NUTRIENT CONTRIBUTIONS OF A COASTAL PLAIN STREAM TO LAKE BLACKSHEAR

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INTRODUCTION

Lake Blackshear is a hydro-electric impoundment located on the Flint River and is owned by the Crisp County Power Commission. The lake was created in 1930. It has a surface area of 34.5 km^2 and a mean depth of 5.4 m. It is located mainly between Crisp and Sumter Counties, also bordering on Dooley, Lee and Worth.

The lake has had for many years a heavy growth of the filamentous blue-green algae Lyngbya (probably L. wollei, Larry Dyck, pers. comm.). This growth occurs in several of the lake tributaries. Other nuisance algae and related problems have caused concern for lake users. The lake was described as eutrophic based on a 1973 study (USEPA, 1975). In 1983, Proctor and Gamble Corp., owners of a bleached pulp plant upstream from Blackshear sponsored an intensive evaluation of the river and lake. This study was under the direction of the Academy of Natural Sciences of Philadelphia (ANSP, 1984). Study sampling was done in April, August, and October. Results demonstrated that nutrient loading was sufficient in the spring and summer to classify the lake as eutrophic.

A nutrient budget study (Foth and Van Dyke, 1985) applying the model of Vollenweider (1978) to the nutrient data of the 1973 study (USEPA, 1974) was done at the request of the Crisp County Power Commission. The study stressed the importance of lake tributaries and local sources such as septic tanks as nutrient sources for this lake. The Gum Creek embayment was considered to be very important to this lake enrichment process.

The Foth and Van Dyke study recommended the establishment of a Watershed Association and also recommended a detailed study of the Gum Creek system. The study reported here is an outcome of that recommendation and was conducted under the sponsorship of the newly formed Lake Blackshear Watershed Association.

This study was designed to evaluate the relative non-point and point source nutrient contributions from different land usages and to develop recommendations for decreasing lake enrichment.

We believe that this study more clearly delineates the nutrient sources of Gum Creek and once again demonstrates the role of stream habitats, including riparian woodlands, in reducing down-stream transport of nutrients. Management policy development derived from information of this study may be applied to other tributaries of Lake Blackshear, as well as to other stream systems in the State. As an outgrowth of this study, an extensive multi- agency project, sponsored by the State Soil and Water Conservation Commission, has been undertaken to evaluate agricultural impact and to demonstrate non-point source reduction activities in the Gum Creek watershed. This project has broad state and national significance.

METHODS

Study Area Description. Gum Creek is located in Crisp County, Ga. Much of it drains either agricultural or forest land. Some rural housing developments occur in the drainage basin. Gum Creek flows through the city of Cordele where it receives the effluent from the city sewage treatment plant and other urban run-off. The embayed mouth of the creek is located in the Veterans Memorial State Park. The drainage area comprises 48,603 acres. About 44.5 % is agricultural, 46.5% forest and 7% city.

Twelve sampling stations were established on the stream producing twelve sub-sections of the total drainage basin. The intent of this division was to allow categorization of principle land usage of each basin. Eleven of these stations were located at road bridges so that simple gauging stations could be established to allow measurements of stream discharge. The twelfth station was located at the mouth of the embayment. Two additional stations were established in the main lake body, one above Gum Creek and one below. The Gum Creek drainage basin and the twelve sub- basin areas are shown in Figure 1.

The stations can be categorized as follows: Stations 1,2,3,5,8, and 9 are on first or second order streams in forest or agricultural areas. Stations 4,6, 10 and 11 are on the main creek channel with Station 4 located upstream

