

Aquatic Vegetation in Guntersville Reservoir Following Grass Carp Stocking

by

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Introduction

Guntersville Reservoir is a large (27,500-ha, 122-km-long) impoundment of the Tennessee River in northeastern Alabama and southeastern Tennessee and is one of several impoundments operated by the Tennessee Valley Authority (TVA). The reservoir is a multipurpose project that provides for navigation, flood control, power production, recreation, and other uses. Dams at the downstream and upstream ends of the reservoir have hydropower generation units and locks for commercial navigation.

Several exotic submersed macrophytes such as Eurasian watermilfoil (*Myriophyllum spicatum*), spinyleaf naiad (*Najas minor*), hydrilla (*Hydrilla verticillata*) and native species such as southern naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), American pondweed (*Potamogeton nodosus*), small pondweed (*Potamogeton pusillus*), muskgrass (*Chara zeylandica*), and other aquatic macrophytes have created reservoir-use conflicts requiring control in several areas of Guntersville Reservoir. The TVA uses drawdowns and herbicides to control nuisance populations of aquatic macrophytes along developed shorelines, marinas, public-use sites, and commercial recreation areas on Guntersville Reservoir and several other reservoirs in the Tennessee River system (TVA 1994).

In the late 1980s, aquatic macrophytes colonized about 8,200 ha or about 29 percent of the reservoir's surface area. Hydrilla, which was first discovered in Guntersville Reservoir in 1982, colonized about 1,160 ha in 1988 and

was considered a long-term threat to multiple uses of Guntersville Reservoir, as well as several other reservoirs within the TVA system.

As a result of public concerns, TVA and the U.S. Army Corps of Engineers were asked to develop a 5-year plan for reducing submersed aquatic plants in Guntersville Reservoir and to develop and demonstrate more efficient and effective methods of managing aquatic vegetation (Bates, Decell, and Swor 1991). The project, referred to as the Joint Agency Guntersville Project (JAGP), was initiated in 1990 and will continue through 1994.

Grass Carp Demonstration

One component of the JAGP was a large-scale demonstration with grass carp to control hydrilla and reduce populations of other aquatic macrophytes. After preparation of an environmental assessment (TVA 1990), TVA released 100,000 triploid grass carp in Guntersville Reservoir from April to July 1990. This release was equivalent to about 17 fish/vegetated hectare based on aquatic macrophyte coverage measured in 1989. An additional 20,000 grass carp were released in Guntersville Reservoir from 1987 to 1989, primarily by private citizens or lake user groups. Thus, density of grass carp following the stocking of the 100,000 fish in 1990 was estimated to be about 20 fish per vegetated hectare. Incremental stocking of grass carp was planned for the demonstration; but because of unexpected declines in vegetation coverage during the first year of the study, no additional grass carp were released by TVA.

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A monitoring program began in 1990 to document changes in coverage and composition of aquatic macrophyte communities to provide an assessment of grass carp herbivory and to provide supportive data for other assessments, such as fisheries (see Wrenn et al., this volume) and other projects associated with the JAGP. A summary of aquatic macrophyte monitoring results for 1990 to 1992 can be found in Webb (1993).

Prior to this demonstration, studies with grass carp were conducted on Guntersville Reservoir by TVA in a 160-ha screened embayment (TVA 1987, 1989). Bain (1993) also studied grass carp movement within Guntersville Reservoir. While these studies provided a basis for the grass carp demonstration, the numerous uncertainties associated with use of grass carp in large systems (Nobel, Bettoli, and Betsill 1986; Bain 1993) required a reservoir-scale approach to address various questions. Knowledge from the JAGP demonstration will be used to evaluate whether grass carp should be used in other reservoirs within the TVA system.

Materials and Methods

Quantitative sampling of aquatic macrophyte communities has been conducted since 1990 at several locations in Guntersville Reservoir from Tennessee River Mile (TRM) 356.0 to TRM 394.2. Aerial photography has been acquired annually since the late 1970s by TVA's aquatic plant management program and is used as supportive baseline data. Representative data from selected sampling sites (Figure 1) have been included in this report with a generic description of methods.

Coverage of aquatic macrophytes was determined from large-scale (1:7200), color aerial photography acquired annually during September or early October when biomass is typically at its peak. Aquatic macrophyte colonies were delineated on mylar overlays attached to the photographic prints and labeled by species. Area of delineated colonies was obtained using an electronic planimeter.

Aboveground biomass was collected using an open-ended plexiglass box sampler with a sampling area of 0.25 m², a hydraulically operated aquatic plant sampler developed for the U.S. Army Corps of Engineers Aquatic Plant Control Research Program (Sabol 1984) having a sampling area of 0.39 m², or with a mechanical harvester with a cutting head width of 1.6 m. The box sampler was used in shallow-water sites that were generally less than 1 m deep. The hydraulically operated sampler and the mechanical harvester were used to sample deeper water sites (1 to 4 m). Wet weights of plant samples were obtained after spinning the samples in a washing machine for 6 min.

The aquatic plant community at many of the shallow-water sites frequently was composed of a mixture of species such as spinyleaf naiad, southern naiad, muskgrass, small pondweed, and horned pondweed (*Zannichellia palustris*). Because of the excessive amount of the time required to separate individual species, wet weights for this group of plants were determined collectively for each sample. They have been labeled annuals for purposes of this report, although species such as horned pondweed may be a perennial plant. Species such as Eurasian watermilfoil, hydrilla, American pondweed, and coontail were individually separated and weighed, but their wet weights occasionally were summed.

