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SEDIMENT YIELD AND ACCUMULATION IN THE LOWER CACHE RIVER

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Champaign, Illinois

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INTRODUCTION

The Cache River basin is located in the extreme southern part of Illinois, just north of the confluence of the Ohio and Mississippi Rivers, as shown in figure 1. The basin covers parts of the six southern Illinois counties of Union, Johnson, Alexander, Pulaski, Massac, and Pope. The total drainage area of the watershed is 737 square miles. Since the construction of the Post Creek Cutoff in 1915, the Cache River basin has been divided into two subwatersheds: the Upper Cache and Lower Cache River watersheds, as shown in figure 2. The Upper Cache River watershed consists of the eastern part of the Cache River basin with a drainage area of 368 square miles; it drains directly to the Ohio River at River Mile 957.8 through the Post Creek Cutoff. The Lower Cache River watershed consists of the western part of the Cache River basin with a drainage area of 358 square miles; it drains to the Mississippi River at River Mile 13.2 through the diversion channel at the downstream end of the river. Eleven square miles of the Lower Cache River watershed continue to drain into the Ohio River at River Mile 974.7 through the original channel.

Problems Related to Erosion and Sedimentation

Erosion and sedimentation are major sources of the problems in the Cache River basin. The problems are different for the Upper and Lower Cache Rivers. In the Upper Cache River, the main problem is related to the construction of the Post Creek Cutoff, which altered the state of dynamic equilibrium for the Upper Cache River stream channel. Because of the new state of stream dynamics imposed on the Upper Cache River after the construction of the Post Creek Cutoff, the stream started to entrench. The upstream migration of the stream channel and the associated bank erosion and lateral gully formations are threatening the existence of some of the most significant wetlands and natural areas in the state.

In the Lower Cache River, the problem is related to excessive accumulation of sediment that is eroded from upland watersheds and streambanks in wetlands and stream channels. The accumulation of sediment in stream channels retards the flow in the stream and increases flooding potential, while the continuous accumulation of sediment in wetlands changes the

