Effects Of Consecutive Water Fluctuations On Submersed Vegetation Of Black Lake, Louisiana

TERRY L. GOLDSBY[1]

Environmental Specialist, Florida Department of Natural Resources, Tallahassee, Florida 32304

DANA R. SANDERS, SR.[2]

Associate Professor of Biology
Northwestern State University
Natchitoches, La. 71457

ABSTRACT

Consecutive fall-winter drawdowns were performed on Black Lake, Louisiana in an attempt to control submersed hydrophytes. Each drawdown was followed by a period of high water during late winter and early spring months. Changes in vegetative trends were pronounced. Some changes, like prevention of cabomba (*Cabomba caroliniana* Gray) seedling establishment and suppression of vegetative regrowth were attributed to the combined effects of both water level fluctuations. Other changes were due to only one of the drawdowns. It was concluded that consecutive drawdowns can be used to control vegetation more effectively than individual drawdowns.

INTRODUCTION

Aquatic plants have produced problems for man for centuries and thus have often been considered as nuisances and pests. Water level fluctuation is one of the best ways to control these noxious hydrophytes. Lake management and restoration have been accomplished for millions of years by this natural method which until recently has been totally ignored by man. Past experiences indicate that employment of water level fluctuation is imperative in the management of artificial impoundments (2).

The tremendous value of water level fluctuation to fisheries management was foreseen in 1947 after several stabilized pools on Tennessee Valley Authority impoundments had provided poorer fishing than other lakes which were widely fluctuated (5). Results of the drawdown of Nimrod Lake in west central Arkansas in 1955-56 included the harvest of 90,909 kg of commercial food fishes and gar (*Lepisosteus* spp.), marked changes in fish populations as tabulated by weight, higher survival of young black bass (*Micropterus salmoides* Lacépède) and white bass (*Morone chrysops* Rafinesque), clearer water, and better spawning and survival conditions for sunfishes and minnows (9). One of the first recorded recommendations of water drawdown to control hydrophytes was for Chicot Lake in south central Louisiana when Gowanloch (6) recorded the early lake history and problems encountered with rapid intrusion of submersed and emergent vegetation and then suggested a winter drawdown as an experimental method to control the problem. Excellent control of submersed aquatic macrophytes such as pondweed (*Potamogeton* sp.), southern naiad (*Najas guadalupensis* (Spreng.) Morong.), and coontail (*Ceratophyllum demersum* L.) was achieved by use of drawdowns in three Louisiana lakes from summer 1961 to spring 1963 (10). Five consecutive years of drawdown and subsequent refilling of Lake Catherine in central Arkansas produced the removal of elodea (*Elodea* sp.) and coontail, and greatly reduced the population of smartweed (*Polygonum* sp.). Nitella (*Nitella* sp.) and muskgrass (*Chara* sp.) were also significantly reduced (15). Two overwinter drawdowns on Murphy Flowage in Wisconsin provided similar excellent control of many aquatic weeds (1). An extreme drawdown in Lake Tohopekaliga in central Florida resulted in reduction or elimination of several submersed aquatic plants (8). The drawdown of Lake Tohopekaliga also improved physical stability of littoral substrate, increased density and diversity of desirable rooted vegetation, stimulated production of fish-food organisms, and increased the number and size of gamefish and other fishes. A winter drawdown of 1.5 m conducted on Rodman Reservoir from September 1972 to February 1973 produced excellent control of coontail, hydrilla (*Hydrilla verticillata* Royle), southern naiad, and egeria (*Egeria densa* Planchon), but waterhyacinth (*Eichhornia crassipes* (Mart.) Solms-Laubach), alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.), smartweed, and water purslane (*Ludwigia palustris* (L.) Ell.) increased substantially (7).

Davis (4) stated that: "although water level fluctuation has some negative aspects, it can effectively control aquatic weeds; control or balance fish populations; increase spawning activities of desirable fishes; increase fertility of available nutrients in a lake; and result in a two to threefold increase in fish food organisms after the lake refills." Proper utilization of water level fluctuation can allow retardation of aging processes and greatly extend the lifespan and usability of a reservoir (2).

