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Effect Of Water Level Fluctuation And Herbicide On Eurasian Watermilfoil In Melton Hill Reservoir

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ABSTRACT

Eurasian watermilfoil (*Myriophyllum spicatum* L.) has been a serious aquatic plant pest for over 15 years in the Tennessee Valley. Infestations have been reduced since 1972 in Melton Hill Reservoir by use of special water level fluctuations supplemented by herbicide treatment. Drawdowns of short duration during cold weather effectively reduced infested areas and did not proportionally increase infestations at deeper depths. Field surveys following the atypical cold weather of 1976-77 indicated that periodic exposure of 2-3 days duration to subfreezing temperatures had no effect on watermilfoil rootcrown viability. Prolonged exposure sufficient to freeze the hydrosoil was considered necessary to reduce rootcrown viability. Herbicide treatment with the butoxyethanol ester and dimethylamine salt of 2,4-dichorophenoxyacetic acid (2,4-D) at a rate varying from 22.5 to 45 kilograms of acid equivalent per hectare has provided an effective method of integrating physical and chemical control techniques.

INTRODUCTION

Melton Hill Reservoir is a Tennessee Valley Authority (TVA) multipurpose impoundment on the Clinch River, a major tributary of the Tennessee River. Melton Hill Dam, south of Oak Ridge, Tennessee, impounds a 71 kilometer (km) long reach of the Clinch River. The dam is equipped with hydroelectric generating units and a single navigation lock that accommodates river barge and recreational boat traffic. The typical water level fluctuation consists of frequent low amplitude drawdowns of short duration. The fluctuation takes place at irregular intervals depending on the hydroelectric generation load during periods of peak demand (Figure 1). The usual pool level is about 242.2 meters above mean sea level (m MSL) with frequent short duration drawdowns to 241.3 m MSL. At full-pool level, normally 242.5 m MSL, 2,303 surface hectares (ha) are impounded. There is about 85 ha per 0.3 meter (m) contour in the upper 1.5 m of the fluctuation zone and about 65 ha at each lower 0.3 m contour. Therefore, about 425 ha of the littoral zone are subject to varying periods of dewatering.

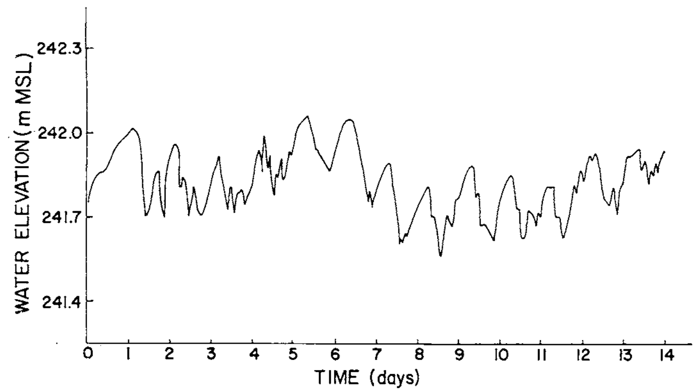

Figure 1. Normal water level fluctuation schedule for Melton Hill Reservoir.

The exotic aquatic angiosperm Eurasian watermilfoil (*Myriophyllum spicatum* L.) was discovered growing in Melton Hill Reservoir in late 1965 when the area of infestation was estimated to be less than 10 ha. Careful examination of colony size, depth, and pattern of infestation indicated that the first colony had been established in the spring of 1964. This species frequently forms dense colonies that interfere with many uses of TVA water resources (6), especially in reservoirs with a difference of only 0.6 to 1.0 m between maximum and minimum water levels (5). Frequency and amplitude of water level fluctuation are known to be primary factors governing littoral vegetation (1), and a slight change in water level can sometimes cause a great change in the response of aquatic vegetation (2). An earlier transplant experiment with Eurasian watermilfoil in the Tennessee Valley indicated that complete dewatering for 21 consecutive days results in plant mortality (3). A drawdown to 239.4 m MSL was conducted on Melton Hill to expose watermilfoil plants within practically all of the infested area during January and February 1966. This deep drawdown greatly reduced the seriousness of the problem, but some plants survived in seepage and moist, silted areas. The Eurasian watermilfoil subsequently recovered to more than its former abundance and by 1971 had spread over an estimated 486 ha, an increase of over 475 ha.