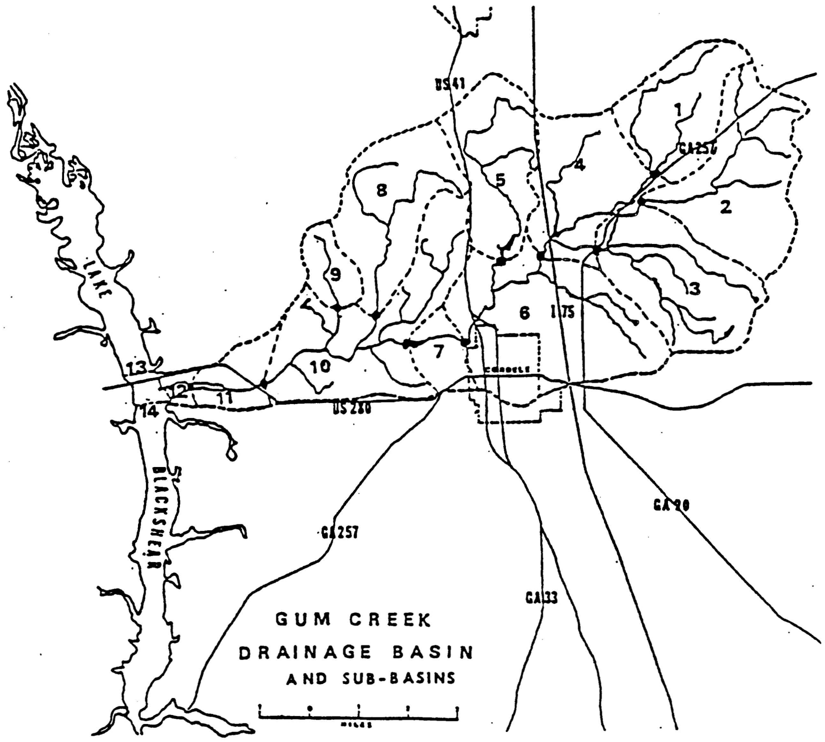

Figure 1

form the city of Cordele, Station 6 within the city, but above the sewage treatment plant outfall; Station 7 below the outfall and below Williams' Lake, just outside the city; Station 10 several kilometers down stream; Station 11 in the embayed channel of the stream and Station 12 at the embayment mouth. Station 13 was located in the lake upstream from Gum Creek and Station 14 located down stream from the creek.

Analysis. During 1987 samples were taken at monthly intervals at each station (if water was present). Stream discharge was estimated from velocity and channel cross-sectional data. Parameters such as dissolved oxygen, conductivity, pH, temperature, hardness and alkalinity were measured in the field. Composite water samples representing different cross channel locations were collected and sent on ice to the Georgia Department of Natural Resources laboratories in Atlanta for nitrogen (nitrate, nitrite, ammonia and Kjeldahl) and total phosphorus determination. Analysis for metals and organic pesticides was also made. Sediment samples were taken less frequently for nitrogen, phosphorus, metal and pesticide analysis. It is the nitrogen and phosphorus content of the water that is the topic of this paper.

RESULTS

Table 1 presents the yearly average concentrations of nitrite/nitrate, total nitrogen (sum of all nitrogen types) and total phosphorus for each station.

Table 2 gives the total nitrogen and total phosphorus mean annual flux for the 6 first and second order agricultural/forest area tributary streams and Table 3 gives the fluxes for main channel stations. Flux is the product of discharge x concentration.

Table 1. Annual mean nitrogen and phosphorous concentrations at Gum Creek sample stations.

Station	NO_3/NO_2 mg/l	Total N mg/l	Total P mg/l
1	0.27	1.38	0.055
2	0.03	1.58	0.042
3	0.05	1.02	0.690
4	0.60	1.14	0.062
5	0.31	1.57	0.072
6	1.22	2.40	0.270
7	2.47	4.04	1.150
8	0.10	2.80	0.140
9	0.58	1.94	0.110
10	1.92	2.75	0.370
11	0.89	1.89	0.140
12	0.48	1.07	0.094
13	0.25	0.85	0.053
14	0.24	0.68	0.054

Table 2. Total nitrogen and total phosphorus mean annual flux at first and second order agricultural and forest area stations.

Station	Total N Flux mg/sec	Total P Flux mg/sec
1	11.04	0.20
2	14.06	0.38
3	45.00	3.05
5	83.00	3.80
8	10.90	0.54
9	5.00	0.29

Table 3. Total nitrogen and phosphorus mean annual flux at main channel stations.

Station	Total N Flux mg/sec	Total P Flux mg/sec
4	33.8	1.8
6	206.4	23.2
7	373.7	106.4
10	336.0	45.2
11	231.0	17.1

DISCUSSION

Nutrient Sources. Tables 2 and 3 show that the major source of nitrogen and phosphorus loading of Gum Creek is associated with the City of Cordele. The rural areas (1,2,8,9) all have low flux. Area 3 included extensive rural development with septic tanks and small livestock operations. Area 5 included a large cattle farm. The relatively low percent of total nitrogen that is nitrate/nitrite N at these two stations suggests nitrogen enrichment through animal sources (see Table 1). Although flux at 3 and 5 is higher than the other rural stations, these fluxes are much less than fluxes downstream from the city. Station 4 is above Cordele, but downstream from 3. Its flux is more like that of the rural stations.