The purpose of this investigation was to document vegetative composition during the 2nd year of water level fluctuation and to evaluate quantitatively effects of consecutive years of drawdown and subsequent refilling on plant populations of Black Lake, Louisiana. Impoundment

---

[1]Present address: Tennessee Valley Authority, Water Quality and Ecology Branch, Muscle Shoals, Ala. 35660

[2]Present address: U.S. Army Engineers Waterways Experiment Station, Aquatic Plant Research Branch, P.O. Box 631, Vicksburg, Miss. 39180.

of Black Bayou in 1930 created this lake, a 5,460-ha reservoir located 19 km northeast of Natchitoches, Louisiana (Figure 1). Stabilization of water level undoubtedly produced conditions favorable for aquatic plant growth within the system. As a result, severe infestations of cabomba, floating bladderwort (*Utricularia inflata* Walt.), and egeria have made necessary the use of water level fluctuation as a means of control.

METHODS AND MATERIALS

A drawdown was initiated 20 July 1972, which lowered the lake level to 2.4 m below normal pool stage by October 1972 (Figure 2). Runoff from heavy rainfall in November 1972 resulted in refilling, and the lake rose to 2.1 m above normal pool stage by May 1973. The total fluctuation was 4.5 m in a 10-month period.

A second drawdown was initiated on 4 September 1973 (Figure 2). The lake level dropped 2.6 m below normal pool stage by 12 October 1973. Beginning in November, heavy rains again initiated refilling and the lake level rose to 3.0 m above normal pool stage by 1 February 1974. The total water level fluctuation was 5.6 m in 6 months, and the lake returned to normal pool stage in April 1974.

Two methods of vegetation sampling were used before and after each drawdown. Eight transects were established at random throughout the lake (Figure 1). A restricted random method was used to select 24 permanent 0.4-ha plots located at various depth intervals (Figure 1).

Vegetation samples were collected along each transect using a 61 by 61 cm sheet metal quadrat as described by Manning and Sanders (14). Laboratory analysis of plant samples included washing, sorting by species, spinning in a centrifuge at 1200 rpm for 2 minutes, and weighing. Percent control achieved for each species at each depth interval for each sampling date in 1973 and 1974 was determined relative to 1972 biomass. Additional percent control achieved for each species at each depth interval for each sampling date in 1974 was determined relative to 1973 biomass. Transect data were combined for purposes of analysis (Tables 1, 2, and 3), and should be considered as representative of changes in vegetation during the study period.

Permanent plot frequency values were recorded for each species in July 1971, 1972 (prior to the first drawdown), 1973 (prior to the second drawdown), and 1974. Three randomly selected lines across each of the 24 0.4-ha plots were sampled using snorkeling gear by diving 20 times along each line and recording each species occurring at each point. Frequencies from plots of similar depth were averaged to obtain mean frequency for particular species

