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Final Report Buffalo National River Ecosystems Part IV

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BUFFALO NATIONAL RIVER ECOSYSTEMS PART IV

AN INTERDISCIPLINARY STUDY

Project Director

R.E. Babcock

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Arkansas Water Resources Research Center

University of Arkansas

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Richard L. Meyer, Principal Investigator
Neil Woomer, Graduate Assistant

Introduction

Sampling point locations and analytical procedures remained unchanged from those outlined in previous Buffalo National River Ecosystem reports. The only significant change in analytical procedures was a reversion to the glass fiber filter method for collection and extraction of samples for chlorophyll analysis. This change was necessitated by a need for filtering a larger volume to obtain enough chlorophyll for an accurate measurement. Samples were collected monthly from April 9 through December 30. No samples were taken in January or February due to the extremely uncertain traveling conditions caused by the frequent snows. Prior research indicates that the December 30 sample is sufficiently reflective of stable winter conditions to obviate the need for more winter samples (see previous reports).

Additional features in this year's report include a discussion of observations made during a 5-day float trip last July on the lower 60 miles of the river from Tyler Bend to the White River. During this trip an attempt was made to characterize the nature and extent of the various habitat types in the river through mapping of riffle-pool sequences and descriptions of the associated substrate types. This has provided additional information on ecological zonation in the river and has suggested several new approaches to the delineation of these zones. Also, campground evaluation forms were completed and photographs taken at several sites in connection with the human carrying capacity study. These later evaluations have been included in the section contributed by E. E. Dale.

The phycological studies were carried on in much the same way as in previous years, although the extensive, detailed taxonomic work that was done last year, particularly with the diatoms, was not repeated. Past identifications have been confirmed and previously not reported species included.

Because of the time-consuming literature search required for validation species identification, all previous studies were restricted to non-quantitative estimations of abundance and/or dominance. The seasonal and positional distributions were given in earlier reports. Although not included in the work statement, we have initiated a study to quantify the temporal and spatial abundance of selected taxa.

An overview of the river system indicate a great diversity of major taxa. These major groups appear to be restricted to segments or seasons by several factors. A major taxon which is ubiquitous, has a simplified life cycle, and taxonomic features easily recognized would serve best as an experimental tool. Certain selected diatoms were chosen for analysis although other taxa were available. A semi-quantitative analysis of selected diatom species was tested for a representative period. The analysis involves measurement of relative abundance and dominance, and calculation of site and system importance indices of the most prevalent species. This method is useful in delineating ecological zones. It may also be used as a management tool to study user impact upon the river ecosystem. The May 1977 sample set was chosen for analysis since it represents a stable, seasonal association. Community structure for all seasons have been described in previous reports.

Water Quality Monitoring and Analysis

There are no significant changes in the water quality of the Buffalo River for 1977. Past water quality trends continued essentially unchanged, and previously observed seasonal patterns were repeated. Thus perturbations from these basic patterns may be used to assess user impact and/or pollution.

The seasonal trends for temperature, turbidity, specific conductance and total alkalinity are shown in Figure 1. Those for pH, silica, nitrate, dissolved oxygen, percent oxygen saturation and orthophosphate are shown in Figure 2. Upstream-downstream trends for these parameters are shown in Figures 3 and 4. The seasonal cycle of temperature was virtually identical to that seen in previous years, as would be expected. Water temperatures ranged from a high of 30.9^{o}C at Highway 14 and Rush in July to a low of 5.3^{o}C at Boxley in December. (Table 1 gives the physical and chemical data for all parameters). As previously reported, there appears to be a slight increase in mean temperature in a downstream direction, but this is probably related to normal diurnal warming at the stations below Ponca. At Ponca and Boxley, groundwater contributions probably result in lower temperatures with less diurnal variation relative to downstream stations.

The seasonal turbidity profile (Figure 1) is somewhat different than last year but this is because of general climatic conditions. The rainfall distribution patterns were interrupted by an extended period of drouth. High water and associated turbidity occurred in the autumn

TABLE 1.

BUFFALO NATIONAL RIVER PHYSICAL AND CHEMICAL DATA (APRIL - DECEMBER 1977)

	Temp.	Turb.	D.O.	% Sat.	Cond.	Silica	Nitrate	Ortho-Phosphate	pH	Alk
Survey Date: 9 April 1977										
Boxley	12.0	4.1	10.8	--	--	4.63	0.029	0.046	7.75	31
Ponca	13.0	3.6	10.6	--	--	4.56	0.136	0.052	7.85	38
Jasper	11.0	2.5	11.0	--	--	4.63	0.136	0.044	8.35	65
Pruitt	16.0	2.8	10.0	--	--	4.08	0.072	0.044	8.15	61
Hasty	16.0	2.5	9.9	--	--	4.29	0.114	0.047	8.45	78
Gilbert	16.0	3.3	9.9	--	--	4.93	0.221	0.057	8.40	77
Hiway 14	16.0	3.4	10.1	--	--	5.78	0.285	0.062	8.50	86
Buffalo Pt.	17.0	3.4	9.7	--	--	5.61	0.285	0.067	8.60	86
Rush	17.0	3.6	9.6	--	--	4.22	0.285	0.055	8.80	86
MEAN	14.8	3.2	10.2	--	--	4.75	0.173	0.052	8.32	68
Survey Date: 15/17 May 1977										
Boxley	23.0	1.7	8.1	93.1	80	3.13	0.096	0.043	7.7	40
Ponca	23.0	1.3	8.6	98.9	115	3.24	0.096	0.001	7.5	58
Jasper	23.0	1.5	9.1	104.6	170	2.91	0.096	0.020	7.5	82
Pruitt	24.0	2.9	8.5	100.0	160	2.91	0.176	0.035	7.5	84
Hasty	24.0	2.5	8.3	97.6	179	3.02	0.136	0.023	7.4	92
Gilbert	24.0	1.3	8.2	96.5	182	4.36	0.208	0.001	7.6	94
Hiway 14	26	1.1	8.5	103.7	205	4.64	0.188	0.004	7.8	104
Buffalo Pt.	26.2	1.8	8.6	104.9	205	4.61	0.208	0.001	7.8	104
Rush	26.3	1.6	8.2	100.0	208	4.67	0.188	0.054	7.7	98
MEAN	24.4	1.7	8.45	99.9	167	3.94	0.54	0.019	7.6	84

TABLE 1.

(Continued)

	Temp.	Turb.	D.O.	% Sat.	Cond.	Silica	Nitrate	Ortho-Phosphate	pH	Alk
Survey Date: 21 June 1977										
Boxley	--	--	--	--	--	--	--	--	--	--
Ponca	24.5	1.2	7.2	84.7	168	5.36	0.164	0.053	7.50	58
Jasper	25.2	2.4	8.3	98.8	227	5.14	0.324	0.016	7.65	110
Pruitt	25.4	3.3	6.9	83.1	222	5.41	0.204	0.018	7.65	116
Hasty	26.5	2.0	7.2	88.3	234	5.85	0.184	0.019	7.85	120
Gilbert	28.2	1.5	9.5	120.3	220	5.78	0.224	0.027	8.05	108
Hiway 14	29.2	1.3	9.6	123.1	208	5.52	0.144	0.024	8.20	110
Buffalo Pt.	29.1	2.3	9.6	123.1	223	7.06	0.144	0.013	8.20	110
Rush	29.0	2.2	12.1	155.1	226	6.95	0.144	0.013	8.70	106
MEAN	27.1	2.0	8.8	109.6	216	5.88	0.191	0.022	7.98	105
Survey Date: 25 July 1977										
Boxley	--	--	--	--	--	--	--	--	--	--
Ponca	27.5	0.8	6.95	86.9	174	12.06	0.205	0.013	7.65	100
Jasper	30.1	2.2	9.00	118.4	224	11.88	0.245	0.005	7.80	113
Pruitt	29.3	2.6	7.50	96.1	213	11.58	0.245	0.020	7.70	110
Hasty	29.0	2.3	7.40	94.9	231	11.88	0.225	0.028	7.80	118
Gilbert	30.5	1.5	8.90	117.9	219	11.88	0.205	0.035	7.95	108
Hiway 14	30.9	1.4	10.20	136.0	210	11.88	0.205	0.041	8.30	102
Buffalo Pt.	30.1	1.8	8.90	117.1	212	11.70	0.205	0.012	8.15	102
Rush	30.9	1.6	9.30	124.0	205	13.92	0.245	0.015	8.20	99
MEAN	30.0	1.8	8.52	111.4	211	12.10	0.222	0.021	7.94	106.5

TABLE 1.

(Continued)

	Temp.	Turb.	D.O.	% Sat.	Cond.	Silica	Nitrate	Ortho-Phosphate	pH	Alk
Survey Date: 13 Aug 1977										
Boxley	--	--	--	--	--	--	--	--	--	--
Ponca	25.1	1.7	8.25	98.2	171	6.79	0.177	<0.001	7.10	98
Jasper	26.3	2.8	7.30	89.4	184	7.05	0.159	0.034	7.30	111
Pruitt	25.8	2.2	7.30	88.7	185	7.05	0.159	<0.001	7.30	111
Hasty	27.0	2.6	7.35	90.7	184	7.20	0.140	<0.001	7.65	110
Gilbert	28.7	3.4	11.30	143.6	169	8.55	0.177	0.031	8.30	102
Hiway 14	28.7	1.7	9.30	118.2	167	9.64	0.159	<0.001	7.80	99
Buffalo Pt.	27.7	1.0	7.80	98.1	169	9.64	0.140	<0.001	7.70	99
Rush	28.2	0.9	6.80	86.3	170	9.79	0.140	<0.001	7.65	97
MEAN	27.2	2.04	8.18	101.7	175	8.21	0.156	0.008	7.60	103.4
Survey Date: 21-22 Sept. 1977										
Boxley	--	--	--	--	--	--	--	--	--	--
Ponca	23.0	2.5	10.1	116.1	131	7.25	0.196	<0.001	7.20	102
Jasper	23.5	3.8	9.0	104.7	197	7.60	0.159	<0.001	7.00	112
Pruitt	23.5	3.2	8.3	96.5	199	6.95	0.140	<0.001	7.70	116
Hasty	23.7	2.6	9.9	115.8	205	7.45	0.103	<0.001	7.05	150
Gilbert	24.2	1.3	9.0	105.6	193	8.00	0.103	<0.001	7.40	120
Hiway 14	22.5	1.3	7.9	90.3	167	8.20	0.177	<0.001	7.30	110
Buffalo Pt.	22.9	1.3	7.9	90.8	180	8.05	0.140	<0.001	7.60	120
Rush	22.0	2.5	7.2	81.8	190	7.95	0.196	<0.001	7.40	104
MEAN	23.2	2.31	8.66	100.2	183	7.68	0.151	<0.001	7.33	117

TABLE 1.

(Continued)

	Temp.	Turb.	D.O.	% Sat.	Cond.	Silica	Nitrate	Ortho-Phosphate	pH	Alk
Survey Date: 19-20 Oct 1977										
Boxley	--	--	--	--	--	--	--	--	--	--
Ponca	15.1	1.0	11.0	107.8	90	6.60	0.203	0.021	7.30	90
Jasper	16.9	2.2	10.5	108.2	162	7.38	0.222	0.015	7.50	106
Pruitt	15.1	2.5	10.1	99.0	150	6.54	0.279	0.177	7.50	112
Hasty	16.3	1.8	11.0	111.1	172	7.08	0.241	0.017	7.40	122
Gilbert	18.6	0.8	11.6	121.5	160	6.72	0.184	0.008	7.90	113
Hiway 14	15.9	0.7	10.8	108.0	160	5.52	0.156	0.016	7.80	116
Buffalo Pt.	16.0	0.8	10.3	103.0	165	5.46	0.156	0.013	7.55	130
Rush	15.5	1.3	9.7	94.2	165	5.34	0.184	0.045	7.10	124
MEAN	16.2	1.4	10.6	106.6	153	6.33	0.203	0.039	7.51	114
Survey Date: 16 Nov 1977										
Boxley	15.1	>25	9.8	96.1	33	5.60	--	0.089	6.6	20
Ponca	16.0	>25	9.6	96.0	53	6.21	--	0.085	6.8	30
Jasper	15.1	>25	9.3	91.2	70	6.09	--	0.104	6.8	42
Pruitt	15.0	>25	9.6	92.2	89	6.18	--	0.144	7.2	54
Hasty	15.0	>25	9.2	90.2	90	6.18	--	0.165	7.5	62
Gilbert	16.0	3.8	10.5	105.0	127	6.18	--	0.049	7.9	100
Hiway 14	15.0	6.7	10.4	102.0	140	6.35	--	0.048	8.4	116
Buffalo Pt.	15.0	6.1	10.2	100.0	145	6.21	--	0.047	8.2	106
Rush	--	--	--	--	--	--	--	--	--	--
MEAN	15.3	>25	9.8	96.6	93	6.13	--	0.091	7.4	66

TABLE 1.

