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A Comparison of Drainage Basin Nutrient Inputs with Instream Nutrient Loads for Seven Rivers in Georgia and Florida, 1986-90

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Abstract

Instream nutrient loads of the Altamaha, Suwannee, St. Johns, Satilla, Ogeechee, Withlacoochee, and Ochlockonee River basins were computed and compared with nutrient inputs for each basin for the period 1986-90. Nutrient constituents that were considered included nitrate, ammonia, organic nitrogen, and total phosphorus. Sources of nutrients considered for this analysis included atmospheric deposition, fertilizer, animal waste, wastewater-treatment plant discharge, and septic discharge.

The mean nitrogen input ranged from 2,400 kilograms per year per square kilometer $(kg/yr)/km^2$ in the Withlacoochee River Basin to 5,470 $(kg/yr)/km^2$ in the Altamaha River Basin. The Satilla and Ochlockonee River Basins also had large amounts of nitrogen input per unit area, totaling 5,430 and 4,920 $(kg/yr)/km^2$, respectively.

Fertilizer or animal waste, as sources of nitrogen, predominated in all basins. Atmospheric deposition contributed less than one-fourth of the mean total nitrogen input to all basins and was consistently the third largest input in all but the Ogeechee River Basin, where it was the second largest.

The mean total phosphorus input ranged from 331 $(kg/yr)/km^2$ in the Withlacoochee River Basin to 1,380 $(kg/yr)/km^2$ in both the Altamaha and Satilla River Basins. The Ochlockonee River Basin had a phosphorus input of 1,140 $(kg/yr)/km^2$.

Per unit area, the Suwannee River discharged the highest instream mean total nitrogen and phosphorous loads and also discharged higher instream nitrate loads per unit area than the other six rivers. Phosphorus loads in stream discharge were highest in the Suwannee and Ochlockonee Rivers.

The ratio of nutrient outputs to inputs for the seven studied rivers ranged from 4.2 to 14.9 percent, with the St. Johns (14.9 percent) and Suwannee (12.1 percent) Rivers having significantly higher percentages than those from the other basins. The output/input percentages for mean total phosphorous ranged from 1.0 to 7.0 percent, with the St. Johns (6.2 percent) and Suwannee (7.0 percent) Rivers exporting the highest percentage of phosphorous.

Although instream nutrient loads constitute only one of the various pathways nutrients may take in leaving a river basin, only a relatively small part of nutrient input to the basin leaves the basin in stream discharge for the major coastal rivers examined in this study. The actual amount of nutrient transported in a river basin depends on the ways in which nutrients are physically handled, geographically distributed, and chemically assimilated within a river basin.

Introduction

An activity undertaken in the Georgia-Florida Coastal Plain (GAFL) study unit (fig. 1), as a part of the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program, was to examine available surface-water-quality data for nutrients (nitrogen and phosphorus compounds) in the study unit. These compounds were selected because they can cause eutrophication of surface waters, and because of the possible health risk associated with the nitrogen compound, nitrate, in drinking water.

As interest in quantifying nitrogen and phosphorus levels in surface waters has increased, interest in describing and quantifying the sources of these nutrients has also increased. Point sources, such as wastewater-treatment plants and industrial outflows, are obvious sources of nutrients. Important nonpoint sources of nutrients include animal wastes, fertilizer from agricultural and urban settings, discharges from septic-tank systems, and atmospheric deposition. Comparison of instream nutrient loads among river basins provides information that can be used by water-quality managers to implement effective nutrient reduction plans.

This report presents information on instream nitrogen and phosphorus loads during 1986-90 in seven rivers of the GAFL NAWQA study unit. This information is compared with input loadings from point and nonpoint sources of these nutrients within each of the studied river basins.

The seven large river basins in the GAFL study unit that were selected for study are referred to by river name for convenience. However, there are two Withlacoochee Rivers in the GAFL study unit, one in central Florida and one in southern Georgia. The basin of the Withlacoochee River discussed in this report is that of the river in central Florida (fig. 1). Physical, hydrologic, and land-use characteristics are described for each basin and listed in table 1; basin boundaries are shown in figure 1.