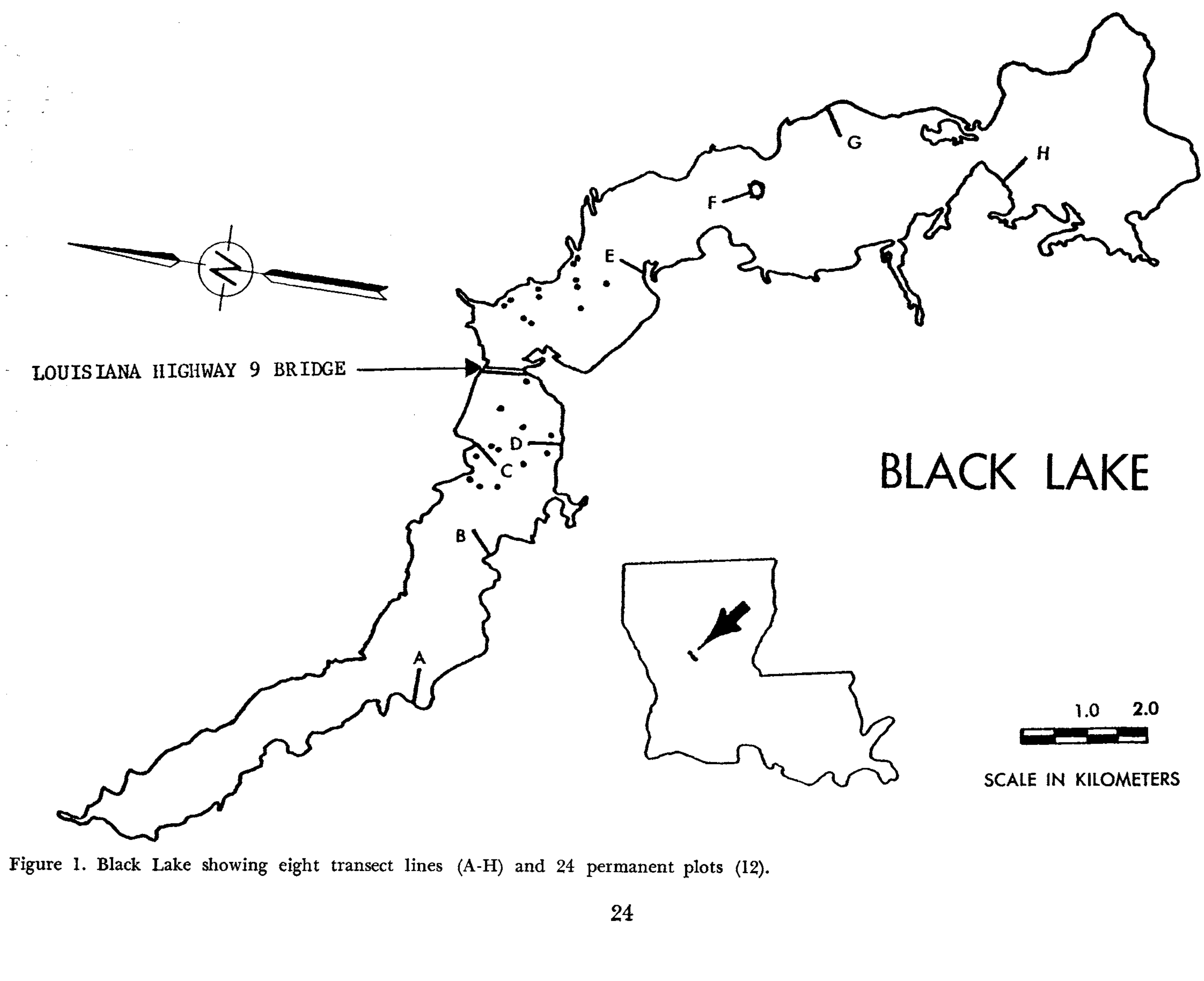

Figure 1. Black Lake showing eight transect lines (A-H) and 24 permanent plots (12).

