# Effects of Season and Water Depth on Eurasian Watermilfoil

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## ABSTRACT

Eurasian watermilfoil (*Myriophyllum spicatum* L.), an exotic, submersed aquatic macrophyte in the Tennessee Valley, was studied to determine distribution by contour levels and seasonal variation in two Tennessee Valley Authority (TVA) reservoirs—Melton Hill and Guntersville, In Melton Hill Reservoir standing crop of this species showed growth phases in summer and in winter and decline phases in autumn and in spring. Plants in Guntersville Reservoir began to decline in July rather than September, reached winter levels of standing crop by September, and showed no winter growth phase. The average standing crop in Guntersville Reservoir was only one third of that in Melton Hill Reservoir. Plants in the shallow water contour of the main band of Eurasian watermilfoil in Melton Hill Reservoir grew more rapidly in the summer, reached a greater maximum amount, and began declining earlier than plants rooted at other contours. Sampling relative to the water surface and conversion to mean sea level elevation using headwater elevations gives results which are comparable for different seasons.

## INTRODUCTION

Eurasian watermilfoil, a perennial, submersed aquatic angiosperm introduced into Watts Bar Reservoir in the 1950's (25), can be detrimental to multipurpose water use.[2] In a given year, it has infested as many as 10,125 ha in the Tennessee Valley reservoirs, and TVA has spent many thousands of dollars in control efforts (24). Much of the expense of control operations is the purchase of (2,4-dichlorophenoxy)acetic acid (2,4-D), a highly effective herbicide (25). Alternate methods of control are being sought to minimize the necessity for chemical application (24).

One method that has received limited testing is water level drawdown. Continuous exposure for 21 days above the water level in January is sufficient to kill plants of Eurasian watermilfoil (23). Complete drawdown below established colonies is seldom possible, and long-term lowering of water levels is frequently incompatible with other uses of a multipurpose reservoir system; therefore, it is of value to know the effects of short-term drawdowns and of water level fluctuations that do not completely strand the plants.

Limitation of terrestrial and emergent plants by water levels is well known (2, 3, 4). Growth in contour zones is also well known for algae (10, 29) and emergent and submersed aquatic angiosperms (2, 17, 18). Many factors govern zonation of emergent plants, including requirements for seed germination and tolerance to different degrees of flooding (2, 4). Photosynthesis apparently is the principal factor that governs the lower limit of growth of submersed aquatics (15, 16, 19), even though some aquatic plants grow saprophytically entirely below their compensation point (7). Hydrostatic pressure has been excluded as a factor governing the lower limit of *Sargassum* (5).

Different species of aquatic plants that are normally submersed have different tolerance to dewatering. The photosynthesis of littoral algae during atmospheric exposure, for example, is related to their usual elevation within the tidal zone (8). Freshwater angiosperms show similar variation in dewatering tolerance (2), which may be one of the principal factors governing their limit of growth in shallow water. However, submersed macrophytes can be absent from shallow water for reasons not well understood (26). Plants of *M. exalbescens* were found restricted to depths greater than 20 cm (6), and *Myriophyllum* sp. was found only in depths greater than 50 cm (26). In the Tennessee Valley, Eurasian watermilfoil was limited in some locations to water depths greater than 80 cm below mean water level (30). Some workers have found maximum photosynthesis in some species below the surface of the water (21, 22), but others claim that maximum photosynthesis occurs at the surface (11, 13, 14). Inhibition of photosynthesis by light levels above optimum could explain the absence of submersed macrophytes in shallow water, but there is no evidence to indicate that this is true for Eurasian watermilfoil (27).

Changes in water levels other than seasonal fluctuation can have detrimental effects on submersed aquatic species. A change of as little as 7.6 cm is known to shift their distribution relative to water depth and to reduce maximum standing crop as much as 19% the following year (20). Water level fluctuation per se can be detrimental to some

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[2] Tennessee Valley Authority. 1972. Environmental Statement, Control of Eurasian watermilfoil (*Myriophyllum spicatum* L.) in TVA reservoirs. Chattanooga, Tenn. 22 pp., 3 appendices.

submersed aquatic plants (12). Growth of coontail (*Ceratophyllum demersum* L.), duckweeds (*Lemna minor* L., *Spirodela polyrhiza* L. Schleid. and *Wolffia* sp.), and southern naiad (*Najas guadalupensis* (Spreng.) Magnus) and seed production of several species were greater in lakes with stable water levels than in those with fluctuating water levels (1, 9).