Exclosures were constructed in the late winter or early spring of 1992 and 1993 from wire or block-nets having openings or mesh size small enough to exclude grass carp. Size of exclosures varied from 1 m² to as large as 2 ha.

Results

Coverage of submersed aquatic macrophytes on Guntersville Reservoir almost doubled from about 4,360 ha in 1984 to 7,830 ha in 1988 during a period of record drought in the Tennessee Valley (Figure 2). Lowest macrophyte coverage was about 2,010 ha in 1991, the second year after the large-scale grass carp

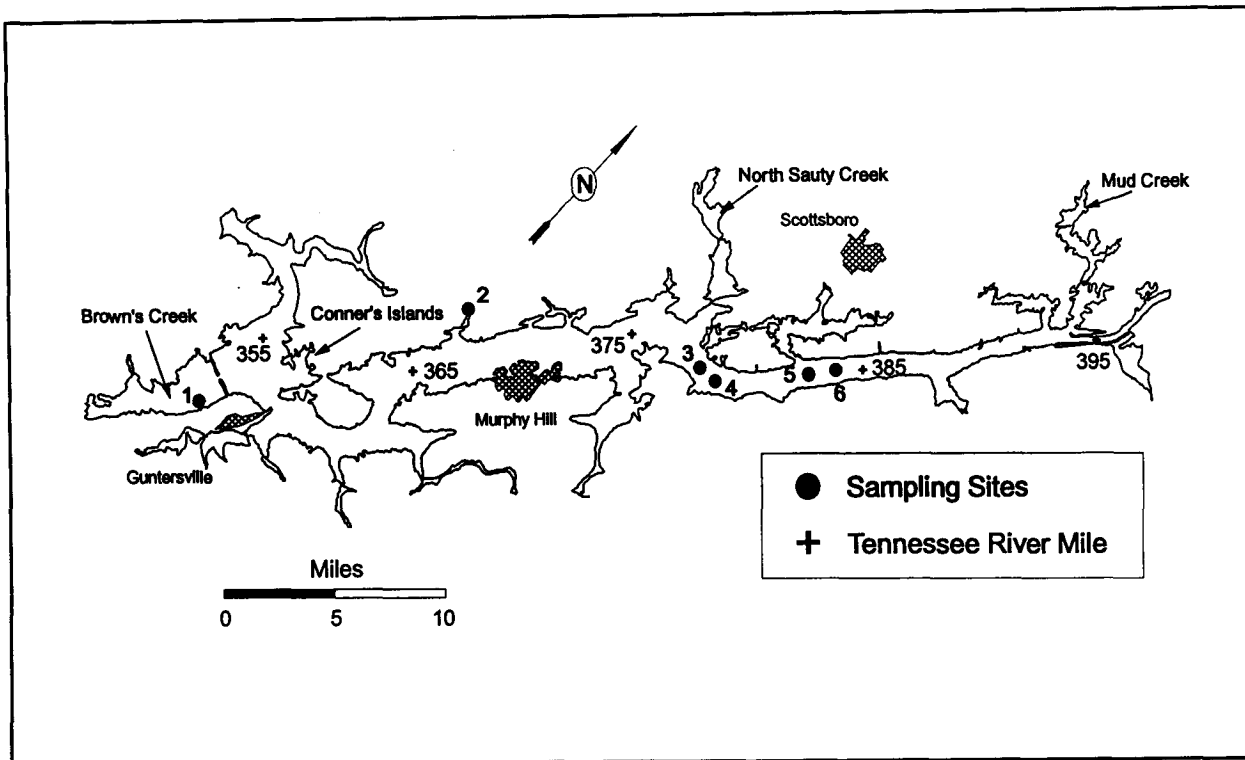


Figure 1. Locations of selected aquatic macrophyte sampling sites on Guntersville Reservoir (1 = Brown's Creek, 2 = Mill Creek, 3 = Powerline Milfoil, 4 = Powerline Hydrilla, 5 = Chisenhall Shallow, 6 = Brewster Hydrilla)

