A Manager's Definition of Aquatic Plant Control

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Defining Aquatic Plant Control:

During the past few decades demand for access and use of U.S. surface waters has increased. This is evident in freshwater systems where human activities have expanded. These uses include real estate, recreation, irrigation, hydropower, potable water, navigation, and efforts to conserve environmental attributes such as fish and wildlife habitat. Aquatic plants are a natural and important component of many freshwater systems, and resource managers consider a diverse assemblage and a moderate level of aquatic vegetation to be beneficial for numerous ecosystem functions. Nonetheless, an overabundance of aquatic plants, particularly invasive non-native plants, can impair freshwater systems, requiring some level of aquatic plant management to conserve water body uses and functions. These aquatic plant management activities routinely take place on water bodies ranging in size from small private ponds to large public multi-purpose lakes and reservoirs.

With increasing demands and values associated with surface waters has come a greater need for aquatic plant control. Nonetheless, the term "control" can take on many meanings depending upon the type and amount of use of each water body, the species of plants present, the responsibilities of resource managers, and the objectives of various stakeholder groups associated with the water body. A quick review of reference materials provides the reader with dozens of descriptions and synonyms for "control", and yet for various reasons none of these efforts would provide a meaningful definition for aquatic plant management. The Aquatic Plant

Management Society (APMS) looks to address this deficiency by providing an aquatic plant manager's working definition of aquatic plant control.

While the terms aquatic plant control and aquatic plant management are often considered synonymous, many resource managers consider control efforts as being operational in nature, and management as a process more aligned with program goals and objectives.

The APMS defines aquatic plant control as **techniques used alone or in combination that result in a timely, consistent, and substantial reduction of a target plant population to levels that alleviate an existing or potential impairment to the uses or functions of the water body.**

The above definition best applies to management techniques that directly target a reduction in plant biomass. It is recognized that some management strategies seek to impact factors such as plant reproductive capacity (e.g., production of flowers, seeds, tubers, etc.) or nutrient availability, and while these techniques are often recognized as a valuable component of an integrated management program, physical reduction of plant biomass may not result for many years. Moreover, in our definition, the use of the term "substantial" may seem ambiguous; however, we feel there is an inherent problem with using quantitative guidelines (e.g., a 70 percent biomass reduction results in acceptable control) to define what is in most cases a series of qualitative field observations by the aquatic resource manager and stakeholders to determine the success of the management activity. Aquatic resource managers should always consider if the proposed management technique has a successful track record, and know the limitations of the potential strategy. Claims that a product or technique can provide control should be supported by peer-reviewed literature, experiences from other resource managers with similar management objectives, or current research and demonstration efforts.

No single definition of aquatic plant control can cover each specific contingency therefore, good communication on the front end is a key. **The resource manager and stakeholders must first establish expectations for the amount and duration of plant control prior to the initiation of a control activity, and then implement a management strategy to meet these expectations.** This definition and the attached paper are intended to address factors that relate directly and indirectly to aquatic plant control. Numerous variables influence aquatic plant control operations and many of these parameters, including water body uses, environmental conditions, and available management tools are presented in Appendix 1, along with the influences they may have on the planning or outcomes of aquatic plant control operations. The white paper and Appendix may be useful to managers responsible for conserving identified uses and functions of public waterways, and who must explain to stakeholders the reasoning behind management plan selection and the ultimate results.

Linking Management Decisions to Aquatic Plant Control Expectations: Factors that Influence Decisions and Outcomes

Aquatic plants have been controlled in U.S. surface freshwaters under organized programs for more than a century, so it is natural to ask why it is necessary to provide a definition of aquatic plant control at this point in time. In questioning a number of managers, researchers, and other stakeholders, it became obvious that opinions on what constituted acceptable control of an aquatic plant population were widely varied. While agricultural managers have been using terms such as "weed free periods" and "crop yield reductions" to define the economic benefits of weed control in cropping systems, aquatic plant managers have a different focus than their terrestrial counterparts. Agricultural weed managers usually attempt to control a broad-spectrum of weeds in order to enhance one or more crop species in a fairly controlled environment with a specific function. Aquatic plant managers usually try to control one or two weeds (usually invasive exotic species) to conserve or enhance perhaps dozens of desirable plants as well as multiple uses of aquatic systems. In essence, an agricultural definition of "weed control" does not encompass many of the issues associated with aquatic plant management.