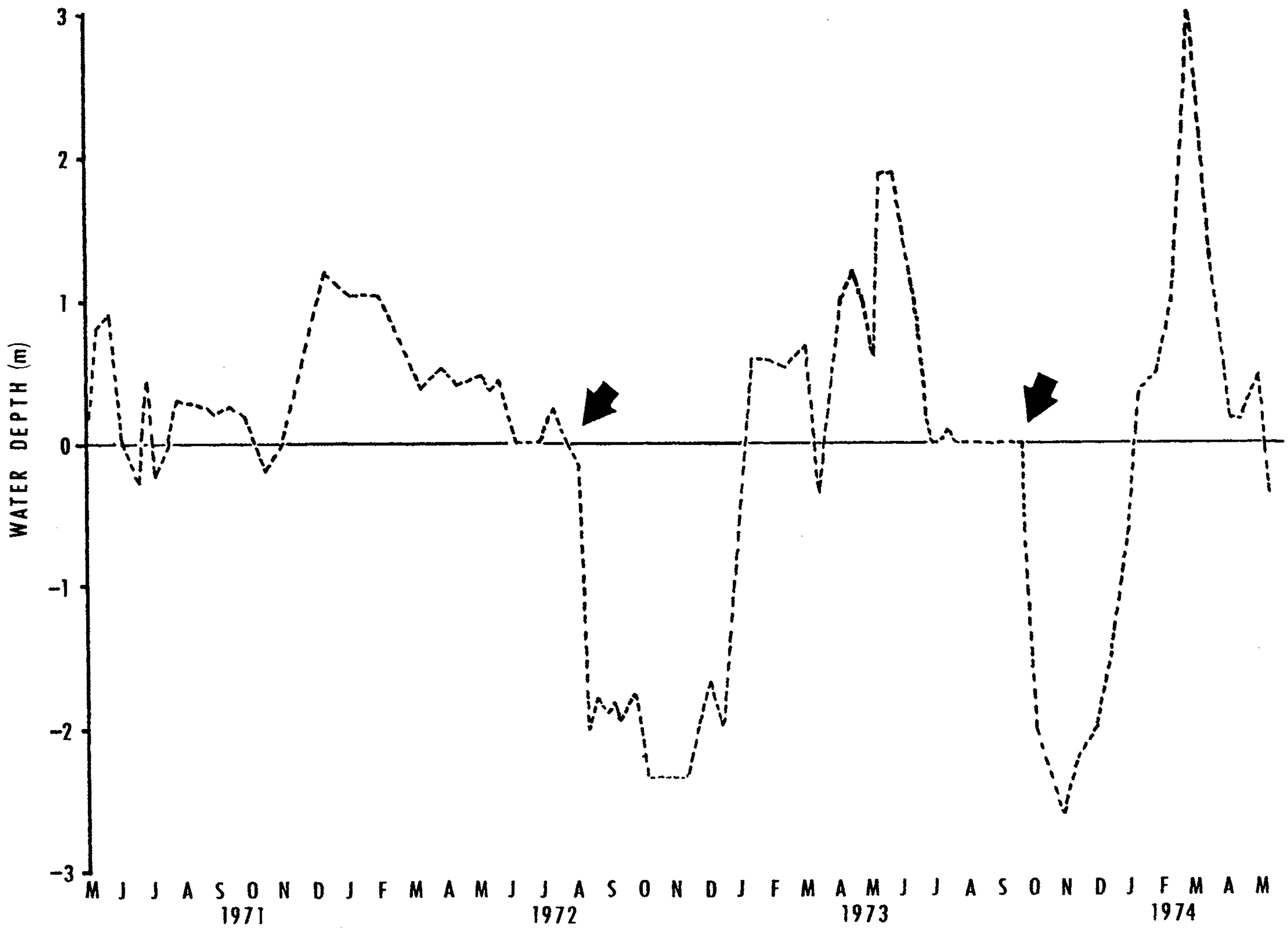

Figure 2. Water level of Black Lake from May 1971 to June 1974 relative to normal pool stage. The zero line represents normal pool stage and the arrows indicate drawdown initiations.

at designated depth intervals. Self Contained Underwater Breathing Apparatus (SCUBA) was used to check the bottom in each plot prior to sampling and plots void of vegetation were not sampled.

RESULTS AND DISCUSSION

Egeria was present in large quantities at all depths sampled in 1972 in Black Lake, Louisiana (Tables 1, 2, and 3). The first water fluctuation decreased egeria in all of the lake by nearly 100% and no egeria was found during June and July 1974 after the second drawdown. Therefore, egeria was considered to have been eradicated by the water fluctuations. A similar response of egeria to water level manipulation was obtained in Sibley Lake, Louisiana (13). Management of egeria can be accomplished by periodic fall-winter drawdowns and eradication may occur if consecutive drawdowns are performed.

Cabomba figures were reduced for the entire lake by 99% in August 1973 compared to July 1972 and only a trace of cabomba was found in 0 to 1.2 m of water depth in June 1974 (Table 1). Control of cabomba in July 1974 was still in excess of 99% overall compared to 1972. Cabomba increased in abundance in 0 to 1.2 m of water depth between sampling dates during both summers (Table 1). Seed germination which occurred after refilling, produced this response. Seeds of several species in the Nymphaeaceae family are capable of remaining viable for prolonged periods of time and germinating after years of dessication (3). Cabomba seeds probably have this characteristic.[3] Results indicate that cabomba can be effectively controlled by the use of consecutive fall-winter drawdowns. However, two consecutive annual drawdowns are not likely to eradicate the plant due to its seed dormancy.

A 10-fold increase in coontail was noted at the 0 to 1.2 m depth after the first drawdown (Table 1). However, total fresh weight increase was slight due to the fact that coontail was not abundant prior to drawdown. Manning and Sanders (14) partially explained this increase by stating that coontail was not anchored in hydrosoil and drifted into shallow areas when the lake returned to normal. Coontail was increased only 100% at the 0 to 1.2 m depth after the second drawdown compared to 1972, representing an 82% decrease from the previous year. A total lake decrease of

[3]David P. Tarver. 1975. Personal Communication.

Table 1. Average Fresh Weight ($g \cdot m^{-2}$) and Control (%) of Aquatic Plants in Eight Transects in 0 to 1.2 M of Water.