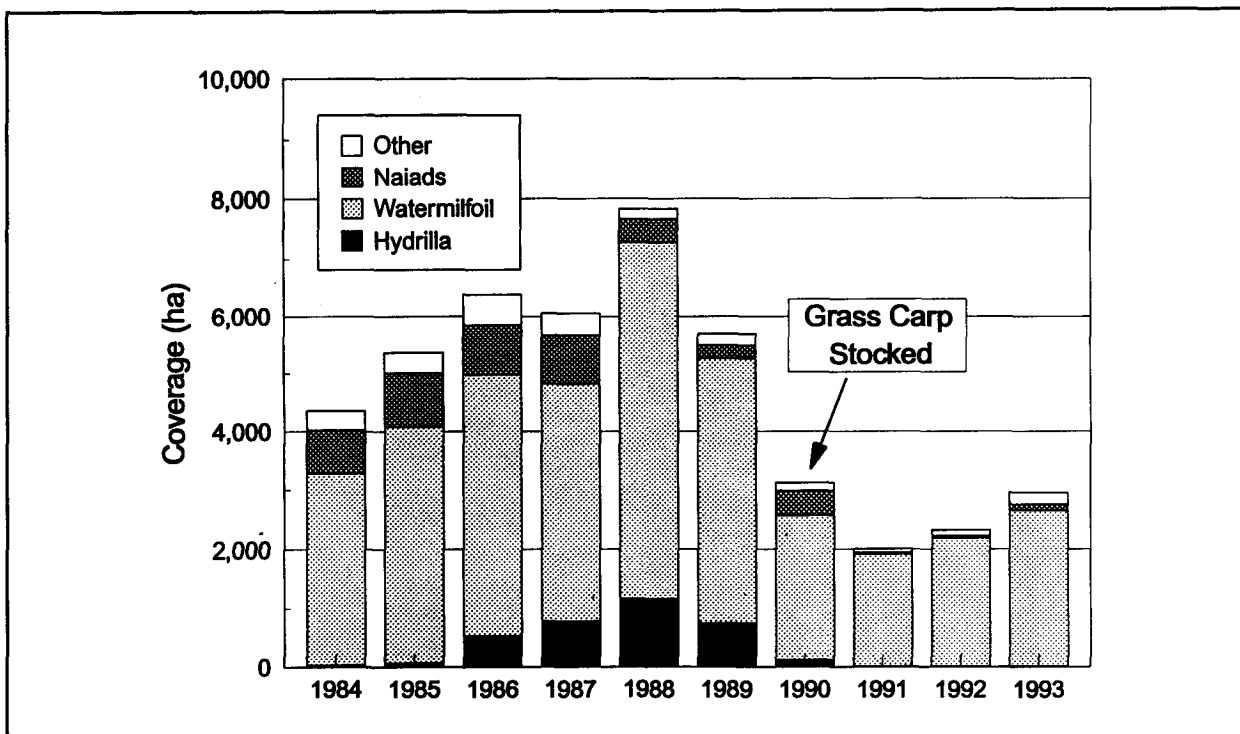


Figure 2. Submersed aquatic macrophyte coverage determined from aerial photography on Guntersville Reservoir from 1984 to 1993

stocking. Since 1991, macrophyte coverage has increased on Guntersville Reservoir and was about 2,960 ha in 1993.

Since the stocking of grass carp, coverage of several species such as spinyleaf naiad, southern naiad, small pondweed, muskgrass, and hydrilla declined, then showed evidence of regrowth. Naiads, which colonized about 410 ha in 1990, declined to less than 30 ha in 1991, but increased to about 100 ha in 1993. Since 1991, colonies of naiads, muskgrass, and narrow-leaved pondweeds generally occurred as small colonies in very shallow water or in shallow subembayments that were isolated from the main reservoir.

Hydrilla, which colonized about 750 ha in 1989 (the year prior to the large-scale grass carp stocking), declined to about 130 ha in 1990 and to less than 1 ha during subsequent years (Figure 2). The 130 ha of hydrilla in Guntersville Reservoir in 1990 was primarily in overbank habitats along the old river channel from TRM 378 to TRM 384. The only hydrilla colonies visible at the surface in Guntersville Reservoir in 1991 and 1992 were about 1 ha in coverage and occurred as a narrow band in the vicinity of TRM 390.5. This colony and another in a backwater slough in the same vicinity were "topped out" in 1993. Widely scattered plants of hydrilla also were visible in 1993 at the surface at TRM 368.7 at the downstream end of a submersed island (Pine Island) that was colonized by more than 100 ha of hydrilla in 1988.

Eurasian watermilfoil coverage was about 80 percent of the total submersed macrophyte coverage in 1989 and 1990 and about 90 to 95 percent of the total in 1991, 1992, and 1993 (Figure 2). From 1990 to 1991, several large colonies of Eurasian watermilfoil "disappeared" from the portion of the reservoir downstream of TRM 373. Beginning in 1992, Eurasian watermilfoil recolonized some overbank habitat from TRM 363 to 373, but is still sparse in downstream overbank habitat and embayments from TRM 354 to 358 where it was abundant in 1990.

A decline in submersed aquatic macrophyte coverage comparable with Guntersville Reservoir occurred in other mainstream TVA reservoirs such as Kentucky, Wheeler, and Chickamauga reservoirs from 1988 to 1990 (Figure 3). The increase in macrophyte coverage from 1984 to 1988 was related to optimum growth conditions (low flow and clear water) associated with record drought years, while the decline from 1988 to 1990 was caused largely by high flows and associated factors. Since 1990, submersed aquatic macrophytes have increased on these reservoirs and, with the exception of Chickamauga, exhibit trends comparable with Guntersville Reservoir. The increase corresponds to the return to more normal flow and growth conditions in the Tennessee Valley.

Biomass and Community Composition

A comparison of biomass from 1990 to 1992 of various macrophyte species from shallow-water sampling sites showed an almost total loss or significant decline in spinyleaf naiad, southern naiad, muskgrass, and small pondweed, which typically dominate the annual aquatic plant community. This occurred not only in Mill Creek embayment (Figure 4), but at other shallow-water sampling sites in North Sauty Creek and Mud Creek embayments. In 1993, the annual plant community increased at the Mill Creek site (Figure 4) and at the sample site in Mud Creek embayment. In North Sauty Creek embayment that had a mean depth of about 1 m, regrowth of annuals did not occur, and Eurasian watermilfoil occurred in monospecific stands.

Field observations from other portions of Guntersville Reservoir during 1990 to 1992 indicated a similar reservoirwide trend for annual plants in shallow-water habitat. In 1991 and 1992, the annual plant community was almost totally absent except in shallow-water habitats that were only a few centimeters deep and in small coves that had beaver dams or other physical barriers to grass carp movement.

