when aquatic plant growth is within 2 feet of the surface In this case other methods of removal are recommended prior to dye use. This can increase program costs considerably. Repeat dye treatments may be necessary throughout the growth season. Aquashade should not be used in drinking water supplies, in flowing waters, or in chlorinated waters.

Costs
Costs for Aquashade are approximately $50/gallon, which can be used to treat one acre of water at average depth of 4 feet at the recommended dosage of 1 ppm (part per million).

Permits
Currently no permits are required by State agencies for water column dye applications in freshwater systems. However, be sure to check with your local jurisdiction or watershed council before beginning any aquatic plant management activities in a waterbody.

Mechanical Control Methods

Mechanical methods for aquatic plant control include:
- Mechanical harvesting
- Weed Rolling
- Rotovation/cultivation (underwater bottom tillage)
- Diver-operated suction dredging

Mechanical Harvesting

Principle
Mechanical harvesting is considered a short-term technique to temporarily remove plants interfering with recreational or aesthetic enjoyment of a waterbody. Harvesting involves cutting plants below the water surface, with or without collection of cut fragments for offshore disposal. To achieve maximum removal of plant material, harvesting is usually performed during summer when submersed and floating-leafed plants have grown to the water's surface.

Conventional single-stage harvesters combine cutting, collecting, storing and transporting cut vegetation into one piece of machinery. Cutting machines are also available which perform only the cutting function. Maximum cutting depths for harvesters and cutting machines range from 5 to 8.2 ft with a swath width of 6.5 to 12.1 ft. Cooke et al.[13] summarizes aquatic plant cutters and harvesters available in North America.

Control Effectiveness and Duration
Since harvesting involves physical removal and disposal of vegetation from the water, the immediate effectiveness in creating open water areas is quite apparent. The duration of control is variable. Factors such as frequency and timing of harvest, water depth, and depth of cut are suspected to influence duration of control. Harvesting has not proven to be an effective means of sustaining long-term reductions in growth of milfoil. Regrowth of milfoil to pre-harvest levels typically occurs within 30 to 60 days,[24] depending on water depth and the depth of cut.

Advantages
Harvesting is most appropriately used for large, open areas with few surface obstructions. There is usually little interference with use of the waterbody during harvesting operations. Harvesting also has the added benefit that removal of in-lake plant biomass also eliminates a possible source of nutrients often released during fall dieback and decay. This is of important consequence in those water

bodies with extensive plant beds and low nutrient inputs from outside sources. Furthermore, harvesting can reduce sediment accumulation by removing organic matter that normally decays and adds to the bottom sediments. Depending on species content, harvested vegetation can be easily composted and used as a soil amendment. Mechanical harvesting costs can be relatively low compared to other physical/mechanical techniques.

Drawbacks
Cut plant material requires collection and removal from the water. Harvesting creates plant fragments. This is of great concern with Eurasian watermilfoil, given its ability to rapidly disperse by fragmentation. Harvesting can be detrimental to non-target plants and animals (e.g., fish, invertebrates), which are removed indiscriminately by the process. Harvesting can lead to enhancement of growth of opportunistic plant species that invade treated areas. Capital costs for machine purchase are high and equipment requires considerable maintenance.

Costs
Harvesting program costs depend on factors such as program scale, composition and density of vegetation, equipment used, skill of personnel, and site-specific constraints. Detailed costs are not uniformly reported, so comparing project costs of one program with another can be difficult. However, average costs of local harvesting operations range from $200/acre to $700/acre.

Permits
Currently, no permits are required by the State for mechanical cutting operations for aquatic plant control. However, you should check with your local jurisdiction or watershed council to determine if local regulations apply to mechanical cutting activities in a waterbody.

Weed Rollers

Principle
Weed rollers control aquatic vegetation by agitating and compacting the lake sediments. The method uses a commercially available, low voltage power unit that drives a roller on the lake bottom through an adjustable arc of up to 270 degrees. A reversing action built into the drive automatically brings the roller back to complete the cycle. Fins on the rollers detach some plants from the soil, while the rollers force other plants flat, gradually inhibiting growth. Detached plants should be removed from the water with a rake or gathered by hand to prevent them from rooting in other locations.

Once the plants are cleared from the area, the device can be used as little as once per week or less to keep plants from recolonizing the area. When not in use the roller should be parked under the dock to prevent injury from accidental contact.

Control Effectiveness and Duration
Weed rolling can provide long-term vegetation control to areas around docks and shorelines. After the initial clearing of plants, the device will only have to be used periodically in order to maintain the clearing. Little maintenance is required on the machinery which has a life of over five years.

Advantages
Weed rolling provides an inexpensive method of controlling weeds in a small area particularly around docks and adjacent open water.