(Continued)

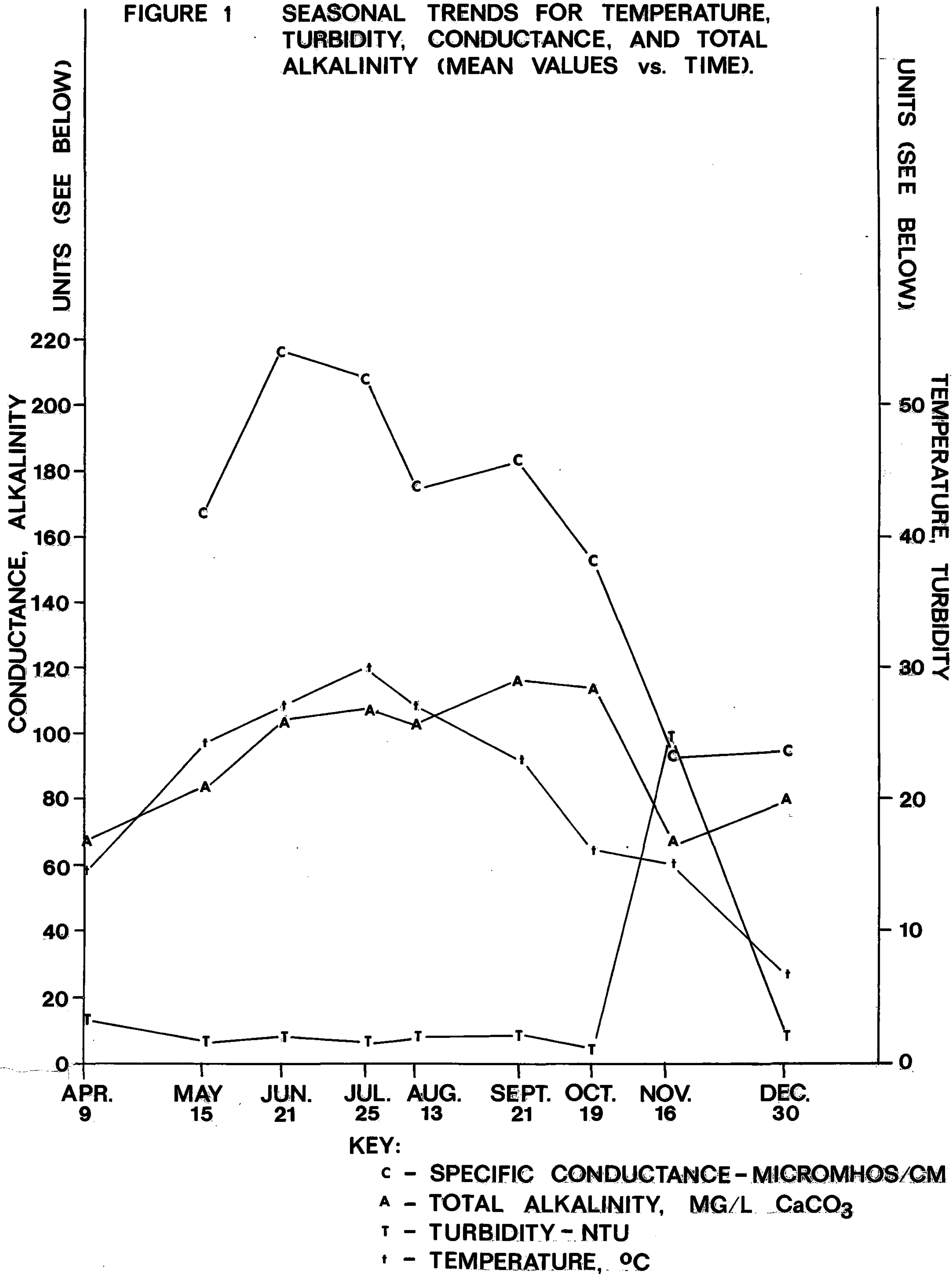
	Temp.	Turb.	D.O.	% Sat.	Cond.	Silica	Nitrate	Ortho-Phosphate	pH	Alk
Survey Date: 30 Dec 1977										
Boxley	5.3	3.0	12.3	97.6	28	5.49	0.153	0.015	7.1	30
Ponca	7.9	2.5	12.2	101.7	68	5.82	0.190	0.015	7.4	48
Jasper	7.8	1.8	12.1	100.8	95	5.47	0.340	0.007	7.4	72
Pruitt	6.5	2.5	12.6	102.0	90	5.82	0.172	0.005	7.5	76
Hasty	5.8	1.6	12.7	100.8	93	4.16	0.190	0.005	7.6	88
Gilbert	7.5	2.0	13.3	110.4	102	4.90	0.228	0.019	7.9	92
Hiway 14	6.0	2.0	13.9	111.2	116	4.30	0.190	0.013	8.0	104
Buffalo Pt.	6.0	1.5	13.8	110.4	117	4.39	0.190	0.011	8.0	104
Rush	7.2	1.4	13.5	111.6	149	3.95	0.190	0.011	7.8	106
MEAN	6.7	2.0	13.0	105.2	95	4.92	0.204	0.011	7.6	80

rather than in the spring. Turbidity readings ranged from a high of greater than 25 NTU at Hasty and above in November, to a low of 0.7 NTU at Highway 14 in October. With the exception of November, mean turbidity levels were uniformly low throughout the year. Paradoxically, mean turbidity (as shown in Figure 3), tends to decrease in a downstream direction. This shows the influence of the high values found at Hasty and above in November, when runoff water from a storm in the headwaters had not yet reached the lower stations at the time of sampling.

The related parameters pH, conductivity and alkalinity generally behaved in a consistent and predictable way. Alkalinity and conductivity (Figure 1) both increased during low flow periods and decreased during periods of high diluting runoff. Alkalinity ranged from a high of 150 mg/l at Hasty in September to a low of 20 mg/l at Boxley in December. pH values were a bit more erratic this year, ranging from 6.6 at Boxley in November to 8.8 at Rush in June. There was a definite downstream increase in mean pH (Figure 4), paralleling a similar downstream increase in conductivity and alkalinity. This pattern is to be expected due to the leaching of carbonate and other mineral ions from the bedrock as the river flows over it.

Seasonal trends for dissolved oxygen, percent oxygen saturation, silica, nitrate and orthophosphate are shown in Figure 2. Dissolved oxygen ranged from 13.9 mg/l at highway 14 in December to 6.8 at Rush in August. Dissolved oxygen was near or above saturation at all times, ranging from 81.8 percent at Rush in September to 155.1 percent at Rush in June. This latter supersaturation value was obtained from a sample taken from the water on top of the extensive Chara beds at Rush in later afternoon when

FIGURE 1 SEASONAL TRENDS FOR TEMPERATURE, TURBIDITY, CONDUCTANCE, AND TOTAL ALKALINITY (MEAN VALUES vs. TIME).



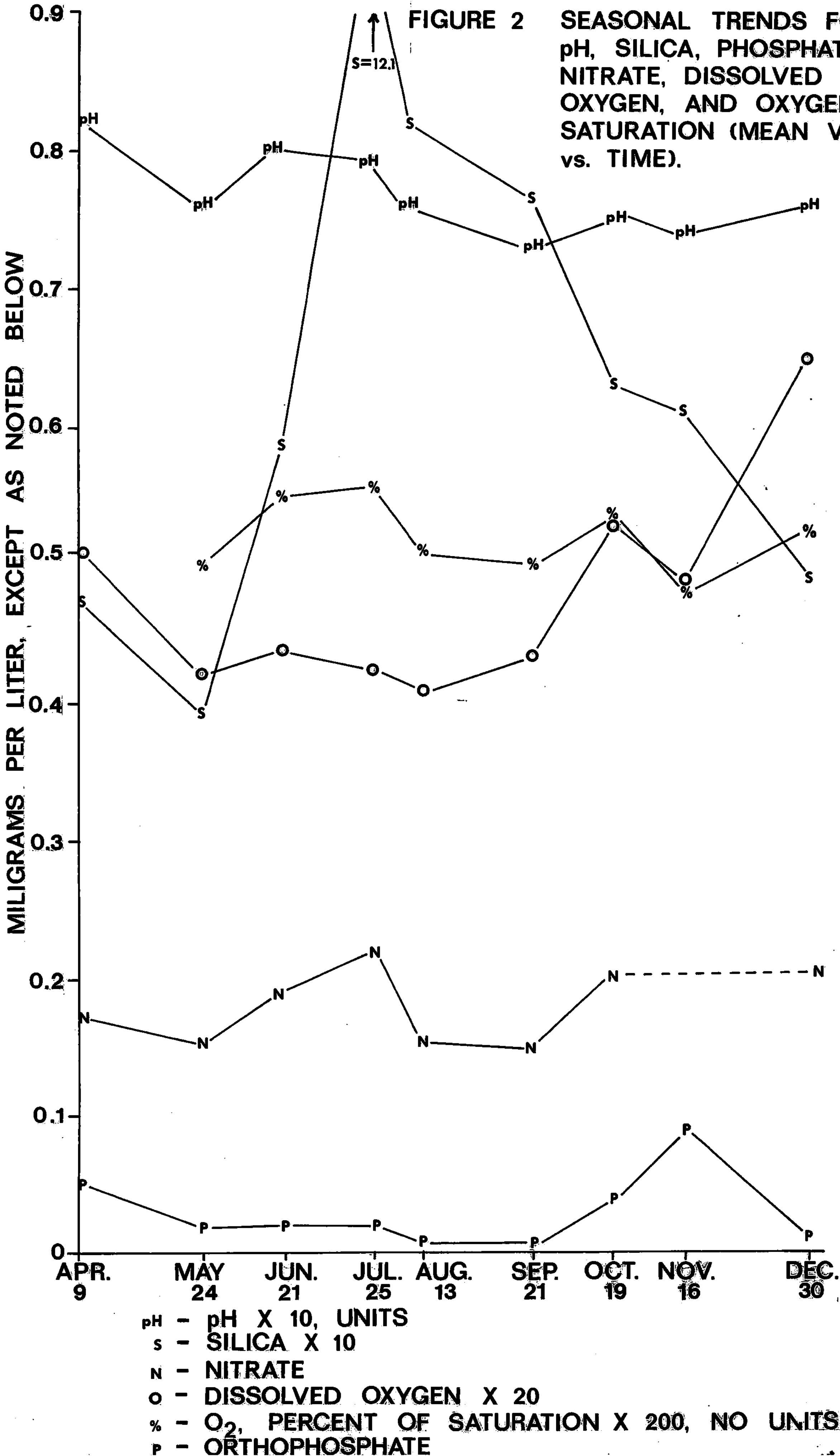


FIGURE 2 SEASONAL TRENDS FOR pH, SILICA, PHOSPHATE, NITRATE, DISSOLVED OXYGEN, AND OXYGEN SATURATION (MEAN VALUES vs. TIME).

FIGURE 3 UPSTREAM-DOWNSTREAM TRENDS FOR TEMPERATURE, TURBIDITY, CONDUCTANCE, AND TOTAL ALKALINITY (MEAN VALUES vs. SAMPLING STATION)

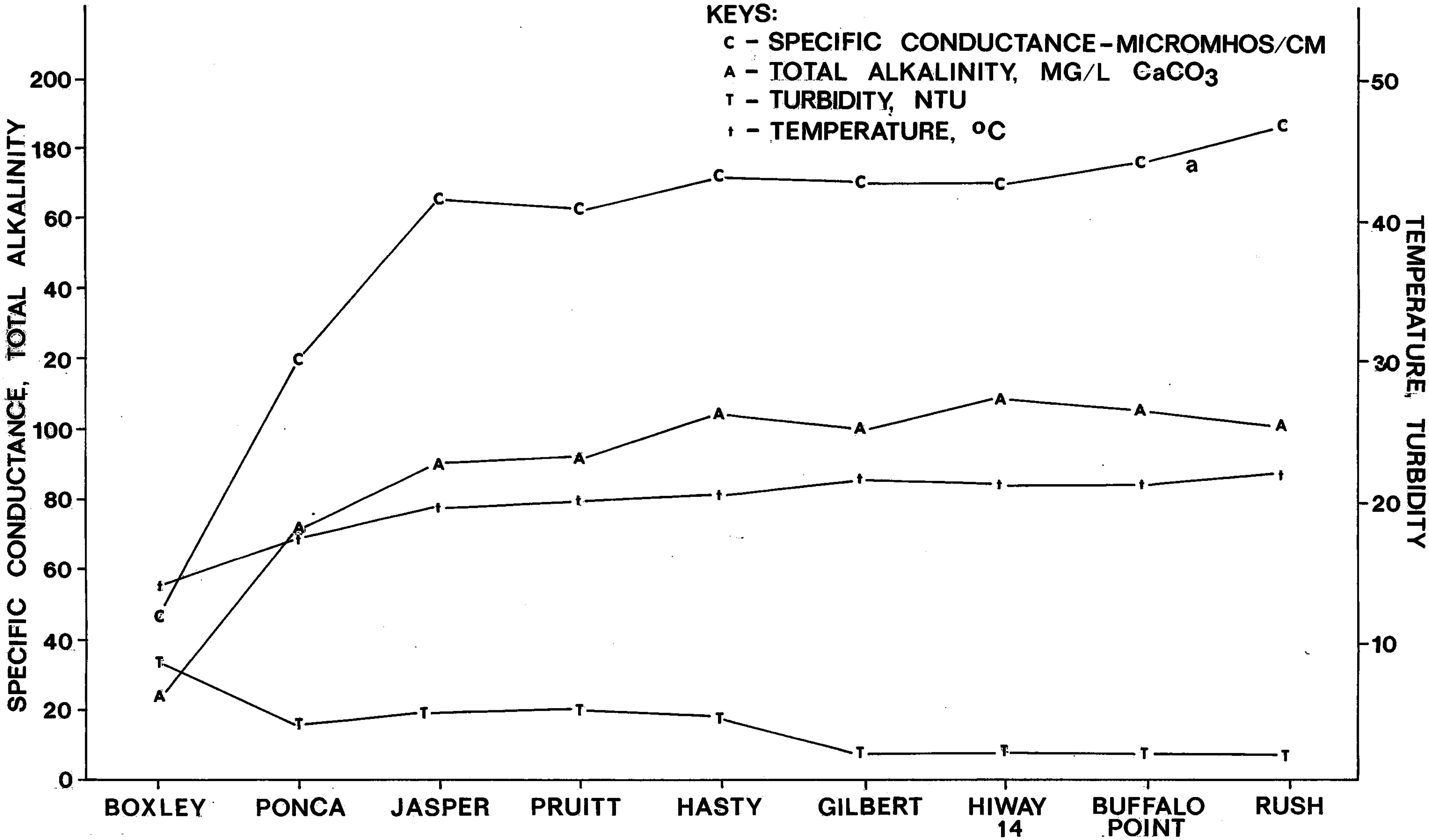
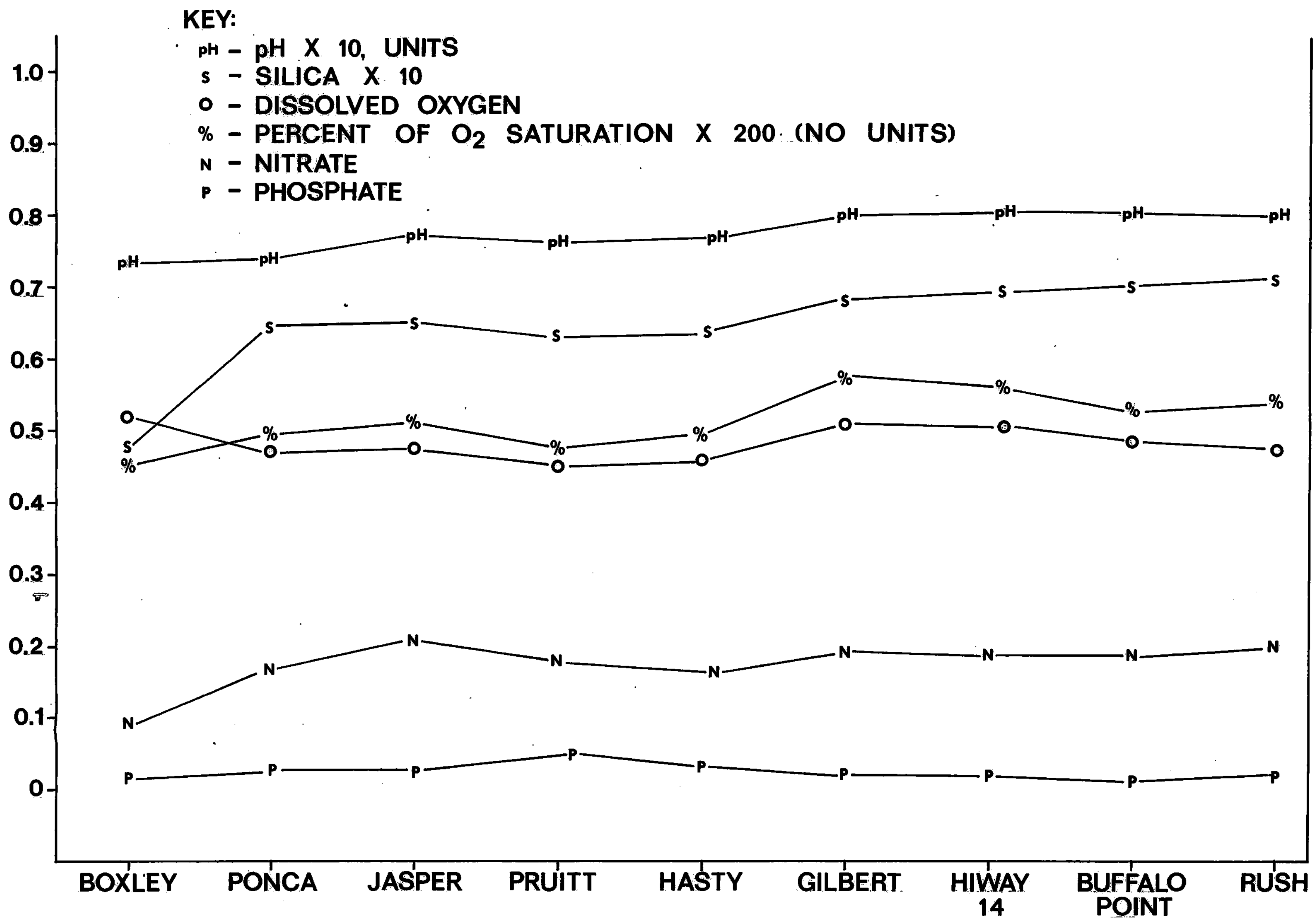


