HYDRILLA CONTROL AND VEGETATION RESPONSE WITH MULTIPLE DEWATERINGS

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Abstract: An experimental multiple dewatering plan designed to control *Hydrilla verticillata* and improve sportfish habitat was implemented on Fox Lake in 1979 and 1980. Hydrilla above the hydrosoil and turions were eliminated while relative abundance of tubers decreased from 19.44 to 1.79 per m^2 by termination of the project. The depth of organic sediments was reduced by 29%, 36%, and 47% for the 30, 60, and 90 cm contour intervals respectively. Expansion of native vegetation was documented by a 40% areal increase in *Vallisneria americana* and basin-wide germination of *Typha latifolia.*

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 35:383-393

The prime objective of fish management in Florida is to maintain or improve the quality of a fishery. The uniqueness of individual waters dictates a variety of management techniques be available for use. Developing new methods or modifying old ones to correct identifiable problems is an ongoing process for the fish manager.

A most recognizable problem is the rapid and near total loss of water recreation due to excessive aquatic plant coverage. While diverse vegetation communities are considered beneficial, some lakes are characterized by excessive monotypic growths of aquatic vegetation, especially nonnative species. The exotic *Hydrilla verticillata* often reaches problematic proportions rapidly and can have a tremendous negative impact on public use of Florida waters. Since our goal is to manage a sport fishery which can be utilized, it is a major challenge to control undesirable aquatic vegetation while not inflicting harm upon desirable species or degrading the lake environment.

Early fisheries researchers recognized the need to fluctuate water levels for improved fish production. Eschmeyer, Manges and Hasbauer (1947) suggested "the winter drawdown apparently limits the abundance of rough fish without serious injury to the game fish populations." Later, other researchers demonstrated the value of water level fluctuation to improve fish production by manipulation of aquatic plant communities. In Florida, Holcomb and Wegener (1971), and Wegener and Williams (1974) documented drastic water level manipulation stabilized bottom substrate, restored diversity in native aquatic vegetation communities and improved invertebrate and fish populations.

Haller, Miller and Garrard (1976), and Hestand and Carter, (1975) described the response of hydrilla to water level manipulation. Hydrilla in Florida can reproduce from tubers, turions, and plant fragments. Tubers formed on rhizomes and turions developed in the leaf axil are asexual reproductive propagules. Because the formation of these propagules is seasonal (Haller et al. 1976), the potential to control hydrilla by strategically timed dewatering became a possiblitiy. A hydrilla control method utilizing timely water level fluctuation was proposed by Haller and implemented on Rodman Reservoir.

In 1978, Fox Lake was plagued with many biological problems, including the excessive growth of hydrilla compounded by shallow water. Although a marginal sportifishery existed, nearly all recreational activities had ceased due to limited access. To alleviate this problem, an experimental multiple dewatering management plan was developed. Established goals were to control the exotic hydrilla, consolidate organic mud deposits, stimulate the growth of native aquatic plants, increase water depth, and restore habitat suitable for game fish production.

This paper reports our findings relative to exotic aquatic plant control and lake habitat improvement.

The authors are grateful to William Wegener for his assistance in all phases of this project. We would also like to recognize the Commissioners of Brevard County for their financial support.

METHODS

Fox Lake (64 ha) is a shallow (average depth 1 m) muck bottomed lake located in Brevard County, Florida. It is connected to South Lake (440 ha) by a 0.6-km manmade canal. Lake vegetation was dominated by hydrilla in navigable areas of the lake. Naiad, *Najas quadalupensis,* and cattails maintained a border around the shallow shoreline. Historically, chemical control of cattails was necessary to maintain recreational usage.

To accomplish the drawdown an earthen dike was placed across the canal to isolate Fox Lake from South Lake (Fig. 1). A metal culvert equipped with a lift gate structure was installed in the base of the dike to allow reflooding from South Lake. A 40.64 cm, 38,000 l per min centrifugal pump (Crissafulli model CP-16) was used to pump water over the dike and into South Lake.