Species	Sample Dates				
	July 1972(12)	June 1973	August 1973	June 1974	July 1974
Egeria	618	7 (99)[a]	1 (100)	— (100) [100][b]	— (100) [100]
Floating Bladderwort	61	51 (16)	83 (–36)[d]	14 (77) [83]	104 (–70) [–25]
Cabomba	11	2 (81)	2 (81)	T[c] (100) [100]	0.1 (99) [95]
Snailseed Pondweed	7	— (100)	3 (57)	— (100) [100]	T (100) [100]
Coontail	2	6 (–200)	22 (–1000)	1 (50) [95]	4 (–100) [82]
Muskgrass	T	—	105	2 [98]	31 [70]
Southern Naiad	T	—	T	T	T
Slender Spikerush	T	1	1	15 [–1400]	84 [–8400]

[a] Each number in parentheses represents degree of control achieved relative to July 1972 values.
[b] Each number in brackets represents degree of control achieved relative to August 1973 values.
[c] T means that at least one plot contained the species, but less than 1 g was found.
[d] Negative values indicate increases over initial weights.

more than 80% was noted in all comparisons after both drawdowns. The first drawdown successfully eliminated coontail as a problem species from deeper lake areas (Tables 2 and 3). The second drawdown reduced coontail fresh weight averages in shallow water areas (Table 1). Consecutive annual fall-winter water level fluctuations had only a slight net affect on the biomass of coontail at 0 to 1.2 m depth.

Floating bladderwort increased by 36% in 0 to 1.2 m of water depth after the initial water level fluctuation

Table 2. Average Fresh Weight ($g \cdot m^{-2}$) and Control (%) of Aquatic Plants in Eight Transects in 1.2 to 2.4 M of Water.

Species	Sample Dates				
	July 1972(12)	June 1973	August 1973	June 1974	July 1974
Egeria	815	0.3 (100)[a]	— (100)	— (100)	— (100)
Floating Bladderwort	111	T[c] (100)	17 (85)	0.2 (100) [99][b]	13 (88) [24]
Cabomba	103	T (100)	T (100)	— (100) [100]	— (100) [100]
Snailseed Pondweed	10	— (100)	— (100)	— (100)	— (100)
Coontail	15	T (100)	T (100)	— (100) [100]	— (100) [100]
Muskgrass	T	—	4	T [100]	T [100]
Slender Spikerush	T	T	3	T [100]	17 [–467][d]

[a] Each number in parentheses represents degree of control achieved relative to July 1972 values.
[b] Each number in brackets represents degree of control achieved relative to August 1973 values.
[c] T means that at least one plot contained the species, but less than 1 g was found.
[d] Negative values indicate increases over initial weights.

TABLE 3. AVERAGE FRESH WEIGHT ($g \cdot m^{-2}$) AND CONTROL (%) OF AQUATIC PLANTS IN EIGHT TRANSECTS IN 2.4 TO 3.7 M OF WATER.

Species	Sample Dates				
	July 1972(12)	June 1973	August 1973	June 1974	July 1974
Egeria	1073	10 (100)[a]	1 (100)	— (100) [100][b]	— (100) [100]
Floating Bladderwort	7	3 (57)	T[c] (100)	T (100)	— (100) [100]
Cabomba	275	2 (99)	— (100)	— (100)	— (100)
Coontail	182	5 (97)	— (100)	— (100)	— (100)

[a] Each number in parentheses represents degree of control achieved relative to July 1972 values.
[b] Each number in brackets represents degree of control achieved relative to August 1973 values.
[c] T means that at least one plot contained the species, but less than 1 g was found.

(Table 1). This increase was related to surviving plants being blown into shallow areas where they became anchored (14). Manning and Sanders (14) stated that the floating bladderwort population would possibly increase in years immediately following completion of the water fluctuation program. Floating bladderwort had nearly doubled to a 70% increase at the 0 to 1.2 m depth by July 1974. A 17% increase over the previous summer was noted for the entire lake by the termination of the second drawdown. Lantz, reported an increase of floating bladderwort in another consecutively fluctuated Louisiana impoundment (11). Bladderwort is less competitive than species such as egeria and cabomba and is prone to flourish when they are reduced or eliminated. This suggests that consecutive fall-winter drawdowns may encourage the increase of floating bladderwort. Floating bladderwort was effectively controlled in water deeper than 1.2 m by the drawdowns performed on Black Lake.