Drawbacks
Weed rolling may disturb some bottom dwelling animals and may interfere with fish spawning. Weed rolling may cause plant fragmentation, which may increase the spread of some invasive weeds. When the cleared area is to be used for activities such a swimming or wading, the rollers can become an obstacle

Permits
Currently, no permits are required by the State for weed rolling for aquatic plant control. However, you should check with your local jurisdiction or watershed council to determine if local regulations apply to weed rolling activities in the waterbody.

Rotovation/Cultivation (Bottom Derooting)

Principle

Mechanical rotovation/cultivation are bottom tillage methods that remove aquatic plant root systems. This results in reduced stem development and seriously impairs growth of rooted aquatic plants. Derooting methods were developed by aquatic plant experts with the British Columbia Ministry of Environment as a more effective milfoil control alternative to harvesting. Essentially two types of tillage machinery have been developed. Deep water tillage is performed in water depths of 1.5 to 11.5 ft using a barge-mounted rototiller equipped with a 6-10 ft wide rotating head. Cultivation in shallow water depths up to a few meters is accomplished by means of an amphibious tractor or modified WWII "DUCW" vehicle towing a cultivator. Both methods involve tilling the sediment to a depth of 4-6 in, which dislodges plants including roots. Certain plants like milfoil have roots that are buoyant and float on the surface where they can be collected. Treatments are made in an overlapping swath pattern. Bottom tillage is usually performed in the cold "off-season" months of winter and spring to reduce plant regrowth potential.

Control Effectiveness and Duration

Bottom tillage has been used effectively for long-term control of Eurasian watermilfoil where populations are well-established and prevention of stem fragments is not critical. Single treatments using a crisscross pattern have resulted in milfoil stem density reductions of 80-97 percent in bottom tillage treatments.[16, 17] Seasonal rototilling in an area is at least as effective as 3 to 4 harvests, and where repeated treatments have occurred at the same site over several years, carryover effectiveness may extend to greater than a year.

Advantages

A high percentage of entire plants (roots and shoots) can be removed by bottom tillage methods. Depending on plant density, carryover effectiveness of rototilling can persist for up to 2 to 3 years without retreatment. Following treatment, rotovated areas in Washington and British Columbia have shown increases in species diversity of native plants, of potential benefit to fisheries. Fish are not removed through rototilling as they are by harvesting operations. Unlike harvesting which is conducted during summertime when plant growth is maximal, rototilling treatments for root removal can be performed during "off season" months of winter and spring. This results in no interference with peak summer-time recreational activities.

Drawbacks

Bottom tillage is limited to areas with few bottom obstructions and should not be used where water intakes are located. Rototilling does create short-term turbidity increases in the area of operation, but increases are usually temporary with a rapid return to baseline conditions often within 24 hours.[13, 16] Since bottom sediments are disturbed, short-term impacts on water quality and the benthic invertebrate community can occur.[16] Rototilling is not advised where bottom sediments have excessive nutrient and/or metals concentrations, because of potential release of contaminants into the overlying water. Rotovation is not species selective, except by location, and can result in unintentional removal of non-target plants. The method does result in production of plant fragments, and is not recommended for use in water bodies with new or sparse milfoil infestations or where release of fragments is a concern. Timing restrictions may be imposed to avoid interference with fish spawning or juvenile use.

Costs

Bottom tillage costs vary according to treatment scale, density of plants, machinery used and other site constraints. Contract costs for rotovation in the State of Washington range from $1000-1700/acre depending on treatment size.

Permits

Rotovation and cultivation that disturbs more than 50 cubic yards of sediment requires a permit from the Corps of Engineers and approval of the Division of State Lands.

Diver Operated Suction Dredging

Principle

Diver dredging was being used in the late 1970s in British Columbia as an improvement to hand removal of sparse colonies of Eurasian watermilfoil.[13] The technique utilizes a small barge or boat carrying portable dredges with suction heads that are operated by scuba divers to remove individual rooted plants (including roots) from the sediment. Divers physically dislodge plants with sharp tools. The plant/sediment slurry is then suctioned up and carried back to the barge through hoses operated by the diver. On the barge, plant parts are sieved out and retained for later off-site disposal. The water sediment slurry can be discharged back to the water or piped off-site for upland disposal.

Control Effectiveness And Duration

Diver dredging can be highly effective under appropriate conditions. Efficiency of removal is dependent on sediment condition, density of aquatic plants and underwater visibility.[13] As it is best used for localized infestations of low plant density where fragmentation must be minimized, the technique has great potential for milfoil control. Depending on local conditions, milfoil removal efficiencies of 85-97% can be achieved by diver dredging.[17]

Advantages

The method is species-selective and site-specific. Disruption of sediments are minimized. Plant pieces are collected and retained, and fragmentation spread is minimized (very important for control of milfoil). It can be used to cover areas larger than practicable for hand digging or diver hand removal, or where herbicides cannot be used. Diver-dredging can be conducted in tight places or around obstacles that would preclude use of larger machinery.

