AFTER THE FLOOD: A FOLLOW UP ON THE TROPHIC STATE OF LAKE BLACKSHEAR, GEORGIA

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Abstract. Chlorophyll *a* based trophic state conditions during the summer in Lake Blackshear in 2001 were compared to pre-flood conditions of 1992. Median values were similar in the transition zone but lower in the middle and lower portions of the reservoir. It is not possible to determine whether lower chlorophyll *a* values in 2001 represent a change in lake productivity following the flooding event or simply reflect low flows during severe drought. Phytoplankton growth in the lake did not achieve the potential level predicted by nutrient concentrations or lake transparency.

INTRODUCTION

Lake Blackshear has long been described as eutrophic based on high nutrients and low transparency. In July of 1994, extensive flooding resulting from Tropical Storm Alberto breached the impounding dam of Lake Blackshear. Lake drawdown required for dam repair exposed much of the lake bottom for about one year. During this time extensive growth of sedges and other vascular vegetation occurred. Upon refilling of the reservoir, the decomposition of this vegetation was accompanied by oxygen depletion in deeper waters. Trophic state evaluation based on chlorophyll *a* and Secchi depth transparency measurements made during the summer of 2001 provided information for comparison with values derived prior to the '94 flood.

Information gained from this study is of significance to the understanding of water quality in the Flint River, since it shows trophic state trends and describes its current state. The strong interrelationship between water quality and quantity must be well understood as management decisions are made regarding the Flint River.

BACKGROUND AND RELATED WORK

Lake Blackshear was created on the Flint River for hydroelectric production in 1929. By the 1960's extensive growth of shallow water vegetation, including the cyanophyte *Lyngbya wollei*, were observed (observations of W.L. Tietjen and others). Work in 1973, as a part of the National Eutrophication Survey, resulted in Lake Blackshear being classed as eutrophic, based on high nutrient values (USEPA, 1975). This finding was substantiated by the Georgia Environmental Protection Division in 1981 (GA EPD, 1981). Sampling of Lake Blackshear and other major lakes in Georgia was continued by the Georgia EPD through 1993. Total trophic state index (TTSI), the sum of the separate trophic state index values of Carlson (1977) for chlorophyll *a*, Secchi depth, and total phosphorus, was reported for each of 132 lakes in Georgia. Based on TTSI values for samples collected during the May-October growing season between 1980 and 1993, Lake Blackshear ranked in the top three for eight of the twelve years sampled; in three of the years, Lake Blackshear had the highest TTSI value (most eutrophic) of all lakes sampled. The TTSI value of 214 found in Blackshear in 1981 was the highest reported for any Georgia lake during the period of 1980 through 1993. The lowest Blackshear value was 162 (1986), while the lowest reported for any Georgia lake was108 (GA EPD, 1992, 1994).

An extensive ecological study of the Flint River / Lake Blackshear ecosystem was conducted in 1983 by the Academy of Natural Sciences of Philadelphia (ANSP, 1984) in response to concerns at that time about degradation of water quality following the startup of a pulp mill in 1981 upstream of the reservoir. Results from this study indicated diverse populations for all functional trophic groups in the lake from bacteria to algae to fish, with communities indicative of natural, healthy riverine and lake ecosystems.

A Phase I Clean Lakes Study, sponsored by the U. S. EPA, the Georgia EPD, and the Lake Blackshear Watershed Association was undertaken from April, 1992 through March, 1993. The study evaluated patterns in dissolved oxygen, temperature, pH, conductivity, Secchi depth, chlorophyll *a*, and nutrients throughout the lake and its embayments (LBWA & GSSU, 2000). Some aspects of this study were reported at the 1995 Georgia Water Resources Conference (Cofer *et al.*, 1995).

Following the dewatering of the lake in July, 1994 some evaluation of lake sediments was done. Observations were made of the extensive vascular plant growth on the exposed lake bottom. Data from regular monitoring of dissolved oxygen in Lake Blackshear since the mid-1980's is available from staff of the Weyerhaeuser Company, owner of the upstream pulp mill.