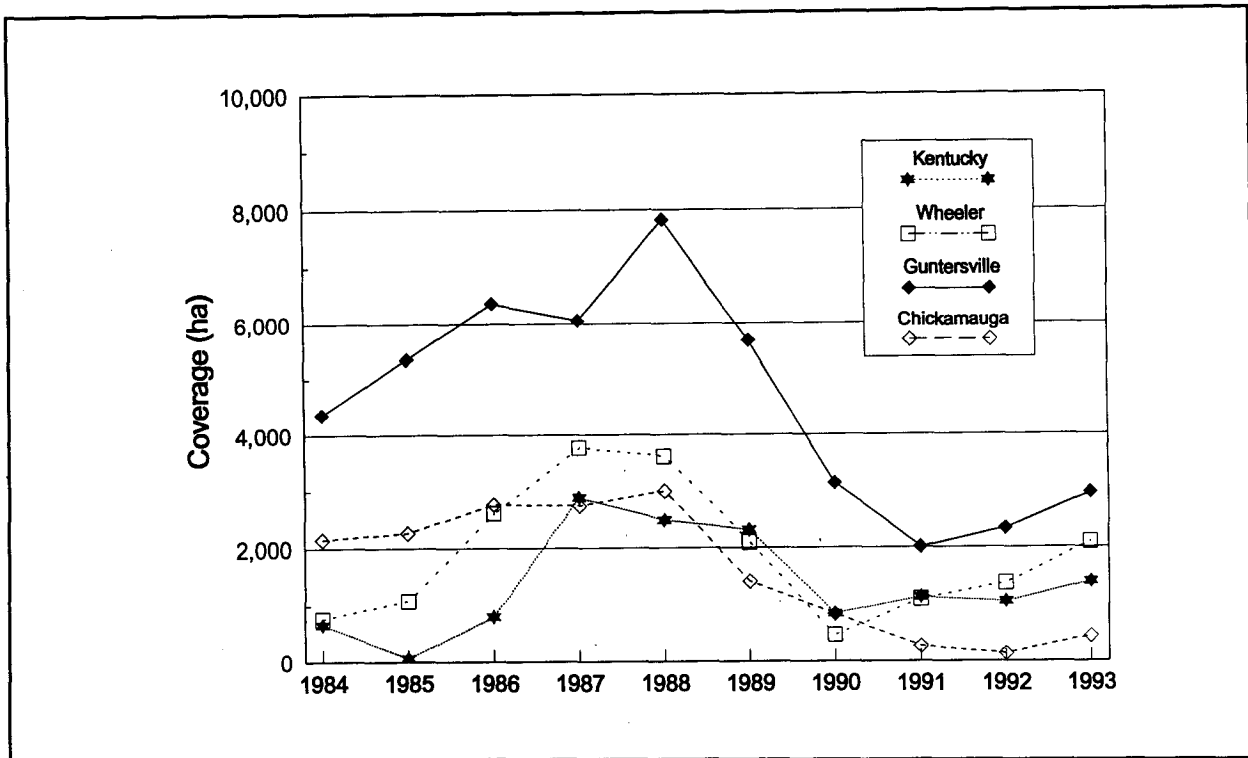


Figure 3. Aquatic macrophyte coverage determined from aerial photography on Kentucky, Wheeler, Gunterville, and Chickamauga Reservoirs from 1984 to 1993