The proposed Fox Lake dewatering schedule consisted of 3 stragetically timed drawdowns (Fig. 2), similar to that proposed by Haller et al. (1976). The 1st (spring) dewatering was timed to: maximize organic sediment consolidation, kill hydrilla plants, stimulate germination of hydrilla tubers and turions and encourage germination of native aquatic vegetation following reflooding. The 2nd (fall) dewatering was timed to kill newly sprouted hydrilla plants prior to normal tuber and turion production occurring from October to April. The 3rd optional dewatering was scheduled for the following spring (Apr - May) to kill remaining hydrilla plants resulting from delayed tuber and turion germination. Small areas of Fox Lake that could not be dewatered or dried, were chemically treated for hydrilla with Hydrothol 191 or Hydout pellets. Cattail germination and expansion was anticipated following dewaterings so mechanical cutting and chemical control (Dalapon, 2-4D and Diquat) were planned and subsequently implemented.

The depth of the organic layer was measured by pushing a graduated clear plexiglass tube (3.8 cm $\times$ 240 cm) vertically through the muck until a firm bottom of sand, clay and/or shell was detected. All material overlying the firm substrate was considered the organic layer. Due to the shallowness of the basin, only 3 contours were monitored. Three core samples were taken at each contour interval (30, 60, 90 cm) along 4 predetermined transect lines (Fig. 1). The estimated organic depth was obtained by averaging measurements within contours.

Vegetation mappings, in addition to tuber, turion and young plant counts were used to monitor the effect of dewaterings on hydrilla. Vegetation maps were

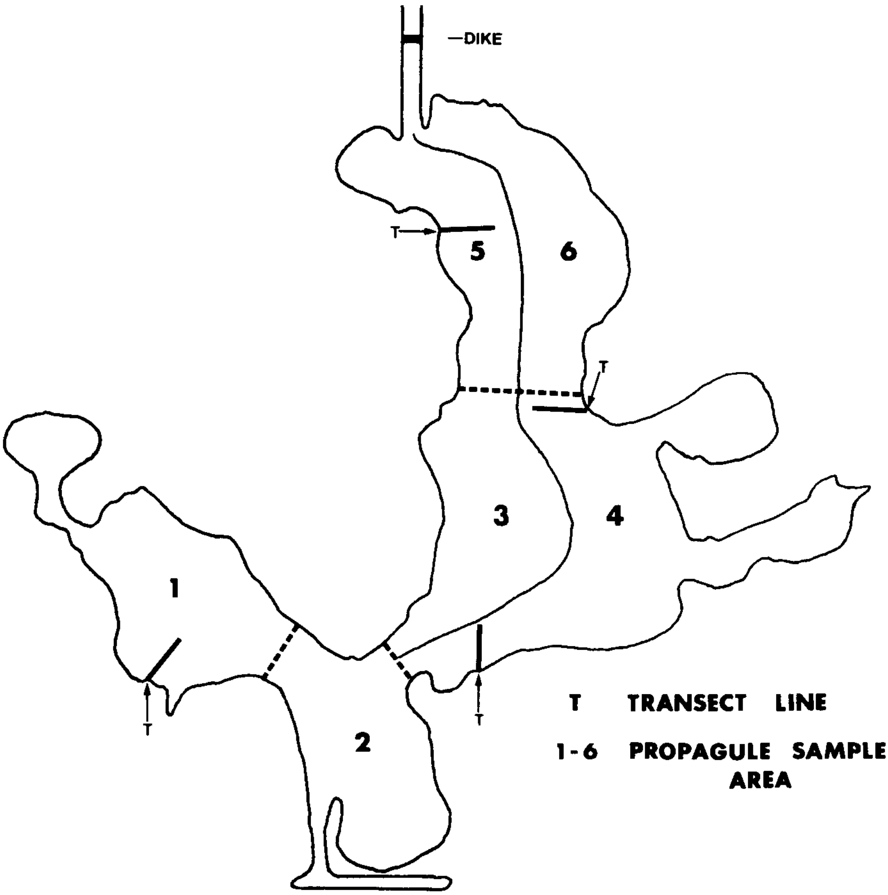

Fig. 1. Tuber and Turion sample areas, organic deposit transect lines and dike location in Fox Lake.

constructed by visual observations made from an airboat moving at a constant speed between known points. Although all plant species were recorded, only the 4 major species are depicted in the vegetation maps (Fig. 3, 4, 5, 6). To determine if germination was from tubers or turions, divers extracted live hydrilla from the hydrosoil with the root system intact. The 2nd dewatering consolidated the soft substrate and thus prevented collection of intact hydrilla roots. Relative abundance of tubers and turions was determined from core samples (10.16 cm in diameter by 30.48 cm deep) as described by Sutton (1982). Fox Lake was divided into 6 approximately equal sections (Fig. 1) and 12 cores were taken in each area from arbitrarily selected sites prior to and following dewaterings. Cores were individually washed in a box with a bottom of mesh screen (18 by 16 wires per square 2.54 cm)