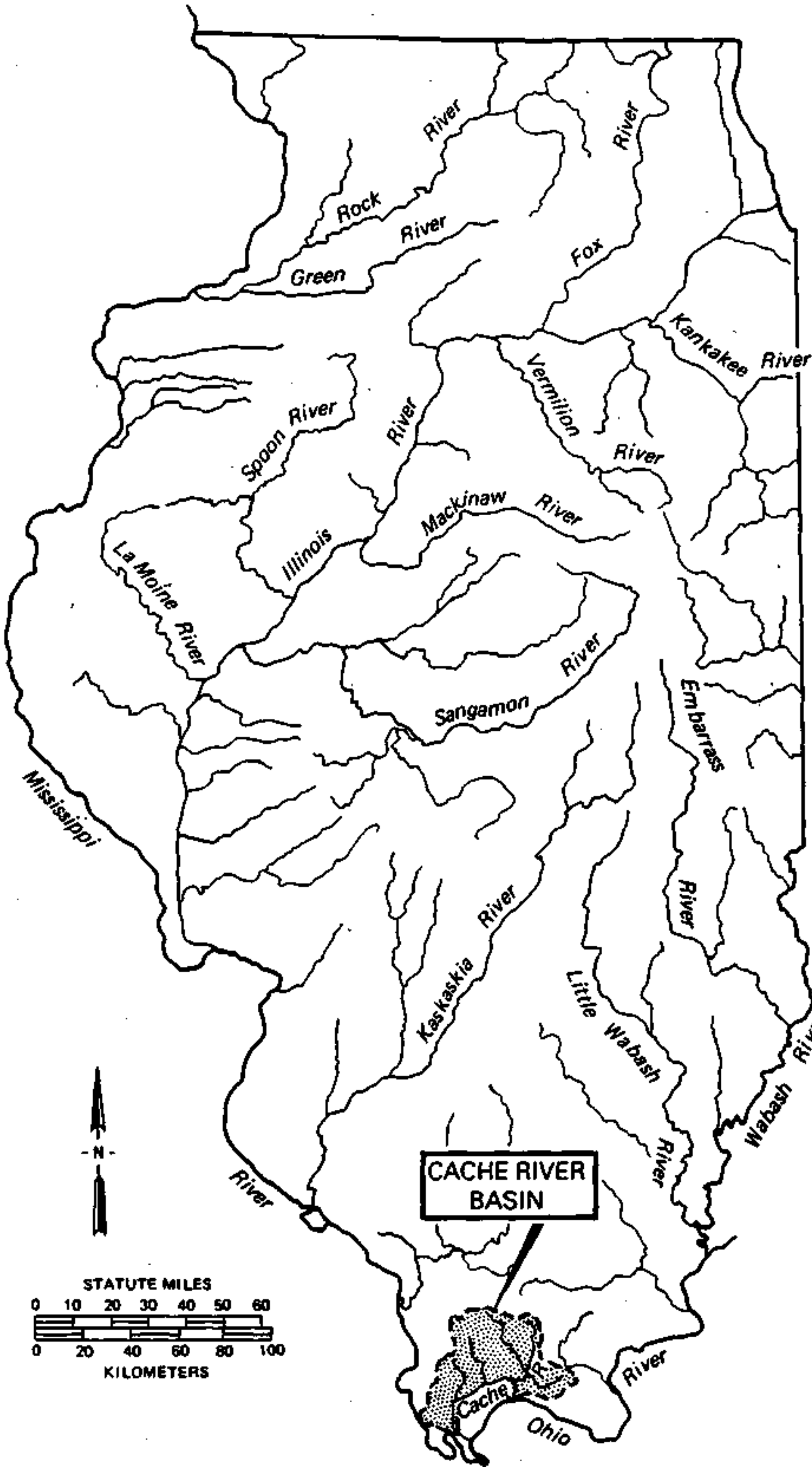

Figure 1. Location of the Cache River basin in Illinois

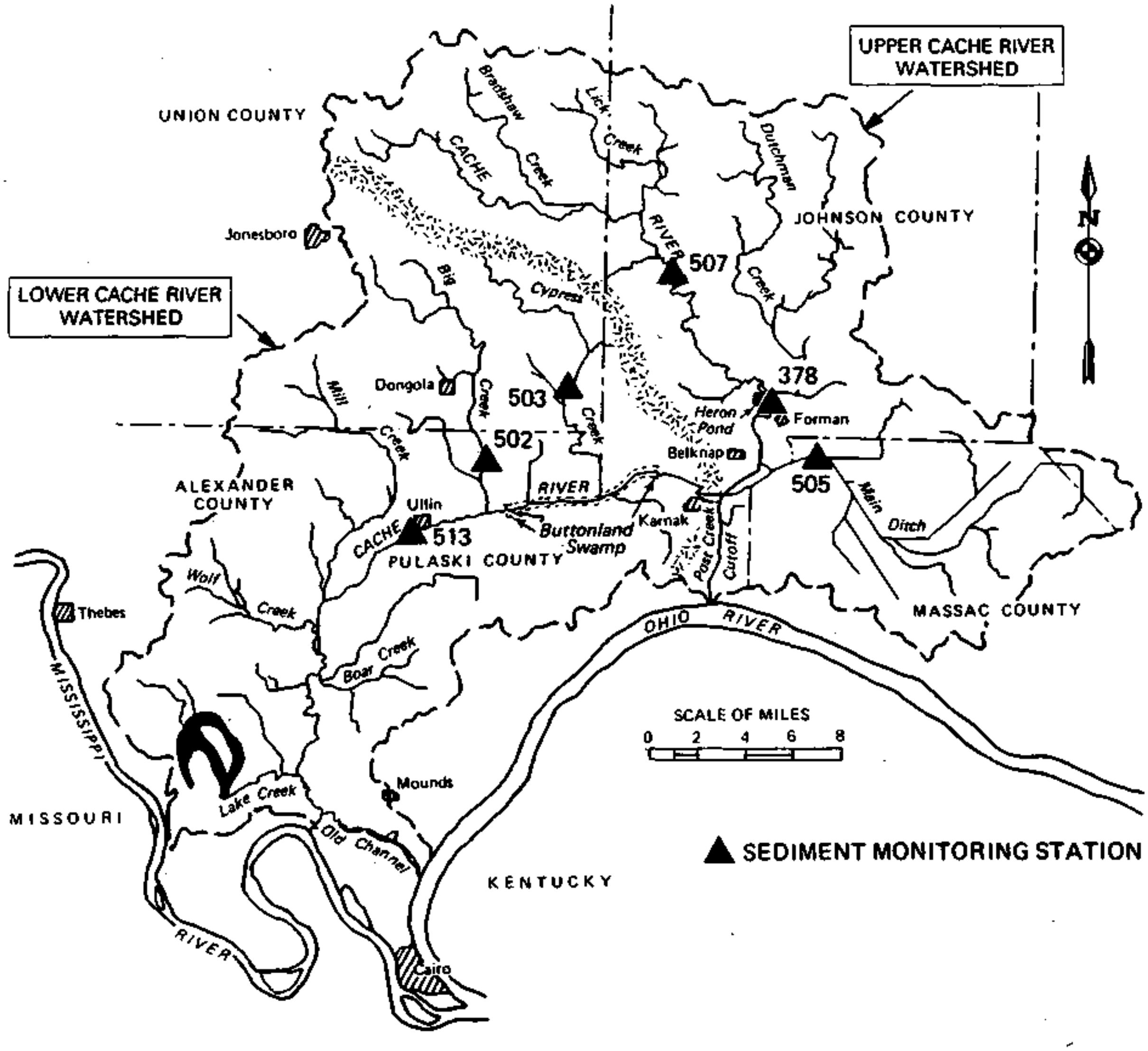

Figure 2. Locations of sediment monitoring stations in the Lower and Upper Cache Rivers

hydrologic balance in the wetland and could in the long run result in a change in the types of plants and animals that could survive in the area.

Because information on erosion and sedimentation is important to the proper understanding of the problems in the Cache River basin, a sediment data collection program was initiated in 1985 as part of the Cache River basin project. The data collection program was designed so that the amount of sediment transported by different streams could be quantified and then used in developing the best alternative solutions for reducing the negative impacts of erosion and sedimentation in the area. The sediment monitoring stations were located at strategic locations that could provide the best information under the project funding limitations. The sediment monitoring stations in the whole Cache River basin, in both the Upper and Lower Cache River watersheds, are shown in figure 2 and listed in table 1. Even though sediment concentrations were monitored at other stations, including the station in Buttonland Swamp at Route 37, these six stations—three in the Upper Cache and three in the Lower Cache-were the main stations where sediment loads could be calculated with accuracy. In the Upper Cache River, two stations were located on the main stem of the Cache River and one station was located on Main Ditch. The results of monitoring the sediment transport rates at these locations were used in developing a sediment transport model to simulate channel scour in the Upper Cache River and the Post Creek Cutoff (Demissie et al., 1989b).

In the Lower Cache River, two stations were located on the two major tributaries draining into the Buttonland Swamp area, and the third was located on the main stem of the Lower Cache River at Ullin to monitor the sediment outflow from the Buttonland Swamp area. This setup will enable us to estimate the amount of sediment that is coming into and going out of this area.

Acknowledgments

This report is based on data collected for the Cache River project, which is funded by the Illinois Department of Conservation. Marvin Hubbell, who is project manager for the IDOC, had significant input in the formulation and design of the project. Surface Water Section staff members who have contributed to the Cache River project significantly include Richard Allgire, Laura Keefer, Ta Wei Soong, and Renjie Xia.

Kathy Brown and Becky Howard typed the report, Gail Taylor edited it, and Linda Riggin prepared the illustrations.

Table 1. Sediment Monitoring Stations in the Cache River Basin

Station number	*Location*	*Drainage area (sq mi)*	*Drainage area (acres×1000)*
Upper Cache River			
378	Cache River at Forman	241	154.2
505	Main Ditch at Route 45	97	62.1
507	Cache River at Route 146	122	78.1
Lower Cache River			
502	Big Creek at Perks Road	31	19.8
503	Cypress Creek at Dongola Road	24	15.4
513	Cache River at Route 51	164	105.0

SEDIMENT YIELD

The results of the sediment yield measurements in the Lower Cache River are presented in this report. The results for the Upper Cache River are summarized elsewhere (Demissie et al., 1989a). The results of the sediment monitoring program in the Lower Cache River are summarized in tables 2 and 3. The sediment loads in table 2 are the total monthly loads in tons, while those in table 3 are tons per 10 acres, which are obtained by dividing the sediment loads in table 2 by the respective drainage areas of the stations.

For comparison and discussion purposes, the sediment yield values given in tables 2 and 3 are plotted in figures 3 and 4, respectively. Figure 3 presents the monthly sediment yield in tons for the three stations. The data are presented separately for Water Years 1985 through 1988. Figure 4 is arranged similarly. The 1985 water year data were not complete, and only data for Big Creek for six months are shown. However, since 1985 is the only wet year for which there are some data, it provides good balance in evaluating the data collected during the project period.