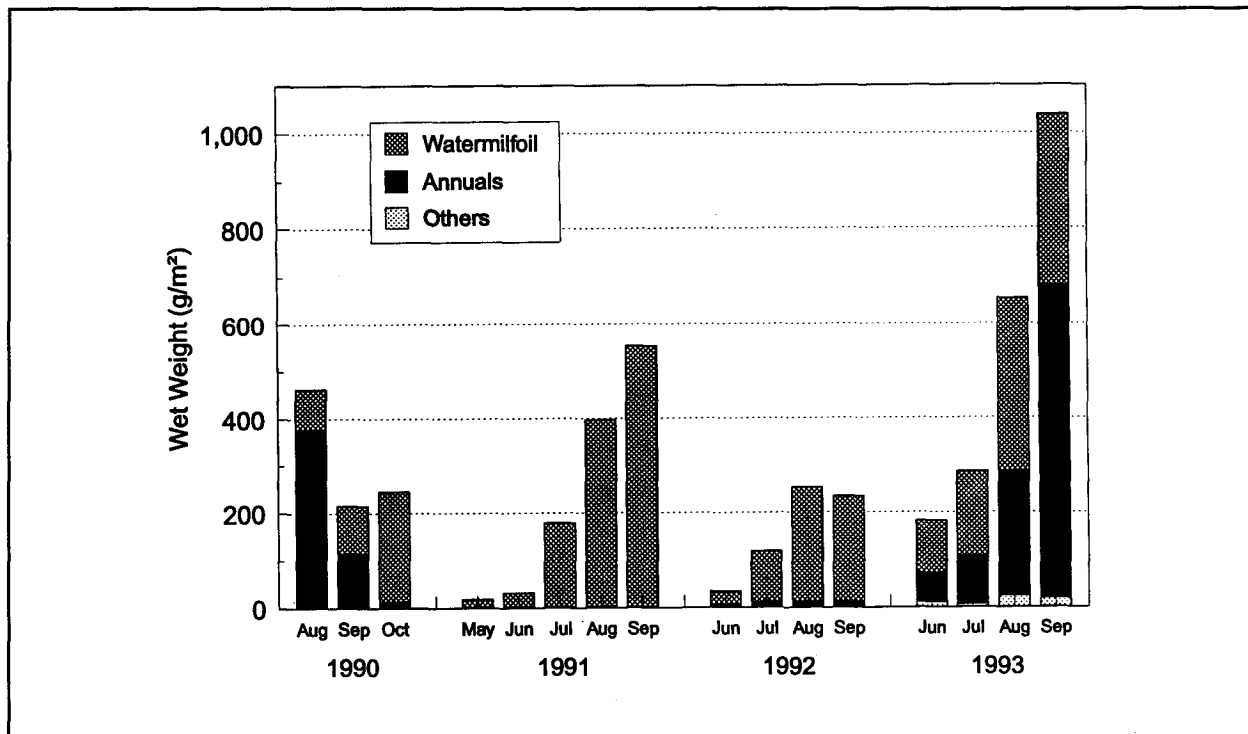


Figure 4. Mean aboveground biomass of aquatic macrophytes at the Mill Creek sampling site from 1990 to 1993

Regrowth of annual species, as was the case in Mill Creek embayment, was observed in shallow-water habitat in 1993 at other scattered localities within the reservoir in slightly deeper water (i.e., 0.5 m).

Peak biomass at sampling sites in deeper water (1 to 2.5 m) from TRM 378.5 to TRM 384 that were colonized by almost monospecific colonies of Eurasian watermilfoil in 1990 (Powerline Milfoil site) remained relatively stable (Figure 5). In contrast, sampling sites dominated by hydrilla in 1990 (Brewster Hydrilla site) had significant declines in this species (Figure 6). Eurasian watermilfoil became the dominant submersed macrophyte at these sites and was present in near monospecific stands by the end of the 1991 growing season. At two of the sampling sites dominated by hydrilla in 1990, Eurasian watermilfoil became the dominant macrophyte in 1991, and peak biomass declined from 3.566 kg/m² at the Powerline Hydrilla site in 1990 to 1.263 and 0.904 kg/m² in 1991 and 1992, respectively, and from 2.725 kg/m² at the Brewster Hydrilla site in 1990 to 1.572, 1.771, and 1.814 kg/m² in 1991, 1992, and 1993, respectively. Although hydrilla was less than 0.3 percent of peak total biomass at the Brewster Hydrilla site from 1991 to 1993, it still occurred in 64 to 100 percent of monthly samples in 1991, 0 to 4 percent in 1992, and from 16 to 40 percent of monthly samples in 1993. Most hydrilla samples consisted only of stems and rhizomes a few centimeters in length.

While hydrilla almost totally declined in overbank areas from TRM 378 to TRM 384 from 1990 to 1991, hydrilla remained in 1991 in 1,000-m² exclosures that were constructed to exclude grass carp in order to conduct insect biocontrol studies with *Hydrellia pakistanae* (Grodowitz and Snoddy 1992).

Exclosures

With few exceptions, there were significant differences in biomass and/or species composition of aquatic macrophytes within exclosures. Biomass within the 27.4- by 27.4-m exclosure at Brown's Creek in 1993 ranged

from 250 to 398 g/m² for monthly sampling June through August compared with no plants outside the exclosure (Figure 7). Eurasian watermilfoil was 100 percent of the biomass within the exclosure during all months. The Brown's Creek sampling site was located in the downstream portion of Guntersville Reservoir where only minimal amounts of submersed aquatic macrophytes have occurred since 1991.

In a 30.5- by 76.2-m block-net exclosure site (Chisenhall Shallow) in an upstream area of the reservoir where Eurasian watermilfoil is abundant and widespread, total biomass (2,111 g/m²) inside the exclosure during the peak month (August) was not significantly different from total biomass (1,525 g/m²) outside the exclosure (Figure 8). However, species composition was significantly different with only 7 g/m² of annual biomass outside the exclosure compared with 1,580 g/m² inside the exclosure. Similar patterns of significantly greater biomass and/or differing species composition occurred inside versus outside exclosures in Brown's Creek and Mud Creek embayments and in Murphy Hill Cove where wire fences excluded grass carp from areas ranging in size from 0.3 to 2 ha.

Discussion

Submersed macrophyte coverage on Guntersville Reservoir declined from about 5,690 ha in 1989 (the year prior to grass carp stocking) to about 3,130 ha in 1990 (the year of stocking) to a low of 2,010 ha in 1991. Since 1991, macrophyte coverage has increased to 2,960 ha. Similar declines and a subsequent increase in macrophyte coverage occurred on most other mainstream reservoirs within the TVA system. Thus, much of the change in macrophyte coverage on Guntersville Reservoir is likely related to climatic conditions and associated factors (e.g., water clarity, flow, and temperature) that can greatly influence macrophyte populations (Smith and Barko 1990).