A water level manipulation schedule which incorporates maximum practical drawdowns for several weeks duration is difficult to conduct because of the conflicting demands of various water uses, such as exist for water supplies, navigation, and power generation. The feasible alternatives for watermilfoil control have been to subject the plants to a shallow drawdown (0.8 m) for a long period of time (6 weeks), a deeper drawdown (1.4 m) for a short period of time, and/or treatment with herbicide. The techniques which have been used effectively since 1966 on Melton Hill Reservoir include two different water-level manipulation schedules, herbicidal treatments, and a combination of both of these. The effectiveness of each technique has been evaluated and comparisons made.

METHODS AND MATERIALS

During the winter of 1971-72, a water level schedule was developed which entailed holding the water level fluctuations within upper and lower limits (Figure 2). From December to mid-February the reservoir pool elevation was to be maintained at or below 241.1 m MSL (at least 1.1 m below summer pool level) to increase the probability of exposure of Eurasian watermilfoil to subfreezing or drying conditions. From mid-February through April, the reservoir pool elevation was to be maintained at or above 241.9 m MSL (no more than 0.6 m below summer pool level) to decrease the probability of ecesis of vegetative propagules into the upper littoral zone. Other upper and lower limits were set consistent with these exposure potentials and with expected operating needs. From December to mid-February 1972 the reservoir level was frequently higher than 241.4 m MSL because of the operating needs for electricity production, but other intermediate and upper operating limits were observed. During the following two seasons, water level fluctuation returned to its usual pattern (Figure 1).

During the next year (1973), all visible colonies of Eurasian watermilfoil in Melton Hill Reservoir were treated with 2,4-dichlorophenoxyacetic acid (2,4-D) in the late spring. Over 567 ha were treated with about 18,400 kilograms (kg) of acid equivalent (a.e.) of 2,4-D as a granular formulation of the butoxyenthanol ester (Table 1). Embayments and low dilution areas were treated at a rate of 22.5 kg/ha, while littoral areas exposed to greater water interchange were treated at a rate up to 45 kg/ha. Colonies within 0.8 km of potable water intakes and narrow shoreline colonies on the upper part of the reservoir were treated with dispersal equipment mounted on a boat. All other areas were treated with a dry chemical spreader mounted on a helicopter.

TABLE 1. USE OF 2,4-DICHLOROPHENOXYACETIC ACID IN MELTON HILL RESERVOIR FROM 1971 THROUGH 1976.

Year	Hectares Treated	2,4-D Applied (kg a.e.)	Cost Estimates/ha[1]
1971	12	544	84
1972	24	1,052	126
1973	567	18,366	116
1974	246	11,049	101
1975	127	5,692	227
1976	142	6,350	215

[1] Cost estimates include labor, equipment maintenance, and herbicide expense.

During the 1974 growing season, two formulations of 2,4-D were used to maintain control of Eurasian watermilfoil. About 240 ha were treated with approximately 11,100 kg a.e. of 2,4-D as the dimethylamine salt or as the butoxyethanol ester (Table 1). All treatment was applied by boat crews to readily observable colonies.

Herbicide treatments were again used to maintain control over the watermilfoil infestation in high-use recreation or residential areas during the 1975 and 1976 growing seasons with 127 and 142 ha being treated, respectively. More than 12,000 kg a.e. of the dimethylamine salt or the butoxyethanol ester of 2,4-D were used to treat these areas. During this period a new water level fluctuation schedule was initiated for the reservoir. This manipulation schedule included lowering the water level to about 241.3 m MSL (1.2 m below normal pool) twice a month from September 1975 through March 1976 and again from August 1976