Special water level fluctuations on Melton Hill Reservoir have resulted in a decrease in surface acreage of Eurasian watermilfoil growing below the minimum water level during dewatering.[3] The repeated stress of low and high water levels could have a considerable detrimental effect on aquatic plants by upsetting metabolic relationships.

The purpose of this research was to develop techniques sufficiently sensitive to detect small changes in populations of aquatic macrophytes and to use these techniques to determine the growth within different reservoirs during an entire annual cycle at various depths. Eurasian watermilfoil was studied because of its availability and the potential for practical application of the results in solving a weed problem in Tennessee Valley reservoirs.

## METHODS AND MATERIALS

Samples of Eurasian watermilfoil were collected from field locations at about 4-week intervals. Five transects were arbitrarily placed at right angles to the shore at sampling locations. Plants were collected at the shallowest locations and at about 15-cm contour intervals thereafter. All plant parts above the ground within a 0.1-$m^2$ metal frame were collected and labeled with strips of waterproof plastic or paper on which an identification code was written. Water depth was measured with a stadia rod marked at 0.3-cm intervals; data on depth were converted to contour elevation above mean sea level by using headwater elevations at Melton Hill Dam at the time of collection. Collections from depths below 1.0 m were made by SCUBA (self-contained underwater breathing apparatus) divers.

Sampling locations were in Melton Hill Reservoir, near Oak Ridge, Tennessee, and in Guntersville Reservoir, near Scottsboro, Alabama. In Melton Hill Reservoir samples were taken from shallow water out to the maximum depth at which the species occurred. In Guntersville Reservoir samples were taken from shallow water out to the water depth that appeared to support the maximum plant biomass or just beyond this depth.

Plants were transported in plastic bags to the laboratory for processing. Roots, debris, and loosely adhering algae were removed by hand and by rinsing in tap water. The plants were spread on paper towels in porcelain pans, dried overnight at 70 C, weighed and ground with a Wiley mill. Subsamples of pulverized plants that weighed 3 to 4 g were placed in 30-ml crucibles, dried overnight at 70 C, weighed, ashed at 600 C for 2 hr, and weighed again. The weight loss of the subsample was used to calculate ash-free weight of the entire sample. All data were converted to ash-free dry weight because of the known dependence of fresh weight and ash weight of Eurasian watermilfoil on water depth.[4]

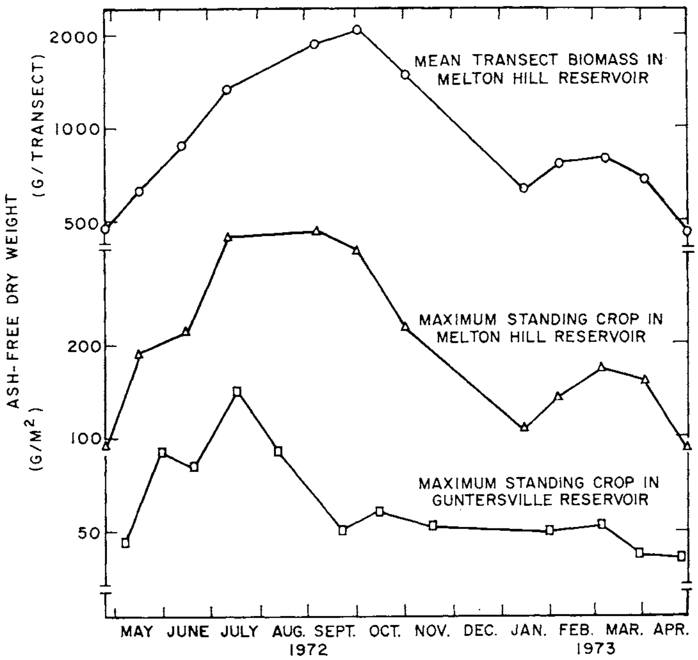

Figure 1. Variation of standing crop and mean transect biomass of Eurasian watermilfoil with season of year—Guntersville and Melton Hill Reservoirs. Mean transect biomass is the sum of means of standing crop along a transect.

## RESULTS AND DISCUSSION

Variation of standing crop with season was different in the two reservoirs (Figure 1). A growth phase began in May in both reservoirs, but decline occurred in August and September for plants in Guntersville Reservoir but not until October, November, and December in Melton Hill Reservoir. There was also a definite winter regrowth and subsequent spring decline of standing crop in Melton Hill Reservoir but not in Guntersville Reservoir. In addition to these qualitative differences in growth pattern, there was a consistent difference in maximum standing crop; at a given time Melton Hill Reservoir generally supported about three times the standing crop of plants present in Guntersville Reservoir. The maximum standing crop in the summer in Guntersville Reservoir was barely greater than that in winter in Melton Hill Reservoir.