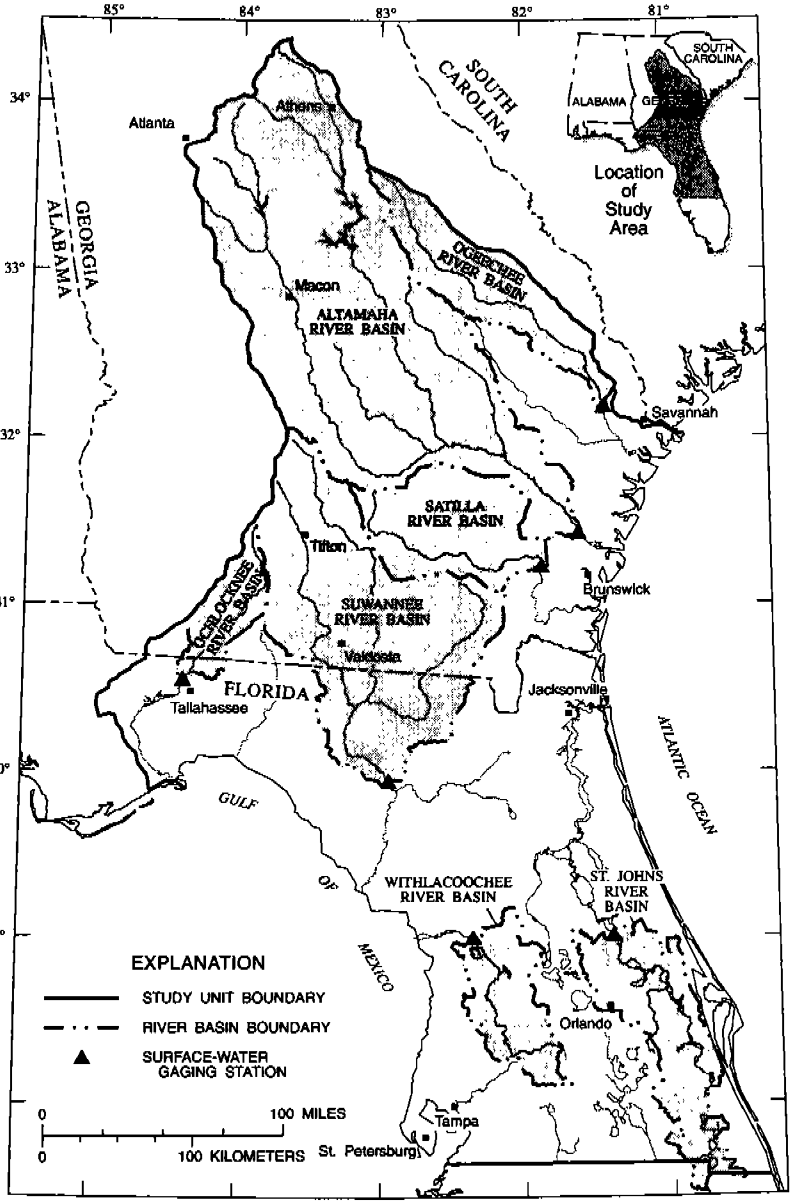

Figure 1. Georgia-Florida Coastal Plain study unit and the seven river basins that were studied.

Table 1. Basin characteristics

[km², square kilometers; m³/s, cubic meters per second]

Station name	Drainage area at gage (km²)	Period of record for discharge data	Average discharge (m³/s)	Land use (percent of basin area)[1]				
				Forest	Wet-land	Agri-cul-ture	Resi-den-tial	Commercial, industrial, other urban
Altamaha River at Everett City, Ga.[2]	36,300	1932-90	382	64.2	4.8	26.4	2.4	0.9
Suwannee River at Branford, Fla.	20,400	1932-90	196	50.4	15.9	31.2	0.8	0.9
St. Johns River near De Land, Fla.	8,690	1934-90	86.2	16.5	24.9	26.9	3.9	1.7
Satilla River at Atkinson, Ga.	7,220	1931-90	63.4	55.1	12.7	30.9	0.7	0.3
Ogeechee River near Eden, Ga.	6,890	1938-90	64.6	48.6	12.0	37.8	0.5	0.3
Withlacoochee River near Holder, Fla.	4,730	1932-90	30.0	16.1	27.3	40.0	2.9	1.0
Ochlockonee River near Havana, Fla.	2,950	1927-90	29.4	44.7	2.3	48.9	1.3	0.8

[1]Data for all land use categories are not presented. Rangeland comprised 19.1 percent of the St. Johns River Basin, and 6.5 percent of the Withlacoochee River Basin. Data source GIRAS (Mitchell and others, 1977).

[2]Discharge for this site obtained from the gage near Doctortown, Ga.

A comparison of the hydrologic conditions was made using the values of mean runoff and mean water yield (ratio of runoff to precipitation expressed as a percentage), which were computed for 1986-90 for each of the seven drainage basins (table 2).

Approach

USGS water-quality monitoring stations with at least 20 years of discharge data and 10 years of nutrient data were used to select the seven rivers that were examined in this report. The station located farthest downstream in each river basin was chosen to establish the downstream limit of the study basin for each river. The boundary of the basin contributing runoff to the farthest downstream station in each study basin was digitized from 1:24,000 or 1:100,000 topographic maps. The digitized areas of six of the basins corresponded well to values previously published in USGS annual data reports (U.S. Geological Survey, 1994), with differences ranging from 0.01 to 2.5 percent. However, the digitized area of the St. Johns River Basin was 9 percent larger than previously reported (U.S. Geological Survey, 1994). This difference was apparently caused by construction of drainage canals for residential and agricultural development during recent years, resulting in artificial expansion of the southeastern part of the St. Johns River Basin. To facilitate comparison of data among the basins (because drainage areas differ approximately tenfold) nutrient input and output values were divided by the area of their respective basin to obtain a nutrient yield.

Methods for aggregating and assessing nutrient inputs and outputs for this report are discussed below. Within each river basin, nutrient input loads were computed for atmospheric deposition, fertilizers, animal waste, septic-tank effluent, and wastewater-treatment plant discharges. Instream nutrient loads were computed for each of the seven selected rivers.