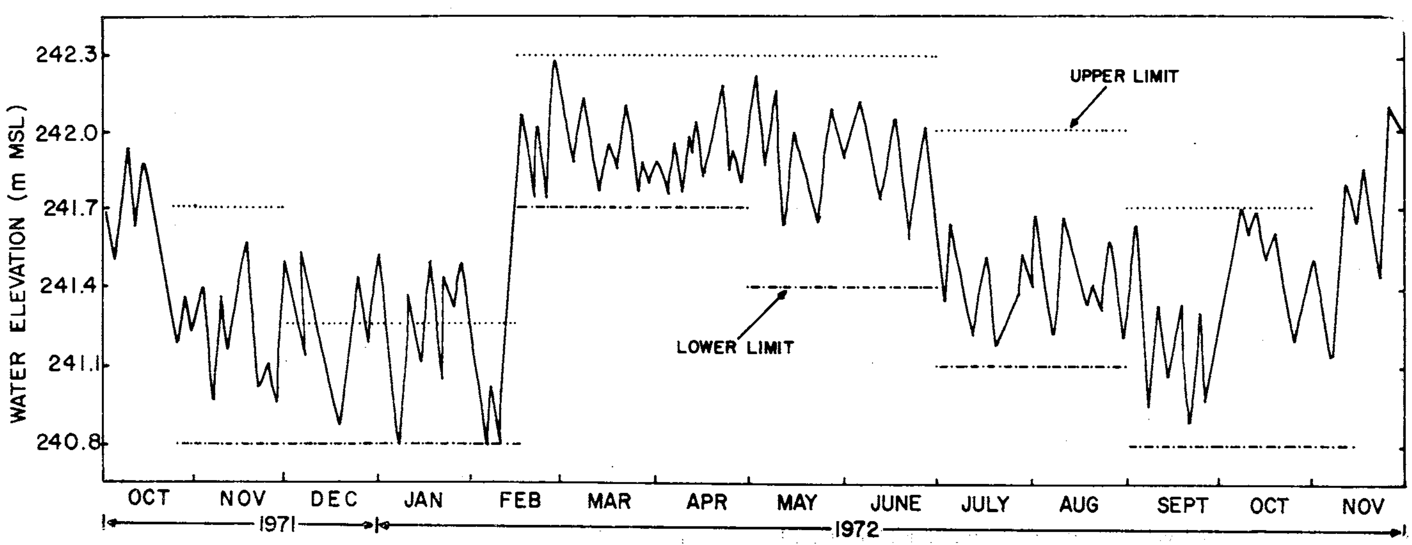

Figure 2. Special water level fluctuation schedule for Melton Hill Reservoir utilized from October 1971 through November 1972.

through March 1977 (Figure 3). The duration of these drawdowns was short, usually lasting two or three days, but the amplitude was great.

Watermilfoil acreage determinations were made each fall during the study period, after control efforts of the previous growing season were completed. During the first two study years (1971-72), percent surface areal cover of watermilfoil was estimated within the reservoir using randomly selected transects and a 1 m^2 quadrat. The quadrat was placed with its midpoint at each one-sixth-meter contour depth interval along each transect and coverage within the quadrat was calculated. The total area of watermilfoil infestation for each one-sixth-meter contour was estimated by multiplying the mean estimate of surface coverage of watermilfoil in selected transects by the area in the reservoir within that contour interval.

From 1973-76 the total area of infestation was calculated using planimetric mapping techniques from base aerial maps. This method was evaluated and accuracy was determined to be comparable to that achieved during the first two years of study.

RESULTS AND DISCUSSION

The water level was consistently lower during 1971 and 1972 than during any other study years as shown by the average midnight headwater elevation for each year (Table 2). The lowest contour elevations reached (Table 2) reflect the extended drawdown during the winter of 1971-72 and the fall-winter fluctuations of 1975-76 and 1976-77. Twenty-one cumulative days of exposure occurred above the 241.3 m contour in 1971 and 1973 and above the 241.1 m contour

TABLE 2. AVERAGE MIDNIGHT HEADWATER ELEVATIONS AND LOWEST WATER ELEVATIONS REACHED FROM 1971-76 ON MELTON HILL RESERVOIR.

Year	Average Midnight Elevation (m MSL)	Lowest Elevation Reached (m MSL)
1971	241.5	240.8 (Dec.)
1972	241.6	240.7 (Jan. & Feb.)
1973	241.8	240.9 (Mar.)
1974	241.9	240.9 (Oct.)
1975	241.8	240.7 (Dec.)
1976	241.8	240.7 (Oct. & Jan.)