FIGURE 4 UPSTREAM DOWNSTREAM TRENDS FOR pH. SILICA PHOSPHATE NITRATE, DISSOLVED OXYGEN, AND OXYGEN SATURATION (MEAN VALUES vs. SAMPLING STATION)



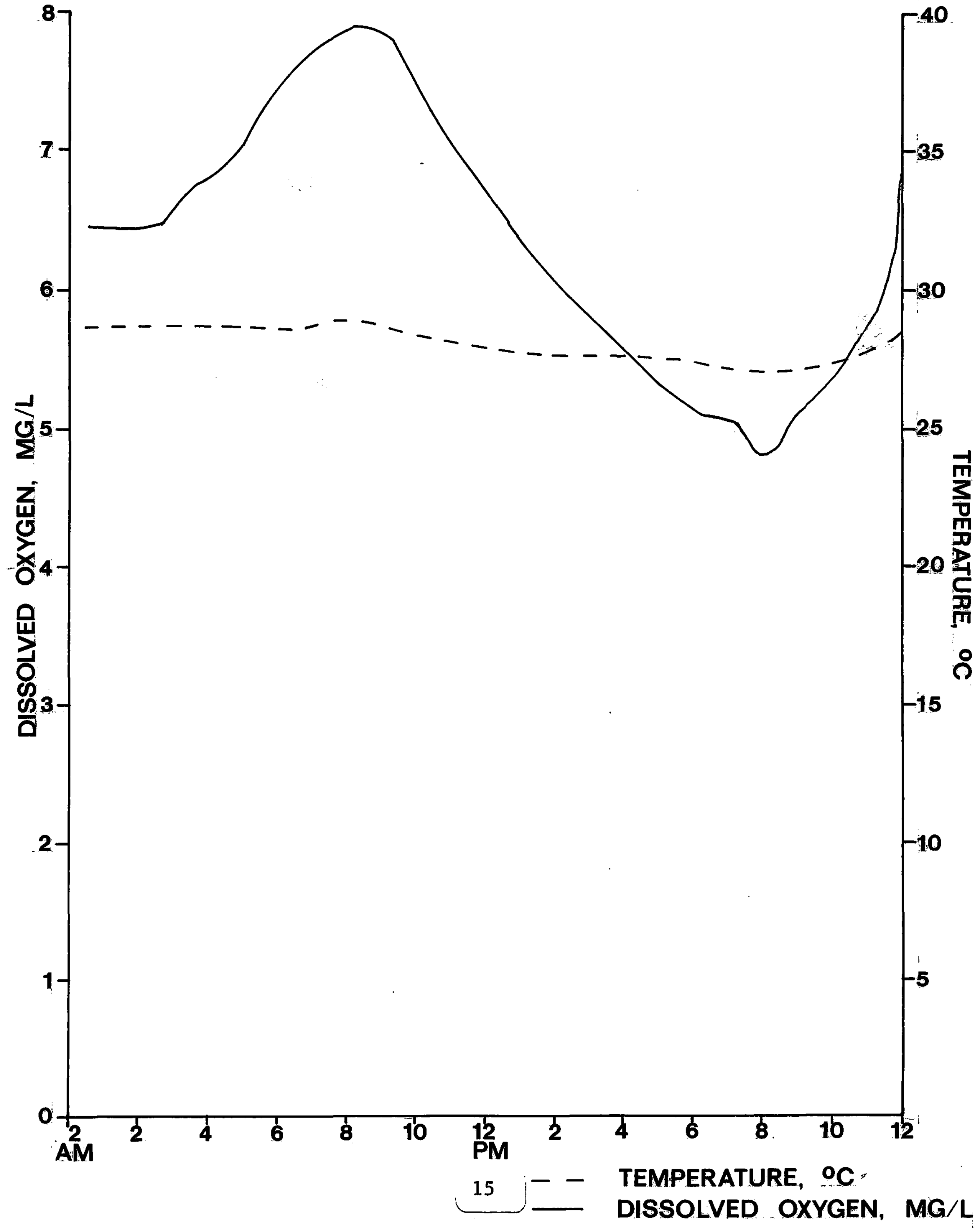
photosynthetically-produced oxygen was at its peak. The oxygen data continue to show that the Buffalo National River is a very pristine stream and that there are no obvious problems with excessive organics or other oxygen-demanding substances.

Two attempts were made to determine diel oxygen profiles. The first attempt, at Rush in late May, resulted in non-usable data due to a malfunctioning oxygen meter. A successful profile was obtained at Rush in mid-August, and this profile is shown in Figure 5. It is typical for streams in mid-summer when primary productivity is highest. The observed dissolved oxygen values ranged from 7.90 mg/l at 8:30P.M. to 4.80 mg/l at 8:00A.M. This is an almost classically balanced profile with the minimum values occurring around dawn and the maximum values occurring near dusk.

The graph for seasonal trends in silica levels (Figure 2) is almost identical in shape to the one shown in the 1976 report, although silica levels were generally higher in 1977. This indicates that the seasonal cyclic pattern described last year is consistent and probably not anomalous. In this cycle low silica levels occur in winter and early spring when diatoms are the predominant algal component, followed by high summer levels as diatoms drop off and other groups not requiring the uptake of silica become dominant. Silica levels ranged from a high of 13.92 mg/l at Rush in July to a low of 2.91 mg/l at Jasper and Pruitt in May.

Mean levels of the nutrient substances, orthophosphate and nitrate, changed little in comparison to past years, and the seasonal graphs (Figure 2) are a virtual continuation of last year's graphs. Again high peaks of orthophosphate coincided with periods of heavy surface

FIGURE 5 SUMMER DIEL OXYGEN PROFILE
RUSH 8/ 2-13/77



runoff, with the highest mean concentration found during the high water in November. The single highest orthophosphate reading was 0.177 mg/1 at Pruitt in October. Replicate analysis confirmed the elevated value. Readings were very low at all other stations that day, and there is no obvious reason for the high reading. Possibly some floating organic solids were dipped up in the sample. Orthophosphate concentrations were below detectable limits in 14 of the 16 samples collected in August and September.

Nitrate levels ranged from a high of 0.340 mg/1 at Jasper in December to a low of 0.029 mg/1 at Boxley in April. The November samples would undoubtedly have been highest, but the test was not conducted due to technical difficulties. There is again no evidence of significant downstream loading of either nitrate or orthophosphate, consistent with last year's results.

The results of water quality analysis in 1977 again indicate that there are no signs of degradation of water quality in the Buffalo National River. Water quality during normal flow rates remains exceptionally high, and deviations from that high quality are readily attributable to surface runoff and not to point sources of pollution or to recreational usage.

Phycological Studies

Chlorophyll data (Table 2) are consistent with the results seen in previous years when chlorophyll concentrations were small to nonexistent. Concentrations of all three types of chlorophylls were below detectable limits in all samples taken in April and October. Highest average concentrations of chlorophylls -a and -b occurred in June, coinciding with the sloughing off of the spring growths of Clado-

TABLE 2.

CHLOROPHYLL DATA (MICROGRAMS/LITER)

	Chlorophyll a	Chlorophyll b	Chlorophyll c		Chlorophyll a	Chlorophyll b	Chlorophyll c
Survey Date: 9 April 77				**Survey Date: 15-17 May 77**			
Boxley	0.000	0.000	0.000		0.000	0.000	0.000
Ponca	0.000	0.000	0.000		0.000	0.000	0.000
Jasper	0.000	0.000	0.000		0.000	0.000	0.000
Puritt	0.000	0.000	0.000		0.000	0.000	0.000
Hasty	0.000	0.000	0.000		0.000	0.000	0.000
Gilbert	0.000	0.000	0.000		0.564	0.037	0.000
Highway 14	0.000	0.000	0.000		0.274	0.148	0.000
Buffalo Point	0.000	0.000	0.000		0.982	0.130	0.000
Rush	0.000	0.000	0.000		0.580	0.000	0.000
Survey Date: 21 June 77				**Survey Date: 25 July 77**			
Boxley	---	---	---		---	---	---
Ponca	0.982	0.130	0.000		1.640	0.833	0.000
Jasper	1.093	0.537	0.000		1.172	1.516	0.003
Pruitt	1.078	0.851	0.000		1.701	2.016	0.397
Hasty	1.776	1.735	0.000		0.658	0.703	0.319
Gilbert	0.531	0.555	0.000		0.515	0.814	0.000
Highway 14	0.344	0.374	0.000		0.129	0.203	0.000
Buffalo Point	0.521	0.710	0.000		0.531	0.555	0.000
Rush	0.898	1.335	0.000		0.002	0.055	0.000

TABLE 2.

(continued)

	Chlorophyll			Chlorophyll		
	a	b	c	a	b	c
Survey Date: 13 August 77				Survey Date: 21-22 September 77		
Boxley	---	---	---	---	---	---
Ponca	0.692	0.241	0.000	0.274	0.148	0.000
Jasper	0.002	0.055	0.000	1.027	1.572	0.061
Pruitt	1.207	1.054	0.000	0.950	0.647	0.000
Hasty	2.118	2.053	0.890	---	---	---
Gilbert	0.000	0.000	0.000	0.000	0.000	0.000
Highway 14	0.257	0.407	0.000	0.145	0.000	0.000
Buffalo Point	0.002	0.005	0.000	0.754	1.424	0.197
Rush	0.130	0.259	0.000	0.257	0.407	0.000
Survey Date: 19-20 October 77				Survey Date: 30 December 77		
Boxley	---	---	---	0.000	0.000	0.000
Ponca	0.000	0.000	0.000	0.000	0.000	0.000
Jasper	0.000	0.000	0.000	0.638	0.622	0.198
Pruitt	0.000	0.000	0.000	0.000	0.000	0.000
Hasty	0.000	0.000	0.000	0.000	0.000	0.000
Gilbert	0.000	0.000	0.000	0.226	0.037	0.000
Highway 14	0.000	0.000	0.000	0.212	0.222	0.000
Buffalo Point	0.000	0.000	0.000	0.161	0.141	0.000
Rush	0.000	0.000	0.000	0.000	0.141	0.000

phora, and the onset of the summer bloom of Spirogyra. The highest individual values were at Hasty in August. Preceding that sampling period there were scattered rainstorms throughout the watershed. The river was rising slightly, and the water was becoming murky. The increase in turbidity was due to surface runoff, resuspension of bottom deposits and scouring of the substrate. The scouring action dislodged a large quantity of periphytic organisms which were included in the collection.

Periphyton and phytoplankton samples were again taken at each of the nine sampling points every month from April through December, with the exception of November, when high water prevented the collection of algae samples. Phytoplankton samples again demonstrated that no true phytoplankton community exists in the Buffalo National River. Some flagellates, such as Dinobryon, Synura, Pandorina and Trachelomonas, were again observed in samples taken from the pools at the Ponca and Pruitt stations in June and July, but the numbers were extremely small. No significant deviations from previously reported patterns of periphyton growth were observed, although 28 additional taxa were added to the list of Buffalo River algae this year (see Table 3). Of these, three species of blue-green algae (Cyanophyceae) occurred in such a way as to be worthy of comment. In December, Cyanodictyon reticulatum, a relatively uncommon and heretofore unseen colonial coccoid blue-green, was found to be quite common all along the river except at Ponca.

In September a thick coating of epipsammic blue-green algae was found covering the sand in the shallow water at the edge of the gravel bar at Gilbert. In past years this coating was found to be exclusively Pseudanabaena schmidlii, a filamentous form. In this year's collections most of the growth was the coccoid form Synechococcus aeruginosa, Although P. schmidlii was also associated but of lesser importance.

TABLE 3.

ADDITIONS TO THE ALGAL FLORA
OF THE BUFFALO NATIONAL RIVER

Chlorophyceae

- Chlorococcales
  - Franceia ovalis
  - Scenedesmus arcuatus
  - Westella botryoides

Conjugatophyceae

- Desmidiales
  - Arthrodesmus convergens
  - Desmidium swartzii
  - Pleurotaenium maximum

Euglenophyceae

- Euglenales
  - Phacus acuminatus
  - Trachelomonas armata, var. longispina
  - Trachelomonas aorensis

Cyanophyceae

- Chrococcales
  - Cyanodictyon reticulatum
  - Synechococcus aeruginosa
- Oscillatoriales
  - Anabaena oryzae
  - Anabaena unispora
  - Anabaena verrucosa
  - Lyngbya lachneri
  - Lyngbya martensiana
  - Lyngbya taylorii
  - Oscillatoria corallinae
  - Oscillatoria cortiana
  - Oscillatoria geitleriana
  - Oscillatoria hamelii

TABLE 3. (continued)

Oscillatoria sancta
Oscillatoria splendida
Oscillatoria subbrevis
Phormidium favosum
Spirulina latissima
Spirulina subsalsa

Also in September, the *Chara* beds at Rush were found to be completely overgrown with a thick extensive coating of a filamentous blue-green, *Anabaena unispora*, the shading effect of which possibly led to an earlier than usual disappearance of these beds. The growth of *A. unispora* may have been enhanced by changes in flow characteristics. Earlier in September, a heavy rain, localized in the Rush Creek watershed, led to the washing out of the gravel take-out and launching area at the mouth of Rush Creek. As a result of this wash-out, a new two foot high gravel bar extended transversely across the river to within about ten feet of the opposite bank. The creation of this gravel bar just below the *Chara* beds certainly altered the flow patterns in the area of the beds, slowing the flow and probably causing backcurrents and eddy currents from the deflection of the river's flow against this new obstacle. The change in flow conditions may have altered the environment so that the copious growths of *A. unispora* became possible.

In mid-July, we undertook a 5-day, 60 mile float trip from Tyler Bend to the White River during which some interesting observations on the ecology of Charales were made. Charales appear at the very first put-in point at Tyler Bend, but this is probably near the upper limit of their range in the Buffalo National River. Growth in this area is sparse and seems to be limited to extreme margins of shallow pools where eddy currents have formed sand-silt deposits. Downstream to just below Buffalo Point, growths become progressively more extensive, with the persistent pattern of *Chara* being restricted to depositional areas with slower flow. Some examples of Charales habitat in this section include depositional areas along the inside of curves in pools, backwater areas, upstream of the mouth of major inflowing tributaries (e.g., Bear Creek), and in deeper pools where sedimentation has occurred. Growth in pools generally occurs to a maximum depth of about 2 meters.

