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Flows and Fluctuations in Water Levels to Manage Aquatic Vegetation

Summary

Where facilities permit, water levels fluctuations in lakes can be used to affect aquatic vegetation, fish populations, nutrients, and bottom sediments. The extent to which water must be drawn down or raised to accomplish management goals depends on a number of factors including water clarity, substrate, temperature, humidity, precipitation, and biology of the plant species. Because aquatic vegetation problems are most common or often originate in shallow water areas of lakes, ponds, and streams, the change in water level to achieve beneficial results may be only a few feet. In shallow lakes, a majority of the hydrosoil may be exposed by drawing down the first few feet of pool elevation.

Drawing down water levels of lakes (drawdowns) to manage aquatic vegetation (both native and introduced invasives) is practiced worldwide with varying degrees of success. Effectiveness for killing aquatic weeds is dependent on the degree of drying and/or freezing. Variation in results is related to species present, duration of the drawdown, temperature, humidity, precipitation, and substrate that contribute to drying and or freezing to kill or stress plants. Drawdowns that adversely affect some species may favor others resulting in a change of abundance or occurrence which may trade one problem for another. In the southern United States, drawdowns can be timed to avoid the peak period for spawning of game fish and to coincide with the average period of low flow, roughly August through January. Short duration drawdowns may be highly affective if temperatures are low enough to freeze aquatic plants and substrates. Reduction in aquatic vegetation may be effective for several years following drawdowns. Additionally, drawdowns can be used effectively in an integrated approach with insect pests of aquatic plants, herbivorous fish, mechanical removal, and herbicide application. The greater the control of inflow and outflow, the greater the probability of success. Drawdowns may be controversial due to effects on navigation, water supply, hydroelectric generation, fisheries, waterfowl and other wildlife, and aesthetics.

Inundation with sufficient depth of water may result in killing or preventing regeneration of some species of emergent aquatic vegetation.

Flushing flows are more often used to alter in-stream and riparian vegetation encroachment and to alter substrate in stream channels below reservoirs. They are used worldwide, especially in New Zealand and Australia where they are sometimes mandated as part of permitting requirements for various reservoirs. Flushing flows may serve to move floating aquatic vegetation into open water areas of lakes and reservoirs where such vegetation may be less successful, stranded in unfavorable habitat, or pass out the spillway. A certain amount of natural flushing may takes place in lakes from flood events on contributing streams. Also, flows may be released for this purpose from upstream reservoirs. Flushing undesired aquatic vegetation from a reservoir or arms of a reservoir may only serve to spread the problem. Floating aquatic plants along margins, in coves, and wooded areas are more resistant to removal by flushing flows.

Drawdowns

General Considerations

Where facilities permit, lake level drawdown to expose aquatic plants and sediments to prolonged drying and/or freezing is an inexpensive means of aquatic weed control.

The publication "Plant Management in Florida Waters Center for Aquatic and Invasive Plants" (University of Florida, and the Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission 2003) offers the following

Aquatic vegetation may be controlled artificially by manipulating water levels. Raising water levels can either drown emerged plants or strand floating plants in upland areas. Alternatively lowering water levels, a technique known "drawdown," can be used to expose emerged, submersed, and floating plants to freezing and drying. Water level manipulation techniques are limited to closed water bodies such as lakes, ponds, canals, and reservoirs.

Drawdowns, or dewatering, have been used for many centuries as a means to oxidize and consolidate sediments, alter fish populations, and to control aquatic weeds. The technique requires a dam or other mechanism to lower water levels. The process may be restricted by water use patterns, water rights, or the lack of a predictable source of water for refilling. Drawdowns generally take place in winter to take advantage of drier weather, freezes, and prescribed fire to further stress target plants. Consecutive drawdowns are more successful than a single drawdown.