Muskgrass and slender spikerush (*Eleocharis acicularis* (L.) R. and S.) increased at the 0 to 1.2 m and 1.2 to 2.4 m depths following the first drawdown (Tables 1 and 2). These increases were indicative of a shift in lake vegetation to an earlier successional stage (14). Muskgrass values were still higher at the 0 to 1.2 m depth after the second drawdown than in 1972, but had decreased somewhat since August 1973. Conversely, slender spikerush showed marked increases after the second drawdown, increasing to a biomass 84 times greater than values obtained in August 1973 at the 0 to 1.2 m depth. This increase reflects a very small average fresh weight in 1973 rather than a tremendous biomass in 1974. Slender spikerush has never been considered a problem plant anywhere in Black Lake. Overall, both muskgrass and slender spikerush displayed net increases after two drawdowns.

Marginal species, such as arrowhead (*Sagittaria subulata* (L.) Buchenau), water primrose (*Ludwigia repens* Forst.), southern water grass (*Hydrochloa caroliniensis* Beauv.), roundleaf bacopa (*Bacopa rotundifolia* (Michx.) Wettst.), smartweed, and frogbit (*Limnobium Spongia* (Bosc.) Steud.), appeared in June 1973 for the first time during the study. All of these species except arrowhead and southern water grass disappeared within 2 months. Arrowhead was still found in small quantities after the second drawdown, but southern water grass had been eliminated. Variable leaf milfoil (*Myriophyllum heterophyllum* Michx.) reappeared briefly in June 1974 but had disappeared by July 1974. Water primrose was again identified in July 1974 and two new species, giant duckweed (*Spirodela polyrhiza* (L.) Schleid) and creeping rush (*Juncus repens* Michx.) were recorded. Most of these species are unable to compete with more aggressive plants and are, therefore, eliminated soon after restablization of the water level.

Southern naiad and snailseed pondweed (*Potamogeton capillaceus* Poir.) were not completely eliminated by the first drawdown but were either present in only trace amounts or absent after the second drawdown (Tables 1 and 2). Eastern bladderwort (*Utricularia gibba* L.) was restricted to shallow areas after the first water level fluctuation and was completely eliminated by August 1974 after the second.

Plant frequency data compiled during the study period by sampling permanent plots is presented in Table 4. Vegetative trends shown by transect analysis were also demonstrated by this method. Frequencies of egeria and cabomba were effectively reduced after the initial drawdown at all depth intervals. A slight additional decrease in frequencies of these species at the 0 to 1.8 m depth was noted after the second drawdown. Coontail and southern naiad frequencies increased slightly at the 0 to 1.8 m depth after initial drawdown, but decreased after the second drawdown to values similar to those observed in 1971 and 1972. Floating bladderwort, muskgrass, and slender spikerush values increased markedly after consecutive drawdowns, especially in shallow water. Drawdown of an impoundment reduces available carbon in a system by exposing organic material to bacterial processes of decomposition and oxidation. Long term effects of reduced available carbon are decreased free carbon dioxide in the water with a resultant increase in pH toward a more alkaline system. Different species of aquatic plants have different CO_2 compensation points, which appear to regulate succession in impoundments by controlling presence and absence of certain species.[4]

[4]William T. Haller. 1975. Personal Communication.

TABLE 4. AVERAGE FREQUENCY (%) OF AQUATIC PLANTS IN 24 PERMANENT PLOTS DURING A 4-YEAR PERIOD.

	0 to 1.8 m				1.8 to 2.4 m			2.4 to 3.1 m			3.1 to 3.7 m		
Species	1971	1972	1973	1974[a]	1971	1972	1973	1971	1972	1973	1971	1972	1973
Floating Bladderwort	49.7[b]	37.5	63.7	61.7	36.7	11.4	2.5	0.0	18.3	1.7	0.0	0.3	0.0
Egeria	42.0	71.1	1.7	0.0	22.2	58.3	0.0	14.7	25.3	0.0	2.5	10.3	0.0
Cabomba	16.7	16.3	8.9	0.6	31.6	32.6	0.0	49.7	42.8	0.0	40.6	43.8	0.0
Coontail	0.8	0.0	27.5	1.7	0.6	4.4	0.8	1.7	2.5	1.7	0.3	10.0	0.0
Muskgrass	0.0	0.0	36.1	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern Naiad	0.0	0.0	4.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Slender Spikerush	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] In 1974 no plants were found in water deeper than 1.8 m.
[b] Mean of 60 samples in each of six plots.