Below Buffalo Point where larger beds of *Chara* develop in deeper, silt laden pools, a repetitive characteristic distributional pattern was discovered. This unique pattern was first observed approximately 3.5 miles below Buffalo Point and extended to within 2 miles of the river's merger with the White River.

A typical pool has essentially no attached macroscopic vegetation at its upstream margin. The transition zone between riffle and pool is delimited by a band of shifting sand. Tufts of previously dislodged *Spirogyra* are usually seen caught on some of the larger rocks within this band, but generally flow is too swift or the substrate too unstable to permit the establishment of *Chara*. As the pool deepens the substrate changes from sand, gravel and small stones to larger rocks with a sand-silt base. Copious blooms of *Spirogyra* are associated with this substrate type. If the pools are deep and the current reduced, *Chara* may occur within this zone, but it is restricted to the shallow edge nearest the gravel bar at bends in the river.

As the pool gradually becomes shallower and intergrades towards the succeeding riffle, *Chara* beds are more extensive and with the highest density. The substrate, usually a mixture of sandy-silt, gravel and stones is distributed into a characteristic undulating pattern generally perpendicular to the flow of the stream. The *Chara* plants form beds in the protected troughs of these undulations. These plants are slightly shorter than those occurring in the deepest portion of the pool.

As the pool becomes even shallower and interfaces with the lower riffle, the current quickens and the substrate contains less sandy silt. In this broad lower region of the pool, extensive growths of *Chara* were observed. The pattern of distribution in this region is a series of parallel rows lying along the direction of current flow and perpendicular to the previous *Chara* zone. This pattern seems to suggest that after a pioneer plant becomes established in a suitable microhabitat it provides a new protected microhabitat in its lee. The emerging pioneer produces turbulence and eddies in the laminar flow which effectively reduce the flow rate on its leeward side. This modification in stream velocity enables the downstream directed pioneer *Chara* stolons to establish new vertical shoots. Conversely, the lateral and upstream unprotected shoots are exposed to increased stream velocities which are restrictive. Beyond the zone of higher velocity, another pioneer may become established and repeat the sequence. The observed parallel linear rows represent an interaction of the *Chara* plant with its physical environment.

During this float trip we also mapped the river in terms of general habitat types along this stretch. USGS 7½' Quadrangle maps were used, and the river was blocked off and each section was characterized as being in general a deep or a shallow pool, a shoal area or a riffle area. The general definitions used in describing a given stretch as fitting one of these categories are as follows:

Riffle - Where depth is sufficiently low and current sufficiently high that the water surface is disturbed by flow over rocks and other bottom irregularities.

Shoal - An area where water is sufficiently deep that the surface is relatively undisturbed, but flow rate is still quite high due to channel constriction or slope.

Shallow Pool - Area of no surface disturbance and low flow rate where water depth is less than or approximately one meter.

Deep Pool - Area of no surface disturbances and low flow rate where water depth is greater than one meter.

On the maps, each area was further described in terms of the predominant substrate type, whether silt, sand, gravel, rock, bedrock, boulders, or any combination of these.

An unexpected result emerged from summarizing the information contained in the habitat mapping project. The popular idea of the lower part of the river is that it consists mainly of very long pools with very little fast-moving water. A comparison of our characterization of the 23 ½ miles above the mouth of Clabber Creek (below Rush) with the 23 ½ miles from that point to the White River reveals that the lower stretch contains 66 riffle or shoal areas, while the upper stretch contains only 37. In terms of discrete areas and without reference to total linear distance, riffle-to-pool ratio in the upper stretch is 0.80, as compared to 1.20 in the lower stretch. Our generalized observations suggest that the relatively seldom seen lower stretch of the river below Rush contains a more diverse and variable habitat than the area from Gilbert to Rush.

Some other perhaps pertinent observations were made on this float trip. We had been informed that the Tyler Bend site is being considered for development into a camping area as soon as land acquisition is complete. At present a considerable number of cattle have access to the river at that site, and they spend much of the time during hot days standing in the shaded water at the head of the riffle leading into the probable landsite pool. The enrichment effects of this activity are obvious in this shallow pool. The *Spirogyra* bloom is extremely heavy, and it seems at least possible that this heavy growth is directly related to the cattle wastes. If cattle access is to be halted after the National Park Service acquires this land, it would present an excellent opportunity to study the relative degree of productivity in the pool before and after cattle are removed from the area. Measuring the growth, development and abundance of *Spirogyra* with associated factors at this location may assist in determining a management protocol for its general control.

Numerical Analysis of Selected Periphytic Algae

Earlier studies of the algae, more specifically the periphyton, have concentrated on developing a synoptic overview. This synoptic summary provided insight into the seasonal occurrence of many species. Based upon repetitive sampling at standard stations, for several years, certain patterns were recognized. These prior studies provided a very thorough understanding of temporal and spatial distributions of greater than 250 species. However, only subjective relative abundances could be ascertained.

The methods and procedures given below provide an approach for quantifying community structure. The analysis also establishes a basis upon which the similarities and differences can be more accurately described. These techniques can be used for comparisons between sites at the same sampling period, the same site at different sampling intervals, sub-sections within one site, and various other combinations. The analytical approach can be applied to assessing pertubations to the ecosystem caused by extensive use, point source pollution and for estimating rates of recovery. Based on the following example we feel that this analytical approach should warrant consideration as a management tool.

Following last year's detailed work on the identification and classification of diatom species, we attempted this year to determine which of these species were most important in terms of abundance and dominance in the Buffalo National River system. Since direct enumeration from natural substrates is impractical, and no satisfactory artificial substrate has yet been devised for use in flowing water systems, a procedure for determining relative abundance and site and system importance indices was chosen.

The procedure used for the initial calculations was essentially identical to that described by Czarnecki, et. al. (1976) in their analysis of the periphytic microflora of the Colorado River in Grand Canyon. The samples were taken at the nine standard sampling locations. At each site all available habitats were sampled and a composite subsample from each site was prepared for diatom identification and counting by boiling in potassium permanganate and concentrated sulfuric acid to oxidize all extraneous organic material and intracellular components. This procedure leaves only the siliceous diatom frustule, which is the portion upon which the classification of the group is based. The samples then undergo several cycles of alternate washing and centrifugation to remove all acid and permanganate. The clean sample is then shaken to suspend the frustules, and a small drop is placed on a coverslip which is then flooded with distilled water to distribute the diatom frustules evenly over the surface. The coverslip is gently warmed until dry and it is then mounted on a microscope slide in Hyrax mounting medium.

The slides are then examined under 1000X, and the first 200 randomly encountered complete and undamaged frustules are identified and counted. From this data several relative abundance and importance parameters can be calculated, and semi-quantitative information on upstream-downstream and seasonal distribution patterns can be derived. Table 4 is a list of diatoms identified in the nine samples collected in May, 1977, along with their site and system importance indices as calculated by the method described below. Figure 6 gives kite diagrams showing percent composition at each site along the river for the taxa which ranked among the top five in terms of percent composition in at least one sample.

The derivation of the importance indices involves the determination of an abundance value (av) which is an arbitrarily chosen number based upon the percentage composition of each taxon at each site, as follows:

$> 50\%$, av=6

25 - 50%, av=5

10 - 24%, av=4

5 - 9%, av=3

1 - 4%, av=2

$< 1\%$, av=1

For determination of the system importance value (SIV), the sum of the abundance values for the taxon is divided by the total number of samples. For the site importance values (sIV), the sum of the abundance values for the taxon is divided by the number of samples in which the taxon occurred.

System Importance Value (SIV) $= \frac{\Sigma av}{n_1}$; n_1 = total # of samples

Site Importance Value (sIV) $= \frac{\Sigma av}{n_2}$, n_2 = # of samples of occurrence

TABLE 4.

SITE AND SYSTEM IMPORTANCE VALUES FOR DIATOMS FOUND IN THE BUFFALO RIVER IN MAY 1977

TAXON	Samples of Occurence	ΣAV	Site Importance Value	System Importance Value
Cymbella affinis	9	41	4.56	4.56
Achnanthes minutissima	9	31	3.44	3.44
Nitzschia dissipata	9	23	2.56	2.56
Achnanthes linearis	8	23	2.88	2.56
Navicula cryptocephala	9	21	2.33	2.33
Navicula cryptocephala, var. veneta	9	21	2.33	2.33
Coconeis placentula, var. lineata	8	18	2.25	2.00
Diatoma vulgare	6	18	3.00	2.00
Cymbella delicatula	9	16	1.78	1.78
Cocconeis pediculus	7	16	2.29	1.78
Cymbella minuta	7	14	2.00	1.56
Synedra socia	6	13	2.17	1.44
Cymbella sinuata	9	12	1.33	1.33
Nitzschia palea	6	12	2.00	1.33
Nitzschia tabellaria	6	11	1.83	1.22
Cymbella cymbiformis	5	11	2.20	1.22
Achnanthes lanceolata, var. dubia	7	10	1.43	1.11
Navicula exigua, var. capitata	6	9	1.50	1.00
Synedra ulna	5	8	1.60	0.89
Gomphonema intermedia	5	7	1.40	0.78
Cymbella turgidula	5	6	1.20	0.67
Gomphonema parvulum	4	6	1.50	0.67
Navicula radiosa, var. tenella	4	6	1.50	0.67
Nitzschia fonticola	3	5	1.67	0.56
Cymbella turgida	3	5	1.67	0.56
Nitzschia acicularis	3	5	1.67	0.56
Melosira varians	2	4	2.00	0.44

TABLE 4 (continued).

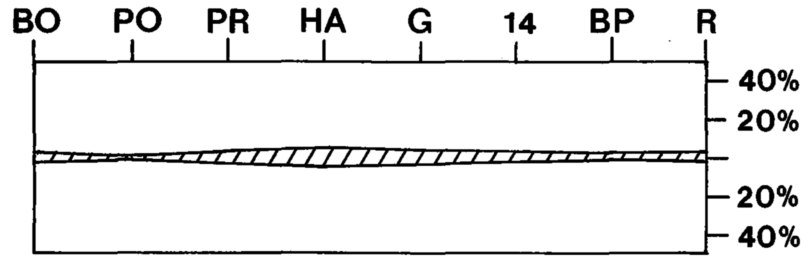
TAXON	Samples of Occurence	ΣAV	Site Importance Value	System Importance Value
Synedra rumpens, var. familiaris	2	4	2.00	0.44
Gomphonema sphaerophorum	3	3	1.00	0.33
Amphora ovalis, var. pediculus	3	3	1.00	0.33
Gomphonema olivaceum	3	3	1.00	0.33
Navicula viridula, var. linearis	3	3	1.00	0.33
Cymbella hustedtii	2	3	1.50	0.33
Fragilaria construens	2	3	1.50	0.33
Navicula subhalophila	2	3	1.50	0.33
Achnanthes lanceolata	2	3	1.50	0.33
Gomphonema intricatum	2	3	1.50	0.33
Navicula exigua	2	2	1.00	0.22
Eunotia arcus	2	2	1.00	0.22
Gomphonema ventricosum	1	2	2.00	0.22
Navicula dystrophica	1	2	2.00	0.22
Nitzschia romana	1	2	2.00	0.22
Achnanthes microcephala	1	2	2.00	0.22
Cymbella prostrata, var. auerswaldii	1	2	2.00	0.22
Navicula pseudoreinhardii	1	2	2.00	0.22
Cymbella tumida	1	1	1.00	0.11
Navicula pupula, var. rectangularis	1	1	1.00	0.11
Navicula shonfeldii	1	1	1.00	0.11
Synedra ulna, var. ramesii	1	1	1.00	0.11
Gomphonema longiceps	1	1	1.00	0.11
Gomphonema angustata	1	1	1.00	0.11
Surirella ovata	1	1	1.00	0.11
Surirella angustata	1	1	1.00	0.11
Cymbella prostrata	1	1	1.00	0.11

TABLE 4 (continued).

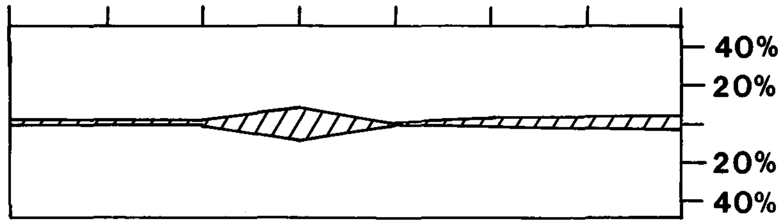
TAXON	Samples of Occurence	ΣAV	Site Importance Value	System Importance Value
Achnanthes clevei	1	1	1.00	0.11
Amphipleura pellucida	1	1	1.00	0.11
Cyclotella meneghiniana	1	1	1.00	0.11
Epithemia reicheltii	1	1	1.00	0.11
Cymbella amphicephala	1	1	1.00	0.11

FIGURE 6, CONTINUED

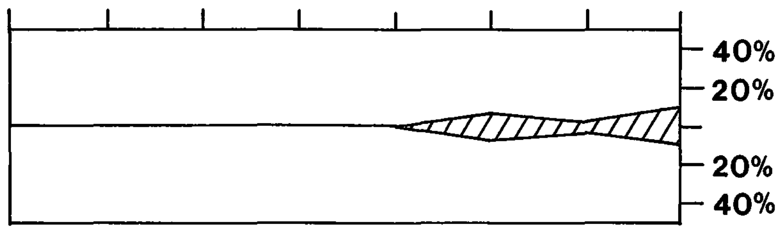
NAVICULA CRYPTOCEPHALA



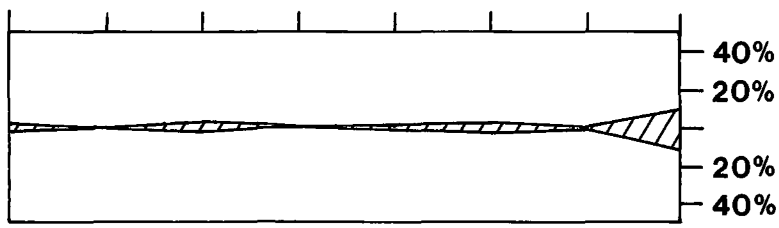
NAVICULA CRYPTOCEPHALA, VAR. VENETA



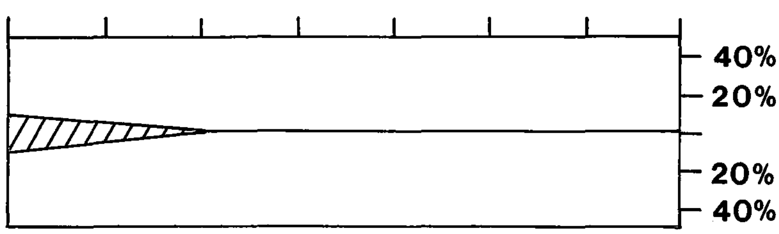
COCCONEIS PEDICULUS



COCCONEIS PLACENTULA, VAR. LINEATA



CYMBELLA CYMBIFORMIS



It is assumed, based on these calculations, that those taxa having high system importance values and low site importance values have a wide range of ecological tolerance, occurring throughout the system but not dominating at any point. Those having a low system importance value and a high site importance value are generally those with more restrictive habitat requirements that are representative of specific habitat types or zones. Information on such species derived in this way could be quite useful in the delineation of zones of specialized habitats in the river. Taxa with both high site and high system importance values are those that are best adapted to the entire system, occurring in abundance in all habitat types.