Drawdown success is determined by:

- Time of year: winter freezes enhance drawdowns; summer drawdown can enhance growth of nuisance plants such as cattail
- The nature of the substrate: sand dries faster than clay
- Vertical extent of the drawdown to thoroughly dry out the underlying sediments
- The rate of desiccation
- Restrictions imposed by water usage
- Susceptibility of nuisance species to dehydration
- The formation of a "skin" layer due to the drying of the canopy which can protect underlying plants and root stocks from dehydration
- Release of nutrients from decaying vegetation
- Growth of plants in remaining water
- Dissolved oxygen reduction in shallow water
- Changes in benthic invertebrate communities and the indirect effect on waterfowl and fish
- Interference with migratory animal populations such as water fowl.

However, drawdown does not always produce desirable results. Responses can be unpredictable. For example, Brazilian elodea (*Egeria densa*) is easily controlled by drawdown and control may last several years. Hydrilla (*Hydrilla verticillata*) is only partially controlled by drawdown and hydrilla's underground tubers can survive several drawdowns, resprouting and overwhelming the native plants as soon as the water body is refilled. Water hyacinth (*Echhornia crassipes*) and water lettuce (*Pistia stratiotes*) can be controlled by drawdowns, but seeds germinate upon reflooding and the infestation is reborn. Drawdown will not control torpedograss (*Panicum repens*), a plant that is adapted to living in water several feet deep or in dry soils.

Advantages to drawdown are low cost; secondary benefits of sediment oxidation and consolidation and fisheries enhancement; and long term effects (two or more years). However, drawdown may reduce the diversity of desirable plant and/or fish species; may

expand undesirable species, like hydrilla, into deeper areas; may produce floating islands (tussocks) upon reflooding; may affect storage water and recreational benefits of water body; may promote algal blooms due to nutrient release from sediments; and may otherwise affect fish and wildlife.

The Aquatic Ecosystem Restoration Foundation (AERF) includes drawdowns in its publication *Aquatic Plant Management, Best Management Practices in Support of Fish and Wildlife Habitat* (January 2005, 2nd printing). Under giant salvinia, is the following paragraph:

The purpose of drawdowns in giant salvinia control programs is to strand the plants on the shoreline for a sufficient period to cause mortality by desiccation or freezing. If water control structures are available on a body of water, this method can be effective in controlling fairly large areas at a low cost. However, this technique may have significant detrimental effects on the aquatic ecosystem, and on wildlife and recreational access to water. It is probable that viable individuals of the plant will remain in the water to re-infect the system. These plantlets may require brief repeats of chemical or mechanical control methods, or long-term biological control, to avoid continued infestation.

In regard to water hyacinth, it states the following:

Drawdown of the water column has been suggested for control of water hyacinth, but is limited to lakes or ponds that have sufficient water control structures and hydrologic characteristics to manipulate water levels, and where a drawdown will not interfere with other primary water uses such as domestic or irrigation supplies, navigation, or hydrologic power.

McFarland, et al. (2004) in a publication entitled *Salvinia molesta* D. S. Mitchell (Giant Salvinia) in the United States: A Review of Species Ecology and Approaches to Management offers the following overview concerning drawdowns:

Habitat alteration

Water-level drawdown is a relatively inexpensive technique for controlling aquatic weeds in lakes with sufficient water-level control structures (Chilton et al. 2002). The primary goal of the drawdown is to destroy the target plant by thorough drying and/or exposure to lethal (freezing) temperatures (Cooke et al. 1986). The success of this procedure in controlling *S. molesta* would largely depend on the structure of the plant mat and its ability to protect and insulate embedded ramets. Where the mat is thick and dense, the most exposed plants and plant parts are subject to desiccation and/or being frozen, while plants close to the sediment may survive. Unless the sediment becomes dry (and/or frozen) for a long enough period, plants deep in the mat may regenerate the colony on the return of suitable conditions.