In developing a manager's definition for control, it was initially tempting to utilize the language of research to provide a quantitative definition. Both the amount and duration of plant control can be readily quantified within the framework of an experimental study or demonstration project. Nonetheless, many experimental studies result in destructive sampling of the target plants at a given point in time (e.g. 90 percent reduction at 8 weeks after treatment), and they often don't allow us to determine if even better control or subsequent recovery would result at a later point in time. While this efficacy information can be very useful to managers regarding the expected performance of a specific management technique, the uses, functions, and environmental conditions can vary widely among water bodies and within water bodies through time. This will influence not only the level of management that may be attempted, but also the outcomes of each control operation. While research projects utilize methods that allow for quantification of control, the vast majority of aquatic plant control operations are ultimately judged by fairly subjective visual observations and qualitative means (e.g. the target plants are near the bottom, difficult to find, and the current level of control is rated as good). Therefore, plant control or lack thereof is largely based on whether or not the resource manager and stakeholder expectations have been met.

As noted above, there are numerous issues that either directly or indirectly influence aquatic plant control and management strategies. Before selecting control tools or developing management strategies, three key elements should be addressed that will ultimately influence the manager's decision making process.

Native vs. Non-native, vs. Invasive Aquatic Plant Control:

The National Invasive Species Council defines an invasive species as:

> "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health".

While there are major distinctions between invasive exotic and native species, the main objective of this white paper is to clarify the term "control" and as such will not make significant distinctions between managing invasive exotic species and nuisance growths of native plants. Whether a plant is a native or exotic, it can cause problems for given water uses (e.g., water conveyance, access). Nevertheless, two key distinctions between nuisance native and invasive plants deserve further discussion. First, problems associated with nuisance native vegetation are typically site specific while invasive plants can impair uses and functions of waters across a broad spectrum of conditions and on a regional scale. The vast majority of large-scale aquatic plant control efforts in the U.S. target invasive species. These plants have the potential to spread and dominate new ecosystems and they also have demonstrated the ability to become established in relatively stable aquatic systems. The philosophy behind invasive plant management programs often is to reduce the potential for spread within and among water bodies by reducing the plant biomass to the greatest extent practicable. The second distinction involves early detection and rapid response (EDRR) programs. These efforts are typically unique to invasive exotic species. A significant and costly multi-agency effort may be initiated to control a very small infestation; however, given the potential negative properties of many invasive exotic plant species, these front-end efforts are viewed as necessary and cost-effective.

Efficacy vs. Control

It is tempting to define aquatic plant control in terms of an expected percent reduction in coverage or biomass of a target plant population. Some regulatory agencies (e.g., California EPA, Canada Pest Management Regulatory Agency) require that herbicide manufacturers prove the efficacy of their products prior to registration. In this regulatory scenario, a product must reduce a target pest population by greater than 70 or 80 percent to provide efficacy. Within the discipline of aquatic plant management, numerous techniques can provide both a rapid and significant reduction in a target plant population (>70 percent), but these results may only be sustained for a few weeks or months. Therefore, depending upon when the efficacy of a management technique is measured, one assessment may suggest that control was achieved, while a subsequent assessment conducted weeks, months, or a season later may lead to the conclusion that the management effort failed to provide any level of control.

If resource managers and stakeholders have agreed to implement a strategy to provide an entire season of biomass reduction and the target plants recover within one or two months, then by our definition, control has not been achieved. In contrast, some methods may result in slow initial impact on a target plant population, but may ultimately provide one or more seasons of control. To complicate matters, many stakeholders fail to grasp that an aquatic plant problem may require more than one treatment or strategy. It is incumbent upon resource managers to understand the strengths and weaknesses of the various management techniques and then convey this information to the stakeholders. If expectations are not defined properly, the stakeholder may lose confidence in the management program. When managers do not establish clear expectations, they are often questioned if control was achieved. Attempting to assess aquatic plant control when clear expectations were not established on the front end is one of the biggest challenges in coming up with a meaningful definition or even assessment of control.