One important observation that can be made from figures 3 and 4 is the significantly higher sediment yields in 1985 and 1986 than in 1987 and 1988. The highest monthly sediment yield recorded was 25.7 tons per 10 acres (50,840 tons) in May 1986 (figure 4b). The second highest was 18.4 tons per 10 acres (36,461 tons) in August 1985 (figure 4a). Both of these yields were measured at the Big Creek station. In comparison, the sediment yields in 1987 and 1988 never exceeded 5 tons per 10 acres in any one month at any of the stations.

Both Water Years 1987 and 1988 were dry years with very low streamflows and thus extremely low sediment yields. The 1986 water year was near normal in precipitation and streamflow. The 1985 water year was wet; however, data collection was not initiated at all the stations in 1985. The partial record for Big Creek in 1985 shows significant sediment yield.

The maximum monthly sediment yields recorded for Cypress Creek and the Lower Cache River were 5,119 and 12,630 tons, respectively, during the major flood in May 1986 that generated 50,840 tons from Big Creek. For Cypress Creek, the next-highest monthly sediment yield was 2,106 tons in December 1987. For the Lower Cache River, the second-highest sediment yield was 7,309 tons in March 1988. The data collection period is strongly biased toward dry periods, and thus average values based on the data collected so far will be far less than what would be expected in a normal mix of dry, normal, and wet years.

The second important observation is the dominance of Big Creek in terms of sediment yield in the Lower Cache River. In general, the sediment yield per unit area is higher for Big Creek than for Cypress Creek or for the whole Lower Cache River as monitored at Ullin. Only during some periods with relatively low sediment yields, such as June and July 1987, does sediment yield per unit area from Cypress Creek exceed that of Big Creek.

The total annual sediment yields from the three monitoring stations in the Lower Cache River for the four water years when some sediment data were collected are summarized in table 4 and compared in figure 5. Figure 5a shows the total sediment yield in tons, while figure 5b shows the sediment yield in tons per 10 acres. In terms of total sediment yield, the Big Creek watershed generates more sediment than Cypress Creek and even more than the whole Lower Cache River upstream of Ullin that includes the Big Creek watershed itself. In 1986, a near-normal water year, the total annual sediment yield from the Big Creek watershed was 85,284 tons as compared to 8,166 and 25,723 tons for Cypress Creek and Lower Cache River at Ullin, respectively. Therefore the total amount of sediment from Big Creek was more than 10 times that of Cypress Creek and more than 3 times that of the Lower Cache River. In 1987, a low-flow water year, the total annual sediment yield from Big Creek was 16,429 tons as compared to 4,030 and 8,699 tons for Cypress Creek and the Lower Cache River, respectively. In 1988, another low-flow year, the sediment yield from Big Creek was 17,432 tons as compared to 6,019 and 15,446 tons for Cypress Creek and the Lower Cache River. Therefore the sediment yield from Big Creek is generally several times that of Cypress Creek and up to 3 times more than that of the Lower Cache River. The sediment yield from the Lower Cache River at Ullin is less than that of Big Creek because a significant amount of the sediment from tributary streams entering the area is trapped within Buttonland Swamp and the adjoining wetlands and floodplains before it reaches the gaging station at Ullin.

On the basis of sediment yield per unit area as shown in figure 5b, the sediment yields per 10 acres for 1986 were 43 tons for Big Creek, 5.3 tons for Cypress Creek, and 2.5 tons for the Lower Cache River. For 1987 they were 8.3 tons for Big Creek, 2.6 tons for Cypress Creek, and 0.8 ton for the Lower Cache River. In 1988 the yields were 8.8 tons for Big Creek, 3.9 tons for Cypress Creek, and 1.5 tons for the Lower Cache River. Therefore, the sediment yield per unit area from Big Creek is from 2 to 8 times that of Cypress Creek and 6 to 17 times that of the Lower Cache River.

The reasons why the Big Creek watershed yields more sediment per unit area than the Cypress Creek watershed must be related to differences in watershed characteristics, land use, stream channel characteristics, and floodplain wetlands. Since the watersheds are adjacent to each other, there is not much difference in climatic conditions or even in soil characteristics. Some factors that are evident are the differences in the stream channels and floodplains of the two creeks. While the floodplains of Big Creek are relatively void of trees, many places along Cypress Creek are forested and uncleared. These forested floodplains tend to trap sediment and reduce sediment yield downstream.

Table 2. Monthly Suspended Sediment Loads
in the Lower Cache River Basin (in tons)

		Station		
		502	***503***	***513***
Water Year 1985				
1984	Oct	.	-	.
	Nov	-	-	-
	Dec	-	-	-
1985	Jan	-	-	-
	Feb	-	-	-
	Mar	-	-	-
	Apr	2946	-	-
	May	10666	-	-
	Jun	842	-	-
	Jul	32	-	-
	Aug	36461	-	-
	Sep	998	-	-
Water Year 1986				
1985	Oct	624	-	-
	Nov	2068	-	-
	Dec	599	-	-
1986	Jan	28	-	-
	Feb	18661	7	1190
	Mar	2621	1076	1803
	Apr	43	82	134
	May	50840	5119	12630
	Jun	639	487	2398
	Jul	2388	490	5617
	Aug	6053	729	1212
	Sep	721	177	740
Water Year 1987				
1986	Oct	1450	192	682
	Nov	12	6	90
1987	Dec	194	146	625
	Jan	9	1	21
	Feb	5942	432	317
	Mar	7229	545	2827
	Apr	163	264	557
	May	31	1	468
	Jun	884	1462	725
	Jul	506	981	2348
	Aug	3	1	27
	Sep	7	0	14

Table 2. Concluded

		Station		
		502	*503*	*513*
Water Year 1988				
1987	Oct	1	0	10
	Nov	8	10	24
	Dec	9670	2106	2184
1988	Jan	3457	1431	1032
	Feb	1548	870	743
	Mar	2337	1336	7309
	Apr	326	232	3148
	May	26	1	443
	Jun	7	0	33
	Jul	16	2	30
	Aug	8	21	42
	Sep	28	12	449