Data on weekly wet deposition of nitrate and ammonium for 1986-90 were obtained for nine sites (fig. 2) in the National Atmospheric Deposition Program (NADP) in Florida, Georgia, Alabama, South Carolina, and North Carolina (National Atmospheric Deposition Program (NRSP-3)/ National Trends Network, 1993), and summarized by year. Dry (particulate, aerosol, and gaseous) deposition is also an important additional atmospheric source of nitrogen (Baker, 1991). Dry deposition of nitrogen in the basins was estimated by multiplying the estimated wet deposition by 0.96, which is the mean estimate of the ratio of dry deposition to wet deposition for Florida (Baker, 1991). Atmospheric deposition of nitrogen was estimated as the sum of dry and wet deposition. Concentrations of organic nitrogen and phosphorus are not collected as part of the NADP and, therefore, those nutrient components were not included in the computations.

Table 2. Rainfall, runoff, and water yield for the seven study basins (1986-90)

River basin	Mean rainfall (centimeters per year)	Range of yearly rainfall (centimeters)	Mean runoff (centimeters per year)	Range of yearly runoff (centimeters)	Mean runoff/ mean rainfall (percent)
Altamaha	114	95-130	27	16-40	24
Suwannee	120	97-132	30	15-45	25
St. Johns	109	83-146	25	18-36	23
Satilla	114	98-133	26	5-47	23
Ogeechee	113	86-129	24	12-36	21
Withlacoochee	124	100-142	14	7-18	11
Ochlockonee	127	102-156	34	8-66	26

The Thiessen polygon method (Gilman, 1964) was used to estimate annual atmospheric deposition loading for nitrogen to the study basins. Thiessen polygons were intersected with the drainage basins to assign atmospheric deposition to each basin. Where more than one Thiessen polygon intersected a drainage basin, atmospheric deposition was assigned proportionate to the area it covered in that basin, and a basin deposition value was derived from an area weighted average.

Data for manure and fertilizer inputs are reported for 1986-90, but not all data were available for all years. The manure and fertilizer data were accumulated annually for the period of July 1–June 30, rather than by calendar year or water year, whereas other data were available on a monthly or weekly basis. Inputs of nutrients from crop fertilizers were estimated from summaries of annual fertilizer sales (as nitrogen and phosphorus) by county for Georgia and Florida (Janice T. Berry, Tennessee Valley

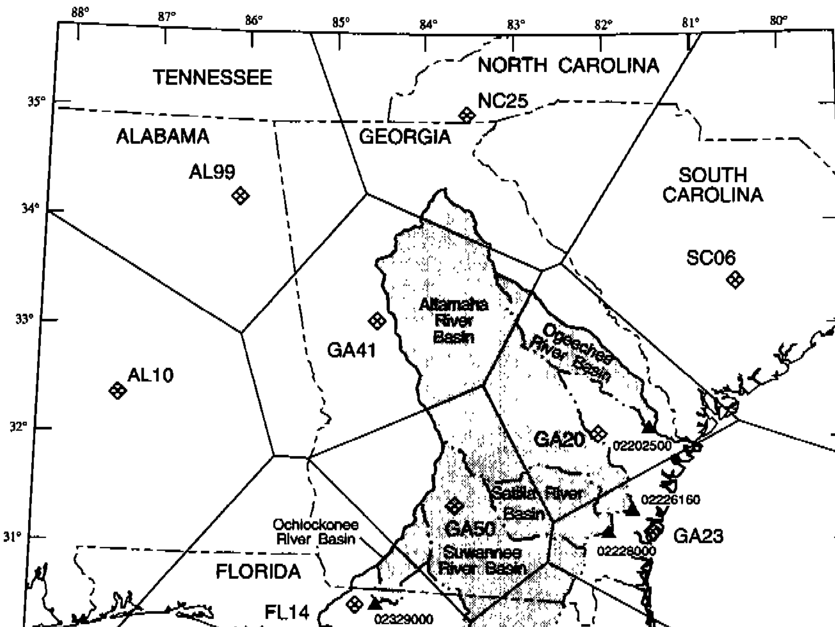

Figure 2. Atmospheric deposition sites and Thiessen polygons used to estimate annual deposition and atmospheric nutrient loads to each basin.

Authority, 1993, written commun.). Annual fertilizer input for each basin was estimated as the sum of inputs for counties included completely or partly in the basin. Where counties were partially included in a basin, fertilizer use was proportionately distributed based on area within the basin.

Estimates of nitrogen and phosphorus inputs from animal manure were calculated for 1986-90 from the numbers of hogs, beef cattle, dairy cattle, broiler chickens, and egg-laying chickens in each county (Bureau of the Census, 1989a,b; Florida Agricultural Statistics Service, 1992; Georgia Agricultural Statistics Service, 1993), and the estimates of the nutrient content of manure for each of these groups (table 3). Because data were not available for 1986, data for 1987 were used as an estimate for 1986. Manure inputs were estimated for the study basins by summing the manure loading for all the counties contained in a given basin. Where counties were partially included in a basin, the manure load was proportionately distributed based on county area with the basin. These estimates do not consider losses of nitrogen by volatilization that might occur during storage, handling, and application. Such losses under certain conditions can decrease the nitrogen content of manure by 25 to 80 percent (Kay and Hammond, 1985). These estimates do not consider nutrient recycling that occurs when animals are fed grains grown within the basin.