Environmental Controls

Managers must be careful not to confuse slow-acting control methods with natural variations in plant populations. While it is often tempting to link a prior control effort with the large-scale decline of a target plant population, environmental events (e.g. droughts, floods, hurricanes, seasonal senescence, etc.) often are largely responsible for these declines. If empirical data do not exist to support a cause and effect relationship between a control effort and plant biomass decline, managers should avoid making claims that can not be supported by evidence. Some managers rely on environmental events (e.g. flooding events that scour submersed plants or move floating vegetation, and prolonged periods of high dark water that prevent light penetration for submersed plants) to provide control. While this can be effective, in order to be considered an aquatic plant management technique, there should be some level of predictability associated with the environmental event. From a management perspective there is a big difference in relying on routine seasonal flooding events to control a given plant population versus relying on 100-year floods or droughts to provide plant control.

Levels of Aquatic Plant Control

At the most basic level there are three possible aquatic plant control approaches: 1) no attempt to control, 2) control efforts to eradicate a plant species, or 3) some level of intermediate control that is either incomplete or temporary.

No Attempt to Control

Despite its connotation, the "no control" option is a valid management decision whose potential outcomes must be considered by managers and explained to stakeholders. Factors that influence a manager not taking active control measures may include:

- plant species – Is the plant invasive? Is it a native plant impairing water body uses or is it just unwanted by stakeholders?
- size of infestation – Is this a pioneer infestation consisting of a few plants? Is it an established, but stable, population? Is it an established population or starting to approach problematic thresholds?

- plant location – Is the infestation in an isolated location? Is the location conducive to spreading the pest plant by fragmentation, flow, etc. Are there important nearby water bodies that are prone to becoming infested?
- plant biology – Is there a likelihood of a rapid population expansion? Would "no control" permit the plant to produce viable seed or vegetative propagules that could make later control efforts more difficult and expensive?
- exploitation – Is the plant species providing an ecological service (e.g. nutrient uptake, food source for waterfowl, habitat for fisheries, etc.)
- managerial will – Managers may be under pressure to not control a plant because it provides benefits (perceived or real) to a user group. Stakeholders may oppose control because they are not familiar with proposed methods.
- managerial experience – Inexperienced resource managers are often uncomfortable with making aquatic plant management decisions (especially on a large-scale). Until a manager understands the issues and situation, the "no control" option may be viewed as the safest and least controversial.

The consideration of these factors and others may justify a "no control" decision. There are consequences associated with all management decisions and "no control" is not exempt. As previously addressed, plant reductions related to environmental factors could be included within the realm of the "no control" option. While environmental events such as floods, droughts, freezes, or severe algae blooms can be quite effective in controlling aquatic plants, these events are not typically predictable and they are not initiated by managers. Nonetheless, the fact that some managers tend to rely on seasonal or weather events to provide effective control suggests the term "no control" may be a misnomer in these situations.

Eradication

Much like defining control, eradication has proven to have numerous meanings to various managers, researchers, and stakeholders. In a strict sense, eradication means the complete and permanent removal of all viable propagules of a plant population. This is confounded when a population is removed and then reintroduced at a later time. Some plants may be eradicated following single management efforts (e.g. removal of water hyacinth (*Eichhornia crassipes*) plants prior to seed set) while others such as hydrilla (*Hydrilla verticillata*) may requires years of intense surveillance and management. Eradication efforts are typically employed when a region, state, or watershed is threatened with a new introduction of an invasive species that has potential for significant economic or environmental impact. Based on efforts by various resource management agencies to date, aquatic plant eradication programs are characterized by:

- sustained and multi-year efforts to insure elimination of the plant population;
- small-scale efforts to control relatively few plants:
- control costs on a per acre basis can be quite high;
- the overall impact of repeated control efforts on the infested water body is continually weighed against the regional threat posed by the invasive plant;
- control efforts may eventually be reduced; however, vigilant monitoring remains a key to success.