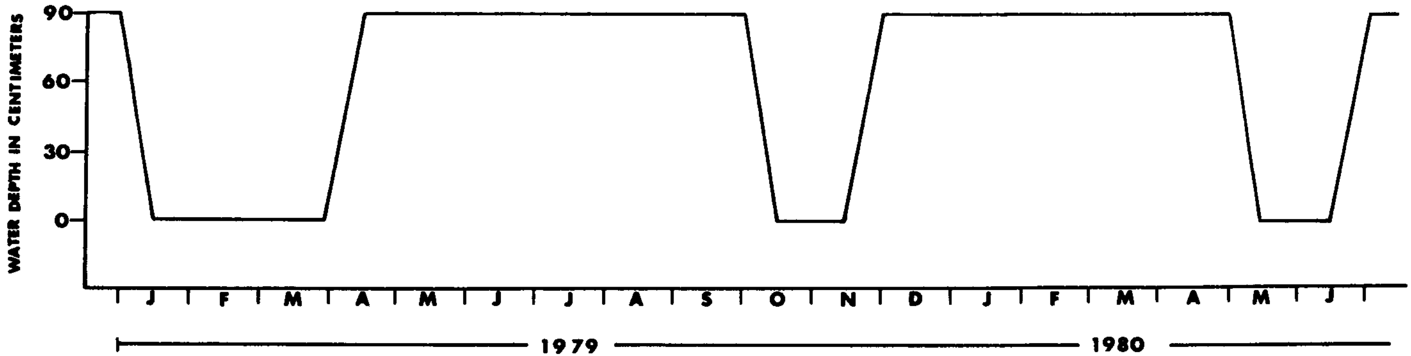

Fig. 2. Proposed water level fluctuation schedule for Fox Lake.

to separate tubers and turions from mud and organic detritus. The number of tubers and turions recovered per core was expanded to estimate number per m^2 of bottom substrate. A Student's t test was used to determine significant ($P < 0.05$) changes in tuber and turion densities.

RESULTS AND DISCUSSION

Vegetation Response

Initial vegetation surveys conducted in July and September 1978 revealed hydrilla occurred over most of the basin and surfaced in approximately 22.8 hectares. The remainder of the lake was bordered by naiad and cattails (Fig. 3).

The 1st dewatering of Fox Lake commenced on February 12, 1979 and lake bottom exposure was achieved in 8 days. This dewatering was approximately 11 weeks in duration. Cloudy and rainy weather persisted throughout this period and the hydrosoil remained moist, resulting in minimal consolidation of organic deposits. Exposed hydrilla was desiccated within a period of 2 weeks. Areas not exposed were relatively small dredge holes and canals fed by groundwater and represented approximately 0.8 ha. Hydrilla was chemically treated in those areas.

Reflooding began May 10, 1979 and normal pool was reached in 13 days. Within 3 weeks cattail seedlings and hydrilla plants 12.7 to 15.2 cm long were observed over most of the basin. A subsequent vegeatation survey in June 1979 revealed that water sprite *(Ceratopteris thalictroides)* and eelgrass had also germinated throughout the basin. Of special interest was the observation of 7 southern bulrush (*Scirpus californicus)* clusters not found in the lake prior to dewatering. A heavy filamentous algal *(Spirogyra* sp.) growth coated the young hydrilla and cattails. Hydrilla appeared dwarfed and young cattails were chlorotic, perhaps resulting from the alga. The alga dissipated within 2 months and cattail germination and growth increased. Aerial chemical spraying and a mechanical cutter were used to control this new growth.

The 2nd dewatering was scheduled to begin September 1979 to desiccate new hydrilla and prevent the production of tubers and turions. Rain generated from Hurricane David and unseasonable heavy precipitation flooded the lake and marsh, delaying the scheduled dewatering until October 20, 1979. So, hydrilla was present during 2 months of the normal tuber and turion formation period (Fig. 4). Sporatic and limited tuber production occurred prior to bottom exposure by November 25, 1979. To compound this problem, inclement weather prevented exposed hydrilla from desiccating. To optimize drying of the organic layer, the duration of the 2nd dewatering was extended from 1 to 4 months (Fig. 7).