Biomass in shallow-water habitat of embayments and deeper (1 to 2.5 m) overbank

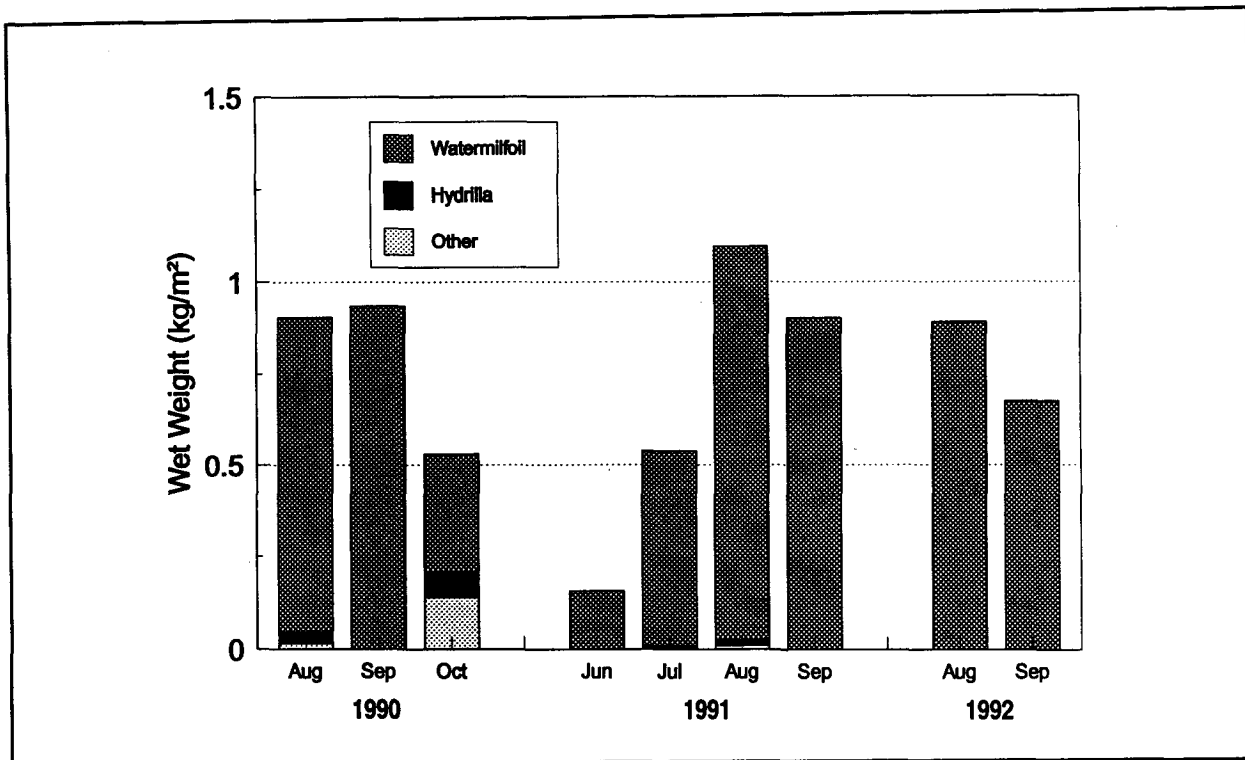


Figure 5. Mean aboveground biomass of aquatic macrophytes at the Powerline Milfoil sampling site from 1990 to 1992

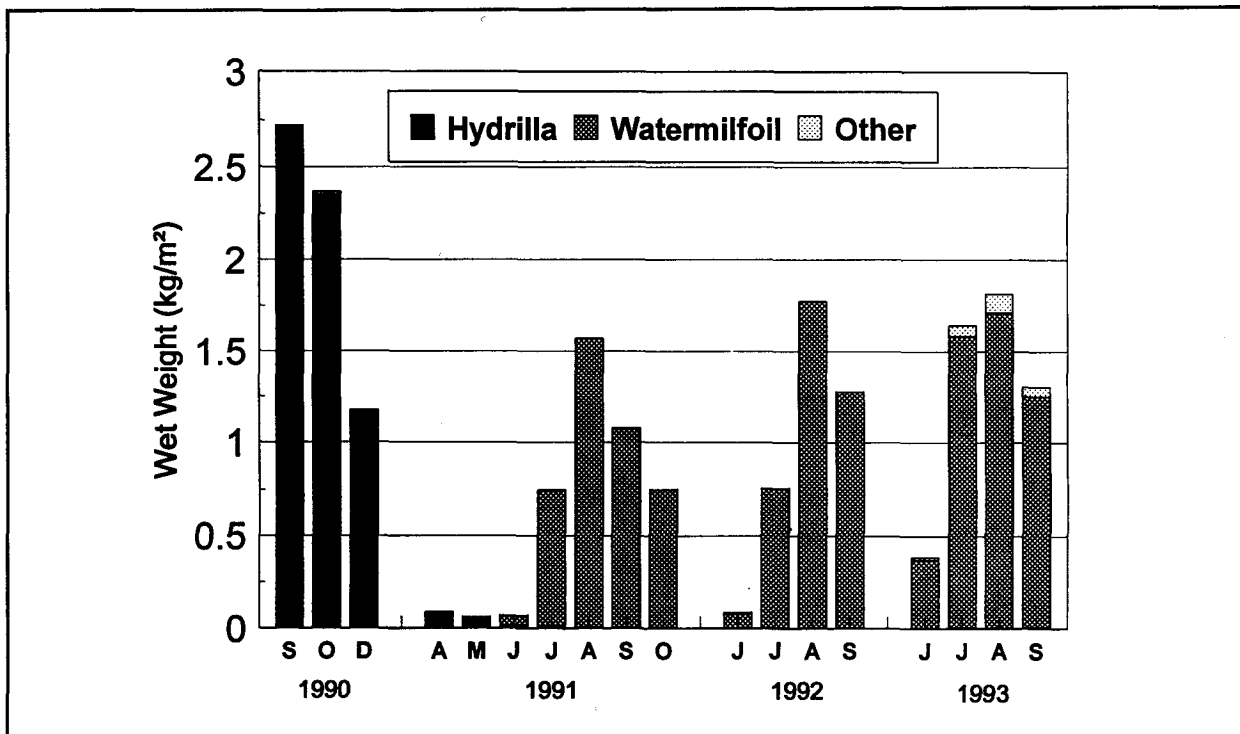


Figure 6. Mean aboveground biomass of aquatic macrophytes at the Brewster Hydrilla sampling site from 1990 to 1993