Drawbacks

Diver-dredging is labor-intensive and expensive. In dense plant beds, the utility of this method may be much reduced and other methods (e.g., bottom barrier) may be more appropriate. Returning dredged residue directly to water may result in some fragment loss through sieves. Where upland disposal of dredged slurry is used, more specialized equipment and materials are required and the process is much more costly. Short-term environmental effects can include localized turbidity increases in the area of treatment. Release of nutrients and other contaminants from enriched sediments can also be a problem. In addition, some sediment and non-target vegetation may be inadvertently removed during the process.

Costs

Dredging costs can be very variable, depending on density of plants, equipment condition and transport requirements of dredged material. In addition, the use of contract divers for dredging work is subject to stringent State regulations on certification, safety and hourly wage payment, which can affect total project cost. Costs range from a minimum of $1200/day to upwards of $2400/day (with no dredged material transport).

Permits

In the State of Oregon, use of suction dredging does require a permit from the U.S. Army Corps of Engineers (COE). Suction dredging of the substrate also requires approval from Oregon Division of State Lands.

Biological Control Methods

Interest in using biocontrol agents for nuisance aquatic plant growth has been stimulated by a desire to find more “natural” means of long-term control as well as reduce use of expensive equipment or chemicals. The possibility of integrating biological controls with traditional physical, mechanical, or chemical methods is an appealing concept. While development and use of effective biocontrol agents for aquatic plant management is still in its infancy, potentially useful candidates have been identified such as plant-eating fish or insects, pathogenic organisms, and competitive plants. Except for exotic species infestation, a realistic objective of biocontrol of aquatic vegetation is not the eradication, but the reduction of target plant

species to lower, more acceptable levels.[13] More importantly, control of nuisance plants using biological agents will be a gradual process, although the effects should be long-lasting. Biocontrol options for most submersed aquatic weeds are limited. Insects have been released for control of Purple loosestife in Oregon with great success. Conact the Oregon Department of Agriculture for additional information on biocontrol of Purple loosestife.

Triploid (Sterile) Grass Carp

Principle

Grass carp or white amur (*Ctenopharyngodon idella* Val.) are exotic, plant consuming fish native to large rivers of China and Siberia. Known for their high growth rates and wide range of plant food preference, these fish can control certain nuisance aquatic plants under optimal circumstances. Stocking rates are dependent on climate, water temperature, type and extent of plant species and other site-specific constraints. Sterile grass carp are most appropriately used for high-intensity control of submersed plants. Recent field studies in Washington State have shown that use of grass carp for maintenance of a desired moderate level of vegetation has rarely been successful[2]. Grass carp require a permit from the Oregon Department of Fish and Wildlife (ODFW). Current rules prohibit grass carp in natural lakes and in reservoirs greater than 10 acres. State fisheries personnel with ODFW should be contacted for more information on specific use and stocking of grass carp in State waters.

Control Effectiveness And Duration

Effectiveness of grass carp in controlling aquatic weeds depends on feeding preferences that are related to age, size and metabolism of the fish. Feeding rates do appear to be temperature-dependent1.[13] Triploid grass carp exhibit distinct food preferences which apparently vary from region to region in the U.S, and even from site to site within a region. Recent laboratory and field studies in Washington State have shown that some plant species appear to be highly preferred, such as the pondweeds, *Potamogeton crispus*, *P. pectinatus* and *P. zosteriform*is; others were variably preferred, such as coontail, *Ceratophyllum demersum*, and some plants were not preferred, such as watershield, *Brasenia schreberi*. Grass carp control effectiveness and duration are site-specific. In general, management studies in Washington waters indicate that substantial removal of vegetation by sterile grass carp may not become apparent until 3-5 years after introduction.

In the 1980s, triploid grass carp were introduced into Devils Lake as an experimental control. Recently, new grass carp rules were adopted that allow the use of the fish in private lakes and reservoirs smaller than 10 acres, and in irrigation canals. Because of uncertainty over possible reproduction, parasites and escape, and due to recent concerns over endangered salmon species, the State has maintained a prohibition on generalized use of grass carp in freshwater systems.