As can be seen in Table 4 and Figure 7, this analysis pinpoints the most important species and their habitat requirements very well. A total of 59 taxa were identified in the 9 samples counted, but only 12 of these attained the top 5 in percentage abundance in one or more samples. An average of 23 taxa were identified in each sample, yet the top 5 taxa accounted for an average of 75% of the 200 frustules counted in each case.

Cymbella affinis has both the highest site importance value and the highest system importance value. This species is most characteristic of the river system in the spring. It is a generally alkaliphilous organism that usually grows attached to hard substrata in cool, flowing waters. It is present in abundance all along the length of the river.

Achnanthes minutissima and Achnanthes linearis are closely related species that are similar both in appearance and habitat requirements. Both are small, and, like C. affinis, are generally found in clean, flowing waters growing attached to hard substrata. These species are also characteristic of the entire system, being found at all points along the river, while generally seeming to prefer alkaline waters. In terms of distribution, these two species of Achnanthes generally make up a larger proportion of the diatom population at the upstream stations at Boxley and Ponca.

Cymbella affinis, Achnanthes minutissima and Achnanthes linearis are all attached, non-motile species. The next three most abundant species, Nitzchia dissipata, Navicula cryptocephala, and Navicula cryptocephala, var. veneta, are all motile, predominantly epipelic forms. The first three, being attached, are more likely to be found in faster water. The latter three are inhabitants of the sediment surfaces in pools and slow water areas.

Diatoma vulgare is a species that is characterized by Patrick and Reimer (1969) as preferring cool, flowing water and being often found in water with a fairly high nutrient content. It is listed as being 40th in a list of the 80 most pollution tolerant species of algae compiled by Palmer (1969). Diatoma vulgare has a high site importance value and a relatively low system importance value. Figure 6 shows it to be a very important species in the middle reach of the river, particularly at Gilbert, where it comprised 52% of the organisms counted.

While this limited data is certainly not sufficient to conclude that the river at Gilbert is more organically enriched than at other sites, it is sufficient to exemplify the kind of relationships that could be derived from a long-term analysis of this type of data. This general approach to the analysis of diatom communities can be very helpful in detecting slow, long-term changes in certain water quality parameters, as well as short-term localized changes due to other types of system perturbations, such as recreational use.

Further Observations on the Distribution and Dominance of Buffalo River Diatoms

The five additional figures show the distribution and relative abundance of six important species of diatoms during all four seasons of the year. Table 5 gives the site and system importance values for these species, based on their occurrence in the 29 samples used in this analysis.

Figure 7 shows that Achnanthes minutissima is present and abundant more or less consistently at all times and at all stations throughout the year, and is the one species that most characterizes the river system throughout its length and throughout the year.

As Figure 8 suggests, Cymbella affinis dominates the system primarily in the spring, with growth apparently beginning in the lower river during the winter. The pattern during the remainder of the year suggests that this species is intolerant of high water temperatures, although it is present to some extent in all the samples.

Figure 9 shows two species that exhibit high site importance and low system importance, indicating that they are restricted in their distribution to certain times of the year and/or certain specialized habitats. Gomphonema olivaceum is strictly a cold water form, and was found only in the lower river in winter. It was totally absent at other times. Cymbella delicatula was restricted to the upper river zones during all seasons except spring when it was virtually absent from the system. Its pattern of dominance suggests that it is primarily a warm-water form preferring more circumneutral and less alkaline waters. Both G. olivaceum and C. delicatula are attached, primarily epilithic, forms.

Cocconeis pediculus, as shown in Figure 10, is primarily an epilithic form, growing on water willow (Justicia americana) and filamentous green algae, such as Cladophora. However, the fact that this species is absent during the summer when water willow is abundant indicates an intolerance to elevated temperatures. It is limited to very small populations in winter when temperatures are more suitable by the absence of satisfactory substrata. This is a good example of a species having a high site importance value and a low system importance value due to rather restrictive habitat and environmental requirements.

Figure 11 gives the distribution pattern for Nitzschia palea, a species having both a low site importance value and a low system importance value. N. palea is commonly cited as being highly tolerant of organic pollution. In fact, it is ranked number 2 in Palmer's (1969) list of most pollution tolerant species of algae. The fact that N. palea was present in 20 of the 29 samples examined yet had very low importance values indicates that the species is ubiquitous in the system, but existing environmental conditions (i.e., low organic levels) limit it to very small populations. It is a motile, epipelic form reaching its peak populations in the lower river zones where sediment pools are more common, and during the summer when decomposition of the organic matter in the sediments is most active. N. palea is an excellent example of a species that is now present in low levels all along this relatively unpolluted river, but which can be expected to increase in dominance as the levels of organic matter in the sediments increase. Periodic analyses of the relative dominance of N. palea in the river would provide a sensitive monitor of increasing organic pollution.

TABLE 5

SPECIES	SAMPLES OF OCCURRENCE	av	sIV	SIV
ACHNANTHES MINUTISSIMA	39	112	3.86	3.86
CYMBELLA AFFINIS	28	88	3.14	3.03
CYMBELLA DELICATULA	18	47	2.61	1.62
NITZCHIA PALEA	20	34	1.70	1.17
COCCONEIS PEDICULUS	14	33	2.36	1.14
GOMPHONEMA OLIVACEUM	7	17	2.43	0.59

Figure 7

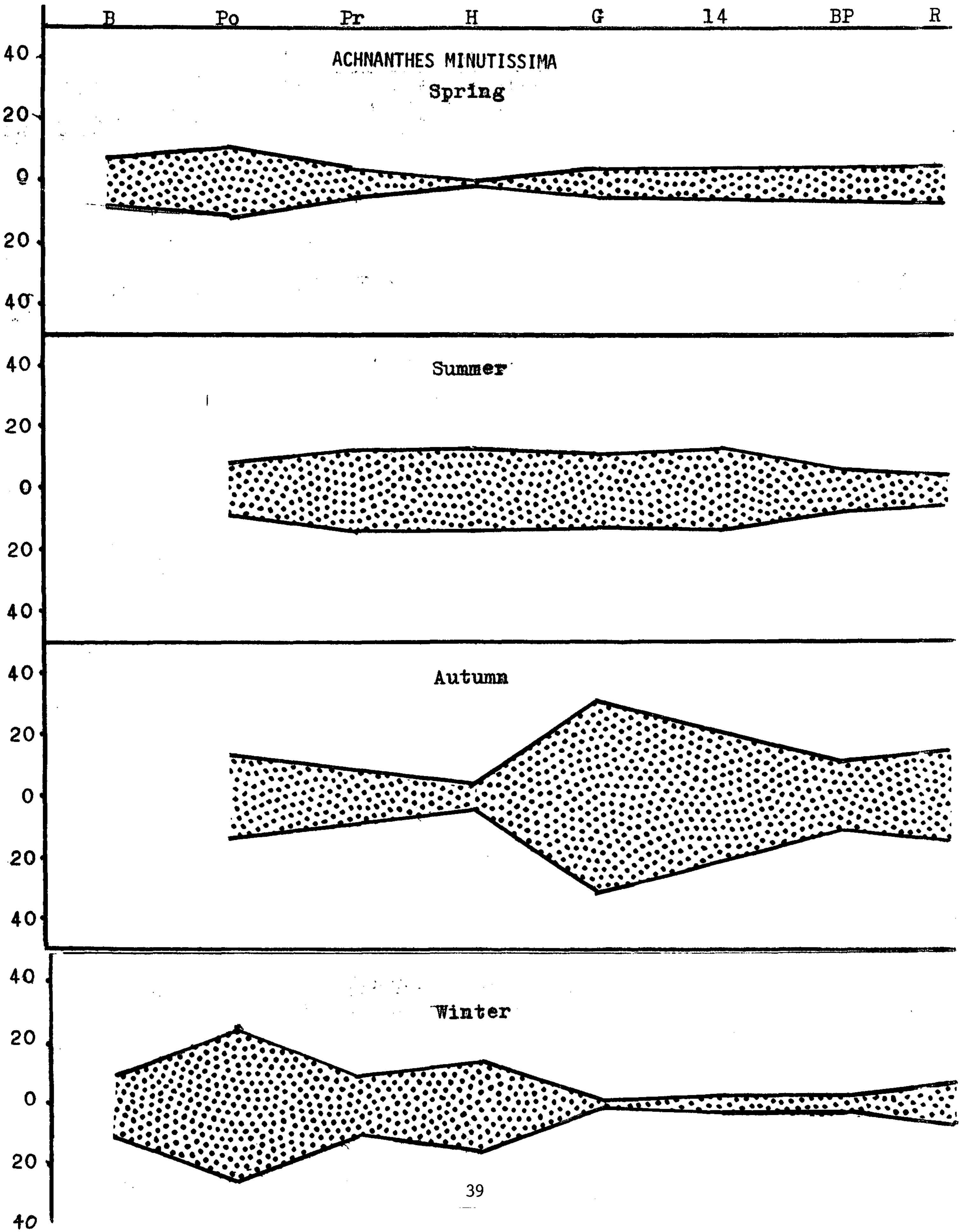

B
Po
Pr
H
G
14
BP
R
ACHNANTHES MINUTISSIMA
Spring
Summer
Autumn
Winter
40
20
0
20
40

Figure 8

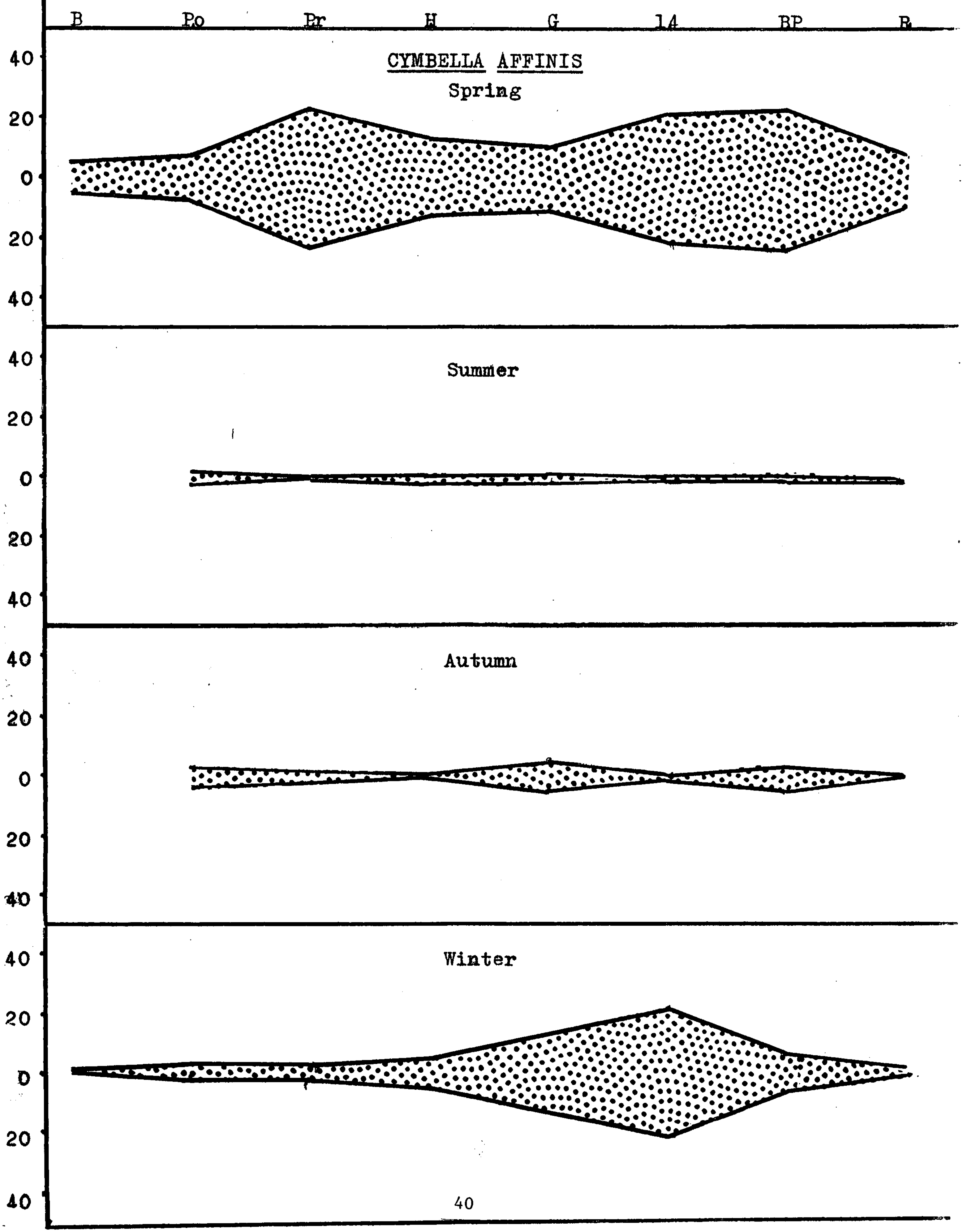
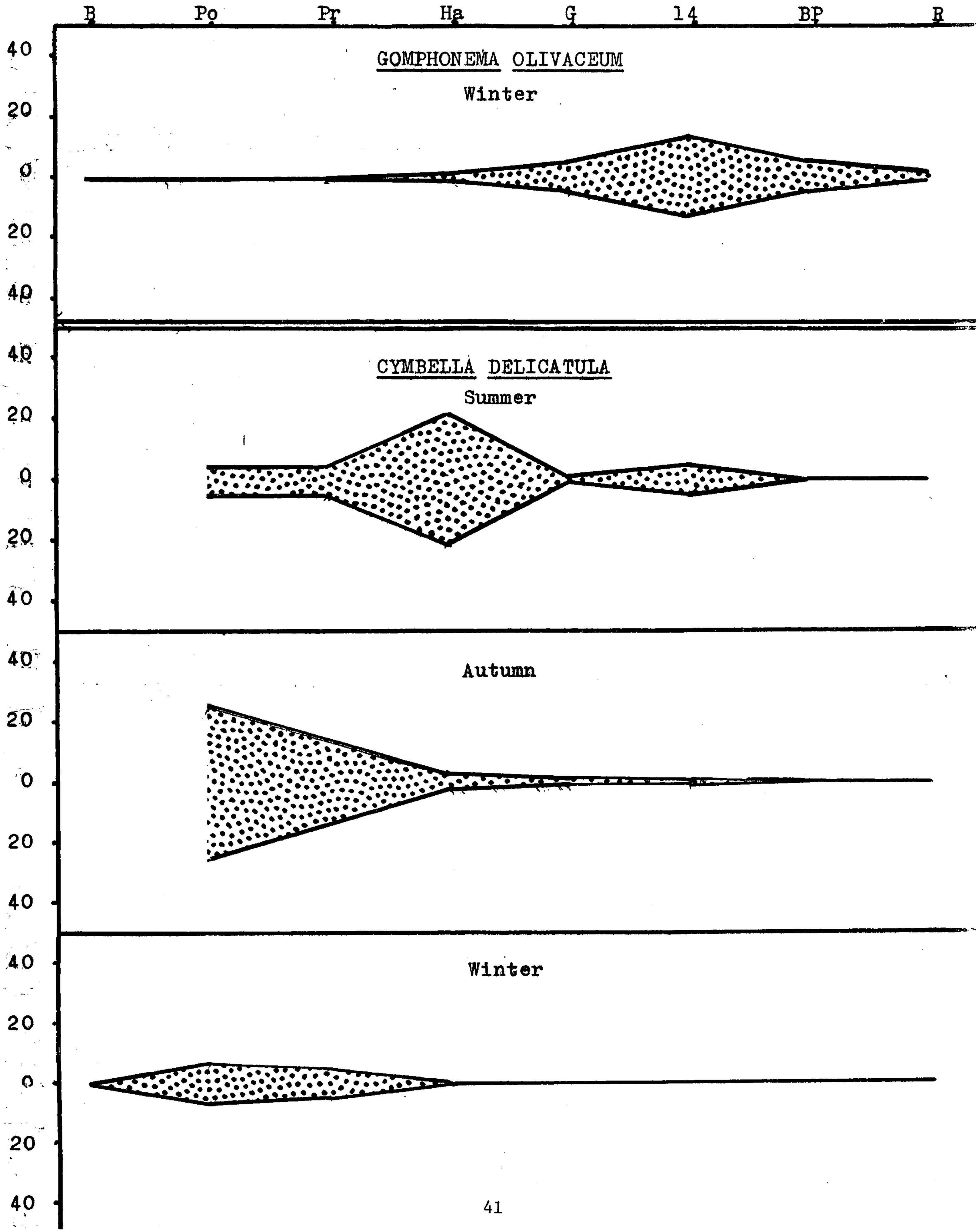