The decline of the standing crop of Eurasian watermilfoil in Guntersville Reservoir in early summer and its lower density (Figure 1) indicate that Melton Hill Reservoir, during the course of this study, was a more favorable location for this species. One difference in the two locations is in the schedule of water level fluctuation. Guntersville Reservoir has a maximum fluctuation of 0.7 m in a year; that in Melton Hill Reservoir is 1.2 m per year. Both have small differences (0.1 to 0.3 m) between average summer and average winter levels. This suggests the possibility

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[3] R. A. Stanley. 1975. Unpublished data.

[4] Unpublished memorandum report "Preliminary Report on Results of Water Depth Study of *Myriophyllum spicatum* L." R. A. Stanley to T. F. Hall, May 26, 1972.

that wide fluctuation increases amount of Eurasian watermilfoil.

Other differences between these two reservoirs may also be important in governing plant density. The location in Guntersville Reservoir had been infested for 9 of the past 10 years and had been infested continuously for the 6 years before this study. The Melton Hill location, on the other hand, had been infested only 4 of the past 6 years and had been infested continuously for only 3 years. Although no data are available, we believe that the Eurasian watermilfoil was much more dense in Guntersville Reservoir in the early years of infestation.

If that is true, it suggests the possibility that long periods of colonization deplete essential nutrients, increase detrimental by-products, or change populations of associated organisms to the detriment of watermilfoil. On the other hand, the standing crops of the oldest colonies in Melton Hill Reservoir were twice as dense as younger colonies (30).

Temperature may also be influential, not only by effects on growth but also by effects on attrition. Guntersville Reservoir is warmer than Melton Hill Reservoir and attribution there may be greater. However, in Melton Hill Reservoir, standing crop is greatest in locations with the highest temperatures (30). It is impossible to conclude from the present data which, if any, of these three possibilities (water level schedule, temperature or length of colonization) may cause the dramatic differences between populations in Melton Hill and Guntersville Reservoirs.

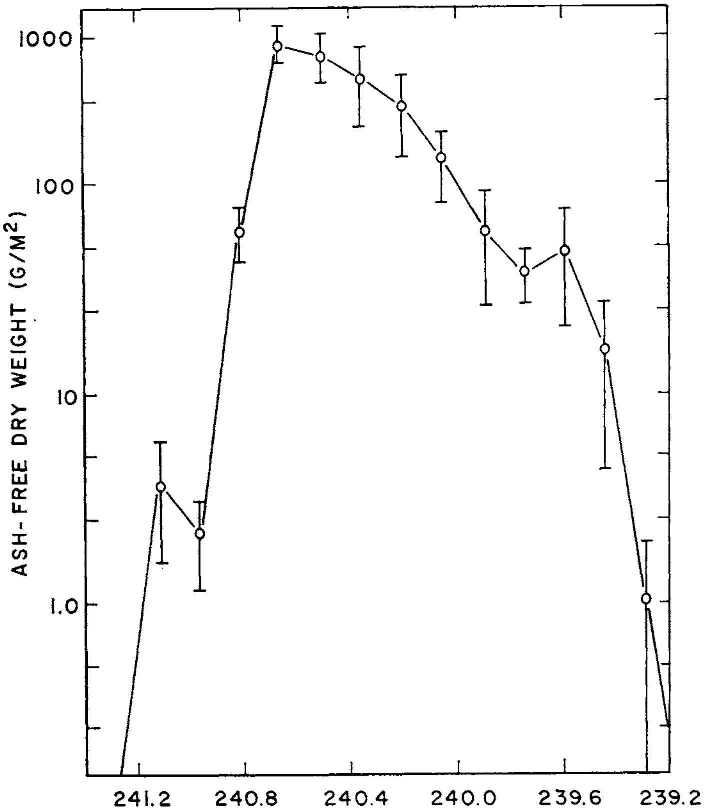

Figure 2. Standing crop of Eurasian watermilfoil at various contour elevations—Melton Hill Reservoir, 13 July 1972 (circle is mean of five determinations; brackets indicate one standard error on each side of mean).