Dredge holes and canals not exposed were again chemically treated. In February and March of 1980 cattail germination and regrowth from rhizomes occurred sporadically throughout the basin. Cattails, and nut sedge *(Cyperus* sp.) covered at least 50% of the basin. Millet *(Echinochloa walteri)* germination paralleled that of the cattail response. Chemical control of cattail was considered but not attempted as all effective cattail herbicides were no longer available for aquatic use.

On March 25, 1980 reflooding of Fox Lake commenced. A partial refilling to an average depth of 15.2 cm was used to again initiate tuber and turion germination, and facilitate the 3rd dewatering. Germination of hydrilla was documented on April

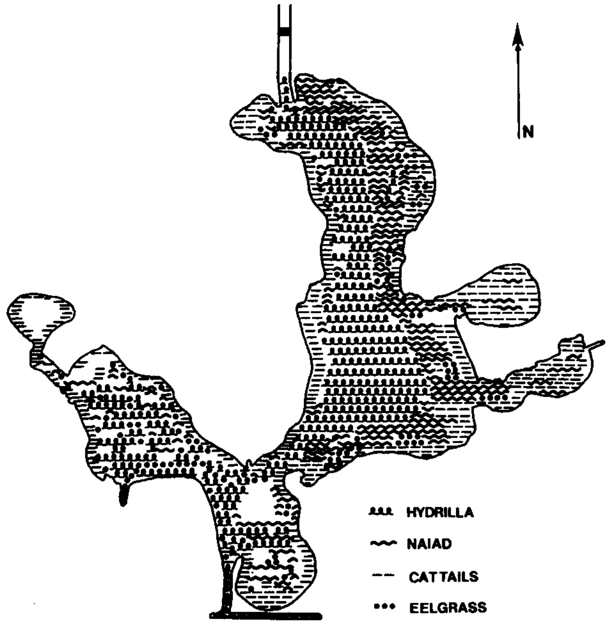

Fig. 3. Vegetation map of Fox Lake in September 1978.

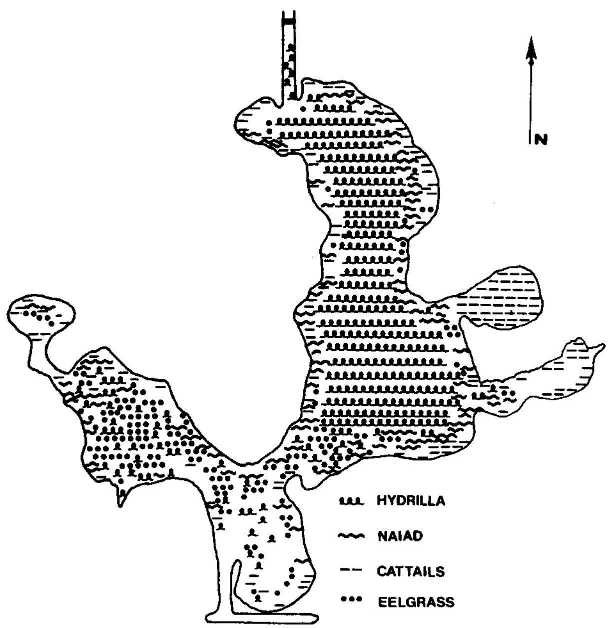

Fig. 4. Vegetation map of Fox Lake in October 1979.

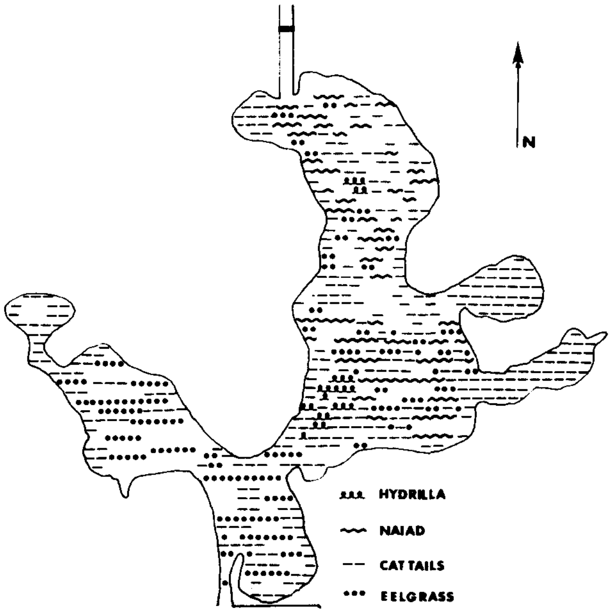

Fig. 5. Vegetation map of Fox Lake in October 1980.