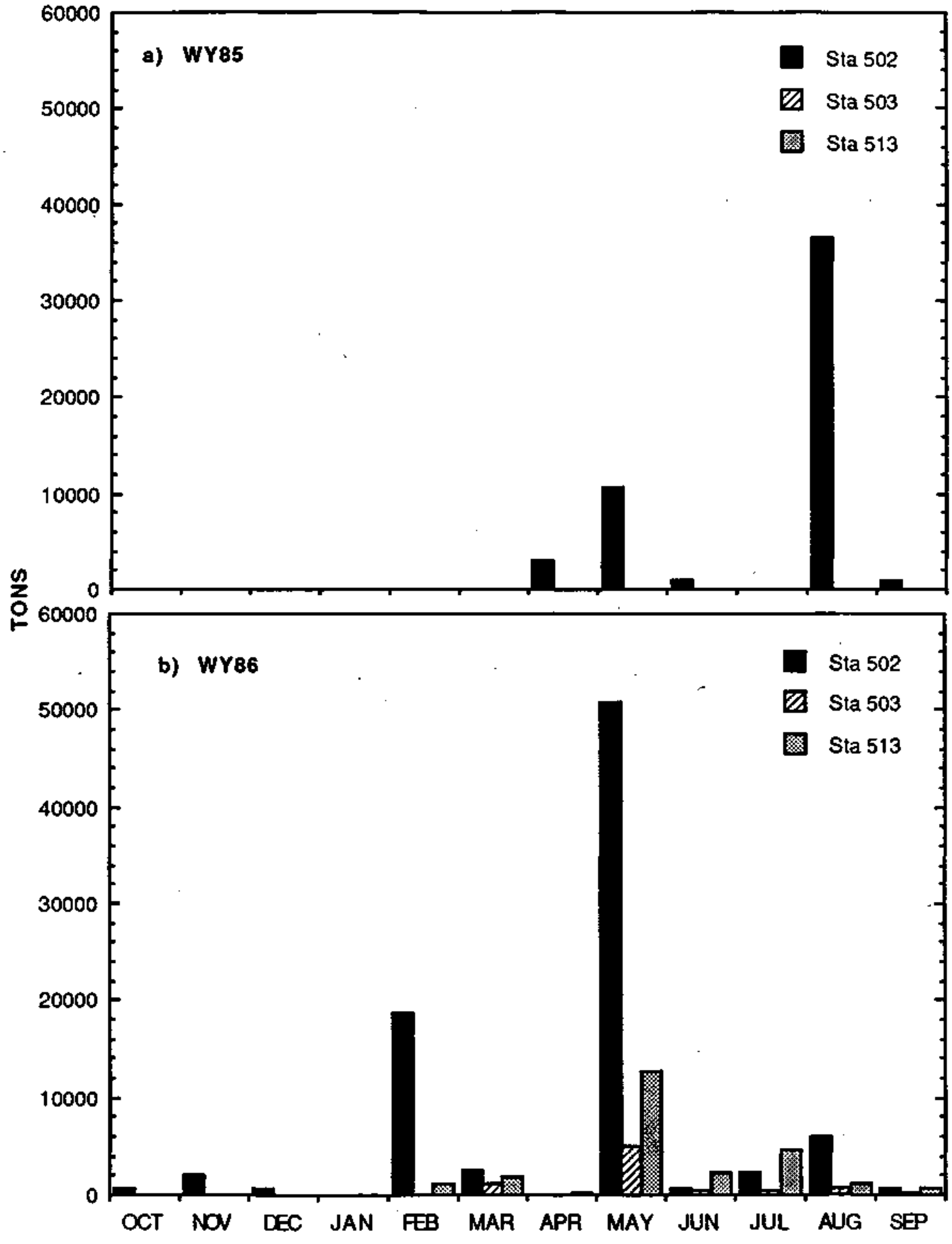

Figure 3. Monthly sediment yields in the Lower Cache River

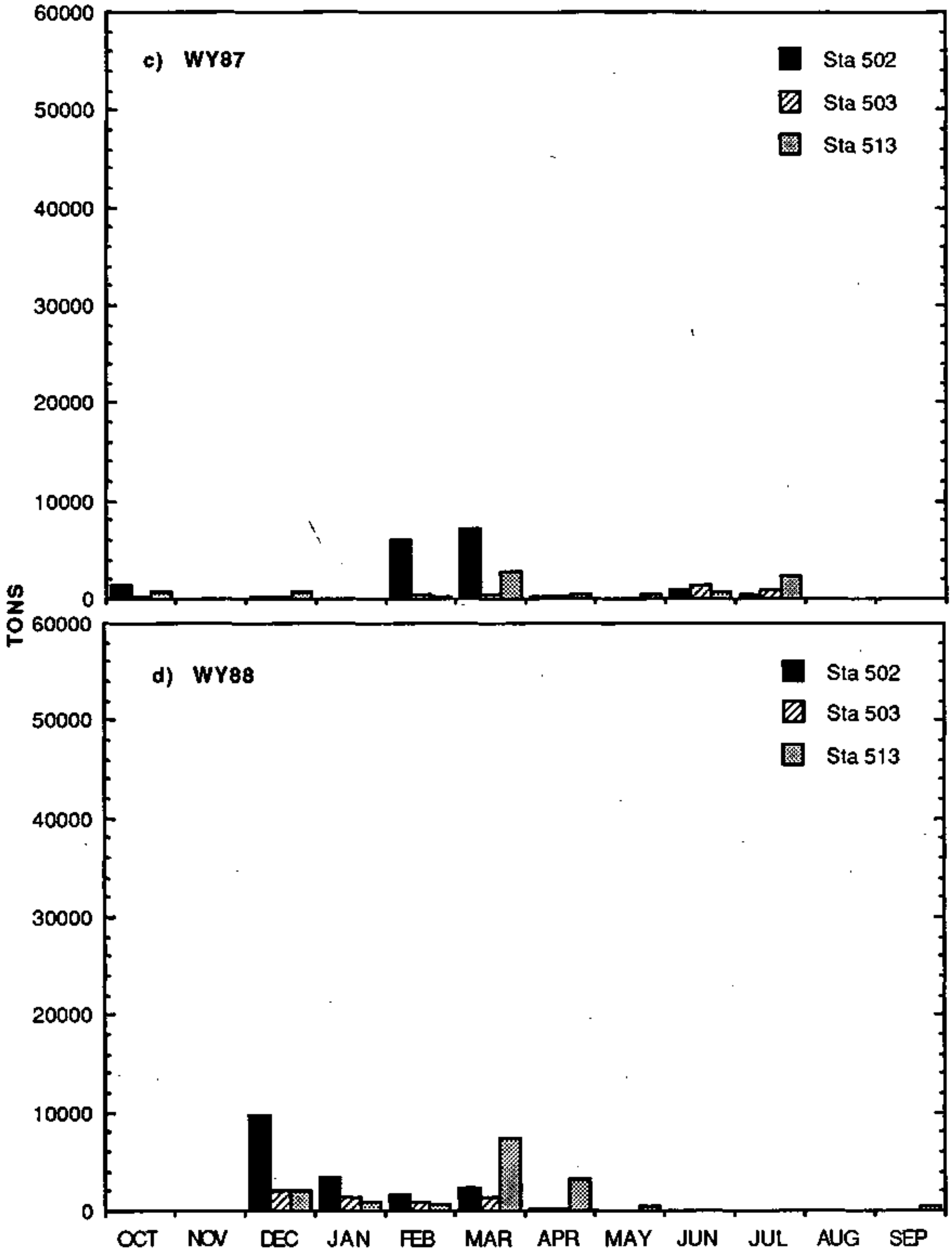

Figure 3. Concluded

Table 3. Monthly Suspended Sediment Loads
in the Lower Cache River Basin (in tons per 10 acres)