Temporary Control

Outside the realm of eradication, all other control efforts are temporary. Temporary control is essentially an acknowledgement that one hundred percent control is either not an economically viable management objective or is not physically achievable. Temporary control is a continuum that can be represented by the short-term reduction of target plants following mechanical harvesting or spot treatments with contact herbicides, to many years of control that may result from grass carp (*Ctenopharyngodon idella*) stocking for submersed plants, or decades of suppression of alligatorweed (*Alternanthera philoxeroides*) by the alligatorweed flea beetle (*Agasicles hygrophila*). Thus, temporary control results when the aquatic plant manager has made the decision that eradication is not a viable endpoint and some level of target plant persistence is acceptable in the management strategy for a given water body.

Temporary control is achievable using a variety of methods. Managers should evaluate each proposed method and the integration of various methods in terms of meeting specific control objectives.

Maintenance Control

Maintenance control is applied on a lake-wide or regional scale over time, usually to reduce and contain invasive species. Once established, invasive aquatic plants can be extremely difficult, if not impossible, to eradicate. However, managing invasive plants at some prescribed level that does not impair the uses and functions of the water body can reduce environmental and economic impacts. As the term implies, maintenance control indicates that a conscious decision has been made to actively control an aquatic plant problem with the added understanding that a long-term commitment to management rather than eradication is the goal. Simply stated, maintenance control involves routine, recurring control efforts to suppress a problem aquatic plant population at an acceptable level.

Maintenance control encompasses a continuum of control objectives. On one extreme, the goal of maintenance control may be to reduce and sustain a plant population at the lowest feasible level that technology, finances, and conditions will allow. This strategy has proven effective in managing established populations of highly invasive aquatic plants. By managing water hyacinth at low levels through frequent small-scale control operations, there is a corresponding reduction in the overall management effort, especially herbicide use and management costs. There also are environmental gains, such as reductions in sedimentation, and dissolved oxygen depressions. At the other end of the spectrum, maintenance control operations can be applied just prior to plant populations impairing the uses or functions of the water body. This strategy entails allowing plants to grow to the brink of problem levels, and therefore may be best employed in controlling slow growing or otherwise non-invasive plants.

Paradoxically, there is often more stakeholder support for crisis management (allowing plants to reach some problem or impairment level) than maintaining invasive species at low levels. This may be related to stakeholders being unaware of invasive plant growth potential. It also may be related to the public's perceptions of control methods – for example, not understanding that less herbicide may be needed to maintain plants at low levels rather than waiting for an obvious problem to develop.

While the examples of grass carp and alligatorweed flea beetle describe multi-season impacts, it must be recognized that the basis for this extended control is the continued presence of adequate populations of the management tool (i.e. the carp or the beetle). If the carp numbers are reduced below a certain threshold (predation, sportfishing, flooding, escape from the system), the target plant will generally re-colonize the aquatic system. Likewise, a severe winter can have adverse impacts on biological control organisms, and this may allow the target plant population to grow back to nuisance levels. The principle of maintaining a continuous pressure on the target plant is an important concept that is often not discussed when describing maintenance control provided by grass carp or biocontrol organisisms. Maintenance control is often used to describe only ongoing herbicide programs, yet it is the integrated use and continuous pressure provided by grasscarp biocontrol organisms, and chemical control tools that best describe a maintenance control approach.

Adaptive Management

Since maintenance control represents a long-term commitment, it must also encompass a strategy known as adaptive management. Uses and functions of water bodies change through time, as do conditions within water bodies and among plant populations. Examples include target and non-target plant growth stages, water temperature, depth, clarity, and flow. All factors may change several times during the year and could require different control strategies or different expectations for control outcomes. Therefore, integrated management plans for each aquatic plant control operation must account for and adapt to these changes.