Lantz et al. (1964), Lantz (1974) and Cooke et al. (1986) have reported water-level manipulation to be an important technique for controlling nuisance plants in many Louisiana reservoirs. Their findings indicate this procedure to be highly species specific and suggest that while drawdown may curtail one plant nuisance, it may promote development of a resistant species. In northern Louisiana, autumn/winter drawdown is most effective in reducing dense growth of *E. crassipes*;

however, the effectiveness of this technique on other plant species and in other locations may improve (or be lessened) by climatic conditions. In addition, water-level drawdown as a management tool has been somewhat controversial because of adverse impacts on secondary uses of the aquatic system, e.g., boat access, hunting, fishing (Chilton et al. 2002). Recent evidence from pond studies in Lewisville, TX, has shown winter drawdown to be successful in reducing growth of *S. molesta* (Dick et al., in review). Yet, further study is needed to determine efficacy of drawdown on *S. molesta* in other areas and when used in an integrated approach with other control methodologies.

The Texas Parks and Wildlife Department (TPWD) publication entitled “Aquatic Vegetation Management in Texas: A Guidance Document” contains the following concerning management of salvinia:

Water Level Manipulation – Water level is usually controlled by the reservoir’s controlling authority. Dropping the water level several feet has proven effective at helping control salvinia. Since salvinia is a small floating plant it is often blown into shallow water nearshore areas, and is therefore susceptible to being stranded on dry ground under falling water conditions. In 1999, a rise and subsequent drop in water level on Toledo Bend Reservoir significantly reduced the salvinia population on the lake. However, in order to be effective, water levels must remain low long enough to allow for the desiccation or freezing of stranded plants.

and the following in regard to water hyacinth:

Water Level Manipulation – Specific strategies vary depending on the reservoir situation, but dropping the water level several feet through the fall and winter can strand plants on the bank. Waterhyacinth can survive for long periods on moist damp soil so stranding plants during cold weather when there is a chance of freezing is most effective.

Case Histories

B.A. Steinhagen Reservoir, Texas

Helton and Hartman (1995, Appendix 1) reported on a winter drawdown to control water hyacinth in B.A. Steinhagen Reservoir, a 6,811 hectare impoundment on the Neches River in southeast, Texas (Appendix 4). A 1.8 meter drop in water level initiated on December 15, 1993, was maintained through February 17, 1994, and included freezing temperatures on 19 days. Waterhyacinth coverage was reported to be reduced from 1,476 hectares in June 1993 to 26 hectares in June 1994.

A 2007 summer drawdown intended for alligator weed control was extended for 13 months due to other causes (E. Chilton personal comm. 2008). Elder and Bennett (unpublished) reported on the results at the 2008 meeting of the Texas Aquatic Plant Management Society. A request for a copy of the presentation has been made but not received at the time this report was finalized.

Fox Lake, Florida

McKinney and Coleman (1981) describe the results of multiple dewaterings of Fox Lake, Florida, a shallow lake averaging 1 meter in depth (Appendix 2). Three dewaterings were scheduled to accomplish the following 1. Spring – maximize organic sediment consolidation, kill hydrilla plants, stimulate germination of hydrilla tubers and turons, and encourage germination of native aquatic plants upon

reflooding; 2. Fall - kill newly sprouted hydrilla plants prior to normal tuber and turion production occurring from October to April; and 3. Following Spring to kill remaining hydrilla plants. Chemical control was used to kill hydrilla in areas not dewatered. Some chemical and mechanical control of cattails (*Typha latifolia*).

The 1st dewatering began on February 12, 1979 and was accomplished in 8 days and lasted approximately 11 weeks. Despite cloudy and rainy weather most hydrilla was desiccated within 2 weeks. Chemical treatment was applied in areas not exposed – dredge holes and canals fed by groundwater. Native aquatics, aquatics and hydrilla appeared upon reflooding.

