# Ecological Implications Of Water Levels On Plant Growth In A Shallow Water Reservoir[1]

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## INTRODUCTION

Water level manipulation has been used for centuries for controlling aquatic plant growth in fish culture ponds, small lakes or reservoirs, and more recently, in larger hydroelectric reservoirs (2). In small impoundments, the role of water clarity and available plant nutrients have been shown to be major factors causing excessive plant growth and aquatic weed problems (7, 8, 9, 10). The development of a shallow water reservoir, on the Oklawaha River between the St. Johns River and the Dead River Swamp, known as Rodman Reservoir (Lake Ocklawaha) presents an interesting example of aquatic plant succession in a nutrient-rich situation. Questions have been raised regarding the influence of water levels on the aquatic plant succession and severity of weed problems.

A study was therefore conducted to document successional changes of aquatic vegetation in this newly formed body of water and to forecast possible future changes resulting from water level manipulation.

[1]Cooperative investigations of the Florida Game and Fresh Water Fish Commission and the Bureau of Sport Fisheries and Wildlife.

## METHODS AND MATERIALS

In August 1970, August 1971, and May 1972, general vegetation maps were made depicting the distribution of aquatic plants in Rodman Reservoir. The map was completed only to canal mile 30 (Figure 1) in 1970 due to inaccessibility by motor boat. However, an airboat was used in later documentation and the entire reservoir to canal mile 36 was mapped. For the purpose of this paper, comparisons will only be made within the general area mapped in 1970.

The vegetation maps were prepared using a map with a scale of 1 inch equals 800 ft. Dominant or the most obvious plants were color coded and recorded on the map in the corresponding area. All plants noted were recorded and a list of plants occurring in the reservoir was made (Table 1). The lake was criss-crossed approximately every 100 to 150 ft and the resulting map was then checked against aerial photographs for accuracy. The acreage of each plant species was figured from the map by using an area calculator.

In May 1972 a few aquatic plant communities were sampled for biomass. These plants were in shallow water

TABLE 1. LIST OF PLANTS OCCURRING IN LAKE OCKLAWAHA, MAY 1972.

| Submerged | Floating | Emerged |
|---|---|---|
| Waterhyssop | Watervelvet | Alligatorweed |
| Coontail | Waterhyacinth | False loosestrife |
| Brazilian elodea | Duckweed | Spatterdock |
| Hydrilla | Waterlettuce | Maidencane |
| False loosestrife | Waterfern | Pickerelweed |
| Southern naiad | | Arrowhead |
| Pondweed | | Bullrush |
| Eelgrass | | Cattail |
| Bladderwort | | |

zones selected because of accessibility. All of the plants in a 3-ft$^2$ area were removed and placed in plastic bags to be dried and weighed in the laboratory. Only one sample of each species was obtained, thus the values are from a single sample.

Water quality analyses were performed on the reservoir, its tributaries, and the river above and below the impoundment. Samples were taken monthly (Table 2) and comparisons made revealed that no significant difference existed between years. All analyses were performed in accordance with standard field and laboratory techniques (1).

## RESULTS

The 1972 map combines coontail *(Ceratophyllum demersum L.)* and naiad *(Najas quadalupensis* (Spreng.) Magnus) into one community type. In the previous maps they had been separated and the acreages were as follows: coontail covered 1,076 acres in 1970 and 455 acres in 1971; naiad covered 110 acres in 1970 and 336 acres in 1971. Combined in 1972 they covered 1,027 acres (Table 3). This was an increase of about 200 acres over 1971. Coontail is presently the dominant submersed species in the lower half of the lake from mileage marker 28 (upstream from Orange Creek) to Rodman Dam. Naiad was present as an understory species throughout the area where coontail was found and becomes the dominant species as hot summer weather ensues and coontail growth subsides (usually in August).

Eelgrass *(Vallisneria americana* Michx.) was not recorded in 1970 but in 1971, 7 acres were recorded. In May 1972, 22 acres of eelgrass were found. In general, eelgrass was sparse but found in the deeper water zones of 3 to 8 ft depth.