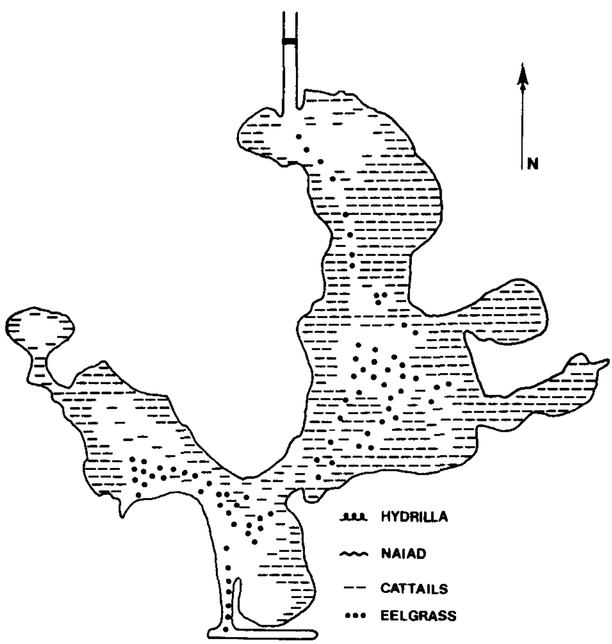

Fig. 6. Vegetation map of Fox Lake in June 1981.

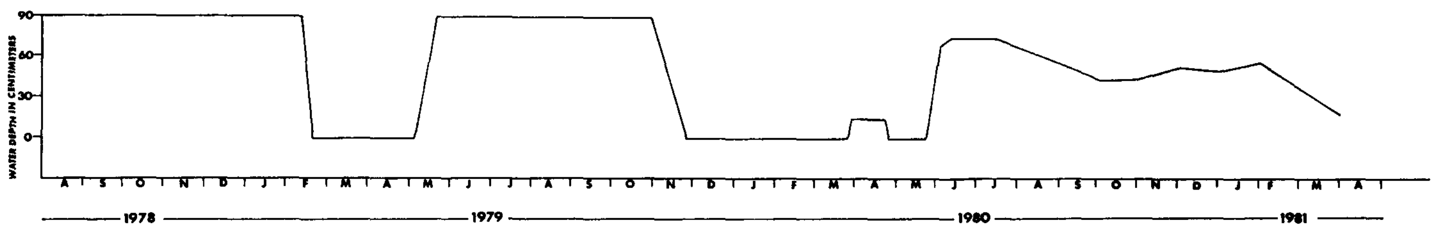

Fig. 7. Actual water level fluctuation in Fox Lake from August 1978 to June 1981.

18, 1980, and was confined to 1 moist area on the eastern side of the lake. Origin of the growth was not determined.

The 3rd dewatering began April 22, 1980 and the hydrosoil was exposed in 72 hours. Desiccation of hydrilla was rapid. Dry weather conditions occurred for the 1st time since implementation of the project and excellent drying of the top 5 to 10 cm of the organic sediment was obtained. However, moist, organic muck deposits remained below this crust. Neither viable hydrilla above the hydrosoil nor hydrilla fragments in the moist muck were observed. Cattail and millet germinated during the 2nd dewatering (Mar 1980) survived the 15.2 cm inundation and, with plants germinated in May 1980, produced dense stands. Where dense stands of millet existed young cattail seedlings could not compete and subsequently died. Conversely, areas that did not support millet, produced dense stands of cattails. Since adequate reflooding was impossible due to drought conditions, control of cattails using a mixture of Diquat and 2-4D was attempted but failed.

Final reflooding began on May 22, 1980 and by June 5 water depth was sufficient to mow cattails. Sparse germination of hydrilla was documented on June 19, 1980 and occurred in the same area previously observed. This germination probably came from tubers and turions present but not sprouted during the 2nd reflooding. These newly sprouted plants were chemically treated since no more dewaterings were planned. Germination of eelgrass, water sprite, naiad, spikerush (*Eleocharis cellulosa)*, and bulrush was observed on June 30, 1980. A vegetation map made in October 1980 (Fig. 5) revealed eelgrass coverage had increased by approximately 40% over pre-dewatering estimates and hydrilla occurred in 1.7 ha. Extensive cattail expansion was documented. Mapping was again conducted in June 1981 (Fig. 6). Due to an extreme drought, approximately 50% of the lake bottom was again exposed and the remainder of the lake averaged 10 to 13 cm deep. No hydrilla was observed. Eelgrass was found in scattered patches in most areas. Cattail coverage had increased over that of the October survey and dominated the lake basin due to optimum growing conditions.