		Station		
		502	*503*	*513*
Water Year 1986				
1984	Oct	-	-	-
	Nov	-	-	-
	Dec	-	-	-
1985	Jan	-	-	-
	Feb	-	-	-
	Mar	-	-	-
	Apr	1.487	-	-
	May	5.384	-	-
	Jun	0.425	-	-
	Jul	0.016	-	-
	Aug	18.404	-	-
	Sep	0.504	-	-
Water Year 1986				
1985	Oct	0.315	-	-
	Nov	1.044	-	-
	Dec	0.302	-	-
1986	Jan	0.014	-	-
	Feb	9.419	-	0.113
	Mar	1.323	0.701	0.172
	Apr	0.021	0.054	0.013
	May	25.662	3.333	1.204
	Jun	0.323	0.317	0.229
	Jul	1.205	0.319	0.536
	Aug	3.055	0.475	0.116
	Sep	0.364	0.115	0.071
Water Year 1987				
1986	Oct	0.732	0.125	0.065
	Nov	0.006	0.004	0.009
1987	Dec	0.098	0.095	0.060
	Jan	0.005	0.001	0.002
	Feb	2.999	0.281	0.030
	Mar	3.649	0.355	0.270
	Apr	0.082	0.172	0.053
	May	0.016	0.001	0.045
	Jun	0.446	0.951	0.069
	Jul	0.255	0.639	0.224
	Aug	0.002	0.001	0.003
	Sep	0.003	0.000	0.001

Table 3. Concluded

		Station		
		502	*503*	*513*
Water Year 1988				
1987	Oct	0.001	0.000	0.001
	Nov	0.004	0.007	0.002
	Dec	4.881	1.371	0.208
1988	Jan	1.745	0.931	0.098
	Feb	0.781	0.566	0.071
	Mar	1.180	0.870	0.697
	Apr	0.165	0.151	0.300
	May	0.013	0.000	0.042
	Jun	0.004	0.000	0.003
	Jul	0.008	0.001	0.003
	Aug	0.004	0.014	0.004
	Sep	0.014	0.008	0.043