TABLE 3. COMPARISON OF AREA COVERED IN LAKE OCKLAWAHA BY AQUATIC PLANTS IN 1970, 1971 AND 1972.

| Species | Acres Covered 1970 | 1971 | 1972 |
|---|---|---|---|
| Coontail | 1,076 | 455 | — |
| | | | 1,027 |
| Southern naiad | 110 | 336 | — |
| Waterhyacinth | 773 | 535 | 462 |
| Brazilian elodea | — | 7 | 43 |
| Cattail | 29 | 13 | 157 |
| Spatterdock | — | 7 | 9 |
| Hydrilla | — | 2 | 11 |
| Eelgrass | — | 6 | 22 |
| Bladderwort | — | 8 | 20 |

Hydrilla *(Hydrilla verticillata* Royle) was not recorded in 1970 but in 1971 many small patches were found covering about 1 acre. In May 1972, hydrilla in the same areas covered 11 acres. Hydrilla, a notorious exotic from Southeast Asia, was growing densely behind the wingwalls in the channel upstream from Buckman Lock, in scattered stands along the shoreline and into mid-channel of the barge canal going into Lake Ocklawaha. Little or no competition from other species exists in this area. Hydrilla was also found in scattered stands on the southwest side of the lake from the dam to the vicinity of Blue Springs (between mileage markers 23 and 21) and in the embayment about the boat landing (Site 2-B) at Rodman Dam (Figure 1). Hydrilla was competing with coontail and naiad. However, these stands are vigorous colonies that should quickly spread throughout these zones now occupied by coontail, naiad and bladderwort.

Brazilian elodea *(Egeria densa* Planch.) was present from the vicinity of Orange Creek (mileage marker 27) and becomes the dominant submerged species over coontail as one progresses upstream to Paynes Landing (mileage marker 31) and was the overwhelming dominant submerged species upstream to Eureka (mileage marker 33) in waters less than 6 ft in depth.

Waterhyacinth *(Eichornia crassipes* Mart.) Solms) covered 733 acres of the lake in August 1970. In August 1971 waterhyacinths were repressed by "root rot"[2] and covered 384 acres. In May 1972, the waterhyacinth seemed to be overcoming the disease and covered 462 acres.

[2]The agent of this disease is unidentified and currently under study by D. R. Charudattan, Dept. of Plant Pathology, U. of Fla., Gainesville, Fla.

TABLE 2. WATER QUALITY MEASUREMENTS FOR LAKE OCKLAWAHA, ITS TRIBUTARIES AND OUTFALL. EACH VALUE REPRESENTS THE MEAN OF 24 SAMPLES TAKEN MONTHLY BETWEEN JUNE, 1970 AND MAY, 1972 (DATA ADAPTED FROM DUCHROW (3,4).

| Parameters | Oklawaha River (inflow) | Lake Ocklawaha | Oklawaha River (outflow) | Orange Creek | Deep Creek |
|---|---|---|---|---|---|
| Specific conductance (mhos) | 384 | 455 | 441 | 115 | 158 |
| pH | 7.6 | 7.6 | 7.7 | 7.3 | 7.0 |
| Calcium (ppm) | 58.0 | 56.0 | 51.0 | 11.0 | 18.0 |
| Magnesium (ppm) | 9.0 | 10.4 | 9.1 | 2.9 | 4.8 |
| Potassium (ppm) | 1.3 | 1.8 | 2.0 | 0.9 | 0.7 |
| Iron (ppm) | 0.2 | 0.1 | 0.2 | 0.3 | 0.4 |
| Nitrate nitrogen (ppm) | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| Ortho phosphate (ppm) | 0.12 | 0.10 | 0.10 | 0.24 | 0.17 |
| Total phosphate (ppm) | 0.20 | 0.17 | 0.25 | 0.32 | 0.21 |