Tuber and Turion Responses

A decreasing trend in the relative abundance of tubers per m^2 occurred after each drawdown compared to pre-drawdown estimates. Tuber density stabilized at a very low level at project completion. Turion densities fluctuated through July 1979 and gradually decreased to zero by August 1980.

Pre-dewatering sampling demonstrated an increase in tuber density from 19.44 to 58.33 per m^2 during colder months (Table 1). Turion densities were variable prior to the 1st dewatering and following reflooding. A Student's t test revealed no significant decrease in turion or tuber densities after the 1st dewatering (Sept 1978 - Oct 1979). This would be expected as tuber and turion production during the cooler months prior to the 1st dewatering increased the number of propagules in the hydrosoil.

Haller et al. (1976) reported tubers are the major propagule responsible for hydrilla regrowth, however, turions may be equally important at certain times of the year. This was demonstrated following the 1st dewatering when the collection of 232 plants revealed 53% germinated from turions with 47% sprouted from tubers.

Table 1. Relative abundance of tubers and turions collected by a core sampler from Fox Lake (Sept 1978 - Mar 1981).

Date	Relative abundance Tubers/m^2	Relative abundance Turions/m^2
September 1978	19.44	3.56
December 1978	42.44	192.78
February 1979	58.33	21.22
July 1979	28.33	47.78
August 1979	15.89	7.11
October 1979	6.22	6.22
April 1980	7.11	3.56
July 1980	7.11	3.56
August 1980	0.00	0.00
September 1980	3.56	0.00
October 1980	3.56	0.00
November 1980	3.56	0.00
December 1980	3.56	0.00
January 1981	1.78	0.00
February 1981	1.78	0.00
March 1981	1.78	0.00

No significant decrease in tuber and turion densities was found for samples taken prior to the 2nd dewatering (Oct 1979) and the 2nd reflooding (April 1980). This was expected since limited propagule production occurred just prior to the 2nd dewatering and sampling was conducted while these new propagules were germinating (Apr 1980).

The relative abundance of tubers and turions in April 1980 (2nd reflooding) remained unchanged compared to July 1980 (3rd reflooding). One explanation for this occurrence is that some propagules were nonviable and consequently were not stimulated by the final dewatering.

Estimates of hydrilla propagules from pre- and post-project samples were compared. A significant decrease in tuber and turion densities was observed when December 1978 and December 1980 data were tested. The same result was obtained when a comparison was made of data collected during February 1979 and February 1981.

Organic Deposits

The bottom of Fox Lake prior to project initiation was typified by loose, flocculent muck overlying deposits of shell, clay or sand. Estimates of the muck deposits were 15.5, 19.8 and 42.9 cm for the 30, 60 and 90 cm contour intervals respectively.

Immediately following the 1st dewatering, (May 1979) reductions in depth of 31%, 49% and 47% in the organic layer were recorded; similar to that described by Wegener and Williams (1974).

Final cores were taken in October 1980 and an increase over measurements taken after the 1st dewatering was noted. This was attributed to cattail and millet debris deposited from cutting or die off due to inundation. However, final depth estimates were 29%, 36% and 47% less than those taken prior to the project, and an indurate crust had formed over most of the basin.

CONCLUSION

The experimental water fluctuation schedule was successful despite adverse conditions prevalent during the project. Unseasonable rainfall prevented optimum drying to kill hydrilla and stimulate tuber and turion germination. However, sufficient drying did occur to accomplish hydrilla control, stimulate germination of desirable aquatic native vegetation, and form a "new" lake bottom.

Prior to initiation of the project, cattails grew along the shoreline, however, by termination of the dewaterings this species occurred in dense stands over most of the basin. These stands may offer desirable fish habitat but if uncontrolled will interfere with boating and angling.

Germination of desirable native aquatic vegetation, compaction of the organic layer, and hydrilla control with significant reductions in the relative abundance of tubers and turions, support multiple dewaterings as a management tool for hydrilla control and fishery habitat restoration.

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