B
Po
Pr
H
G
14
BP
R
CYMBELLA AFFINIS
Spring
Summer
Autumn
Winter
40
20
0
20
40

Figure 9



B
Po
Pr
Ha
G
14
BP
R
GOMPHONEMA OLIVACEUM
Winter
CYMBELLA DELICATULA
Summer
Autumn
Winter
40
20
0
20
40

Figure 10

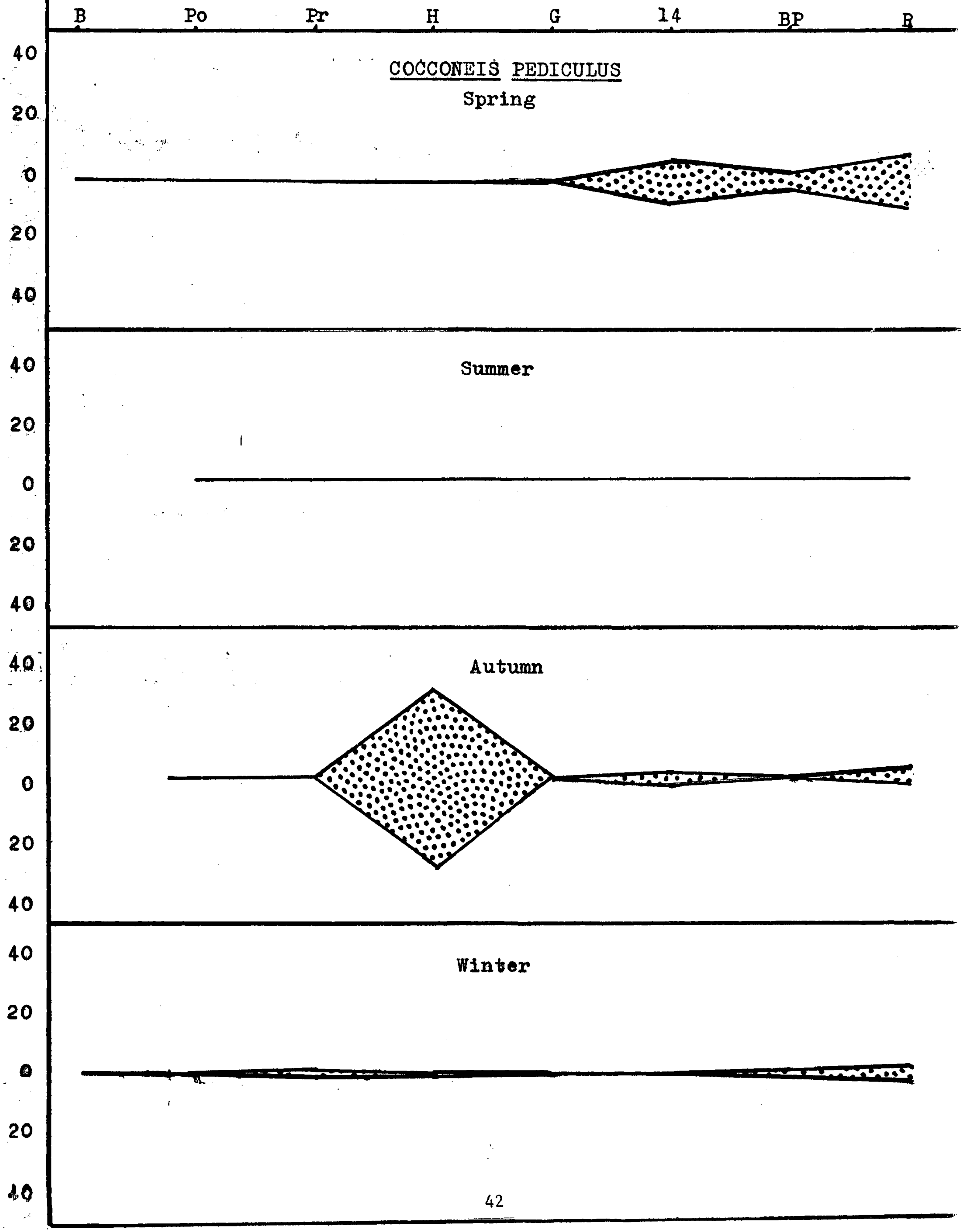
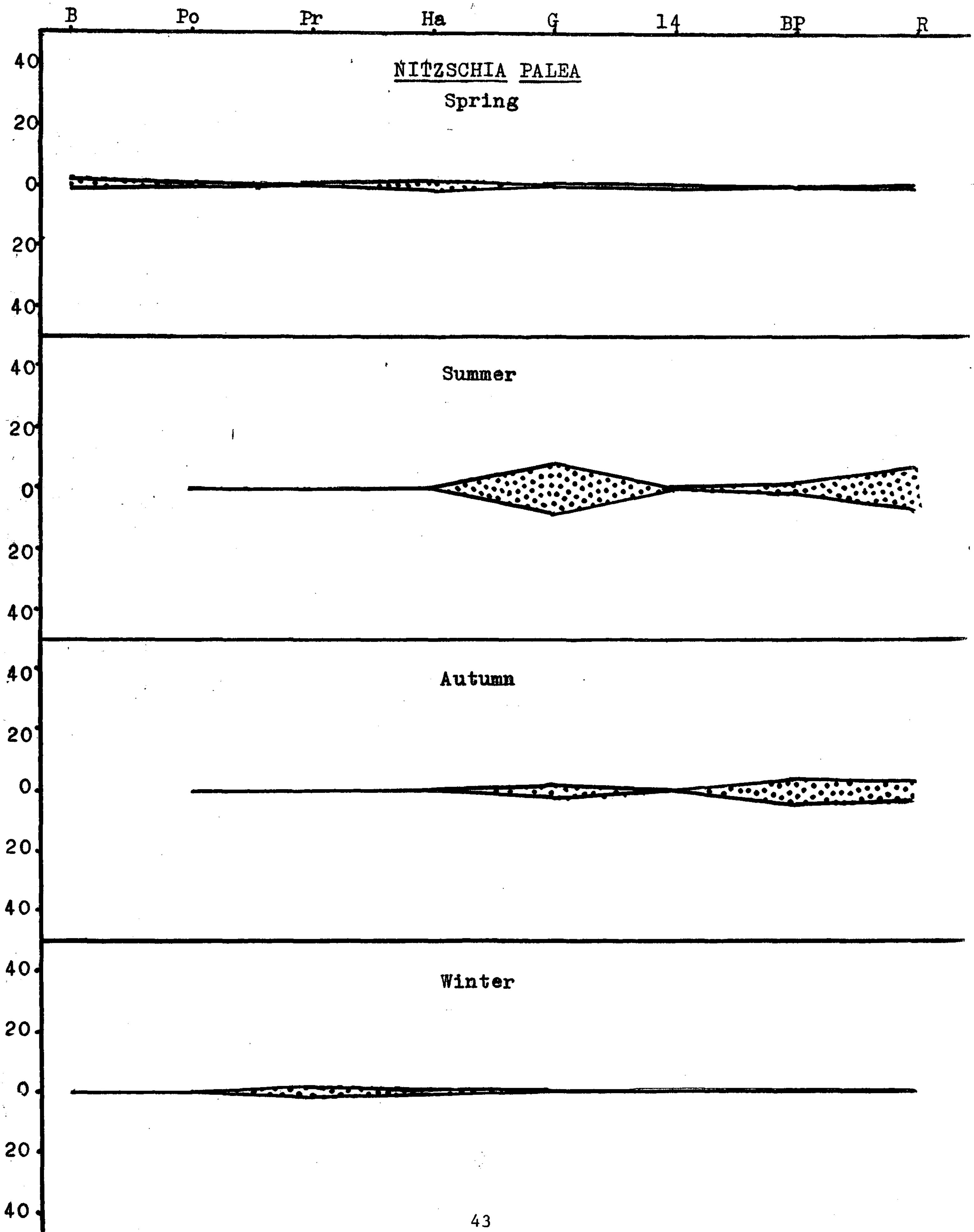

B
Po
Pr
H
G
14
BP
R
COCCONEIS PEDICULUS
Spring
Summer
Autumn
Winter
40
20
0
20
40

Figure 11



B
Po
Pr
Ha
G
14
BP
R
NITZSCHIA PALEA
Spring
Summer
Autumn
Winter
40
20
0
20
40

RARE, THREATENED, AND ENDANGERED VASCULAR PLANTS OF THE BUFFALO NATIONAL RIVER

Edwin B. Smith, Principal Investigator
Burnetta Hinterthuer, Assistant

The objective of this study is to bring together a list of all vascular plants of the Buffalo National River area that are rare, threatened, or endangered. The determination of the status of particular species is not always easy because of generally inadequate collecting in Arkansas. If the number of collections is very low for a particular species, it is assumed to be rare (it could be more common but simply not collected). Some species are rare in the Buffalo National River area but are common in other parts of the United States; these generally have been included in the list. Introduced plants (e.g. European weeds) have been excluded from the list.

For clarity, the terms rare, threatened, and endangered are defined much as they were in the Endangered Species Act of 1973 (House of Representatives Report No. 93-740. Dec. 19, 1973) and in Tucker (1974).

RARE: A species that occurs in small numbers of specialized habitats, seldom found in large populations; not in immediate danger of extinction. In general (in this study), present in four or fewer counties in Arkansas and known to be declining in numbers.

THREATENED: A species which is likely to become endangered within the foreseeable future throughout or nearly throughout its range; not in immediate danger of extinction, but in greater jeopardy than the rare species. The Park Service should consider protecting these species, for without protection they may disappear.

ENDANGERED: A species which is in danger of extinction throughout or nearly throughout its range; in immediate danger of extinction. Often they are present in only one or a very few sites. The Park Service should protect these species and their habitats, for without protection they will very likely disappear.

Materials and Methods

Eighty primary sites in the Buffalo National River area were selected for the study:

Newton County

1. Lost Valley
2. Leatherwood Creek
3. Indian Creek
4. Sneed Creek
5. Big Bluff
6. Hemmed-in-Hollow

Marion County

7. The Rush area

Searcy County

8. Bluff area near Gilbert

Several additional (secondary) sites were visited: Boxley, Shaddox, Jasper, Hasty, the bridge area near Highway 14, Buffalo Point, Richland Creek, Terrapin Branch Creek, and the Henry Koen Experimental Forest.

Field trips to each of the eight primary sites were made at least once by the principal investigator or by the assistant. A total of more than 14 sites along the Buffalo were visited. During the field trips, suspected rare plants were collected for pressing and mounting. Vouchers of these species have been sent to the Park Headquarters Herbarium in Harrison. Determination of status (rare, threatened, endangered) was made by comparing the suspected rare species with the material on file in the University of Arkansas Fayetteville Herbarium and other regional herbaria. A survey of the 62,000 specimens at the University of Arkansas Fayetteville Herbarium was completed to establish a list of potentially rare plants of Arkansas and the Buffalo River area. The suspected rare species were compared with this list. A partial survey of the literature for reports of rare plants along the Buffalo River was made, but failed to turn up records of any help.

Results

Table 6 is a list of the known rare, threatened, and endangered vascular plants of the Buffalo National River area as of the Fall, 1977. The following columns are used in the table.

Scientific Name:
The plants are arranged by family in phylogenetic order according to Fernald (1950). Within families, the genera and species are arranged alphabetically.

Common Name:
The vernacular name, as listed in Steyermark (1963), Correll & Johnston (1970), or other manuals, is given in quotation marks if available. If a species lacks a common name, the common name of the genus is given. In one case (Diarrhena americana), neither the species nor the genus has a common name.

Table 6. Known Rare, Threatened, and Endangered Vascular Plants of Selected Areas of the Buffalo National River.

Scientific Name	Common Name	Arkansas Counties	Status in Buffalo	N. A. Distribution
CUPRESSACEAE - Cypress Family				
Juniperus ashei Bucholz	"Ashe's Juniper"	14	R	Texas, Okla., Mo.
GRAMINEAE - Grass Family				
Diarrhena americana Beauv.		4	R	SE 1/3 of U.S.
COMMELINACEAE - Spiderwort Family				
Tradescantia ozarkana Anderson & Woodson	"Spiderwort" (genus)	9	R (T:E)	SW Mo. & E. Okla. (endemic to Ozarks & Ouachitas)
CYPERACEAE - Sedge Family				
Carex careyana Torr.	"Sedge" (genus)	1 (Newton)	E	Ontario; NE¼ U.S.
Carex jamesii Schwein.	"Sedge" (genus)	1 (Newton)	E (T:E)	Ontario; NE¼ U.S.
LILIACEAE - Lily Family				
Trillium pusillum Michx. var. *ozarkanum* (Palmer & Steyerm.) Stererm.	"Ozark Trillium"	7	T (T:E)	S. Mo. (endemic to Ozarks)
ORCHIDACEAE - Orchid Family				
Cypripedium calceolus L. var. *parviflorum* (Salisb.) Fern.	"Small Yellow Lady Slipper"	7	T	Canada; E and C U.S.
Goodyera pubescens (Willd.) R. Br.	"Rattlesnake Orchid"	5	T (T:PE)	E Canada; E 1/2 of U.S.
FAGACEAE - Beech Family				
Castanea pumila Mill. var. *ozarkensis* (Ashe) Tucker	"Ozark Chinquapin"	31	E (T:E)[1]	SW Mo. & NE Okla. (endemic to Ozarks)
CARYOPHYLLACEAE - Pink Family				
Cerastium arvense L. var. *villosum* (Muhl.) Hollick & Britt.	"Mouse-ear Chickweed" (genus)	1 (Newton)	E	Ontario; N 1/2 of U.S.