As previously mentioned, drawdown shifts an impoundment toward more alkaline conditions with lower CO_2 concentrations. The total alkalinity average for Black Lake from September 1973 through February 1974 (during the second water level fluctuation) was 2.4 mg per liter while the average from March 1974 through August 1974 (after the second water level fluctuation) was 27.4 mg per liter. This indicates a lower concentration of CO_2 after the second drawdown and explains the shift in Black Lake vegetation from the dominant species present before initial drawdown (egeria and cabomba) to the earlier successional plants (muskgrass and slender spikerush) which increased throughout the program. Results indicate that egeria and cabomba have compensation points of medium level CO_2 concentration while the compensation point of slender spikerush may be considerably lower. Muskgrass has a compensation point that approaches 0 mg per liter CO_2.[5]

Consecutive drawdowns continue to reduce the concentration of free carbon dioxide by exposing and oxidizing larger amounts of organic material. This tends to maintain an impoundment in early stages of succession and prevents encroachment of more competitive problem species for longer periods.

Excellent control of two problem plant species was achieved by consecutive fall-winter water level fluctuations of Black Lake, Louisiana. These drawdowns removed egeria and significantly reduced cabomba. A consecutive water fluctuation program for a lake may provide more persistent control of submersed macrophytes after the program is discontinued.

ACKNOWLEDGMENTS

The authors gratefully acknowledge financial support by the U.S. Army Corps of Engineers, New Orleans District and the Office of Chief of Engineers, Contract No. DACW29-72-CO186. Assistance by Louisiana Wildlife and Fisheries Commission personnel and the use of their sampling device is also greatly appreciated.

[5] *Ibid.*

LITERATURE CITED

1. Beard, T. D. 1973. Overwinter drawdown—impact on the aquatic vegetation in Murphy Flowage, Wisconsin. Department of Natural Resources Tech. Bull. No. 61. Madison, Wisconsin. 14 pp.
2. Burkhalter, A. P., R. L. Lazor, and L. V. Richardson. 1972. Recommendations for aquatic plant control and management of Ross Barnett Reservoir. Unpublished report of Florida Department of Natural Resources and Louisiana Wildlife and Fisheries Commission, Tallahassee, Fla. and Baton Rouge, La. 137 pp.
3. Crocker, W. and L. V. Barton. 1953. Physiology of seeds. Chronica Botanica Co., Waltham, Mass. 267 p.
4. Davis, J. T. 1971. Water fluctuation. La. Conservationist 19:5-7.
5. Eschmeyer, R. W., D. E. Manges, and O. F. Hasbauer. 1947. Trends in fishing on T.V.A. storage waters. J. Tenn. Acad. Sci. 22:45-56.
6. Gowanloch, J. N. 1945. Lovely Lake Chicot is setting for important researches. La. Conservationist 3:5-8.
7. Hestand, R. S. and C. C. Carter. 1974. Effects of a winter drawdown on aquatic vegetation in a shallow water reservoir. Hyacinth Contr. J. 11:54-58.
8. Holcomb, D. E. and W. L. Wegener. 1971. Hydrophytic changes related to lake fluctuation as measured by point transects. Proc. S. E. Ass. of Game and Fish Comm. 25:570-583.
9. Hulsey, A. H. 1957. Effects of a fall and winter drawdown on a flood control lake. Proc. S. E. Ass. of Game and Fish Comm. 10:285-289.
10. Lantz, K. E., J. T. Davis, J. S. Hughes, and H. E. Schafer, 1964. Water level fluctuation—its effects on vegetation control and fish population management. Proc. S. E. Ass. Game and Fish Comm. 18:483-494.
11. Lantz, K. E. 1974. Natural and controlled water level fluctuation in a backwater lake and three Louisiana impoundments. La. Wildlife and Fisheries Bull. No. 11. 36 pp.
12. Manning, J. H. 1974. Effects of water fluctuation on vegetation and water quality of Black Lake, Louisiana. Unpubl. M. S. Thesis, Northwestern State University of Louisiana. 47 pp.
13. Manning, J. H. and R. E. Johnson. 1975. Water level fluctuation and herbicide application: an integrated control method for hydrilla in a Louisiana reservoir. Hyacinth Contr. J. 13:11-17.
14. Manning, J. H. and D. R. Sanders, Sr. 1975. Effects of water fluctuation on vegetation in Black Lake, Louisiana. Hyacinth Contr. J. 13:17-21.
15. Mathis, W. P. 1965. Observation on control of vegetation in Lake Catherine using Israeli carp and a fall-winter drawdown. Proc. S. E. Ass. of Game and Fish Comm. 19:197-205.