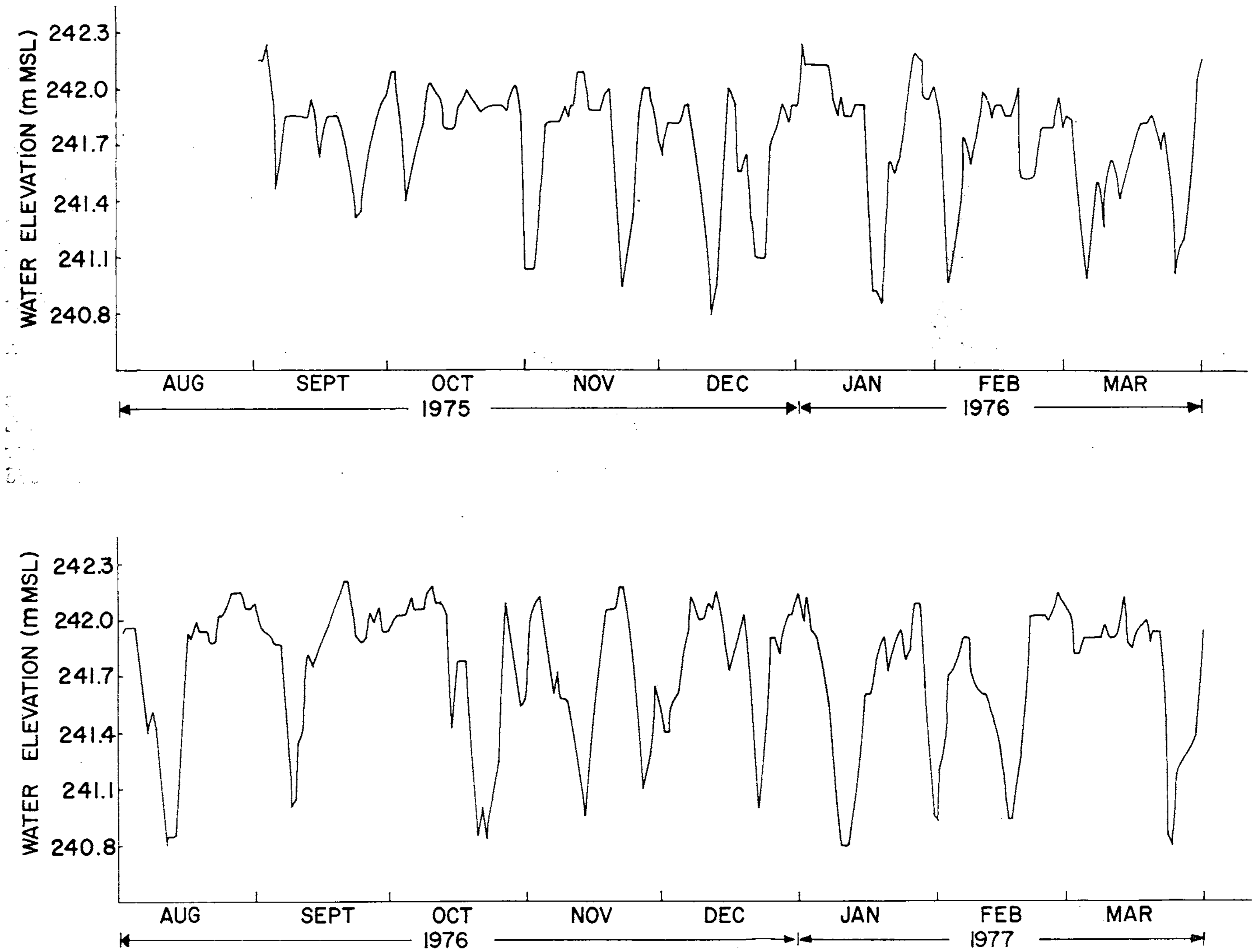

Figure 3. Special water level fluctuation schedule for Melton Hill Reservoir utilized from September through March 1975-76 and August through March 1976-77.

in 1972. Water levels were generally 0.6 m lower in the winter of 1972 than in 1971.

The estimated area colonized was lower at the end of the 1972 season than in 1971 (Table 3) and was attributed to lowering of the water level. The greatest decline in infestation was between 0.8 and 1.5 m below the full-pool level, but some decline in the areal cover of watermilfoil occurred as much as 2.6 m below the full-pool level. These data on contour distribution indicated that Eurasian watermilfoil infestation was greatly reduced in shallow water without an inversely proportional increase in infestations in deeper water using this drawdown scheme.

TABLE 3. ESTIMATES OF THE EURASIAN WATERMILFOIL AREA (HECTARES) REMAINING EACH FALL AFTER SEASONAL CONTROL EFFORTS IN MELTON HILL RESERVOIR FROM 1971 THROUGH 1976.