Advantages

Depending on the problem plant species and other site constraints, grass carp can achieve long-term reductions in nuisance growth of vegetation, although not immediately. In some cases, introduction of grass carp may result in improved water quality conditions, where water quality deterioration is associated with dense aquatic plant growth.[12]

Drawbacks

Since sterile grass carp exhibit distinct food preferences, they do not graze all plants equally well, limiting their applicability. The fish may avoid areas of the waterbody experiencing heavy recreational use, resulting in less plant removal. Plant reductions may not become evident for several years. Grass carp grazing is not recommended for milfoil control, especially where other beneficial, more palatable species are present. In fact, use of grass carp could indirectly increase milfoil populations in a waterbody by selectively removing highly preferred native plants.[19]

Overstocking of grass carp could result in eradica-

tion of beneficial plants and have serious impacts on the overall ecology of the waterbody. Full ecological impacts of grass carp introductions in Northwest waters are still being determined. An escape barrier on the outlet (if present) is required to prevent movement of fish out of the system and avoid impacts on downstream non-target vegetation. Fish loss due to predation, especially by ospreys and otters is possible. Grass carp are only permitted in reservoirs less than 10 acres in size.

Costs
Based on the few large-scale grass carp implantations made in the State of Washington since 1990, costs can range from approximately $50/acre to $2000/acre, at stocking rates ranging from 5 fish/acre to 200 fish/acre and average cost of $10/fish (range $7.50/fish to $15.00/fish).

Permits
A permit is required by Oregon Department of Fish and Wildlife prior to grass carp introduction to a waterbody. Grass carp introduction into lakes or salmon-bearing waters is currently prohibited, because of serious environmental and ecological concerns. Grass carp may be used in irrigation canals and private ponds for eradication of aquatic plants following strict rules to prevent escape, reproduction, and spread of disease.

Milfoil Weevils

Native weevils (*Euhrychiopsis lecontei*) have been found to impact populations of Eurasian watermilfoil in lakes in the Northeastern United States. The weevils have been found in Washington state, however none have been found in Oregon. The weevils in Washington have not caused declines in milfoil populations in Washington lakes.

Principle
E. lecontei is a native weevil that appears to have shifted its preferred host plant when Eurasian watermilfoil invaded North America. Prior to the Eurasian watermilfoil invasion *E. lecontei* is thought to have eaten native milfoil species. The instar larvae feed on the plant meristem while older larvae bore into the stems and feed on the cortical and vascular tissue. The adults eat some stem tissue but primarily feed on leaves. There are several companies that sell weevils for introduction. It is preferable to have an established population that can be nurtured to populations high enough to provide some level of milfoil control.

Control Effectiveness and Duration
The efficacy of *E. lecontei* for control of Eurasian watermilfoil is quite variable. Although weevil herbivory has been implicated in some declines in milfoil populations, efforts to introduce the insects for control have had mixed results. There is no good evidence that stocking of the weevils will result in milfoil control.

Benefits
The weevils are a native organism and therefore, there are no stringent controls on introduction of the insect.

Drawbacks
Dependable control cannot be achieved. The method is still in the experimental development stage. The cost of importing a control agent of unknown effecacy may be prohibative.

Costs
There are several companies that market the Middfoil® process using the weevil to control milfoil. The weevils alone cost one dollar each with minimum lots of 1000. They are not sold without a proper monitoring program and having a site suitability study completed.

Permits
An APHIS form 526 from the Department of Agriculture is required to transport the weevils into the state.

Chemical Control Methods

Historically, use of aquatic herbicides has been the principal method of controlling nuisance aquatic weeds in Oregon. While cost and target species efficacy have been important factors in choosing herbicides for use in management schemes, other

Table D-1. Common Aquatic Weed Species And Susceptibility To Herbicides (Adapted From Westerdahl And Getsinger, 1988)[10]

Excellent, **G**ood, **F**air	Endothall	Glyphosate	Fluridone	Copper	2,4-d	Diquat
Emergent species						
Phragmites spp. (reed)		G				
Scirpus spp. (bulrush)		E			E	F
Typha spp (cattail)		E	G		G	G
Lythrum salicaria (purple loosestrife)		G				
Floating species						
Brasenia schreberi (watershield)	G		G		E	F
Eichhornia crassipes (water hyacinth)	F	F			E	E
Lemna minor (duckweed	F		E		G	E
Nuphar.luteum (spatterdock)	G	E	G		G	
Nymphaea odorata (fragrant water lily)	G	E	G		G	
Submersed species						
Ceratophyllum demersum (coontail)	E		G		F	E
Elodea canadensis (elodea)	F		G			E
Egeria densa (Brazilian elodea)	E		G			G
Hydrilla verticillata (hydrilla)	G		G	G		G
Myriophyllum spicatum(Eurasian watermilfoil)	E		G		E	E
Myriophyllum aquaticum (parrotfeather)	E	F			E	E
Potamogeton spp.(pond weeds)	E*		G*			G

* Dependent on species

factors, such as ecological and environmental impacts on aquatic plants, potential interaction between the environment and management activities, enhanced efficacy of using a combination of different methods have not been explicitly considered. A more prudent approach, one endorsed by this manual, involves moving away from such a dominant generalized practice and toward more selective herbicide use following thorough review of target effectiveness, as well as other environmental, economic, political and social implications.