Monitoring during the Clean Lakes Study and by Weyerhaeuser staff demonstrates that, although Lake Blackshear overturns several times during summer months, stratification frequently occurs with deeper water becoming oxygen depleted. The occurrence of low dissolved oxygen in deeper waters was extensive during the summer following the refilling of the lake in 1995 and is intermittent in other years (Lebo, unpublished data).

A study was conducted during the summer of 2001 to evaluate current trophic state conditions. It was hoped that any significant changes resulting from the effects of the flood and subsequent dewatering would be apparent.

EXPERIMENTAL DESIGN AND METHODS

Site Description

Lake Blackshear is the first impoundment on the Flint River and located about 345 km downstream from river headwaters. Characteristics of the lake were evaluated as a part of the 1992-3 study (LBWA and GSSU 2000). The lake has a surface area of 3,429 hectares, with a length of 30 km. Mean lake depth is 3.2 m, with a maximum forebay depth of 13.5 m. The theoretical retention time of Lake Blackshear is estimated to be 10.7 days. Summer stratification was found to begin in mid-May and continue into mid-September. Within this period lake mixing associated with increased river flow or local thunder storm events occurred. Seven larger tributaries and several smaller ones flow into the lake, resulting in thirteen embayments.

Lake Sampling

Sampling of lake stations for general water quality (temperature and DO profiles), collection of a water sample at a depth of 1.0 m, and measurement of Secchi depth were done semi-monthly from mid-April through mid-August 2001 to characterize recent spatial patterns in some key parameters. Surveys included six lake stations (L1, L2, L3, L5, L6, and L7) from the Clean Lakes study plus sampling near Sawdust Point (Weyerhaeuser station 6A-3) and near Lincoln Pinch to better delineate the lake. Stations were located over the old river channel and ranged from near the lake headwaters at Ga 27 (L1) to the dam forebay (L7). Methods of the 2001 study were basically the same ones used in the Clean Lakes study and followed Greenberg, *et al.*, 1992. Trophic state index values were calculated from chlorophyll *a* concentrations following Carlson (1977).

RESULTS

The growing season median chlorophyll *a* concentrations for each station for both 1992 and 2001 are shown in Figure 1. Table 1 presents mean Secchi depths for stations in the summer of 1992 and 2001. Figure 2 gives the mean trophic state index values for chlorophyll *a* for the individual 2001 stations, as well as trophic state index values from the 1992 study.

DISCUSSION

Chlorophyll *a* concentrations are somewhat similar for 1992 and 2001, although the latter values are lower, especially in the middle and lower reaches of the lake

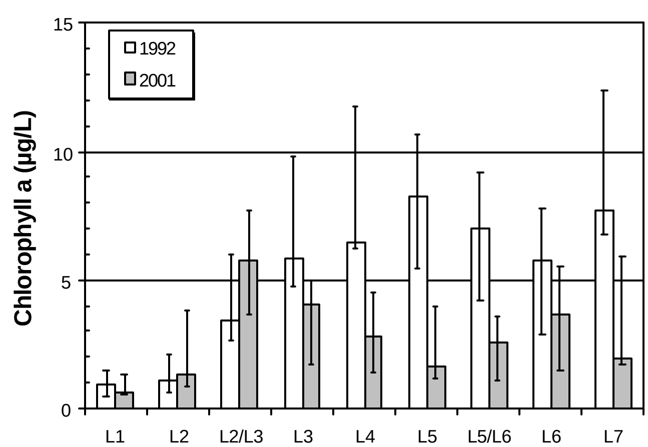

Figure 1. Median chlorophyll *a* concentrations for samples collected during the growing season of 1992 and 2001 by station. Error bars denote the interquartile (25th to 75th percentile) range for measurements. Stations L2/L3 and L5/L6 are for Sawdust Point and Lincoln Pinch, respectively.

Table 1. Means of Secchi Depths from Late April Through Mid-August (depths in cm)

	Station L1	L2	L4	L5	L7	L8
1992	76	63	79	93	99	113
2001	67	60	81	90	102	103

(Figure1). Several possible reasons exist to account for the lower values including experimental error and changes in lake ecology. River flow in 2001 was lower than in 1992 due to regional drought conditions, thus it is likely there was decreased nutrient delivery to the lower portion of the reservoir. However, no nutrient analyses were conducted in 2001 to evaluate the drought hypothesis. It is important to note that mean Secchi transparency was very similar in both years (Table 1).