The 2nd dewatering was delayed to October 20, 1979 due to heavy rain from Hurricane David allowing the presence of hydrilla for two months into the normal tuber and turion period. Inclement weather prevented rapid desiccation of hydrilla so the duration of drawdown was extended to 4 months. Chemical treatment was again applied to dredged holes and canals. Reflooding to 15.2 cm was used to initiate tuber and turion germination.

The 3rd dewatering began April 22, 1980, with exposure of hydrosol in 72 hours. Reflooding began on May 22, 1980. Hydrilla above the hydrosol and turions were eliminated and abundance of tubers were decreased by more than 90%. Also, depth of organic sediments was reduced by 29 to 46%. Native aquatic vegetation increased by 40%.

Lake Austin, Texas

Drawdowns of Lake Austin to control aquatic vegetation began in 1945 and now the lake is drawdown 12 feet on an annual or biannual basis by the Lower Colorado River Authority (LCRA) (Williams 2005, Appendix 3). LCRA schedules drawdowns in January and February in hopes of exposing vegetation to freezing temperatures. The Texas Parks and Wildlife Department in a news release (2005, Appendix 4) reported that “[H]ydrilla is currently present in only about nine acres of Lake Austin, according to the July survey by the Texas Parks and Wildlife Department. This is a decrease from 26 acres in May and 201 acres in July 2004. At the highest point in 2002, hydrilla covered more than 300 acres of the lake.” The reduction was attributed to tactics that include “...lake drawdowns, stocking of sterile grass carp and the release of hydrilla flies to eat the hydrilla, approved pesticides, mechanical harvesting and bottom barriers.”

Lake Bistineau, Louisiana

Lake Bistineau, a shallow 17,200 acre lake (when full at 141 ft msl) in northwest Louisiana Appendix 5 contains a history of Lake Bistineau drawdowns compiled by Hinton (2004). Before a dam was completed in 1938, the lake emptied during dry seasons which helped prevent overcrowding by aquatic plants. Drawdowns to manage aquatic vegetation which proliferated after a full lake level was maintained date back to 1945. Typical period of drawdown has been following Labor Day through January. Drawdown capability of the gates is 7 feet. A drawdown to 137 ft msl reduces the area of the lake to approximately 7,500 acres, exposing more than 50 % of the lake bottom. Native aquatic plants, water hyacinth, and hydrilla have been reduced significantly in years dewatering could be maintained but failures have occurred in some years when inflow has been in excess of gate capacity. A flood event that disrupted a 1996-97 drawdown was believed to have flushed out most of the hydrilla present in February 1997. Opposition to drawdowns has resulted in lawsuits and sabotage of the dam gates.

On April 10, 2008, the Louisiana Department of Wildlife and Fisheries announced a drawdown of Lake Bistineau to control giant salvinia (Appendix 6). A drawdown of 7 feet at a rate of 2 to 3 inches per day was to begin on July 15 and gates closed to refill on January 30, 2009. Seales (e-mail 2008, Appendix 7) indicates that approximately 3,300 acres of giant salvinia were on Lake Bistineau prior to the drawdown and approximately 750 to 1,000 acres at this time (November 10, 2008). Herbicide applications continued through the drawdown period.

Lake Catherine, Arkansas

An integrated approach to rooted aquatic vegetation, mostly coontail (*Ceratophyllum demersum*) and *Elodia* sp., in Lake Catherine, Arkansas was described by Mathis (1965). Lake Catherine is a small reservoir, about 3,000 acres, on the Ouachita River below Lake Hamilton and Lake Ouachita. Water is very clear due to inflow being primarily from the bottom of the pools of the upstream dams allowing light penetration and subsequent aquatic vegetation growth. Nearly the entire surface of the reservoir was impassable. A combination of drawdowns and Israeli carp (*Cyprinus carpio*) resulted in a complete absence of coontail and *Elodia* and a reduction of smartweed (*Polygonum* sp.) around the margins of the shallower bays.