Table 6. (Cont.)

PAPAVERACEAE - Poppy Family				
Stylophorum diphyllum (Michx.) Nutt.	"Woody Poppy"	3	T (T:PE)	NE 1/4 of U.S.
CRUCIFERAE - Mustard Family				
Arabis shortii (Fern.) Gl. var. shortii	"Rock Cress" (genus)	1 (Marion)	E	NE 1/4 of U.S.
SAXIFRAGACEAE - Saxifrage Family				
Heuchera villosa Michx. var. villosa	"Alum Root" (genus)	5	R[2]	SE 1/4 of U.S.
ROSACEAE - Rose Family				
Neviusia alabamensis A. Gray	"Snow Wreath"	4	E (T:E)	Ala. & Mo.
ANACARDIACEAE - Cashew Family				
Cotinus obovatus Raf.	"American Smoke Tree"	12	R (T:E)	Tex. to Ala., Tenn. & Mo.
ARALIACEAE - Ginseng Family				
Panax quinquefolium L.	"Ginseng"	16	T (T:E)	E 1/2 of U.S.
MALVACEAE - Mallow Family				
Abutilon incanum (Link) Sweet	"Pelotazo"	3	E (T:E)	Mexico; W. Tex. to Ariz. (disjunct by about 500 miles)
POLEMONIACEAE - Phlox Family				
Phlox bifida Beck var. bifida	"Sand Phlox"	2	E (T:PE)	NE 1/3 of U.S.
BORAGINACEAE - Borage Family				
Lithosperum latifolium Michx.	"Gromwell" (genus)	6	E (T:E)	NE 1/4 of U.S.

Table 6. (Cont.)

SCROPHULARIACEAE - Figwort Family				
Mimulus floribundus Dougl.	"Yellow Monkeyflower"	6	E (T:E)	W. Canada; Cal. to Mont., Colo. & Ariz. (disjunct by about 700 miles!)
COMPOSITAE - Sunflower Family				
Brickellia grandiflora (hook.) Nutt.	"Tassel Flower"	4	R	SE 1/4 of U.S., & Texas to Cal.
Eupatorium sessilifolium L.	"Upland Boneset"	6	R	NE 1/4 of U.S.

[1]This variety (as *Castanea ozarkensis*) is listed as endangered in the Federal Register (Vol. 41, No. 117, Pt. 4; June 16, 1976). *Castanea ozarkensis* was reduced to a variety of *C. pumila* by G. E. Tucker (Tucker, 1975).

[2]This glabrous calyx form of *H. villosa* var. *villosa* is known only from Arkansas.

Arkansas Counties:
The number of counties of Arkansas in which the species is known to be present is indicated. If the species is present in a single county in the state, that county is listed.

Status in Buffalo:
The status in the Buffalo National River area is indicated. R = rare; T = threatened; E = endangered. If Tucker (1974) listed a species for Arkansas, this fact is indicated. T:PE = Tucker, possibly endangered; T:E = Tucker, endangered. The investigators do not always agree with the status assigned by Tucker. Note that the status assigned is for the Buffalo National River area, and does not apply for Arkansas in general or for the United States.

N.A. Distribution:
The distribution in North America (outside of Arkansas) is indicated, based on the ranges given in the standard manuals.

Table 7 shows examples of locations and blooming dates of the 22 rare, threatened, and endangered plants.

Table 7. The habitats, examples of locations, and blooming dates of the 22 Rare, Threatened, and Endangered plants of the Buffalo National River.

Juniperus ashei Bucholz - limestone balds and slopes, as: cedar glade NW of camp area in Lost Valley, Mar. - Oct.

Diarrhena americana Beauv. - moist, shaded alluvial banks of streams, as: Hemmed-in-Hollow and Leatherwood Creek. June.

Carex careyana Torr. - rich, moist, sandy alluvium on shaded banks of streams, as: middle area of Leatherwood Creek. April - May.

Carex jamesii Schwein. - rich, moist, sandy alluvium on shaded banks of streams, as: middle area of Leatherwood Creek. April - May.

Tradescantia ozarkana Anderson & Woodson - rich, wooded, partly shaded slopes in limestone areas, as: east-facing slope 1 mi. N. of Ponca. Late April - mid May.

Trillium pusillum Michx. var. *ozarkanum* (Palmer & Steyerm.) Steyerm. - shallow draws in cherty soil, in Oak woods, as: rocky hillside by road to Sneed's Creek, ca. 2.4 mi. E. of Hwy 43. April

Cypripedium calceolus L. var. *parviflorum* (Salisb.) Fern. - Rich, moist, shaded and rocky soil near streams, as: NW of camp grounds in Lost Valley. Late April - early May.

Goodyera pubescens (Willd.) R. Br. - Rich, moist shaded areas near sandstone, as: Beech woods in SE Madison County (Probably in the headwaters of the Buffalo River, or nearly so).

Castanea pumila Mill. var. ozarkensis (Ashe) Tucker - Dry soils of upland Oak-Hickory woods, as: near road to Buffalo Pt., about half way to the park. Late May - August.

Cerastium arvense L. var. villosum (Munl.) Hollick & Britt. - Partly shaded, moist, sandy areas on the banks of Sneed's Creek. Late April - May.

Stylophorum diphyllum (Michx.) Nutt. - damp, alluvial, shaded banks and slopes along the Buffalo River, as: across the Buffalo River from Gilbert, and Buffalo Pt. April.

Arabis shortii (Fern.) Gl. var. shortii - sandy, open, partly shaded bank of the Buffalo River at Buffalo Pt. April

Heuchera villosa Michx. var. villosa - moist, partly shaded boulders and rock outcrops near rich streams, as: Lost Valley, Indian Creek, Leatherwood Creek. August - September.

Neviusia alabamensis A. Gray - rich, limey alluvial banks with seepage, along intermittantly flowing streams, as: Henry Koen Expt. Forest. April.

Cotinus obovatus Raf. - wooded limestone balds and ledges, often near streams, as: Lost Valley, Hemmed-in-Hollow. May - June.

Panax quinquefolium L. - moist, shaded, rich alluvial banks and slopes, as: middle area of Leatherwood Creek. May - June.

Abutilon incanum (Link) Sweet - limestone balds and ledges with seepage, as: Big Bluff. June - July.

Phlox bifida Beck var. bifida - partly shaded pockets of sand near rich, moist streams, as: Lost Valley, and Indian Creek. Late March - April.

Lithospermum latifolium Michx. - rich woods, alluvial slopes and banks of streams, as: Lost Valley, and vicinity of Ponca. May - early June.

Mimulus floribundus Dougl. - moist sandy pockets and patches in sandstone with seepage, partly shaded, as: Richland Creek, and Big Creek ESE of Jasper. Late May - July.

Brickellia grandiflora (Hook.) Nutt. - limestone ledges with seepage, and limey gravel of slopes near streams, as: Leatherwood Creek, Bug Bluff, Lost Valley. September - October.

Eupatorium sessilifolium L. - open, dry, upland woods in rocky limestone areas, as: Henry Koen Expt. Forest. Late July - August.

Discussion

A total of 22 species of vascular plants are known to be rare, threatened, or endangered in the Buffalo National River area. Many of these are species that have a more general distribution in the north-eastern United States and Canada, and are on the southwesternmost margin of their range along the Buffalo River in Arkansas. Two represent long disjuncts with their general distribution in the western or southwestern parts of the United States. Three are regional endemics, limited to the Ozarks and Ouachitas. The Snow Wreath (*Neviusia alabamensis*) was not actually found within the Buffalo National Park boundries, but was close by and was included because it may be found in the Park and because it is one of the rarest shrubs in North America. It is known from four counties in Alabama, one county in Missouri (that station possibly extinct; cf. Steyermark, 1963), and four counties in Arkansas.

A total of nine species are classified as endangered in the Buffalo National River area. These species need protection by the Park Service, if possible, for their continued existence in the area. Most of the endangered species are known from only 1-4 counties in Arkansas; two are present in more than four counties. *Mimulus floribundus* (in six counties) requires a moist but rocky habitat, with adequate shade and proper seepage. The habitat is fragile and easily disturbed. *Castanea pumila* var. *ozarkensis* (31 counties) is known from most of northwestern Arkansas, but is declining in numbers from a blight similar to the one that has devastated the American Chestnut. It will probably continue to decline.

There are five critically endangered species that are known from a single area (county) in Arkansas, or are endangered both in and outside of Arkansas. These five species and the areas where they have been collected are indicated in Plates 1-5 and Figures 12-15 respectively. The figures have been extracted from U.S. Geological Survey Topographic Maps (Jasper & Ponca Quadrangles); the drawings in Plates 1-5 were done by Kathy Kurtz.

Figures 12-32 are provided to help in the identification of the Rare, Threatened, and Endangered plants of the Buffalo National River. They were photocopied from Steyermark (1963), unless otherwise indicated.

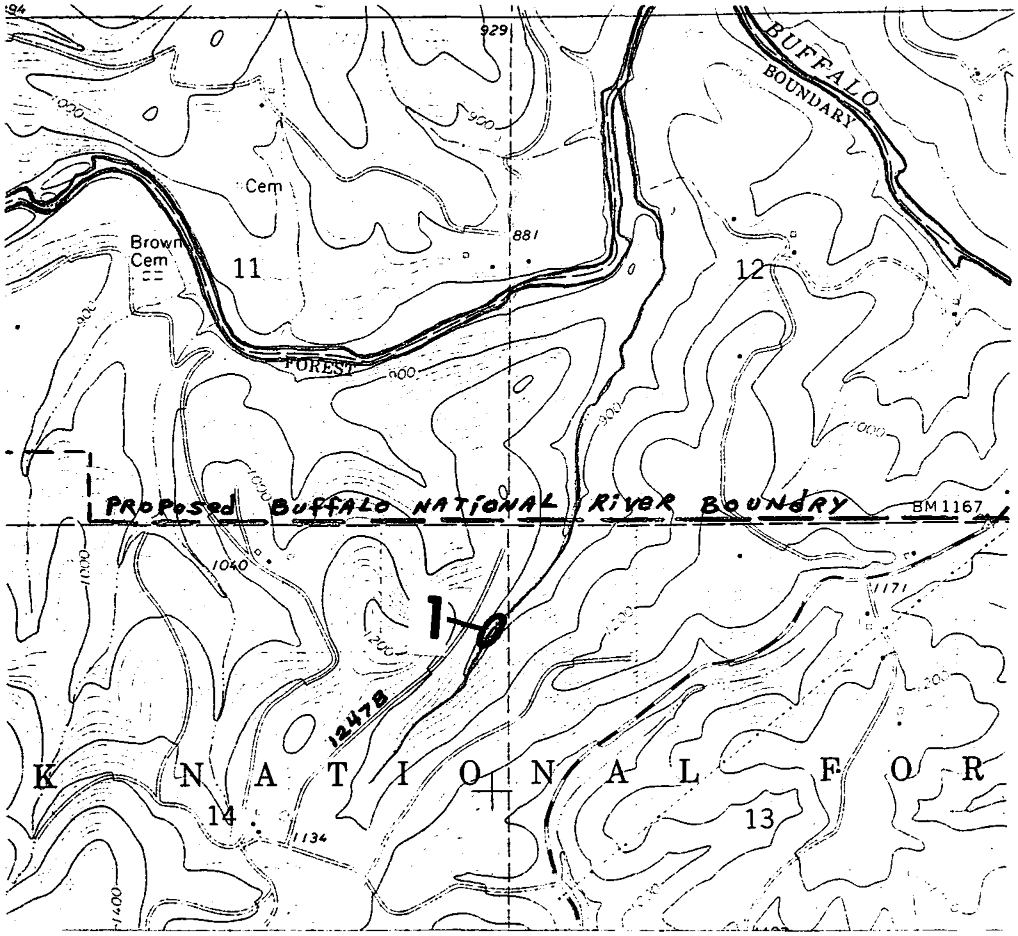


Figure 12. Location of Neviusia alabamensis, just outside of the Buffalo National River, in the Henry Koen Experimental Forest.

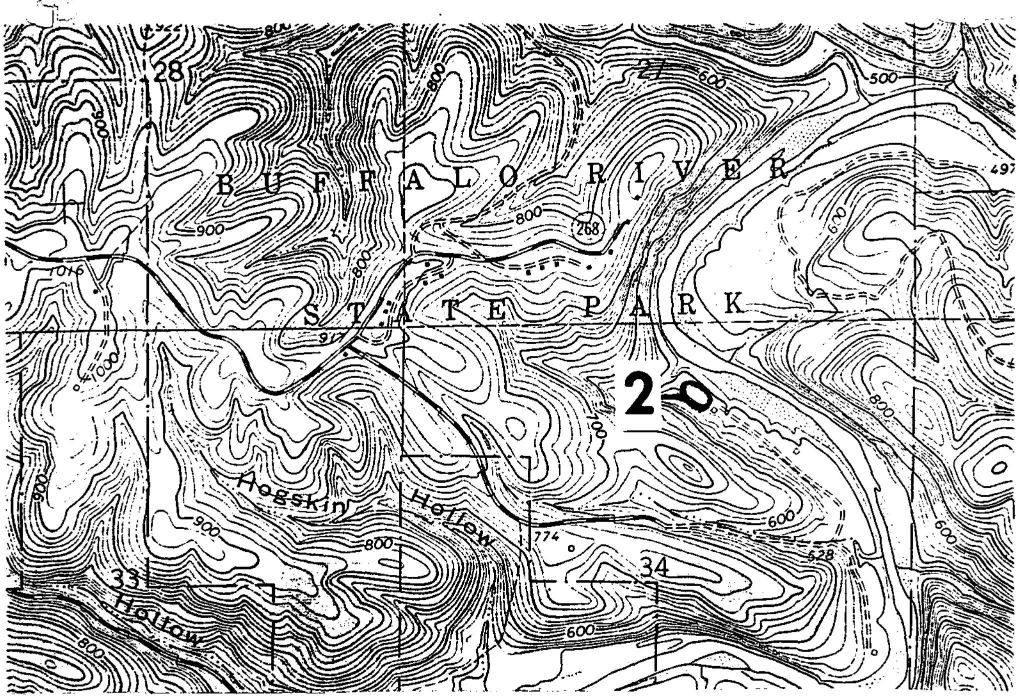


Figure 13. Location of Arabis shortii var. shortii, on the bank of the Buffalo River at Buffalo Point.