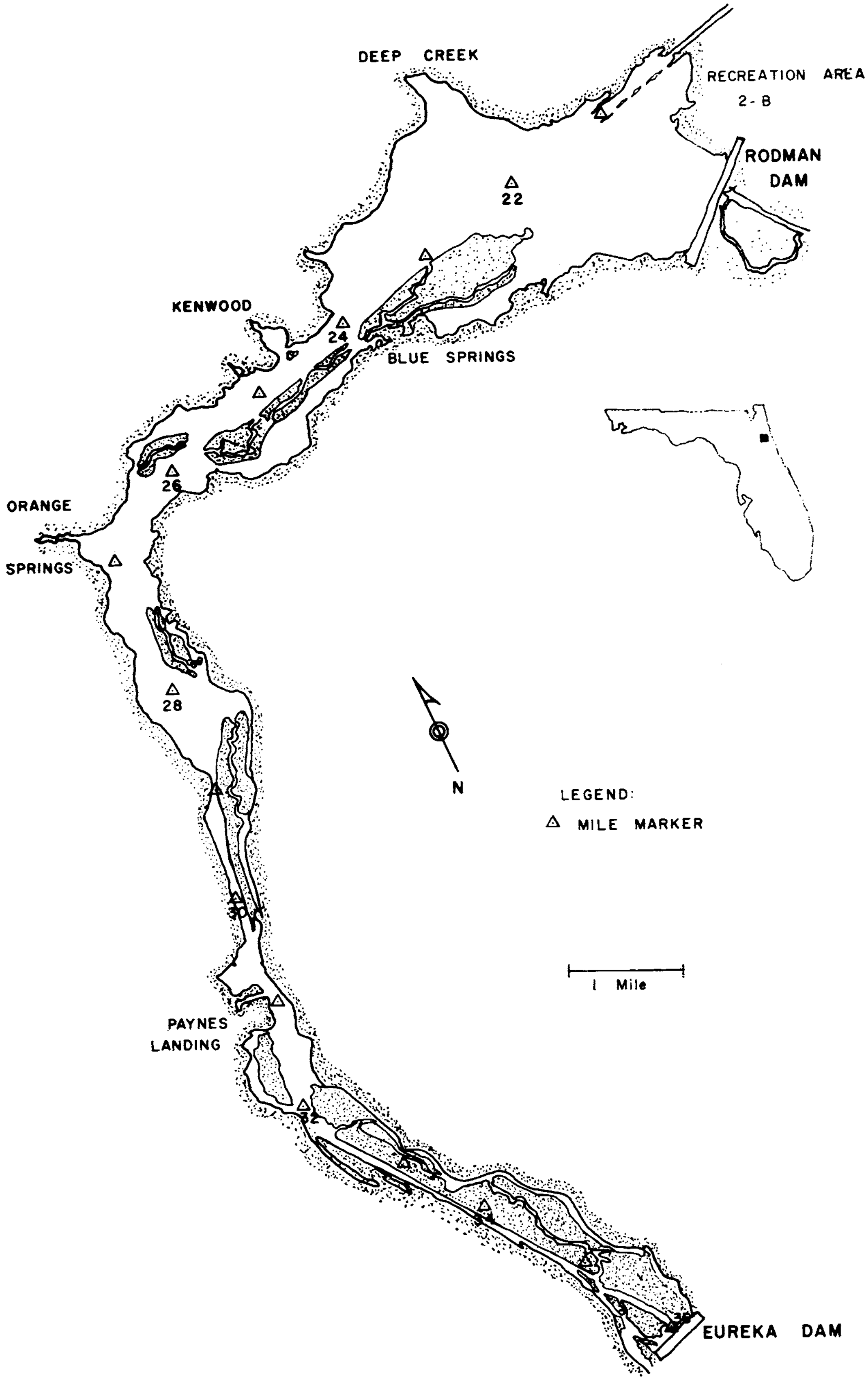


Figure 1. Map of Rodman Reservoir (Lake Ocklawaha) at 18 ft msl.

Waterhyacinth was found in abundance along the entire shoreline, and in protected wooded areas and embayments. It was also commonly associated with the following emergent vegetation: cattails (*Typha* sp.); pickerelweed (*Pontederia lanceolata* Nutt); arrowhead (*Sagittaria* sp.); false loosestrife (*Ludwigia repens Forster*); alligatorweed (*Alternanthera philoxeroides* (Mart. Grissb.); and spatterdock (*Nuphar macrophyllum* (Small) E. O. Beal). Waterhyacinths can dominate large areas of the lake unless controlled;coontail, elodea, and hydrilla can tolerate shading and coexist as the submersed dominates with waterhyacinth in the lower two-thirds of the lake.