The trophic state of Lake Blackshear as evaluated by chlorophyll is appreciably less than suggested by both total phosphorus and Secchi transparency (Figure 2). These differences are supported by an algal diversity evaluation within the Clean Lakes Study (see LBWA and GSSU, 2000). Since chlorophyll *a* represents the real state of algal growth it is the more meaningful metric. Algal growth potential studies during the Clean Lakes study indicate that phytoplanktonic growth does not achieve levels suggested by nutrient concentrations.

Since component TSI values for TP and Secchi depth for Lake Blackshear in the monitoring were consistently much higher than those values derived from chlorophyll *a* concentrations, it is obvious that the three parameters do not equally estimate the algal state of Lake Blackshear. While a general correspondence in TSI derived from the three parameters has been demonstrated for many water bodies, non-nutrient limiting factors to algal biomass have been recognized since trophic classifications were introduced in the 1930's. More recently algal growth control by factors other than nutrients has been suggested as the potential cause for discrepancies among trophic states/classifications (Kimmel *et al.*, 1990; Carlson, 1991; Jones and Knowlton, 1993; Kennedy, 2001).

The differences among the three sets of index values tell something about lake conditions. Historically, the lake has been nutrient rich. High turbidity, as indicated

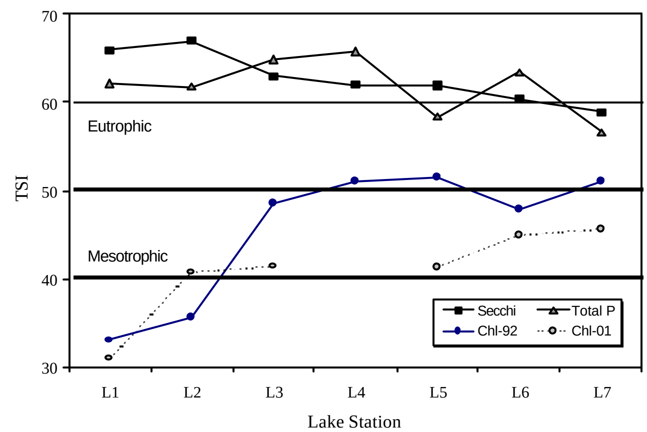

Figure 2. Trophic state index values according to Carlson (1977) calculated by parameter based on average values from May-October in 1992. Chlorophyll values are also included for data collected in 2001.

by restricted lake transparency may reduce photosynthetic activity. Further, the short mean lake retention time of 10.7 days may not allow sufficient time for phytoplankton growth.

Comparisons of Secchi transparency and chlorophyll *a* data do not indicate any profound differences between 1992 and 2001. Obviously, lake conditions were quite different during recovery from flood effects. However, it is not possible to detect any lasting flood effects using data from the present study; nor is it possible to detect any other long term changes from the present study. Clearly, sediment loading remains high, as indicated by low transparency and low chlorophyll values. It is possible to hypothesize also that nutrient loading remains high based on sediment load. Additional study years would be helpful, as would additional nutrient data.

SIGNIFICANCE TO WATER MANAGEMENT

The use of total trophic state index (TTSI) values may lead to improper characterization of a lake. Potentially adverse symptoms of eutrophication are not achieved in Lake Blackshear as indicated by moderate chlorophyll *a* levels. The failure of primary production to achieve the potential provided by nutrients may constrain fishery production in Blackshear.

Any management practices that might be developed that would modify either or both river flow and sediment load have the potential to affect the trophic state of the lake. Reduction in river flow would increase lake retention time, giving more opportunity for algal development. Reduction in flow might result in decreased sediment transport to the lake. Any reduction in sediment loading would have obvious positive effects, but also by providing increased transparency might favor increased algal photosynthesis. Sediment load reduction, as well as, other actions could reduce nutrient loading to the lake. Such nutrient reduction would reduce any eutrophic threat, but also might have a limiting effect on fishery production in Blackshear. It would be most important that any management plans developed for the Flint consider effects on lake algal production. Finally, the importance of adequate data for management decisions is obvious.

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