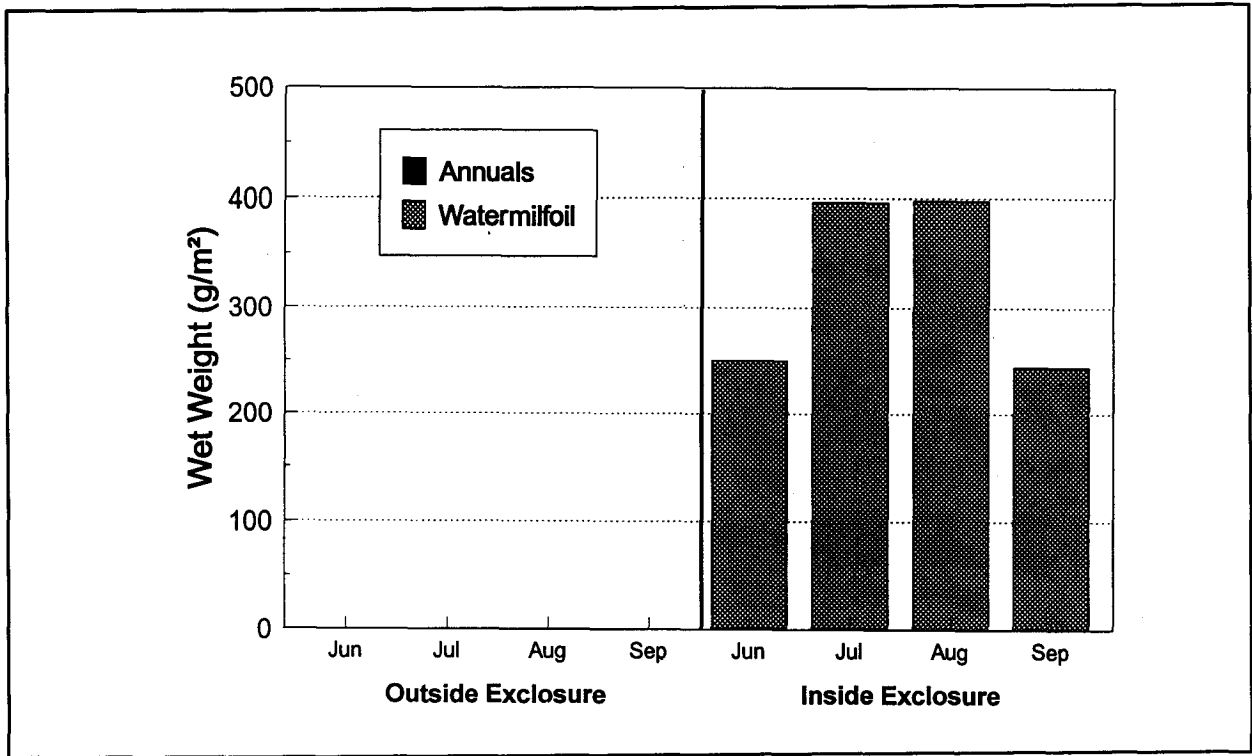


Figure 7. Mean aboveground biomass inside and outside of enclosure at the Brown's Creek sampling site in 1993