Estimates of nitrogen and phosphorus inputs from septic-tank effluent were calculated by multiplying the number of septic tanks in each county for 1990 (Bureau of the Census, 1993a,b) by the estimated average concentration of total nitrogen (45 mg/L) and total phosphorus (13 mg/L) in septic-tank leachate and then by an average effluent volume of 510 liters per day (Tchobanoglous, 1991). Where counties overlapped basin boundaries, the number of septic tanks was assigned to basins according to the estimated percentage of total county population residing within the basins.

Estimates of nitrogen and phosphorus inputs from wastewater discharges within each basin were calculated from water-use data for 1990 in Florida (Marella, 1994) and Georgia (J.L. Fanning, U.S. Geological Survey, 1993, written commun.). Wastewater discharge values

Table 3. Nutrient contributions from animal wastes

[From R.B. Alexander, U.S. Geological Survey, written commun., 1992]

Animal	Nutrient component[1]	
	Nitrogen	Phosphorus
Milk cows	0.400	0.060
Broiler chickens	1.100	0.340
Egglaying chickens	0.830	0.310
Beef cows	0.310	0.105
Hogs	0.280	0.150

[1]Pounds per day per 1,000 pounds of animal.

for each basin were multiplied by the average nutrient concentrations in wastewater, classified by waste type, to estimate loadings of nitrogen and phosphorus (National Oceanic and Atmospheric Administration, 1993). Some of the wastewater discharge data were incomplete or missing, resulting in underestimates of inputs from this source.

Instream nutrient loads were estimated on an annual basis using daily discharge and nutrient data obtained from the USGS National Water Information System for each of the seven selected stations. Nutrient concentrations were modified by aggregating data for related parameters (such as total and dissolved concentrations) which were not statistically different between samples when replicate samples were analyzed (Mueller and others, 1995). In this report, the term ammonia refers to the combination of total and dissolved ammonia as nitrogen. The term nitrate refers to the combination of total nitrite-plus-nitrate as nitrogen, total nitrate as nitrogen, dissolved nitrite-plus-nitrate as nitrogen, and dissolved nitrate as nitrogen. Instream loads of ammonium, nitrate, total Kjeldahl nitrogen (TKN) and total phosphorus were estimated by computer software, implementing the minimum variance unbiased estimator model (Cohn and others, 1989; Gilroy and others., 1990). This model estimates monthly basin nutrient loads as a function of sampled concentrations, time, discharge, and seasonal variation. The monthly loads were summed to estimate annual instream nutrient load. Organic-nitrogen loads were estimated as TKN loads minus ammonia loads, and total nitrogen loads were estimated as TKN loads plus nitrate loads.

Nutrient Inputs

Mean total inputs (1986-90) of nitrogen in the seven basins ranged from about 11 million kilograms per year (kg/yr) in the Withlacoochee River Basin to 198 million kg/yr in the Altamaha River Basin (table 4). Because of the differences in the sizes of the basins, comparisons among these seven basins are best discussed in terms of kilograms of nutrient input per unit area. The mean nitrogen input per unit area for 1986-90 ranged from 2,400 kilograms per year per square kilometer (kg/yr)/km^2 in the Withlacoochee River Basin to a little over 5,400 (kg/yr)/km^2 in both the Altamaha and Satilla River Basins (table 4). The Altamaha, Satilla, and Ochlockonee River Basins had the largest amounts of nitrogen introduced per unit area (fig. 3, table 4).

Nitrogen from fertilizer (urban and agricultural settings) or animal-waste sources predominated in all basins. Animal waste constituted the largest source of nitrogen in the Altamaha, Satilla, and Suwannee River Basins, and fertilizer was the largest source of nitrogen in the other four basins (fig. 3). Animal waste varied widely in relative importance as a source of nitrogen among the seven basins, reflecting differences in the numbers of farm animals among the basins. As a result of the number of broiler chicken cultivation operations, (Florida Agricultural Statistics Service, 1992; and Georgia Agricultural Statistics Service, 1993) the Altamaha, Satilla, and Suwannee River Basins had the highest levels of nitrogen due to animal waste. Fertilizer inputs of nitrogen per unit area were relatively similar in six of the seven basins (fig. 3). Fertilizer inputs of nitrogen per unit area were much larger in the Ochlockonee River Basin than in the other six basins, probably due to the amount of land devoted to agriculture in this basin (table 1) and the predominance of crops (such as cotton and corn) where large amounts of fertilizer are applied (W. Segars, Cooperative Extension Service, 1994, oral commun.). Interestingly, the Withlacoochee

Table 4. Mean nitrogen and phosphorus inputs and stream loads per year and per unit area for the years 1986-90

[Percent stream load to input is circulated using per unit area numbers]