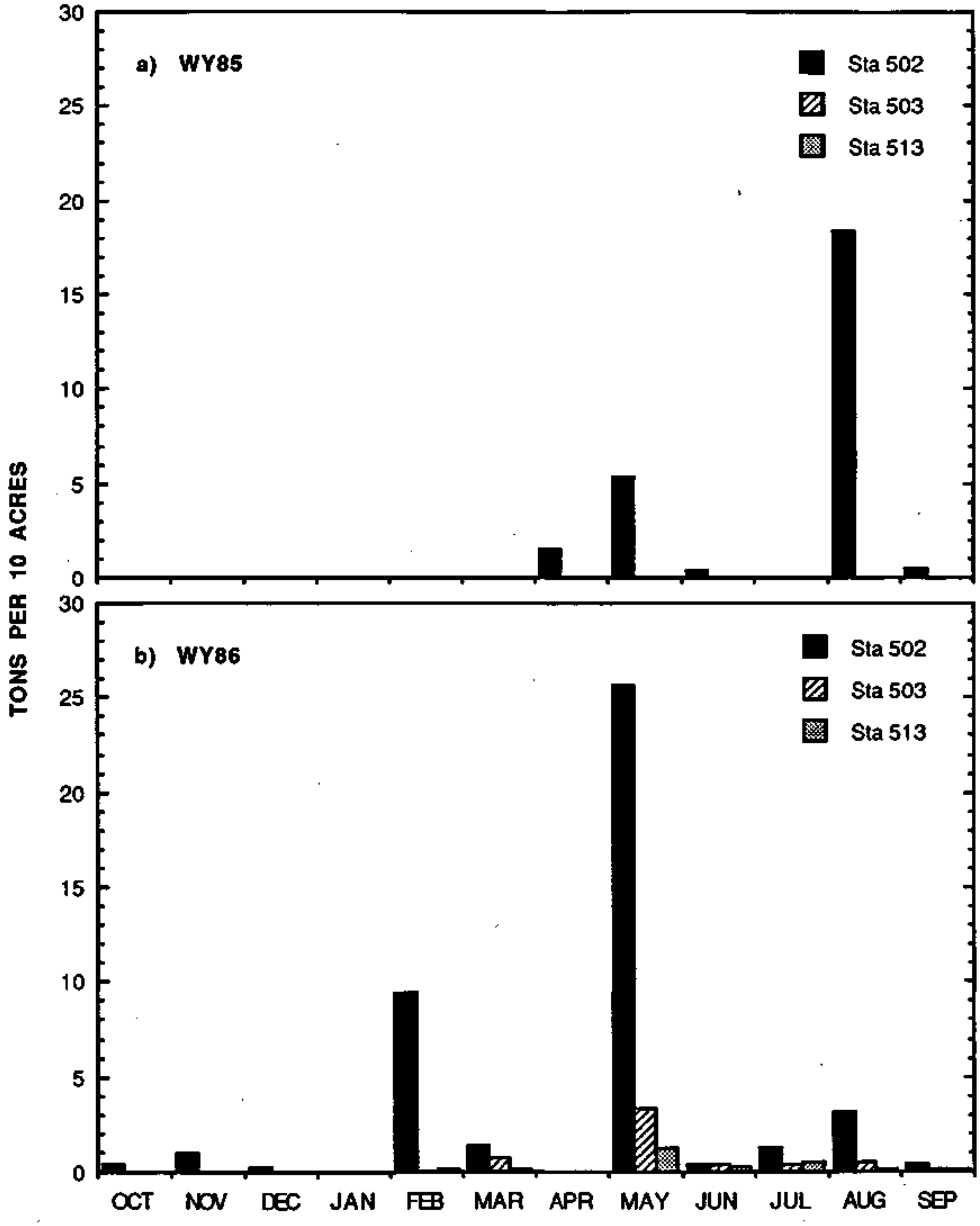

Figure 4. Monthly sediment yields per 10 acres in the Lower Cache River

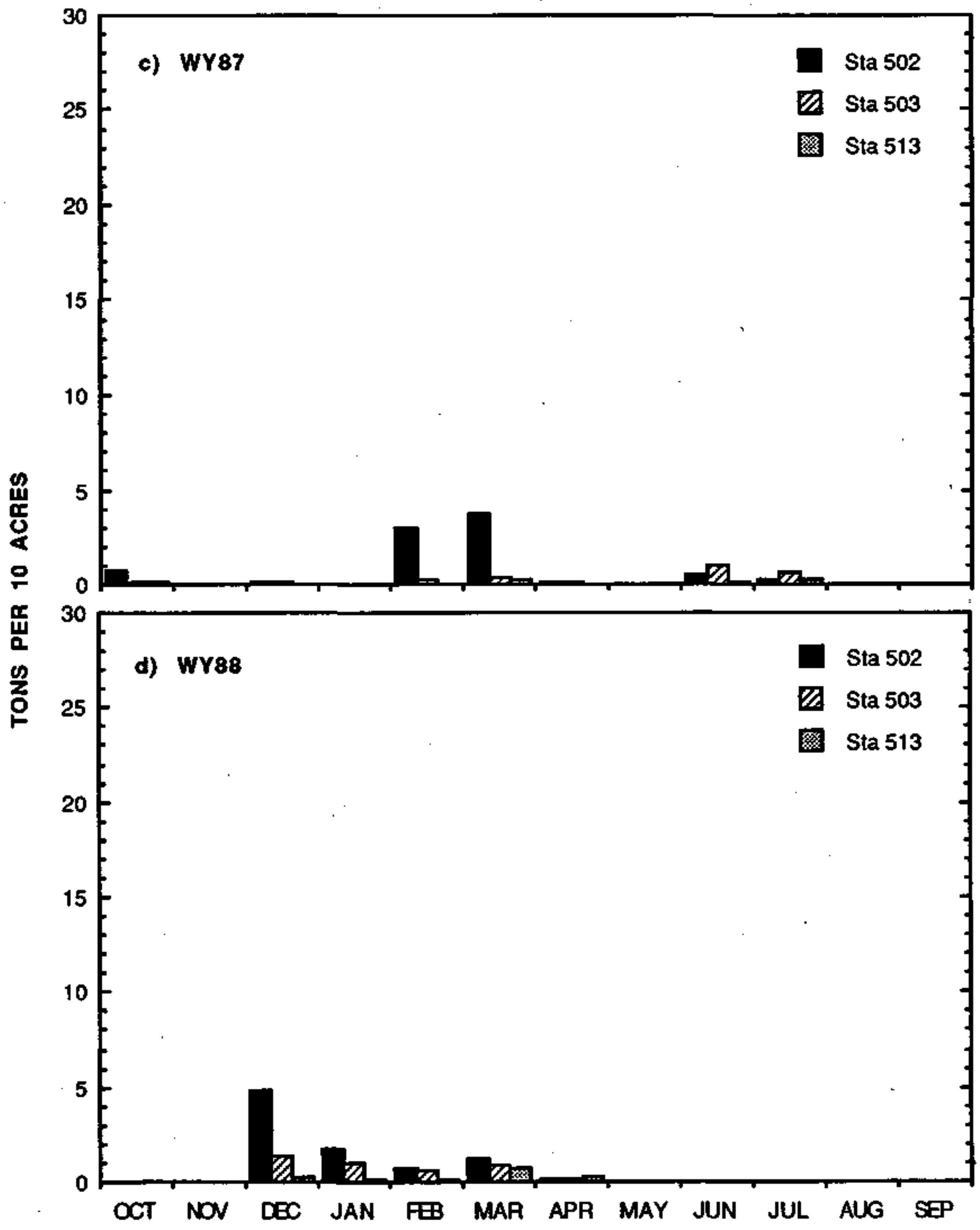

Figure 4. Concluded

Table 4. Annual Sediment Yield in the Lower Cache River Basin

	Station 502		*Station 503*		*Station 513*	
Water Year	***tons***	***tons /10 acres***	***tons***	***tons/ 10 acres***	***tons***	***tons/10 acres***
1985	**51,945***	**26.2***	**-**	**-**	**-**	**-**
1986	**85,284**	**43.0**	**8,166***	**5.3***	**25,723***	**2.5***
1987	**16,429**	**8.3**	**4,030**	**2.6**	**8,699**	**0.8**
1988	**17,432**	**8.8**	**6,019**	**3.9**	**15,446**	**1.5**