The State of Oregon currently permits use of only six aquatic herbicides to control aquatic weeds. They are the systemic herbicides fluridone, 2,4-d and glyphosate, the contact herbicides, endothall and diquat, and certain copper compounds. Systemic herbicides are absorbed by plant roots and shoots, and translocated throughout the plant; systemic herbicides are capable of killing the entire plant, including roots and shoots. In contrast, contact herbicides kill the plant surface with which it comes in contact, leaving roots and unaffected leafy stems alive and capable of regrowth. These six herbicides are reviewed in more detail below.

Another herbicide, the triethylamine salt formulation of triclopyr, has been tested for efficacy against Eurasian watermilfoil in selected waters in Washington State under an Experimental Use Permit (EUP). Triclopyr is a systemic herbicide and is described in more detail by Getsinger et al.[22] and Netherland et al.[21] Preliminary results of 1991 applications in Pend Oreille River (Washington) milfoil beds indicate high selectivity against milfoil, rapid onset of toxicity symptoms, and minimal

damage to non-target plant species. This herbicide is still under study and is not permitted for general use at this time in Oregon State waters. To learn more about aquatic herbicides, see references 1 and 10 listed in Appendix F.

Fluridone

Principle

Fluridone, 1-methyl-3-phenyl-5-[3-trifluoromethyl)phenyl]-4(1H)-pyridinone, is a slow-acting, systemic type herbicide. Fluridone inhibits plant growth by interfering with carotenoid pigment synthesis, leading to chlorophyll degradation and characteristic whitening of leaves in treated plants. Fluridone is available as the EPA-registered herbicide SONAR® (SePro) for use in the management of aquatic plants in freshwater ponds, lakes, reservoirs, and irrigation canals. It is formulated as a liquid (SONAR 4AS) sprayed above or below surface, and in controlled release pellets (SONAR 5P, SONAR SRP) spread on the water surface. Fluridone is effectively absorbed and translocated by both plant roots and shoots.[10]

Control Effectiveness And Duration

Fluridone demonstrates good control of a variety of submersed and emergent aquatic plants, especially where there is little water movement. Its use is most applicable for lake-wide or isolated bay treatments to control a variety of exotic and native species. Eurasian watermilfoil is particularly susceptible to the effects of fluridone. Typical fluridone injury symptoms include retarded growth, "bleached" (white or pink discoloration) leaves, and plant death. Effects of fluridone treatment become noticeable 7-10 days after application, with control of target plants often requiring 60-90 days to become evident.[10] Because of the delayed nature of toxicity, the herbicide is best applied during the early growth phase of the target plant, usually spring-early summer.

Advantages

As a systemic herbicide, fluridone is capable of killing roots and shoots of aquatic plants, thus producing a more long-lasting effect. A variety of emergent and submersed aquatic plants are susceptible to fluridone treatment (See Table on species susceptibility to herbicides). As a result of extensive human health risk studies, it has been determined that use of fluridone according to label instructions does not pose any affect to human health.[1] Fluridone also has a very low order of toxicity to zooplankton, benthic invertebrates, fish, and wildlife.

Drawbacks

Fluridone is a very slow-acting herbicide, and its effects can sometimes take up to several months. Because of the long uptake time needed for absorption and herbicidal activity, fluridone is not effective in flowing water situations. Because of the potential for drift out of the treatment zone, fluridone is not suitable for treating a defined area within a large, open lake. The potential exists for release of nutrients to the water column and consumption of dissolved oxygen from the decaying plants. Non-target plants may be affected, as a variety of plants do show degrees of susceptibility to fluridone treatment. Mitigation of lost vegetation may be necessary. As fluridone-treated water may result in injury to irrigated vegetation, there are label recommendations regarding irrigation delays following treatment. To protect drinking water sources, it is recommended that no applications be made within 0.25 miles of a water intake.

Costs

Treatment costs (materials and application) by private contractor for any of the formulations range from about $900 to $1400/acre, depending on scale of treatment.

Permits

At this time no permits are required for the use of aquatic herbicides. The labeling on the container describes the proper use of the product.

2,4-D

Principle

The term "2,4-d" (2,4-dichlorophenoxy) acetic acid describes a family of chlorinated phenoxy acid compounds with herbicidal properties.