Basin	Nitrogen input		Nitrogen stream load		Percent stream load to input	Phosphorus input		Phosphorus stream load		Percent stream load to input
	kg×10³/yr	(kg/yr)/km²	kg×10³/yr	(kg/yr)/km²		kg×10³/yr	(kg/yr)/km²	kg×10³/yr	(kg/yr)/km²	
Altamaha River	198,000	5,470	8,280	228	4.2	50,000	1,380	704	19	1.4
Suwannee River	80,100	3,930	9,700	476	12.1	19,300	946	1,340	66	7.0
St. Johns River	23,600	2,710	3,520	405	14.9	3,670	422	224	26	6.2
Satilla River	39,200	5,430	1,840	255	4.7	9,970	1,380	92	13	1.0
Ogeechee River	18,500	2,690	1,380	200	7.4	3,250	472	107	16	3.4
Withlacoochee River	11,400	2,400	720	152	6.3	1,560	331	39	8	2.4
Ochlockonee River	14,500	4,920	1,080	366	7.5	3,350	1,140	129	44	3.9

River Basin, although having a significant amount of agricultural land use, had the second lowest input of nitrogen from fertilizer.

Atmospheric deposition contributed less than one-fourth of the mean nitrogen input to all basins and was consistently the third largest of the five sources of nitrogen in all basins except the Ogeechee, where it was the second largest source (fig. 3). Wastewater-treatment plant discharges and septic-tank discharges made the smallest contributions (less than 7 percent each) to the nitrogen inputs per unit area in all basins (fig. 3).

Mean inputs (1986-90) of phosphorus (table 4) varied similarly to nitrogen inputs between basins (table 4). The mean phosphorus input ranged from 331 (kg/yr)/km^2 in the Withlacoochee River Basin to a little more than 1,300 (kg/yr)/km^2 in the Altamaha and Satilla River Basins (fig. 4, table 4).

Sources of phosphorus from fertilizer (in urban and agricultural settings) and animal wastes predominated in all basins (fig. 4). Similar to nitrogen inputs, phosphorus inputs from animal waste varied more than tenfold among the basins. Phosphorus inputs from animal waste made up the largest input per unit area component in the Altamaha, Satilla, and the Suwannee River Basins, whereas phosphorus input from fertilizer was dominant in the Ochlockonee, Ogeechee, and St. Johns Rivers. Phosphorus inputs from fertilizer were quite similar among basins, with the exception of the Ochlockonee River Basin which had noticeably higher inputs per unit area from fertilizer.

Wastewater-treatment plant discharges made small contributions to the mean total input of phosphorus when compared to fertilizer and animal wastes in the seven basins (fig. 4). Inputs from septic tanks were also relatively small except in the St. Johns and the Withlacoochee River Basins where they constituted 13 and 16 percent of phosphorus inputs, respectively (fig. 4).

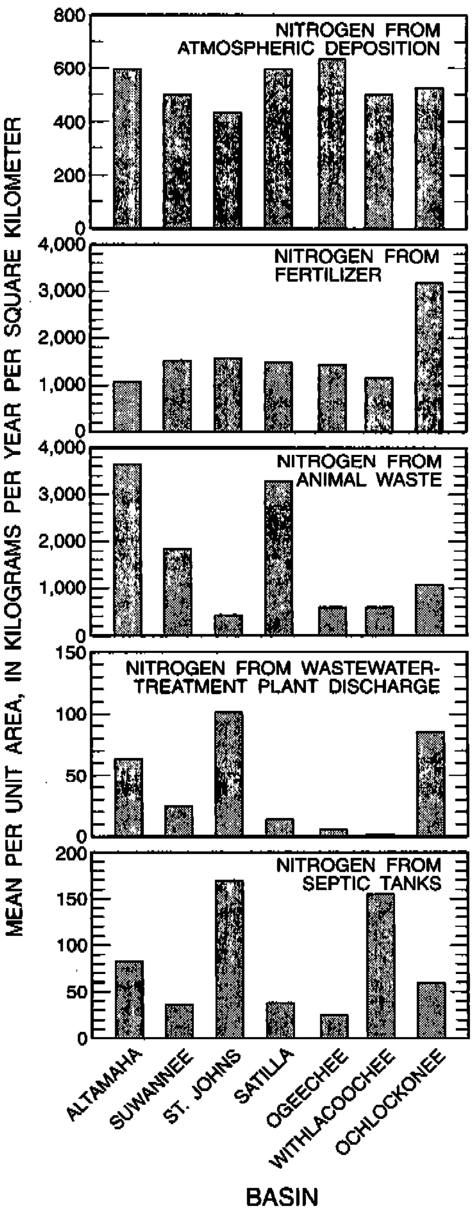

Figure 3. Mean total nitrogen inputs by source for each study basin. (Mean computed for years 1986-90.)

Instream Nutrient Loads

The Suwannee River Basin had the largest instream annual load per unit area for both nitrogen and phosphorus (fig. 5A). Organic nitrogen was the most abundant nitrogen compound, and the highest organic nitrogen loads per unit area occurred in the St. Johns River. The highest instream nitrate loads per unit area occurred in the Suwannee River followed by the Ochlockonee and the Altamaha Rivers (fig. 5B). Instream ammonia loads in all seven rivers are relatively low when compared to organic nitrogen and nitrate loads (fig. 5B).