- No data

*** Partial record**

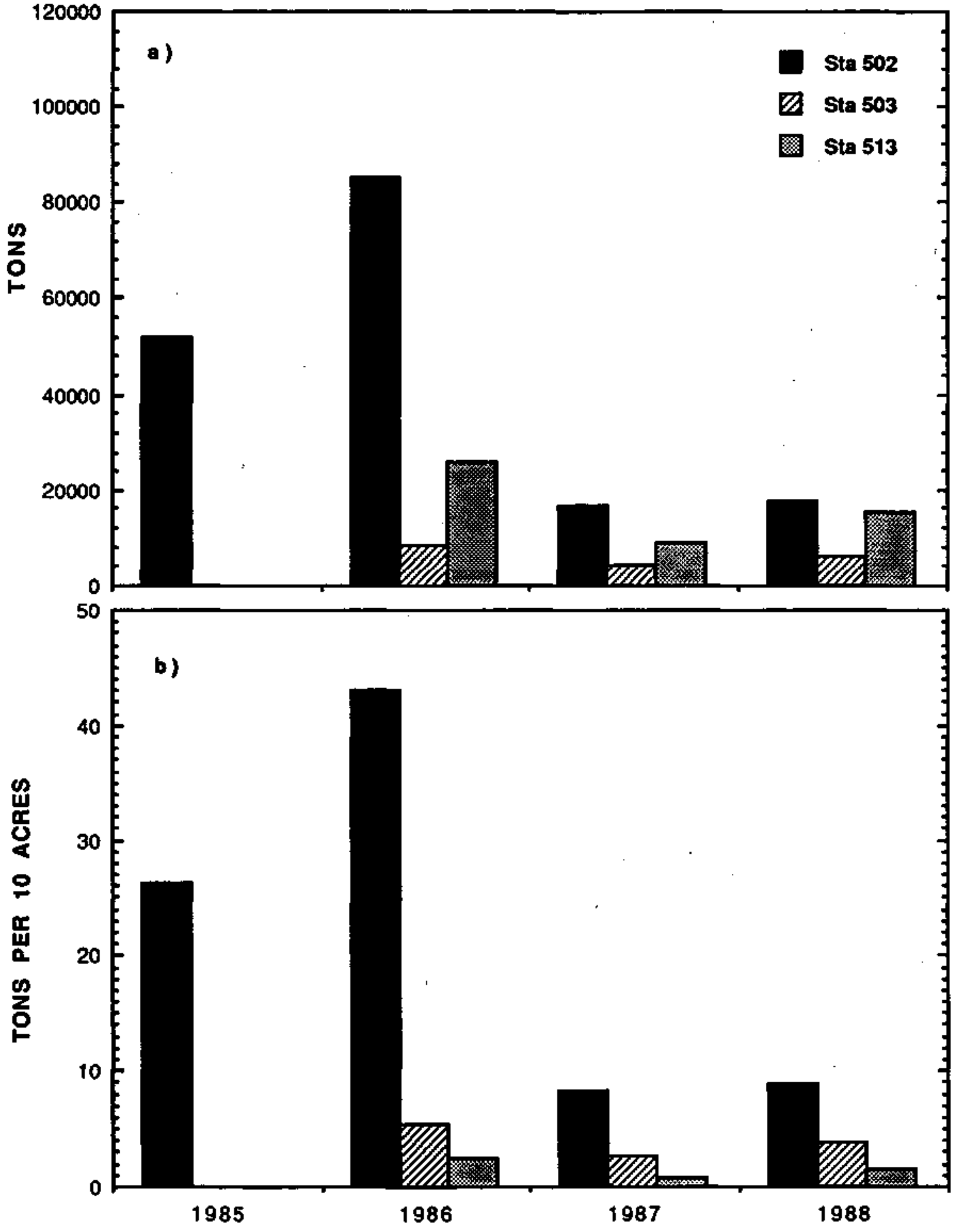

Figure 5. Annual sediment yield

SEDIMENT BUDGET OF THE BUTTONLAND SWAMP AREA

As pointed out in the introduction, the problem of the Lower Cache River related to sediment is the accumulation of excessive sediment in wetlands and stream channels. Because of its location and hydraulic characteristics, the Buttonland Swamp area of the Lower Cache River is a sedimentation basin. Sediment data collected at the three sediment monitoring stations were used in developing a sediment budget for the Buttonland Swamp area. Sediment yield values calculated for Big and Cypress Creeks were used for those watersheds not monitored to generate the total sediment into the Buttonland Swamp area. The sediment outflow from the area was calculated from that measured in the Cache River at Ullin and was adjusted for outflow through the culverts at the Cache River levee on the east end of the Buttonland Swamp area. The sediment discharge measured in the Cache River at Ullin was increased by 10% to account for the outflow through the culverts.

The sediment budget calculations for the Buttonland Swamp area are summarized in table 5. The whole area draining into the Buttonland Swamp area can be subdivided into 9 sub-watersheds, shown schematically in figure 6. Sub-watersheds 1 and 8 are the Big Creek and Cypress Creek watersheds, which have been monitored at the gaging stations shown in figure 2. The other sub-watersheds either join Big and Cypress Creeks or drain directly into the Cache River. The sediment yield rate used for the sub-watersheds was that of Cypress Creek except for sub-watershed 2, which is the Little Creek watershed that is adjacent to the Big Creek watershed. The sediment yield rate for the Big Creek watershed was used for that watershed. Overall the sediment yield rate assigned to the sub-watersheds is on the conservative side and thus would somewhat underestimate the sediment yield from the whole area. However, the results from the calculations provide a reasonable estimate of the sediment yield and accumulation in the Lower Cache River.

The results of the calculations are given in table 5. The calculations were made for the three years when data were collected at all the stations. Water Year 1985 was excluded because data were not available for two of the three stations. For Water Year 1986, it was calculated that 173,400 tons of sediment entered the Buttonland Swamp area and only 28,300 tons left the area. Therefore 145,100 tons of sediment were trapped in the area, which indicates an 84% trap efficiency. In Water Year 1987, which was a dry year, the sediment inflow into the area was only 44,100 tons, while the outflow was 9,600 tons. The trap efficiency is therefore 78%. In Water Year 1988 (another dry year), the total sediment inflow was 54,500 tons and the outflow was 16,900 tons, resulting in a trap efficiency of 69%. Therefore, the results from the three years of data collection indicate that 69 to 84% of the total amount of sediment that enters the Buttonland Swamp area is trapped in the area. This is a very high

Table 5. Sediment Budget of the Buttonland Swamp Area

Sub-watersheds	Drainage areas (sq mi)	Drainage areas (acres × 1000)	Sediment yield rates (tons/acre) 1986	1987	1988	Sediment yields (tons × 1000) 1986	1987	1988
SW1	31.4	20.1	4.3	0.83	0.88	86.4	16.7	17.7
SW2	18.7	11.9	4.3	0.83	0.88	51.2	9.9	10.5
SW3	12.6	8.0	0.53	0.26	0.39	4.2	2.1	3.1
SW4	6.1	3.9	0.53	0.26	0.39	2.1	1.0	1.5
SW5	22.1	14.1	0.53	0.26	0.39	7.5	3.7	5.5
SW6	11.6	7.4	0.53	0.26	0.39	3.9	1.9	2.9
SW7	22.3	14.3	0.53	0.26	0.39	7.6	3.7	5.6
SW8	24.0	15.4	0.53	0.26	0.39	8.2	4.0	6.0
SW9	6.7	4.3	0.53	0.26	0.39	2.3	1.1	1.7
Total	155.5	99.4				173.4	44.1	54.5
Sediment yield at Cache River at Ullin						25.7	8.7	15.4
Adjusted sediment yield for the Lower Cache River						28.3	9.6	16.9
Sediment trapped in the Buttonland Swamp area						145.1	34.5	37.6
Trap efficiency						84%	78%	69%