In the 1960 – 1963 period, 145,000 Israeli carp weighing 22,000 pounds were stocked in Lake Catherine. A 3 ft. fall and winter 1960-61 drawdown resulted in improvement by the following Spring of 1961. A fall and winter drawdown was made in 1961-62 and increased to 7 feet in 1962-63. After the 1963-64 drawdown only a few strands of floating vegetation were observed. A complete absence of *Elodia* and coontail, very little smartweed, and a significant reduction in *Nitella* and *Chara* were observed in Spring 1964.

Toledo Bend Reservoir, Texas

Elder (2005) in a press release entitled “Vegetation Problem in Toledo Bend Reaches Critical Mass” (Appendix 8) stated:

An extended drawdown in 2001 dramatically reduced giant salvinia populations on Toledo Bend. A gradual but steady increase of the invasive fern followed in spite of annual herbicide treatments by Texas and Louisiana. Annual fall drops in water level helped isolate giant salvinia infestations to the backs of creeks and drainages, holding their expansion to a minimum. High water levels on Toledo Bend throughout 2004 allowed small populations of giant salvinia to grow unchecked and expand to new areas. Surveys on the Texas portion of the reservoir in 2004 indicated giant salvinia had increased from 150 acres to over 3,000 acres. Flushed from its refuge in the backs of numerous bayous by heavy rains, large mats of giant salvinia were pushed south into the main portion of the reservoir, many as far south as the dam itself. In many areas, heavy wave action left large amounts of giant salvinia stranded on the bank. The end result after several cold fronts and accompanying winds was an effective seeding of the reservoir with small viable colonies of giant salvinia. Spring surveys now estimate over 3500 acres of giant salvinia spread throughout the reservoir. These seedling colonies represent the most severe ecological threat to Toledo Bend and neighboring reservoirs like Sam Rayburn since the discovery of giant salvinia in 1998.

Miscellaneous Reports of Interest

Poovey and Kay (1998) conducted tests in tanks with silt loam and sand substrates to determine the length of time to kill monoecious hydrilla. Under ambient conditions in summer, a one week simulated drawdown was sufficient for killing hydrilla on sand but was not effective on silt loam as roots were not desiccated. A 2 week or longer drawdown on silt loam suppressed regrowth and tuber reproduction. The authors suggested that short-term summer drawdowns might be useful in monoecious hydrilla management, but that hydrosol type may determine length of drawdown period required. Doyle and Smart (2001) studied hydrilla tubers in Lake Ray Roberts, Texas during a 12 month drawdown and found no reduction in tuber numbers or viability and apparently never sufficient dessication. They also conducted pond studies with drawdowns of from 1 to 20 months. Although tuber numbers were greatly reduced by the repetitive drawdowns, "... hydrilla tubers were not eradicated from the pond."

Tipping and Center (2005) studied the population dynamics of the salvinia weevil (*Cyrtobagous salviniae*) in south Florida (Appendix 9). These authors speculated that the specialized herbivorey by weevils prevents common salvinia from becoming as great a problem in south Florida as in other parts of the United States. They found that salvinia weevil populations rebounded quickly after drought events when sites dried up causing loss of host plants and later rehydrated and salvinia began to grow again. They stated "...local extinction events can be ameliorated by the metapopulation dynamics of this species, which is capable of flight dispersal to new sites."

Owens, et al (2007) reported that "[A]ll giant salvinia plants exposed to air temperatures of -16°C (48hr) were killed while those exposed to -3°C (48hr) survived due to incomplete ice formation in the surface water of the container." Also, "... desiccation studies found that viability of giant salvinia buds was unaffected until tissue moisture content was below 30%."