The magnitude of annual nutrient loads in the seven river basins for the various nutrient species appears to be proportional to annual river discharge (fig. 6) with several exceptions. Nitrate loads are highest per unit area in the Suwannee River where ground-water/surface-water interactions may affect this relation. The Altamaha River has high discharge and relatively low nutrient loads, and the Ochlockonee River has low discharge and relatively high nutrient loads (fig. 6).

The ratio of the mean instream nutrient load to the mean nutrient inputs in each basin, although not entirely definitive, provides a way to compare the nutrient assimilative capacity of the seven basins. Comparison of these ratios, expressed as percentages for the seven river basins, reveals that the instream nitrogen and phosphorus loads remaining in these river basins are much smaller than the sum of the source inputs of these nutrients to these basins (table 4). The percentage of nitrogen remaining in these rivers ranged from 4.2 to 14.9 percent, with significantly higher percentages of nitrogen remaining in the St. Johns (14.9 percent) and Suwannee (12.1 percent) Rivers than the other basins (table 3). Percentages of phosphorus remaining were lower and ranged from 1.0 to 7.0 percent, with higher percentages of phosphorus remaining in the St. Johns (6.2 percent) and Suwannee (7.0 percent) Rivers than in the other basins (table 3).

The small fraction of nutrient inputs that remain in river water in each of these basins shows that each of these river basins is capable of assimilating, retaining, and recycling a significant part of the nutrient inputs. Some basins are more effective than others in assimilating nutrients, and further study is needed to determine the environmental factors that control nutrient cycling in each basin.

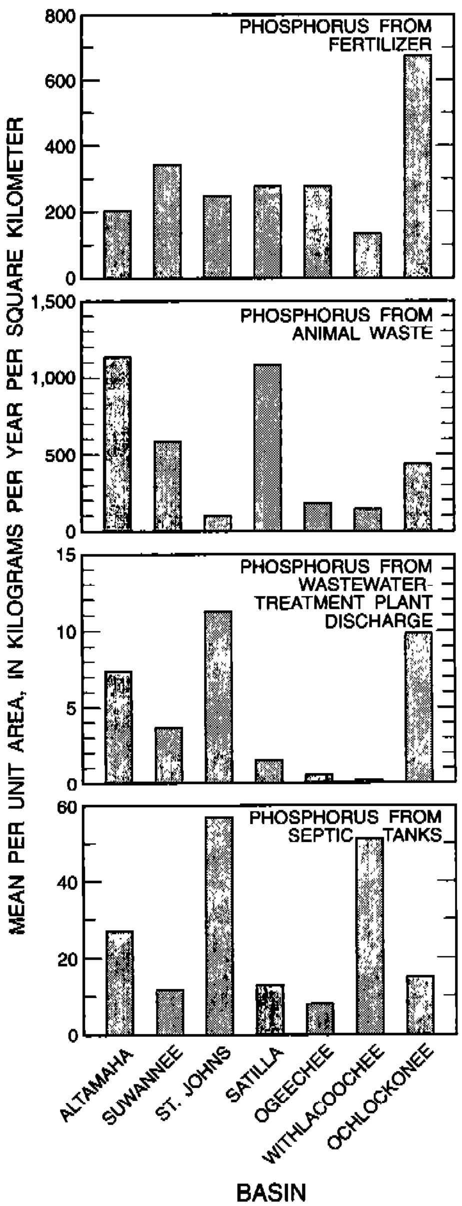

Figure 4. Mean total phosphorus inputs by source for each study basin. (Mean computed for years 1986-90.)