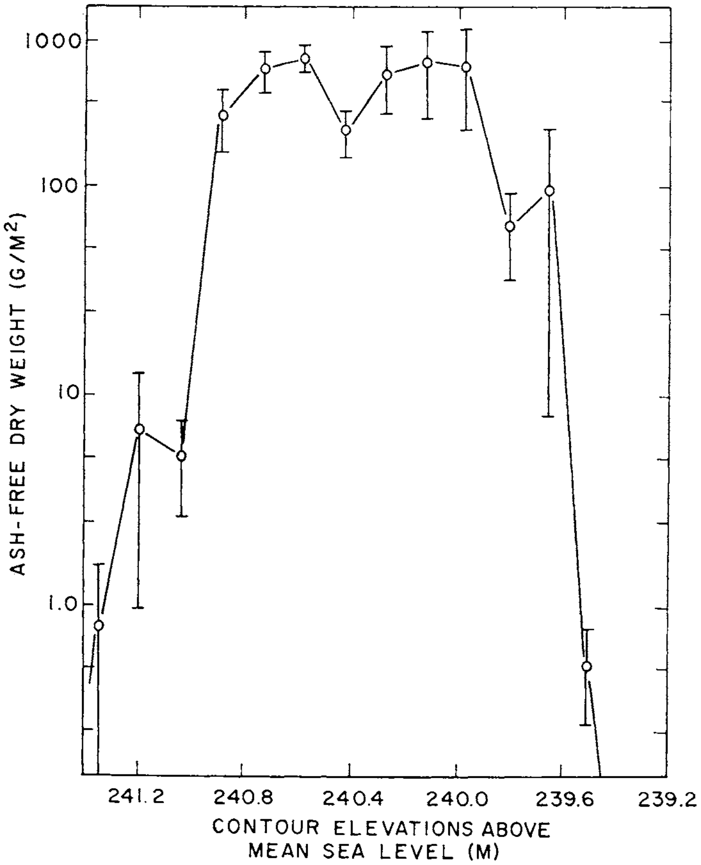

Figure 3. Standing crop of Eurasian watermilfoil at various contour elevations—Melton Hill Reservoir, 3 October 1972.

The mean of standing crop determined in Melton Hill Reservoir at different contours were summed to obtain a "mean transect biomass" independent of contour and slope (17). The mean transect biomass followed the same general seasonal changes as maximum standing crop except for September and October (Figure 1). This difference in curves emphasizes the following seasonal sequence. During the summer growing season, standing crop of Eurasian watermilfoil reached a sharp maximum in shallower water, gradually lessened to about 239.6 m (MSL), and sharply lessened in deeper water (Figure 2). Standing crop at 240.7 m (MSL) began declining in early autumn, while some colonies below 240.4 m (MSL) were increasing (Figure 3). For the remainder of the year, rate of decrease was proportional to standing crop (Figure 3). Eurasian watermilfoil in shallow water did not grow more rapidly than that in deeper water during the winter (Figure 5).

This difference in standing crop peaks at different times depending on water depth (Figures 2 and 3) was previously noted with a bulrush (*Scirpus subterminalis* Torr.) (17) and suggested by data on Eurasian watermilfoil (30). Results reported here suggest that excessive density (400 g/m²) is detrimental to the plant populations and can result in a decline in standing crop even while adjacent colonies continue to grow. A dense population might interact with an environmental variable, such as decreasing

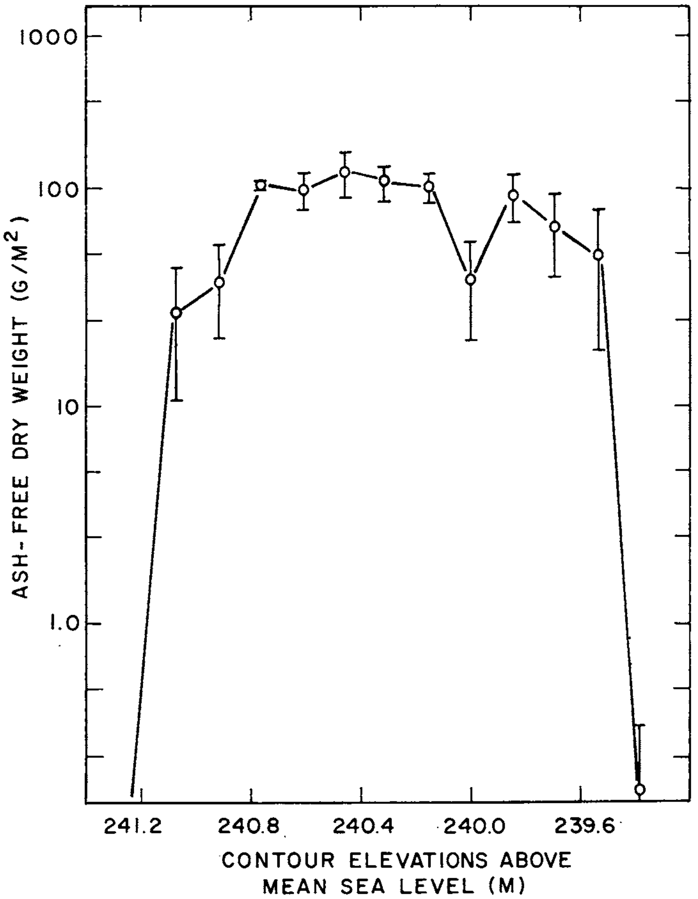

Figure 4. Standing crop of Eurasian watermilfoil at various contour elevations—Melton Hill Reservoir, 17 January 1973.