Chlorophenoxy acid herbicides function as systemic growth regulators with hormone-like activity at low concentrations and behave as a contact-like herbicide at higher concentrations. 2,4-d is absorbed by roots and shoots and readily translocated throughout the plant. Absorbed 2,4-d inhibits cell division of new tissue and stimulates abnormal, non-symmetrical growth of mature plant tissue, resulting in total cell disruption and plant death. Of the many 2,4-d formulations available, the dimethylamine salt (2,4-d DMA) and the butoxyethanol ester (2,4-d BEE) forms are most commonly used. Liquid and granular formulations are available. 2,4-d can be applied to quiescent or slow-flowing systems and turbid water.

Control Effectiveness And Duration
Phenoxy herbicides are more selective for broadleaf, dicot species, but some aquatic monocots (e.g., water hyacinth) are also susceptible. Species of Myriophyllum (watermilfoil) can be effectively controlled with 2,4-d formulations in flowing and quiescent waters. Carry-over effectiveness of one year or more with a 50-75% reduction in biomass was demonstrated in Eurasian watermilfoil areas of the Pend Oreille River receiving two same season treatments of 2,4-d DMA (Gibbons and Gibbons, 1985). Other aquatic plant species like coontail (Ceratophyllum demersum) and naiad (Najas spp.) are less susceptible to 2,4-d. Initial symptoms of 2,4-d toxicity in susceptible plants (stem elongation and curling, leaflet fusion) are usually apparent within a week, with plant collapse and defoliation occurring due to tissue decay within two weeks. Regrowth can occur within 4 to 5 weeks if roots are not killed.

Advantages
As a systemic herbicide, 2,4-d is capable of killing roots and shoots of aquatic plants, thus producing a more long-lasting effect. Ester formulations of 2,4-d are generally more phytotoxic than amine forms. Toxicity effects are fairly rapid, with control of most target vegetation occurring within two weeks. A variety of emergent and submersed aquatic plants are susceptible to 2,4-d treatment (See Table on species susceptibility to herbicides). Amine formulations of 2,4-d have a low order of toxicity to zooplankton, benthic invertebrates, fish, and wildlife.

Drawbacks
Ester formulations of 2,4-d are more toxic to fish than the amine compounds. Greater toxicity effects are apparent with both amine and ester forms of 2,4-d at lower pH (e.g., 6.5) than at higher pH conditions[10] of the water. Because of the potential for drift out of the treatment zone, 2,4-d is not suitable for treating a defined area within a large, open lake. The potential exists for release of nutrients to the water column and consumption of dissolved oxygen from the decaying plants. Non-target plants may be affected, as a variety of plants do show degrees of susceptibility to 2,4-d treatment. Mitigation of lost vegetation may be necessary. There are label restrictions delaying use of treated waters for irrigation, spraying, livestock watering and domestic uses of up to three weeks post-treatment.

Costs
Treatment costs (materials and application) by private contractor for any of the formulations range from about $700 to $1000/acre, depending on scale of treatment.

Permits
At this time no permits are required for the use of aquatic herbicides. The labeling on the container describes the proper use of the product.

Glyphosate

Principle
Glyphosate (N-(phosphonomethyl)glycine) is a non-selective, broad spectrum herbicide used primarily for control of emergent or floating-leafed plants like water lilies. Mode of action studies of the herbicide indicate an interruption of biosynthesis of aromatic amino acids. Glyphosate is a systemic herbicide that is applied to the foliage of actively growing plants. The herbicide is rapidly absorbed by foliage and translocated throughout plant tissues, affecting the entire plant, including

roots. Glyphosate is formulated as RODEO® or Pondmaster® (Monsanto) for aquatic application.

Control Effectiveness And Duration
Glyphosate is effective against many emergent and floating-leafed plants, such as water lilies (Nuphar spp.) and purple loosestrife (*Lythrum salicaria*). According to the manufacturer, RODEO is not effective on submersed plants or those with most of the foliage below water. The herbicide binds tightly to soil particles on contact and thus is unavailable for root uptake by plants. As a result, proper application to emergent foliage is critical for herbicidal action to occur. Symptoms of herbicidal activity may not be apparent for up to 7 days, and include wilting and yellowing of plants, followed by complete browning and death.

Advantages
As a systemic herbicide, glyphosate is capable of killing the entire plant including roots, producing long-term control benefits. Glyphosate carries no swimming, fishing, or irrigation label restrictions. Glyphosate dissipates quickly from natural waters, with an average half-life of 2 weeks in an aquatic system. The herbicide has a low toxicity to benthic invertebrates, fish, birds and other mammals.

Drawbacks
As a non-selective herbicide, glyphosate treatment can have an affect on non-target plant species susceptible to its effects. While the possibility of drift through aerial application exists, it is expected to be negligible if application is made according to label instructions and permit instructions.

Costs
Treatment costs (materials and application) by private contractor for any of the formulations average approximately $250/acre, depending on scale of treatment.