	Eurasian watermilfoil	
Year	Total area	Decrease[2]
1971	295	0
1972	179	115
1973	57	238
1974	62	233
1975	134	161
1976	72	219

[2] Based on 1971 area.

Estimates of areal cover of watermilfoil in 1973 showed a 68 percent reduction compared with 1972 (Table 3). This is attributable to a twenty-fold increase in 2,4-D applied throughout the reservoir (Table 1) since no special drawdown scheme was employed during 1973. This decline in watermilfoil infestation was equivalent to a reduction of 81 percent when compared with 1971, a year without upper and lower seasonal limits on water level fluctuation. Contour distribution in 1973 indicates watermilfoil infestations did not decline proportionately in both the deep and shallow portions of the depth distribution range. For example, both the lakeward and shoreward edges of the colonies had moved into shallower water, but the lakeward edges had moved a greater distance. To some extent this was probably an adjustment to the discontinuation of the limits on water level fluctuation from the previous year. However, comparison of depth distributions of 1971 with those of 1973 indicates that deep-water colonies were more sensitive to 2,4-D treatments than shallow-water colonies. This was probably due to a reduction in photosynthesis of shallow-water plants caused by siltation.

In 1974, areal coverage of Eurasian watermilfoil remained about the same as that for the previous year despite a reduction in the quantity of 2,4-D applied (Table 3). This suggested that Eurasian watermilfoil colonies could be maintained at a low level of infestation by using less herbicide than is normally needed to reduce colonies from a high level to a low level. Areal distribution by contours was the same in 1974 as in 1973, and there appeared to be no difference in depth selectivity as a result of selective control herbicide treatments versus total treatment with herbicides.

Following the 1975 growing season, when special water level controls were not maintained, watermilfoil areal coverages were double those of the previous year. The major portion of this increase, however, corresponded to a 50 percent reduction in the amount of 2,4-D applied.

During 1976 the watermilfoil infestation was again reduced to a "balanced-control" infestation which was similar to the infestation in 1974, even though the quantity of 2,4-D applied remained about the same as in 1975. This reduction was attributed to the special semi-monthly drawdowns which were employed during the winter of 1975-76. Based on preliminary data the semi-monthly drawdowns during the 1976-77 winter have been effective in maintaining innocuous infestations.

A survey in March 1977 was made to determine the effects of the unusually severe winter of 1976-77 combined with the semi-monthly drawdowns on subterranean watermilfoil rootcrown viability. No rootcrowns were found above the 241.4 m MSL contour within the zone of prolonged exposure while all of the perennating rootcrowns below the minimum water level (241.4 m MSL) were viable. Therefore, it is concluded that the synergistic effects of herbicides and semi-monthly winter drawdowns eliminated watermilfoil above 241.4 m MSL in Melton Hill Reservoir while the harsh winter of 1976-77 did little to reduce the infestation within the deeper contours. Most of the hydrosoil in which viable rootcrowns were found was not completely dewatered nor was soil moisture significantly depleted during the cold winter temperatures.

An evaluation of the effect of the programmed water level fluctuation for Melton Hill Reservoir during the winter of 1971-72 indicated that Eurasian watermilfoil was completely eliminated at contours that were dewatered for three cumulative weeks or longer. A significant reduction in infestation occurred at lower elevations that were dewatered for shorter periods of time. A partial reduction in areal cover occurred at some elevations that were continually inundated. Similar control results were achieved by semi-monthly drawdowns during the winters of 1975-76 and 1976-77 without holding the water level within defined limits for prolonged periods of time. The factors that govern growth and persistence of Eurasian watermilfoil in shallow water are not positively known, but temperature and turbidity are two likely factors. It has been demonstrated that a decrease in standing crop of watermilfoil occurs as a result of special low water levels during cold weather (5). Siltation on the shallow water edge of infestations of Eurasian watermilfoil also appears to be greater than siltation on plants in deeper water, thereby decreasing the photosynthetic rate and increasing the mechanical stress forces.

Herbicidal treatment of colonies throughout the entire reservoir has been effective in reducing the total infestation of Eurasian watermilfoil; however, surviving colonies remain throughout the reservoir, and reinfestation will occur at a rapid rate unless annual treatments with herbicide and/or special low water levels are used to maintain a satisfactory level of control. A combination of "maintenance" herbicide treatments and high frequency, short duration winter drawdowns seems to be most effective and economical for control of Eurasian watermilfoil on Melton Hill Reservoir.

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