Communicating Control Expectations to User Groups

Many stakeholders view aquatic plant management endeavors as a one-time control effort with no further need for additional management. This does not reflect the reality of the discipline of aquatic plant management. The vast majority of management programs require a sustained effort over multiple years to keep unwanted vegetation under control. For example, while grass carp can provide long-term control of hydrilla, this result is due to their continuous presence and feeding on existing biomass and propagules. Carp can sustain control for many years, yet removal of the carp due to natural losses or on purpose will typically result in the recovery of the target plant. Likewise, a single treatment with fluridone herbicide may remove or reduce a target invasive plant such as Eurasian watermilfoil (*Myriophyllum spicatum*) within a system for one to several years. Upon discovery of new plants, many stakeholders are dismayed that the treatment did not eradicate the problem. In some cases these plants may have recovered from dormant seed or they may have been introduced from a nearby system that was not managed. Aside from the use of an effective classical biological control organism (highly selective) or high stocking rates of grass carp (non-selective), user groups must be informed about the importance of maintaining continuity in an aquatic plant management program. Single small-scale efforts that don't address the problem at an adequate scale often lead to claims that "we tried that and it didn't work." A lake full of hydrilla or Eurasian watermilfoil may require whole-lake management efforts. The control may last one or two seasons or even longer, but experience suggests that these invasive plants will ultimately return at some level.

One of the bigger challenges facing aquatic resource managers relates to the promotion of unproven and often costly technologies that are packaged as environmentally friendly approaches to aquatic plant management. As noted earlier, claims of a product or device providing "control" should be supported by published or ongoing research, or by another reputable resource manager who has successfully applied that technique or strategy and met similar control objectives.

APPENDIX A

Parameters that Influence Aquatic Plant Control Decisions and Outcomes

Aquatic plant management is a complex discipline that blends predictable sciences of chemistry and hydrology with variable parameters of biology and meteorology for application in venues with boundaries defined by human values and economics. Before aquatic plant control activities are initiated, one of the first and most important steps is to identify the various uses and functions of the water body. Identifying uses clarifies environmental and economic values of the water body that may be at risk. It also helps in selecting management tools and strategies that are compatible with, and will help to conserve, the various uses and functions of the water body.

After the uses and functions are identified, a management objective must be developed for the water body that considers these uses as well as concerns of the various stakeholders with interests in the water body. Management objectives are fairly straight forward for waters with relatively few uses or an emergency plant problem. Conflicts in developing objectives arise more frequently when there are many shared uses, multiple stakeholder groups, and an unclear vision if plants, that currently may be enhancing an identified use, may in time impair this or other uses. After management objectives are developed, managers must list all of the potential control tools and select the best tool or combinations that will achieve the stated objective.

There are direct and indirect environmental and economic costs associated with aquatic plant management activities. Responsible resource managers must understand these consequences and choose options that are proven effective and compatible with the current conditions at the site of interest. This information can be obtained through peer-reviewed literature, from direct experience, or through consulting with reliable sources with successful experiences controlling similar plant problems under similar conditions.

Table 1 lists various parameters to consider in developing an aquatic plant control program. Many of these considerations or constraints may influence both the scope of the program and the level of control achieved. While immediate and complete removal of a plant problem may be a desired goal or outcome, in practice, the control process may take months and may be temporary in nature and consequently will need to be repeated on a routine basis. Water body and plant conditions are constantly changing as are tools available to manage plants. Rarely can one person keep track of all of these changes or become an expert in each control tool; therefore, except for the most basic control situations, aquatic plant management experts should be consulted and stakeholders informed about impending aquatic plant control operations. Paramount in this communication is conveying to the non-technical stakeholder why particular methods were chosen and what are the anticipated or expected outcomes of selected (and perhaps rejected) control options, and a receptiveness of stakeholders to respect the multiple uses and functions that may be associated with each water body and to review control tools and options based on their potential for achieving management objectives rather than from a personal preference or bias.