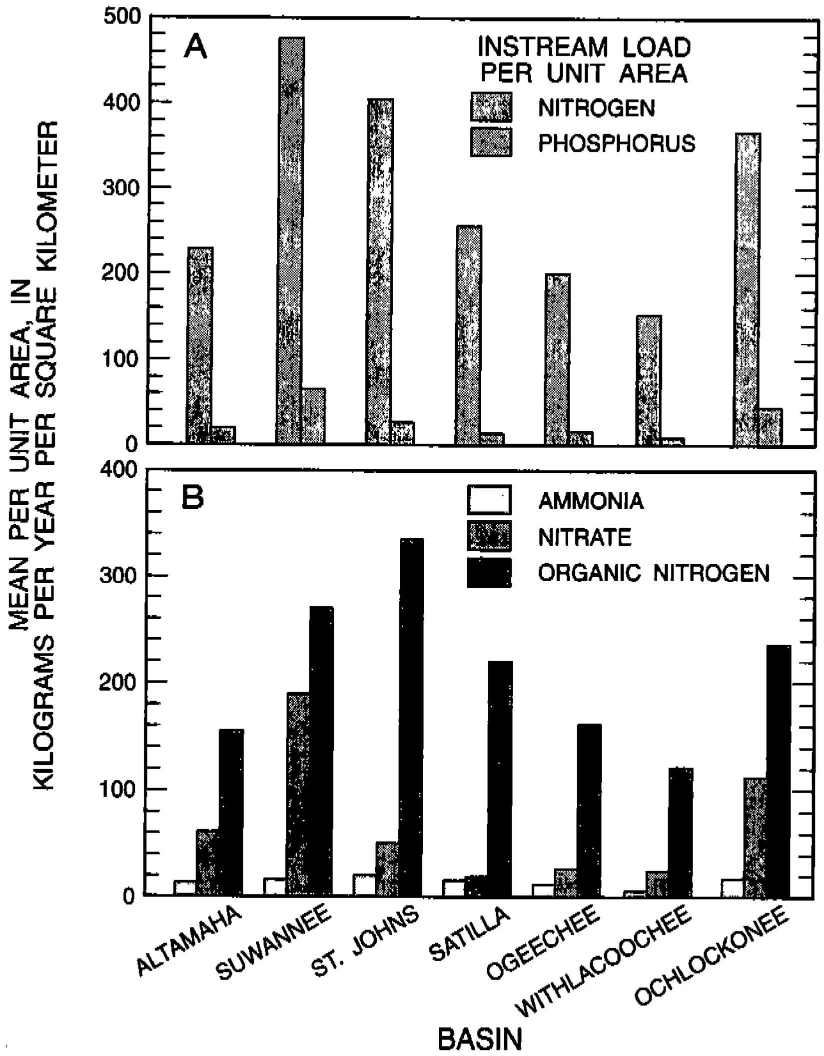

Figure 5. (A) Mean instream loads of nitrogen and total phosphorus by basin, and (B) mean instream loads of nitrogen species and total phosphorus. (Mean computed for years 1986-90.)

Summary and Discussion

This report compares nutrient inputs in river basins with nutrient loads in rivers. There was no intent to compute nutrient storage in these basins because of the uncertainty and magnitude of such a task. Some of the factors contributing to the uncertainty of assessing nutrient cycling on a basin scale are related to processes associated with storage or attenuation of nutrients within a river basin and their relative degree of importance. These processes include the degree of net biotic production, biological nitrogen fixation, soil sorption, denitrification, and volatilization.

Nutrient inputs and instream loads were analyzed and compared for the Altamaha, Suwannee, St. Johns, Satilla, Ogeechee, Withlacoochee, and Ochlockonee River Basins in the Georgia-Florida Coastal Plain study unit of the National Water-Quality Assessment Program. The nutrient constituents that were considered included nitrate, ammonia, organic nitrogen, and total phosphorus; the inputs of nitrogen and phosphorus that were considered included atmospheric deposition, fertilizer, animal waste, wastewater-treatment plant discharge, and septic-tank discharge.

The mean nitrogen input for 1986-90 ranged from 2,400 (kg/yr)/km^2 in the Withlacoochee River Basin to 5,470 (kg/yr)/km^2 in the Altamaha River Basin. The Satilla and Ochlockonee River Basins had nitrogen input totals of 5,430 and 4,920 (kg/yr)/ km^2, respectively.

Nitrogen input was predominantly from fertilizer (in agricultural and urban settings) or animal waste in all basins. Animal waste constituted the largest mean input of nitrogen in the Altamaha, Satilla, and Suwannee River Basins, and fertilizer was the largest mean input of nitrogen in the other four basins. Atmospheric deposition contributed less than one-fourth of the mean nitrogen input to all basins. Wastewater-treatment plant discharges and septic-tank discharges made relatively small contributions to the nitrogen inputs per unit area (less than 7 percent each) in all basins.

The mean total phosphorus input ranged from 331 (kg/yr)/km^2 in the Withlacoochee River Basin to 1,380 (kg/yr)/km^2 in both the Altamaha and Satilla River Basins. The Ochlockonee River Basin had a phosphorus input of 1,140 (kg/yr)/km^2.

As with nitrogen, fertilizer or animal-waste sources of phosphorus predominated in all basins, and wastewater discharges made only small contributions relative to other sources. Phosphorus inputs from septic-tank discharges however, were somewhat elevated in the St. Johns and Withlacoochee River Basins (13 and 16 percent of total phosphorus, respectively).

The Suwannee River Basin had the highest instream nitrogen and phosphorus loads of any of the seven basins, both on a total basis and per unit area. Also, the Suwannee River Basin had much higher instream nitrate loads per unit area than the other six rivers. Instream phosphorus loads were highest in the Suwannee and Ochlockonee Rivers. Organic nitrogen loads per unit area dominated in all river basins.

Comparison of the ratio of nutrient instream loads to inputs, expressed as percentages for the seven river basins, reveals that the nitrogen and phosphorus loads leaving these river basins in surface-water discharge is a small fraction of the nutrient inputs to these basins. The highest percentage of nitrogen remaining in a basin was that of the St. Johns River Basin (14.9 percent) and the lowest was the Altamaha River Basin (4.2 percent). The highest percentage of phosphorus remaining in a basin was that of the Suwannee River Basin (7.0 percent), and the lowest was the Satilla River Basin (1.0 percent).