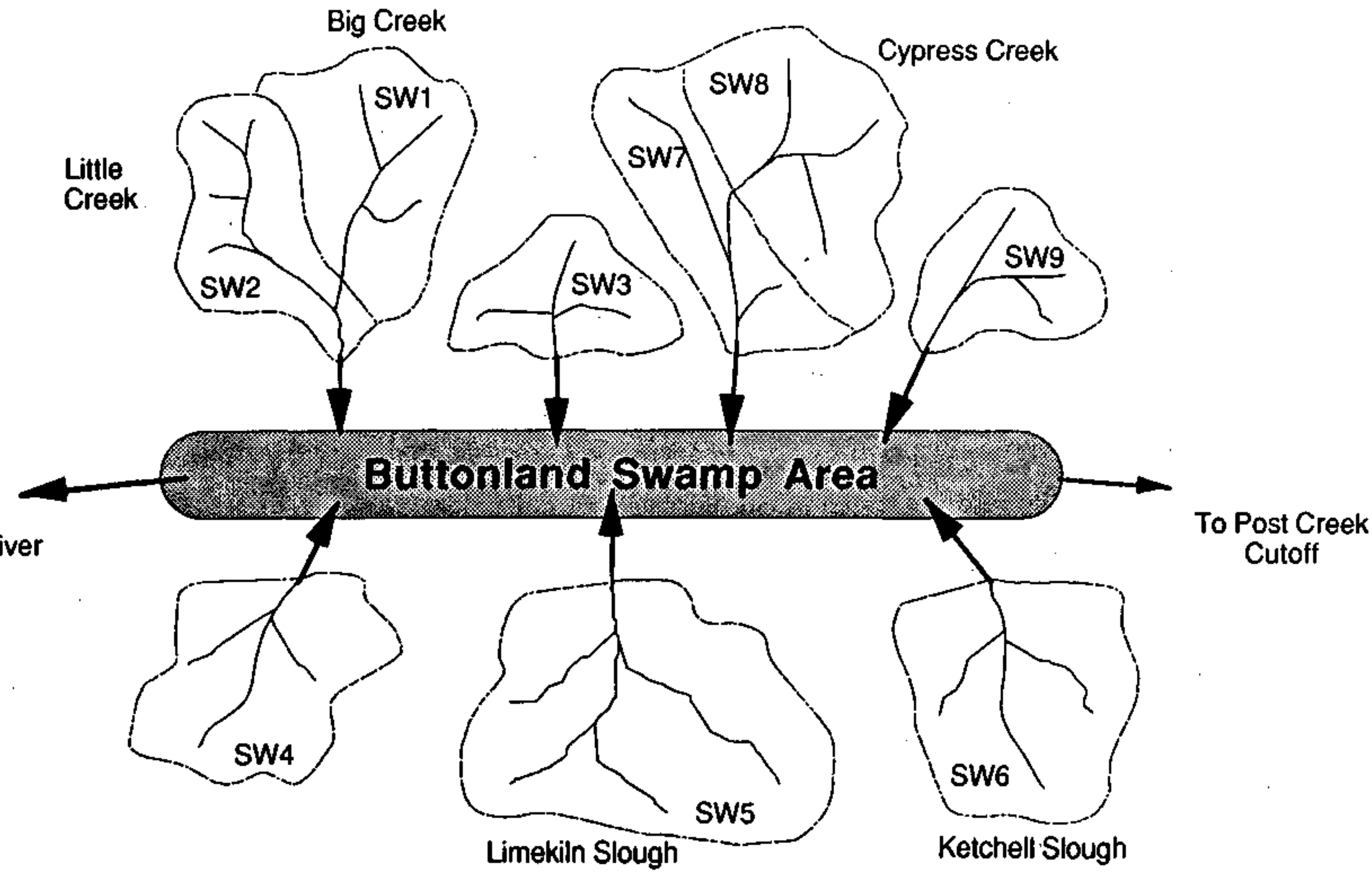

Figure 6. Sub-watersheds draining into the Buttonland Swamp area

sediment trapping efficiency, which in part explains the high sedimentation rate within the Buttonland Swamp area.

SUMMARY AND CONCLUSIONS

A significant component and one of the main objectives of the Cache River project was to collect enough data to determine the amount of sediment being transported by the different streams in the basin. Suspended sediment loads were monitored at six monitoring stations in the Cache River basin. Three of the stations are in the Lower Cache River, and three are in the Upper Cache River. The results from the Lower Cache River stations are presented in this report. The stations in the Lower Cache River are located on Big Creek, Cypress Creek, and the Lower Cache River at Ullin. The data from Big and Cypress Creeks provide information on the amount of sediment being transported into the Buttonland Swamp area by tributary streams, and the data from the Lower Cache River station at Ullin provide information on the amount of sediment leaving the Buttonland Swamp area.

For the three complete years of data collection, the annual sediment yield from Big Creek ranged from a low of 16,429 tons in 1987 to a high of 85,284 tons in 1986. For Cypress Creek, the annual sediment yield ranged from a low of 4,030 tons in 1987 to a high of 8,166 tons in 1986. The corresponding numbers for the Lower Cache River measured at Ullin are 8,699 tons in 1987 and 25,723 tons in 1986. It is interesting to note that not only is the sediment yield of the Lower Cache River at Ullin lower than the combined yield from the two major tributaries, but it is less than the yield from Big Creek alone. This implies that the sediment yield from the Big Creek watershed is very high, and the wetlands and floodplain in the Lower Cache River upstream of Ullin, including Buttonland Swamp, trap a significant amount of the sediment delivered from the tributary streams. The significance of Big Creek and the sediment-trapping capacity of the Lower Cache River can be further exemplified by comparing the sediment yields in terms of yields per unit area instead of in terms of the total sediment yield. The annual sediment yield per 10 acres ranged from 8.3 to 43 tons for Big Creek and from 2.6 to 5.3 tons for Cypress Creek. At the same time, the sediment yield per 10 acres for the Lower Cache River at Ullin ranged only from 0.8 to 2.5 tons. The Big Creek watershed thus yields from 2 to 8 times more sediment than the Cypress Creek watershed for the same area. The sediment yield per unit area from the Lower Cache River after it passes through the wetlands and floodplains upstream of Ullin is only 1/6 to 1/17 of that of Big Creek.

In terms of sediment budget and based on the three years of data collected, it was estimated that the Buttonland Swamp area traps from 69 to 84% of the sediment that enters the area.

The major conclusions of this analysis are: 1) Big Creek is by far the major source of sediment in the Lower Cache River; 2) the Buttonland Swamp area of the Lower Cache River traps a significant amount of sediment from tributary streams. Therefore any program dealing with erosion control and reduction of sedimentation in Buttonland Swamp has to give high priority to the Big Creek watershed. Based on preliminary analysis, there is a strong indication that stream channel and floodplain conditions might be the main reason for the high sediment delivery rate by Big Creek as compared to other streams in the same general area. A more detailed investigation is required to identify and document the factors and areas that lead to high sediment yields and delivery ratios in Big Creek, Cypress Creek, and other streams in the area.

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