"Plant Management in Florida Waters Center for Aquatic and Invasive Plants" (University of Florida, and the Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission 2003) provides the following example of an integrated approach utilizing drawdowns and herbicide applications:

Although it is difficult, and usually impossible to completely drain most Florida lakes, and residential shoreline development precludes extreme flooding in most cases, managers use water level manipulation to enhance large-scale hydrilla control. Prior to initiating large-scale hydrilla management with fluridone herbicide, managers attempt to lower water levels by a few to several feet. This reduces the lake volume and therefore reduces the amount of herbicide used and treatment costs, sometimes by a factor of two to three times. (A six-foot reduction in the water level on 19,000-acre Lake Toho reduced application cost by nearly \$6 million.) After fluridone has been in the water for 60-90 days, water levels are then increased by several feet to reduce light penetration, further stressing hydrilla and increasing the duration of control.

Hoenke (1969) reported using water level fluctuations to control aquatic vegetation and improve fisheries in Lake Bistineau, Iatt Lake, Cotile Lake, Bussey Lake, Cheniere Lake, D'Arbonne Lake, Anacoco Lake, Bundick Lake, and Chicot Lake under the Louisiana Department of Wildlife and Fisheries lake and reservoir management program.

Inundation

"Aquatic Vegetation Management in Texas: A Guidance Document" (TPWD no date) states "...generally holding the water level at several feet above normal pool in the spring can reduce light transmission to

established vegetation thereby reducing its growth. “

Flushing

Flushing flows are more often used to alter in-stream and riparian vegetation encroachment and substrate in stream channels below reservoirs than to remove vegetation or nutrients from lakes. A Google keyword search indicates that flushing flows are used worldwide, especially in New Zealand and Australia where they are sometimes mandated as part of permitting requirements for various reservoirs. The following explanation was extracted from a Genesis Energy (New Zealand) web posting entitled “Environmental effects of our activities” (<http://www.genesisenergy.co.nz>)

Flushing flow releases

Every now and then, a large volume of water is scheduled for release for a short time below some dams to flush the river of sediment, algae and other organic material which has accumulated downstream. These flushes are designed to replicate flood events. Provided the flows occur at the right time and with the right amount of water, they can significantly improve water quality and enhance habitat.

Flushing flows may serve to move floating aquatic vegetation into open water areas of lakes and reservoirs where such vegetation may be less successful, stranded in unfavorable habitat, or pass out the spillway. A certain amount of natural flushing may take place in lakes from flood events on contributing streams. Also, flows may be released for this purpose from upstream reservoirs. Flushing undesired aquatic vegetation may only serve to spread the problem as described for Toledo Bend Reservoir by Elder (2005) under “Case Histories” above. Seales (2008, Appendix 7) stated in reference to Caddo Lake that “[T]he Jeem's Bayou area holds the largest concentration of giant salvinia on the Louisiana side of the lake, natural flushing action has assisted with moving some of the giant salvinia out of that area of the lake. I am not aware of any mechanism which would allow us to simulate this natural flushing action in Jeem's Bayou.”

Bartodziej and Leslie 1998. studied water hyacinths in the Saint Marks River, Florida and developed a model of the relationship between flood flows and water hyacinth abundance. They found that:

An 0.4 ft rise in gauge height flushed waterhyacinth from the center of the pool to down-river reaches. Waterhyacinth that migrated to the Gulf of Mexico rarely caused large dams along the narrow (40 m), curvy and snag-filled river reaches. Fluctuations in waterhyacinth abundance in the center of the pool were well represented by the time series model. In contrast, waterhyacinth mats along the margins and especially in the backwaters along the east bank were not responsive to flooding and expanded during monitoring.

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Appendices

Control of Waterhyacinth by Winter Drawdown	1
Hydrilla Control and Vegetation Response with Multiple Dewaterings	2
First Lake Austin lowering celebrates anniversary	3
Partner efforts decrease exotic water weed hydrilla	4
History of Lake Bistineau Drawdowns	5
LDWF Aquatic Plant Control Program Targeting Lake Bistineau	6
Seals, J. November 10, 2008. Email concerning Lake Bistineau drawdown and Caddo Lake.	7
Vegetation Problem in Toledo Bend Reaches Critical Mass	8

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