The uncertainty of quantifying the processes involved with nutrient cycling in each of these basins makes predictions of optimum natural basin nutrient attenuation extremely difficult. Also, there are no definitive means of identifying the specific source of nutrients observed in river discharge. Nonetheless, the examination of nutrient loads in these seven river basins in relation to nutrient inputs is extremely informative and useful in understanding the relative magnitudes of point and nonpoint sources. Even the lack of some point-source data that would tend to underestimate point source input would not alter the interpretation that nonpoint sources are the major contributor in potentially supplying nutrient inputs to river basins in the Georgia-Florida Coastal Plain study unit. This report, however, quantifies only the amount of nutrient present in river discharge and does not address which type of source imposes the most influence to the receiving surface-water body—the direct delivery of more concentrated chemicals to the river (point sources) or the indirect, more spatially dispersed application of less concentrated chemicals (nonpoint sources).

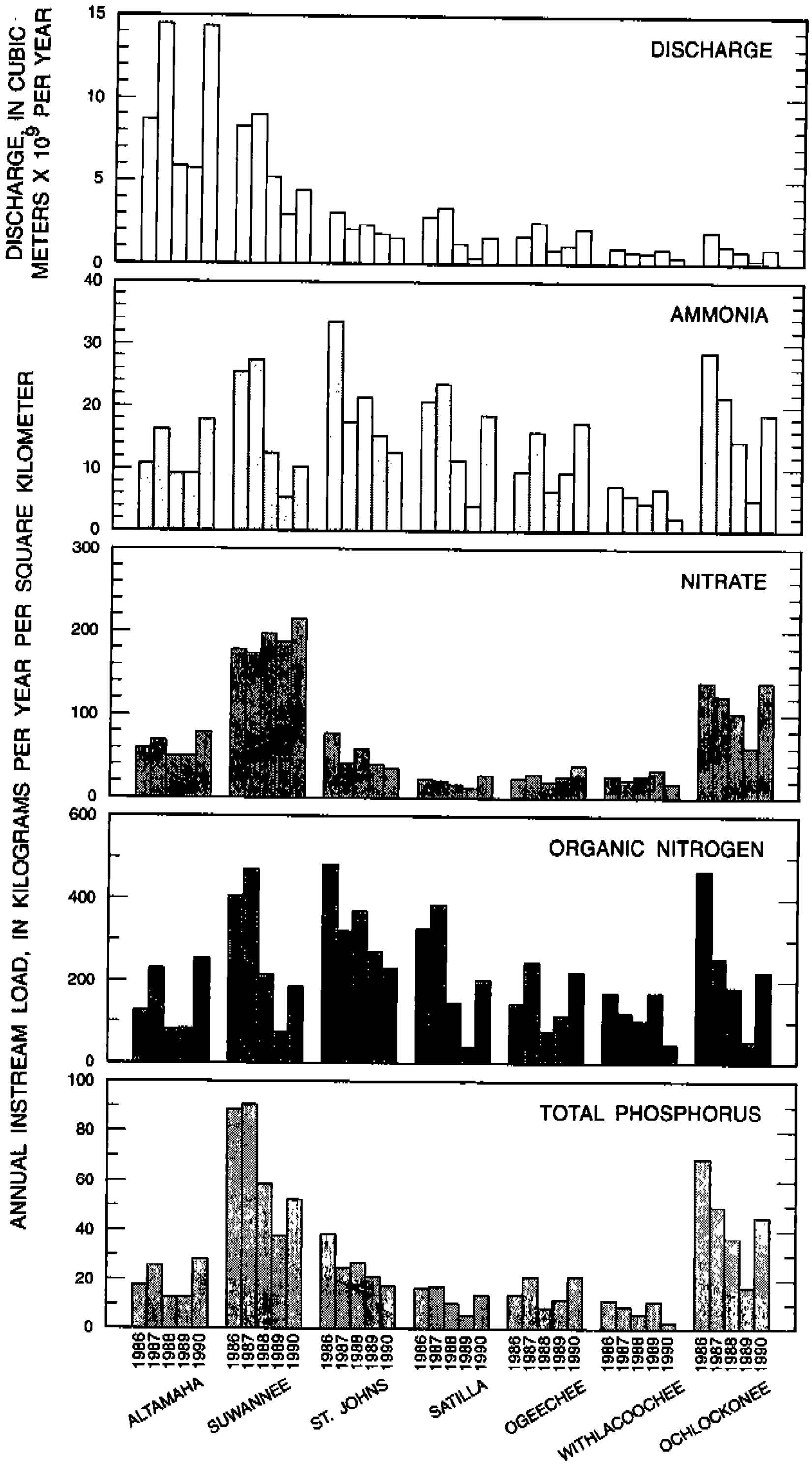

Figure 6. Mean annual discharge and annual stream loads by nutrient species for each study basin.

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U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

The NAWQA Program

The National Water-Quality Assessment (NAWQA) Program, conducted by the U.S. Geological Survey, evaluates the Nation's ground water, rivers and streams. The building blocks of the Program are scientific investigations in 59 hydrologic basins ("study units"). Collectively, these study units cover one-half of the land area of the United States, encompass more than two-thirds of the water resources used in human activities, and include sources of drinking water used by 70 percent of the U.S. population served by public supplies.

The Program's investigative methods balance the unique characteristics of individual watersheds with a nationally consistent emphasis on physical, chemical and biological evidence. Study-unit investigations proceed in 3 to 5 year rotations, with about one-third of the study units involved in intensive sampling at any given time. Each basin is revisited every 10 years to record trends.

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