Waterlettuce (*Pistia stratiotes* L.) succeeds waterhyacinth in sheltered sprayed with 2,4-dichlorophenoxy) acetic acid (2,4-D) because of its tolerance to this herbicide.

Watervelvet (*Azola caroliniana* Willd.), common duckweed (*Lemna minor* L.), and Salvinia (*Salvinia rotundifolia* Willd.) are common species growing abundantly among emergent plants (cattails, pickerelweed, etc.) and on mats of coontail growing to the surface in the middle reaches of the lake from Deep Creek to Paynes Landing.

Alligatorweed appeared as floating mats anchored in the reservoir in isolated colonies that were contained by the flea beetle (*Agasicles* sp. N.) that has been introduced as a biological control agent.

Cattails have reached high density along much of the open shoreline from Deep Creek and Kenwood upstream to Eureka Dam. Cattails dominate the marginal vegetation in shallow water (2 ft in depth and less).

Cattail communities give way in deeper water to a succession of such species as pickerelweed, arrowhead (three or more species), bullrush (*Scirpus californicus* (C.A. Mey.) Steud, and *S. Validus* (Vall), false loosestrife, alligatorweed, waterhyssop (*Bacopa monnieri* (L.) Pennell and *B. caroliniana* (Walter) Robinson), and spatterdock, particularly as one progresses upstream from Orange Creek to Paynes Landing. Spatterdock and pickerelweed dominate south of Paynes Landing in open water areas.

In wooded portions of the lake, waterhyacinth dominates over waterlettuce, waterfern, salvinia, and duckweed except in extensively sprayed areas as previously mentioned in the lower reaches of the lake in the vicinity of Orange Creek and Kenwood. Waterhemlock (*Cicuta maculata* L. or *C. mexicana* C. & R.) forms islands of vegetation on top of waterhyacinth mats and on floating or partially submersed downed timber. Also contributing to the jungle undergrowth appearance are numerous forbs and climbing hempweed (*Mikania scandens* (L.) Willd.) that wind up the stumps and trunks of trees.

The results of the biomass studies are as follows: cattails, 35,833 kg/ha dry wt; spatterdock, 31,899 kg/ha dry wt; Brazilian elodea, 5,135 kg/ha dry wt; and pickerelweed, 27,157 kg/ha dry wt. Only shallow water plants were utilized in this segment due to the lack of gear for deep water studies.

## DISCUSSION

Aquatic vegetation abounds in water less than 6.6 to 9.8 ft deep and will require an expensive and extensive plant control program. Submerged species now grow to the full depth of light penetration of 6.6 to 9.8 ft.

The reservoir is currently at 18 ft msl (mean sea level). The proposed drawdown to 13 ft msl would leave most of the aquatic plants stranded. The aquatic vegetation will then invade and establish in the remaining section of the lake. Thus, in time, boating may be difficult except in the river channel.

The major potential problem is hydrilla, which is extremely difficult to control. In May 1972, between 20 and 100 acres should have been treated since the growth potential of hydrilla is such that it can spread to more than 500 to 1,000 acres of the lake by the end of the 1973 growing season.

According to the Corps of Engineers, waterhyacinth control has been conducted on the Oklawaha River for many years and in 1968 was initiated throughout Lake Ocklawaha. Following drawdown to elevation 18 ft msl, "root rot" effectively reduced waterhyacinth infestations during late 1970 and persisted through 1971 except in the Orange Spring area, where a waterhyacinth spray program with 2,4-D has been conducted to provide access to the Orange Spring landing. With the proposed drawdown to 13 ft msl, enough waterhyacinths may be stranded that a control program will not be needed.