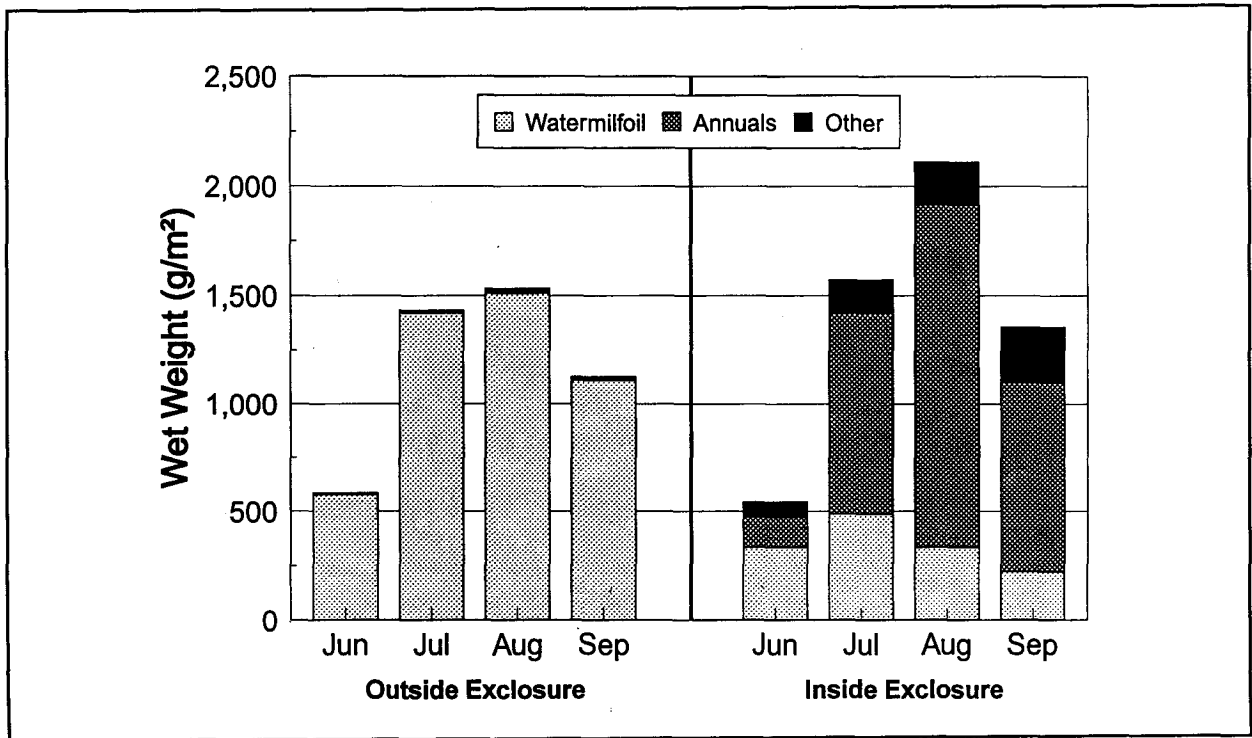


Figure 8. Mean aboveground biomass inside and outside of net enclosure at Chisenhall Shallow sampling site in 1993

habitat and coverage estimates from aerial photography have shown significant reductions in species such as spinyleaf naiad, southern naiad, muskgrass, narrow-leaved pondweeds, coontail, and hydrilla. Most of these plants rank high on the grass carp's food preference list (Miller and Decell 1984; Leslie et al. 1987), and grass carp are known to selectively feed on preferred plants before consuming less palatable species such as Eurasian watermilfoil. The abundance of spinyleaf naiad, muskgrass, and several other preferred species within enclosures constructed on Guntersville Reservoir in 1992 and 1993 supports selective feeding behavior by grass carp. In the first year of stocking (1990), grass carp were observed feeding in extremely shallow water of several embayments on Guntersville Reservoir. As the fish have increased in size, their reluctance to feed in these shallow areas may explain the observed increase in annual species in 1993 at scattered localities having slightly greater depths.

The extent to which grass carp were involved in the reduction of hydrilla from about 750 ha in 1989 to about 130 ha in the late summer of 1990 cannot be estimated from available data. Most of the 620 ha of hydrilla that declined was in relatively deep water (2 to 4 m) in the downstream portion of the reservoir that was more likely to have been adversely impacted by turbidity than hydrilla colonies from TRM 378 to TRM 384 that occurred primarily at depths of 1.5 to 2.0 m. However, grass carp are believed to have caused the reduction of 120 ha of hydrilla from TRM 378 to TRM 384 from 1990 to 1991. Large numbers of grass carp were observed feeding in "topped out" hydrilla colonies in the late summer and fall of 1990. The presence of hydrilla during the early summer of 1991 (Grodowitz and Snoddy 1992) in small enclosures constructed for insect biocontrol studies supports this conclusion. Underwater surveys indicated some regrowth of hydrilla in 1993 in a few areas of the reservoir that had abundant hydrilla in the late 1980s. However, hydrilla stems in some areas (e.g., Pine Island) appeared to have been cropped 0.1 to 0.3 m above the hydrasoil.

Even though Eurasian watermilfoil is not a preferred food species of grass carp (Miller and Decell 1984; Leslie et al. 1987), grass carp will consume it when more preferred species are unavailable (Leslie et al. 1987; TVA 1989). This may in part account for an almost total decline in 1991 of Eurasian watermilfoil in shallow water areas of Conner's Islands and Brown's Creek embayment in the downstream portion of Guntersville Reservoir where watermilfoil colonized about 240 ha in 1990. Regrowth of Eurasian watermilfoil in 1992 and 1993 in some downstream areas (TRM 363 to 373) of Guntersville may indicate a reduction in grass carp herbivory or improved growing conditions. Recolonization in some areas of the reservoir with sparse vegetation also may be slowed by other herbivores such as turtles.

Because it has been difficult to achieve intermediate vegetation levels using grass carp (Leslie et al. 1987), aquatic vegetation control with grass carp is often viewed as an "all or none" scenario with partial control being the exception rather than the rule. However, the "all or none" scenario may not be the case in large reservoirs (such as Guntersville) and in water bodies (TVA 1987, 1989) with a macrophyte community dominated by a species of low palatability such as Eurasian watermilfoil. In reservoirs such as Guntersville, hydrilla, naiads, and other highly palatable species may be significantly reduced without total loss or with minimal impact to nonpreferred plant species if grass carp are stocked at low to intermediate rates. The demonstrated feeding preference of grass carp for hydrilla (Miller and Decell 1984; Leslie et al. 1987) also potentially allows for significant reduction in this particularly invasive species that can rapidly colonize the littoral zone of a reservoir such as Guntersville to depths of 5 m. Stocking of grass carp while hydrilla is in the early stages of establishment within a water body and has a restricted distribution should minimize impacts to nontarget species.

Even when using conservative stocking rates in large systems dominated by non-preferred species, there are uncertainties and

some risks. Feeding may occur in an area where a diversity of aquatic macrophytes is desirable (e.g., wildlife management areas), and the grass carp may move out of the portion of a water body or emigrate to other waters in open systems. Even when grass carp are stocked at conservative rates, natural declines in macrophyte populations may result in more than anticipated, or desired reductions in aquatic vegetation. However, in spite of these uncertainties, the potential benefits of suppressing the spread of species such as hydrilla may fully warrant grass carp use in multipurpose, open-reservoir systems in some instances.

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