Permits
At this time no permits are required for the use of aquatic herbicides. The labeling on the container describes the proper use of the product.

Endothall

Principle
Endothall is a contact-type herbicide that is not readily translocated in plant tissues. Endothall formulations (active ingredient endothall acid, 7-oxabicyclo[2,2,1]heptane-2,3-dicarboxylic acid) are currently registered for aquatic use in Oregon in either inorganic or amine salts. The compound is a membrane active herbicide that inhibits protein synthesis in plants. The dipotassium salt formulation is used for aquatic plant control, while the mono-amine salt is used for control of aquatic plants and algae. Aqueous or granular forms of the dipotassium salt of endothall, Aquathol (Elf Atochem), is permitted in State waters with stringent use restrictions on water contact, irrigation and domestic purposes as per label restrictions. Due to higher toxicity potential, the liquid amine form Hydrothol-191 is not permitted for use in fish-bearing waters in the state.

Control Effectiveness And Duration
As a contact herbicide, endothall kills only plant tissues it contacts, usually the upper stem portions. Thus, the entire plant is not killed. It is therefore used primarily for short-term control of aquatic plants. Duration of control is a function of contact efficiency and regrowth from unaffected root masses. Effective reductions in plant biomass can range from a few weeks to several months. In some circumstances, season-long control can be achieved. Carryover effectiveness of endothall treatments into the following growth season is not typical.

Advantages
Contact herbicides like endothall generally act faster than translocating herbicides such as fluridone; evidence of tissue death is often apparent in 1-2 weeks. There is usually little or no drift impact from proper application of this product. Overall costs of treatment are less than fluridone applications over the same area.

Drawbacks
Because the entire plant is not killed, endothall produces only temporary reductions in aquatic plant growth. As a variety of aquatic plants are susceptible to endothall, non-target plant impacts are possible. There are label restrictions on fish consumption and non-food crop irrigation and domestic use following treatment with endothall formulations.

Costs
As with fluridone applications, endothall treatments vary with total area and dosage rate. Average costs for a small to moderate area application can run between $500-700/acre.

Permits
At this time no permits are required for the use of aquatic herbicides. The labeling on the container describes the proper use of the product.

Diquat

Principle
Diquat (6,7-dihydrodipyrido(1,2-∞:2',1'-c) pyrazinediium dibromide) is a contact-type, non-selective herbicide that is minimally translocated in plant tissues. The herbicide is readily absorbed by foliage, but absorption by root systems is negligible due to rapid inactivation in bottom sediments. Mode of action of the herbicide is rapid disruption of cells and cellular functions by release of strong oxidants. Diquat is currently registered for aquatic use in Oregon in either a concentrated or less concentrated aqueous form. The concentrated formulation (Reward®, 2 pounds diquat per gallon) is labeled for use in lakes, ponds, canals, streams, rivers and drainage ditches that are quiescent or slow-moving, under a federal/state agency use restriction. A less concentrated form (Weedtrine®) is labeled without the above agency use restrictions for non-flowing waters with no or negligible outflow or under control of product user.

Control Effectiveness And Duration
As a contact herbicide, diquat kills only plant tissues it contacts, usually the upper stem portions. Thus, the entire plant is not killed. It is therefore used primarily for short-term control of a wide range of emergent, floating and submersed aquatic plants. Duration of control is a function of contact efficiency and regrowth from unaffected root systems or propagules. Effective reductions in plant biomass can range from a few weeks to several months. Efficacy is substantially reduced in turbid water or mud-coated vegetation because of rapid absorption by sediment particles.

Advantages
Contact herbicides like diquat generally act faster than translocating herbicides such as fluridone; evidence of tissue death is often apparent in less than one week. There is usually little or no drift impact from proper application of this product. Diquat disappears rapidly from the water due to quick uptake by plant foliage and rapid binding to suspended particles and sediments. Overall costs of treatment are less than fluridone applications over the same area.

Drawbacks
Because the entire plant is not killed, diquat produces only temporary reductions in aquatic plant growth. As a variety of aquatic plants are susceptible to diquat, non-target plant impacts are possible. There are label restrictions on water used for animal consumption, crop spraying and irrigation, and domestic use for up to 14 days following treatment with diquat formulations.

Costs
As with fluridone applications, diquat treatments vary with total area and dosage rate. Average costs for a small to moderate area application can run between $600-1000/acre.

Permits
At this time no permits are required for the use of aquatic herbicides. The labeling on the container describes the proper use of the product.

Copper Chelates

Principle
Copper has a long history of use as an algaecide, but has also shown effectiveness in controlling

higher aquatic plants (e.g., hydrilla). Copper is an essential element for plant growth. High concentrations of copper can lead to inhibition of photosynthesis and plant death. In order to maintain effective concentrations of the copper ion in solution, a number of chelated or complexed forms of copper have been developed. These complexed copper compounds are much more effective herbicides than copper sulfate, and are also less toxic to fish.