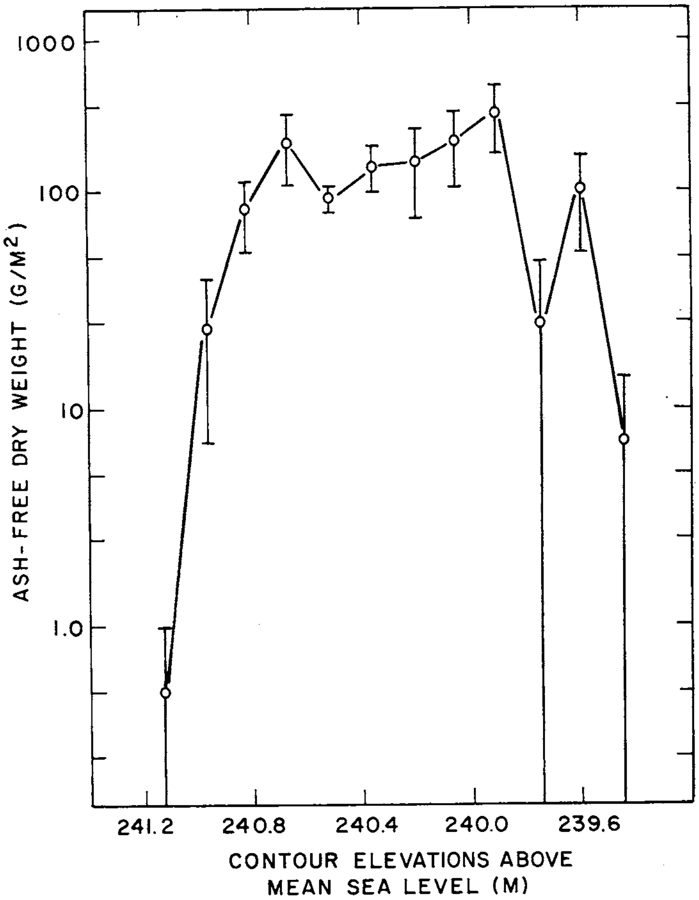

Figure 5. Standing crop of Eurasian watermilfoil at various contour elevations—Melton Hill Reservoir, 7 March 1973.

availability of light, that later triggers the decline of the entire colony.

The winter growth phase following the autumn decline (Figure 1), though surprising, is not without precedent; *S. subterminalis* not only grows under ice cover during winter, but the winter biomass is greater than the maximum biomass in summer (17). This may be largely because of low levels of attrition rather than an unexpectedly high growth rate. The formation of abscission fragments by Eurasian watermilfoil is well known (28, 30) and may be favored by certain combinations of temperature or photoperiod that occur in the autumn and again in the spring.

During the summer it was easy to observe, but difficult to sample by random procedures, a strandline of plants rooted shoreward from the main band of dense colonies (Figure 2). These plants above 241.1 m (MSL) had been largely eliminated by January (Figure 4). This disappearance of rooted Eurasian watermilfoil plants in the strandline is difficult to understand on the basis of low water levels. Between 3 October 1972 (Figure 3), and 17 January 1973 (Figure 4), the shallowest water in which plants were established changed from the 241.4-m contour to the 241.1-m contour, a difference of about two sampling points. During this same period, the water level was below the 241.31-m contour on one occasion, below the 241.34-m contour for a total of only 1 day, and below the 241.40-m contour for 7 days. In the light of previous results, which indicated that 21 days were required to kill all individuals by dewatering (23), it is difficult to understand how these plants failed to survive. One possible explanation is that these plants succumbed to the stresses that preclude plants from shallow-water locations (26).

The consistency of the location of colonies of Eurasian watermilfoil relative to mean sea level from month-to-month indicates the validity of using headwater elevations to correct for water level differences at different sampling times. In one case not reported herein data were inconsistent with both previous and following months. Apparently a misunderstanding between a person sounding the depth and a person labeling the samples resulted in all data being shifted one sampling point deeper than they actually occurred. With proper care in labeling, this technique is very usable for determining the true contour elevation of aquatic macrophytes in fluctuating reservoirs.

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