Station 6 probably has been affected by the existence of former fertilizer manufacturing activities. It is located above the city sewage outfall. The large increase in both nitrogen and phosphorus at 7 must be mainly the result of the sewage treatment plant. It is important to know that the Cordele City sewage treatment operation does an excellent job of treatment and is in compliance with standards. It does not operate a tertiary treatment facility however. Williams' Lake is an impoundment located on the main stream channel downstream from the sewage outfall and serves as a nutrient sink as demonstrated by profuse weed growth on the lake bed during the summer of 1987 when the lake was drained.

Downstream Transport. There is a 62 percent decrease in flux of total nitrogen and a 62 percent decrease in phosphorus flux at mainstream stations from 7 through 11. The conclusion that reduction in total nitrogen is by biological processing through the nitrogen cycle is supported by the percent increase in nitrate/nitrite nitrogen from Station 7 to Station 10 (61% to 69%) while total nitrogen decreases. Reduction of phosphorus is probably the result of accumulation in sediments, along with vegetation uptake. The variable physical nature of sediments prevents a clear description of sediment phosphorus differences. However, sediment phosphorus was as high as 3500 ppm. at Station 11, supporting the idea of phosphorus reduction through sedimentation.

Reduction in nutrient fluxes through downstream action is well established through the work of Wharton (1970), Wharton and Hopkins (1980), Kuenzler, et al. (1980), Lowrance, et al. (1983) and others. Tietjen and Carter (1981) demonstrated extensive phosphorus reduction as sewage enriched water passed through riparian swamp in the Muckalee Creek, a Flint tributary down stream from Lake Blackshear. Extensive riparian woodland occurs between Station 7 and Station 10. Area 8 has as heavy an agricultural usage as Area 5, but the stream channel is buffered by woodland which helps to reduce nutrient loading from that sub-basin.

Export to Lake. It was not possible to determine discharge past Station 12. If, however, it is assumed that Station 12 discharge is at least equal to discharge at Station 10 (which could be determined reasonably well) then it is possible to estimate, using Station 12 concentration data, that the total nitrogen export from Gum Creek to Blackshear was 178,245 Kg. per year and total phosphorus export was 14,800 Kg. per year. This compares quite well with the estimate of nitrogen export of 155,400 Kg. and 11,100 Kg. of phosphorus per year made in the Foth and Van Dyke (1985) study.

The Foth and Van Dyke study estimates an annual downstream transport through the dam of 158,941 Kg. of phosphorus and 2,443,556 Kg. of nitrogen. The study also estimates lake retention of an additional 109,254 Kg. of phosphorus and 1,253,831 Kg. of nitrogen. The present study estimates of export from Gum Creek represent amounts equal to 9.3 percent of the phosphorus and 7.3 percent of the nitrogen exported from the lake or 13.5 percent of the phosphorus and 14.2 percent of the nitrogen retained in the lake.

CONCLUSIONS

(1) The results of the year long study confirm the prediction made in the Foth and Van Dyke study through application of the Vollenweider model that lake tributaries are major sources of nutrient loading to Lake Blackshear.

(2) Gum Creek is estimated to contribute 4.8 percent of the nitrogen and 5.5 percent of the phosphorous entering Lake Blackshear.

(3) Urban derived materials contribute 90 percent of the nitrogen and 98 percent of the phosphorous of the nutrient load of Gum Creek.

(4) Livestock and septic tank sources located close to the stream are of greater importance than other agricultural activity.

(5) Natural stream ecosystem activities are responsible for approximately a 60 percent reduction of downstream nutrient transport.

RECOMMENDATIONS

(1) Every effort must be made to reduce all point and non-point sources of nutrient enrichment. Reduction of nutrient load in Gum Creek would result in a reduction of up to 5 percent of the current nutrient loading of Lake Blackshear. The establishment of a system of tertiary treatment of Cordele City sewage effluent would contribute as much as 90 percent of this reduction depending on the efficiency of the system employed.

(2) Every effort must be made to maintain the natural stream habitat. The loss of this habitat could double the nutrient loading of Lake Blackshear by Gum Creek.

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