The proposed drawdown may leave colonies of alligatorweed stranded in the partially dewatered areas and mud flats as a terrestrial plant. Under these conditions, alligatorweed will not be controlled by the alligatorweed flea beetle since the beetle exists only under plagic or floating mat conditions. Alligatorweed can take over waterhyacinth growths in open shoreline areas to produce an impenetrable jungle-like mat. Without the flea beetle, chemicals may need to be used to suppress these infestations.

We are faced with the continued fertilization of these aquatic plants by the wealth of plant nutrients coming downstream from the Ocklawaha chain of lakes (Table 2). The water clarity of Silver Springs water discharge and its high nutrient content (3, 4), also contribute to the clarity of the water in Lake Ocklawaha at times that the lake is not under the influence of the more turbid discharges from Moss Bluff Lock. Thus, it is not surprising to see the tremendous production of plant life in Lake Ocklawaha. The short retention time of water flowing through the reservoir does not restrict availability of plant nutrients, which are the primary limiting factors to production (kg of biomass per ha) and utilizable energy (cal per $cm^2$). The total biomass of plant growth in Lake Ocklawaha is thus dependent upon the area flooded. The larger the pool, the more acres that enter into production. Since nutrient availability is not a limiting factor in the reservoir, light penetration becomes the major limiting factor of plant growth in the reservoir.

The fragmentation and occurrence of "fragmentation mats" of coontail were not observed on our May 1972 inspection of the extensive growths to the surface. Although some "solarization" (coontail at or above the water surface in dense mats accompanied by extensive growth of filamentous algae) was observed, very little, if any, coontail was fragmented or was found in an *un*-anchored situation. Thus, the proposed drawdown, if conducted at this stage, would minimize the tendency for extensive movement of coontail mats into the reservoir. The anchored mats would tend to be stranded and primarily those growths in deeper water at the 13 to 11 ft msl would pose a problem in revegetation of the lake. The water clarity is such that coontail will quickly grow throughout the remaining reservoir along with hydrilla, naiad, and possibly Brazilian elodea. However, should a delay of drawdown beyond June 1972 occur, solarization of fragmentation mats would form, posing the difficulty of extensive movement of these mats into the lake.

## SUMMARY

We can conjecture that a drawdown of Lake Ocklawaha from the present 18 ft msl to 13 ft msl will dewater the vast majority of submersed aquatic vegetation, since present growth is largely restricted to elevations above 10 ft msl. The majority of the lake area will then be extremely shallow, and with sunlight penetration to the bottom we can expect that aquatic vegetation (coontail, hydrilla, naiad and Brazilian elodea) will completely occupy the entire lake. Ideally, the water level fluctuation regimen should afford a winter drawdown (lowered in November) period, followed by refilling during the spawning and growing season for sport fishes (raised in March).

If the water is lowered to a new temporary operating level of 13 ft msl or lower during the summer of 1972, and left for 2 years, the submersed weeds (hydrilla, coontail, naiad) will cover the entire lake from the bottom to the surface. Should the water level at the end of this period be raised during the active growing season (spring and fall), it is expected that submersed plants will continue growing to the surface in keeping with the available light penetrating these depths. Hydrilla, in particular, can grow to depths in excess of 20 ft and many other species, such as coontail and naiad, can also thrive in depths of 7 to 10 ft. The reflooding of the terrestrial area that has become revegetated during the drawdown period and in the active growing season (spring to fall) will result in a high BOD (Biochemical Oxygen Demand) by rotting vegetation. The stress to fish is generally greatest with the highest water temperatures because the capacity of water to retain oxygen is least, and thus the greater the threat of oxygen depletion and fish mortality.

Should the reflooding at the end of this period occur during the late winter months when plant growth is least, the maximum benefits would accrue to the fishery and for plant control. Water level fluctuation at this time and in this manner accrues "new reservoir-type" benefits that are characterized by spectacular fisheries (5, 6).

Thus, the drawdown and reflooding in this respect may be considered reversible to this extent, that a recovery of the lake fishery is possible. However, the submersed aquatic plants established in deep water and ensuing revegetation throughout the lake will be the primary limiting factor to successful fisheries. Thus, an integrated management plan of water level fluctuation and chemical and/or biological control will be required.

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