Control Effectiveness and Duration

The effectiveness of complexed copper compounds is enhanced by warm temperatures and sunlight, conditions that stimulate copper uptake by sensitive plants. In addition, uptake and toxicity is higher in young, rapidly growing plants, although even mature plants such as hydrilla, Brazilian elodea, and milfoil can be killed, and complexed copper can effectively reduce large standing crops of these species even in late summer.[27] The effect of treatment can be observed within 10 days, with full effects manifested in 4 to 6 weeks. Depending on timing of the initial treatment and regrowth rates a second treatment, after about 12 weeks, may be necessary for full season control.

Advantages

Costs of copper treatment are low relative to other herbicides for submersed plant control. There are no use restriction following treatment; complexed copper can even be used in potable water supplies.

Drawbacks

Copper is persistent in the environment. Applied copper eventually becomes bound to organic materials and clay particles and is deposited in the sediment. Yearly application of copper to lakes can result in elevated copper concentrations in sediments. Although the bioavailability and toxic effects of sediment-bound copper is unknown, the toxicity of the copper ion to fish is higher in soft than in hard water. Copper treatments should not be made in waters with pH less than 6.0 due to increased potential for formation of copper ion and subsequent toxicity to fish[10].

Costs

As with other herbicides, costs of copper treatment vary with area treated and dosage. Costs generally run between $120 and $340 per acre.

Permits

At this time no permits are required for the use of aquatic herbicides. The labeling on the container describes the proper use of the product. Liability issues are an important consideration when using herbicides. Some herbicides may only be applied by a licensed applicator. It is highly recommended that a licensed applicator do all herbicide applications.

APPENDIX E

REFERENCES AND RESOURCES

Agencies and Organizations

A) Department of Agriculture (ODA)
Noxous Weed Program
635 Capitol St NE
Salem OR 97301-2532
(503) 986-4621
http://www.oda.state.or.us

Maintains a list of noxious weeds and assists in their control and erradication.

B) Division of State Lands (DSL)
Western Regional Manager
775 Summer St NE
Salem OR 97301-1279
(503) 378-3805
http://statelands.dsl.state.or.us

The permitting authority for aquatic plant control methods in all waters of the state.

C) Army Corps of Engineers (COE)
PO Box 2946
Portland OR 97208
(503) 808-4340
http://www.nwp.usace.army.mil

Controls all activities in navagable waters in Oregon.
Provides permits for dredging and dredge material discharge.

D) Oregon Watershed Enhancement Board (OWEB)
255 Capitol Street NE 3rd floor
Salem OR 97310-0203
(503) 378-3589 Ext 827
Oregon Plan Information
http://www.oregon-plan.org
OWEB Information
http://4sos.org/group.gweb.html

Supports the work of watershed councils and awards grant funds for watershed restoration activities.

E) Oregon Department of Environmental Quality (DEQ)
Northwest Regional Office
2020 SW 4th ave. #400
Portland OR 97201
(503) 229-6945
http://www.deq.state.or.us

Responsible for permitting herbicides for use in Oregon lakes and reservoirs. Has permitting/certifica - tion authority for Sections 402 (NPDES) and 401 (water quality certification) of the Clean Water Act.

F) Natural Heritage Program
The Nature Conservancy
821 SE 14th Ave
Portland OR 97214-2531
(503) 731-3070 x335 or x338
http://www.heritage.tnc.org/nhp/us/or

Maintains current listing of State endangered, threatened, sensitive plants, as well as high quality native plant communities and wetlands.

G) Oregon Department of Fish and Wildlife (ODFW)
PO Box 59
Portland OR 97208
(503) 872-5255 ext. 5587
http://www.dfw.state.or.us

Processes fish planting permits; Manages and interprets data on wildlife species of concern in the State. Also contact regional offices.

H) Oregon Lakes Association
PO Box 345
Portland OR 97207-0345
(503)725-3833
http://www.esr.pdx.edu/pub/ola

To promote the understanding, protection, thoughtful and responsible management of lakes and watersheds in Oregon.

I) North American Lake Management Society (NALMS)
One Progress Boulevard, Box 27
Alachua, FL 32615
(904) 462-2554
http://www.nalms.org

NALMS is a non-profit, volunteer organization that attempts to forge partnerships among citizens, scientists, and professionals to foster the management and protection of lakes and reservoirs

J) PSU Center for Lakes and Reservoirs
Environmental Biology
PO Box 750
Portland OR 97207
(503) 725-3833

The Center for Lakes and Reservoirs has a task of studying the impact of non-native aquatic species on the health of Oregon lakes.

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