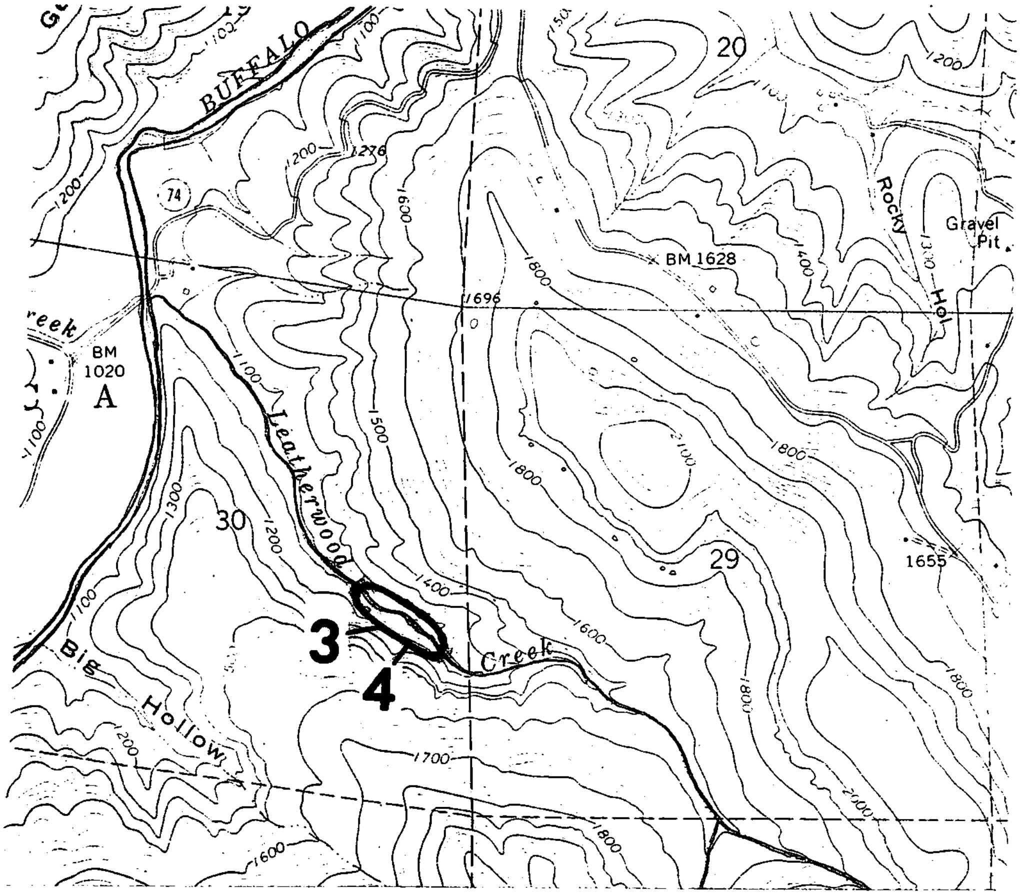


Figure 14. Location of Carex careyana and Carex jamesii, on the banks of Leatherwood Creek.

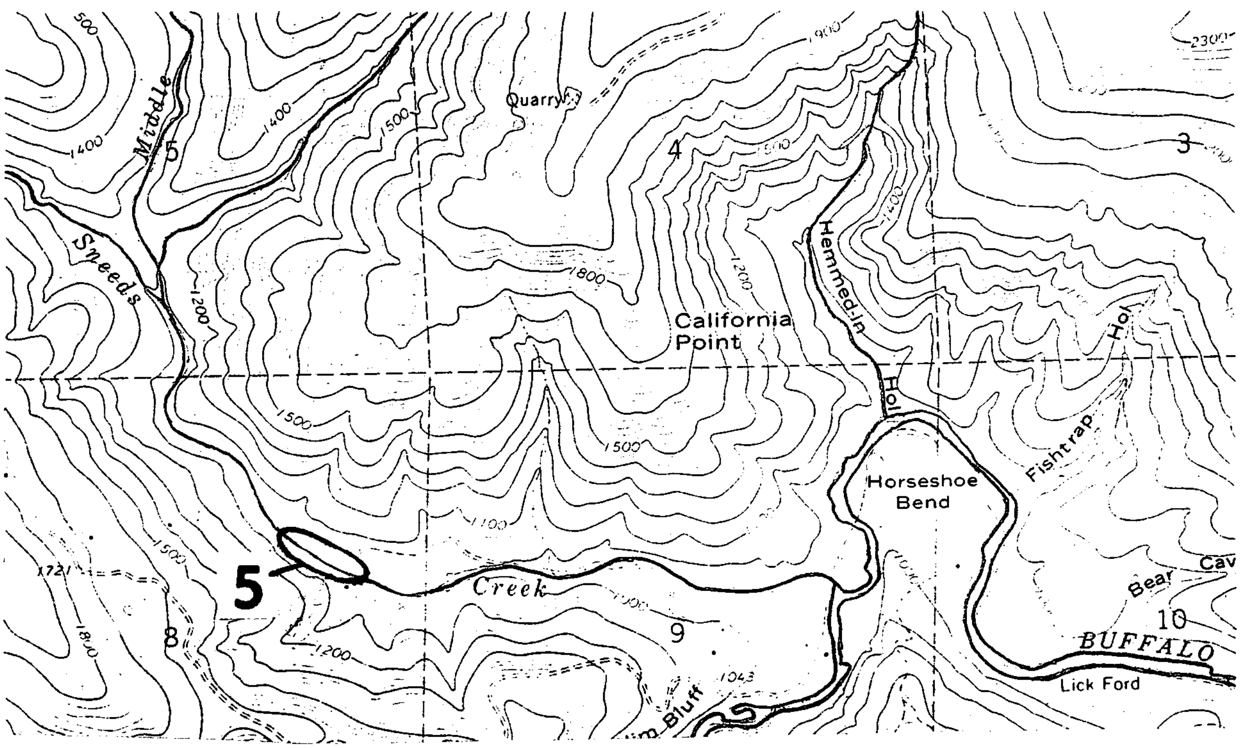


Figure 15. Location of Cerastium arvense var. villosum, on the banks of Sneeds Creek.

Plate 1. Flowering branch of Neviusia alabamensis A. Gray (X1).

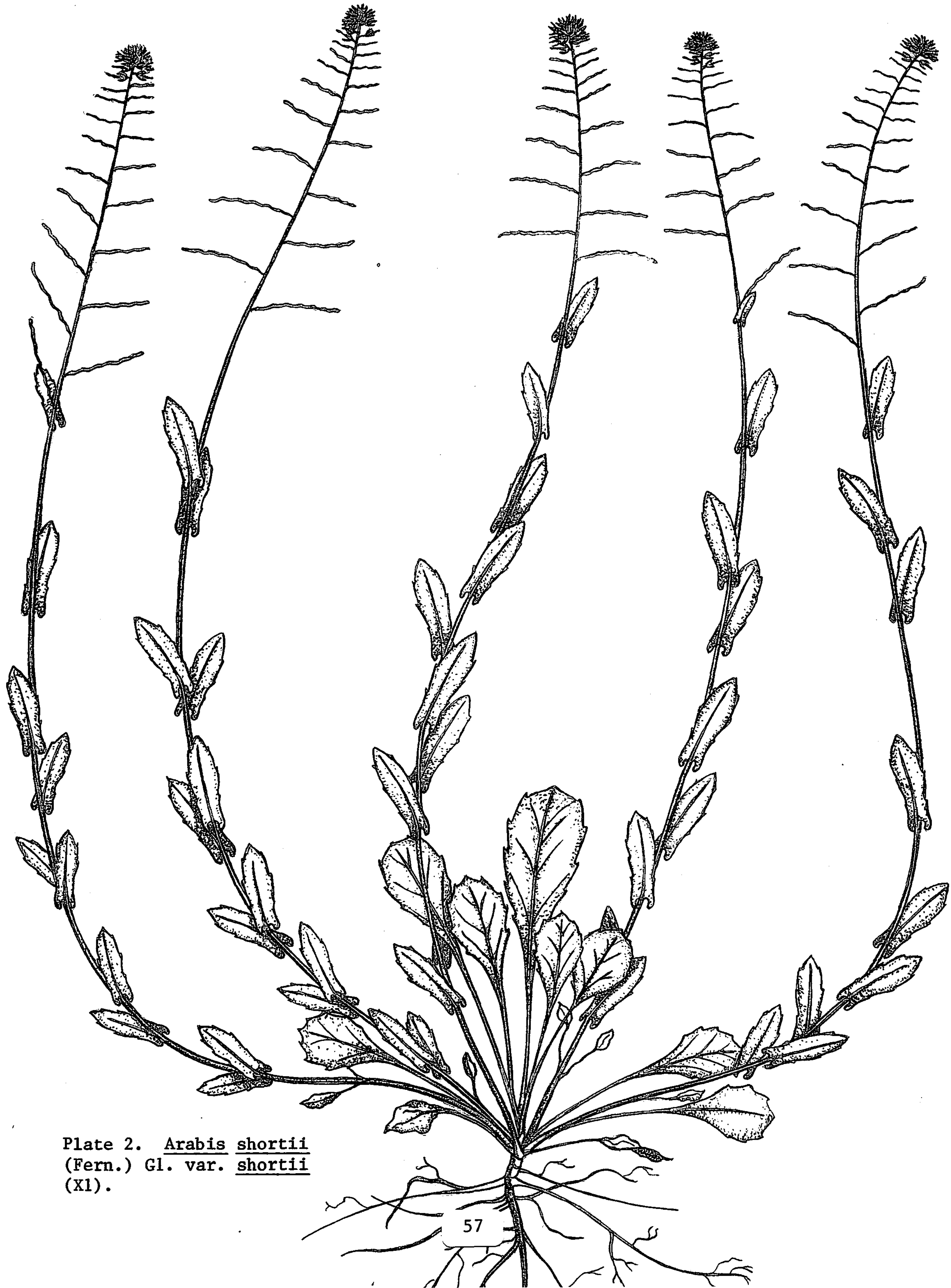


Plate 2. Arabis shortii (Fern.) Gl. var. shortii (X1).

Plate 3. Carex careyana Torr. (X 0.8). Lower right: fruits (X2).

Plate 4. Carex jamesii Schwein. (X1). Lower right: fruits (X3).

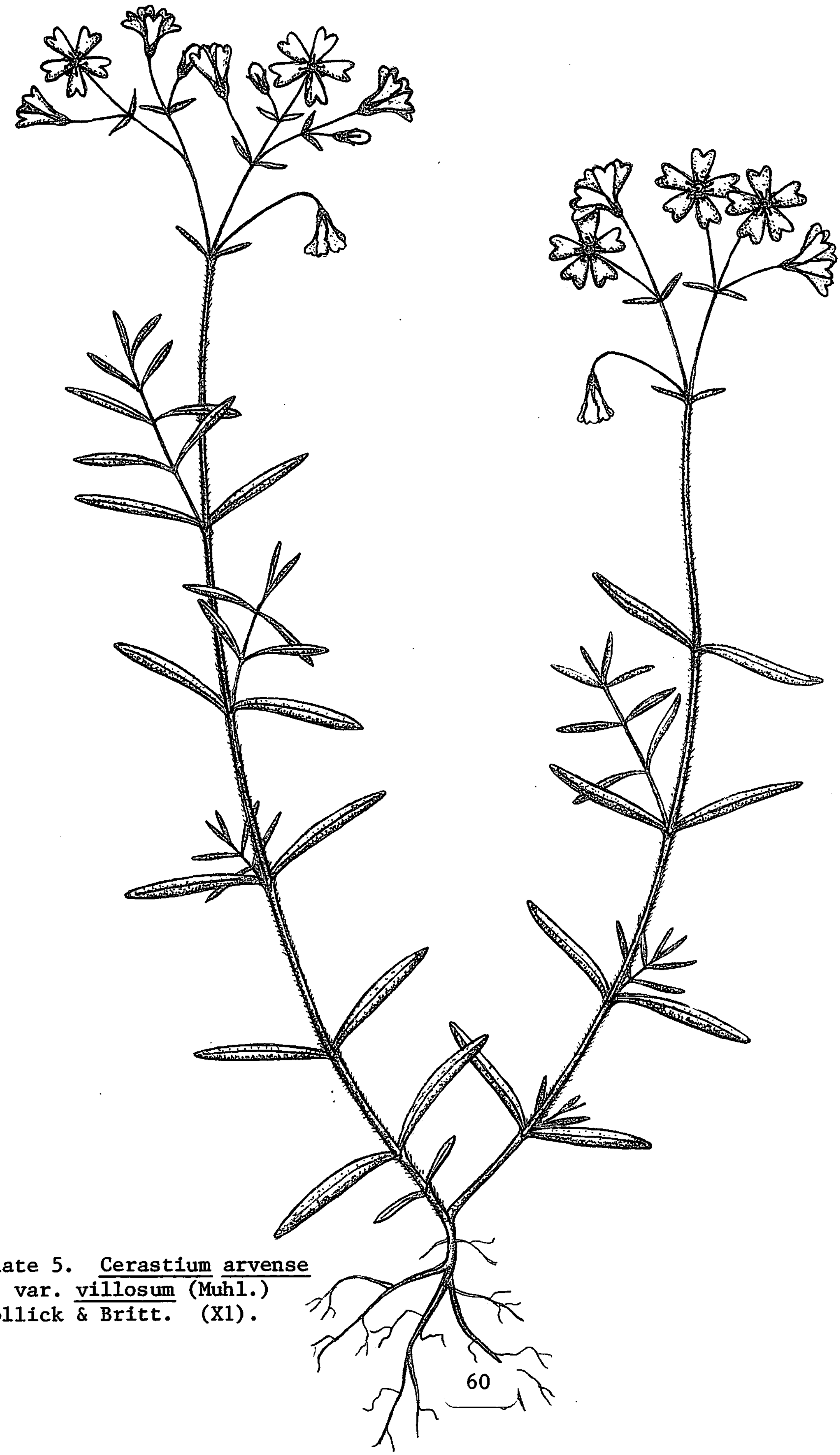


Plate 5. *Cerastium arvense* L. var. *villosum* (Muhl.) Hollick & Britt. (X1).

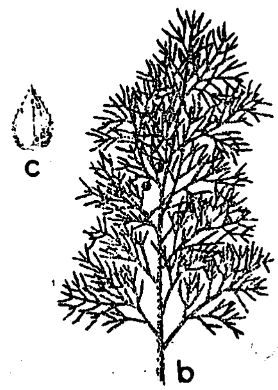


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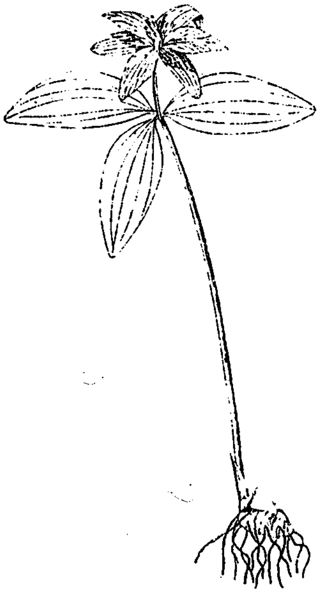
Fig. 16. __Juniperus__ __ashei__; b = twig X2/7, c = scale leaf X8 4/7.
Fig. 17. __Diarrhena__ __americana__; a = plant X3/8, b = spikelet X3 3/4, c = floret X3 3/4.
Fig. 18. __Tradescantia__ __ozarkana__; X2/7.



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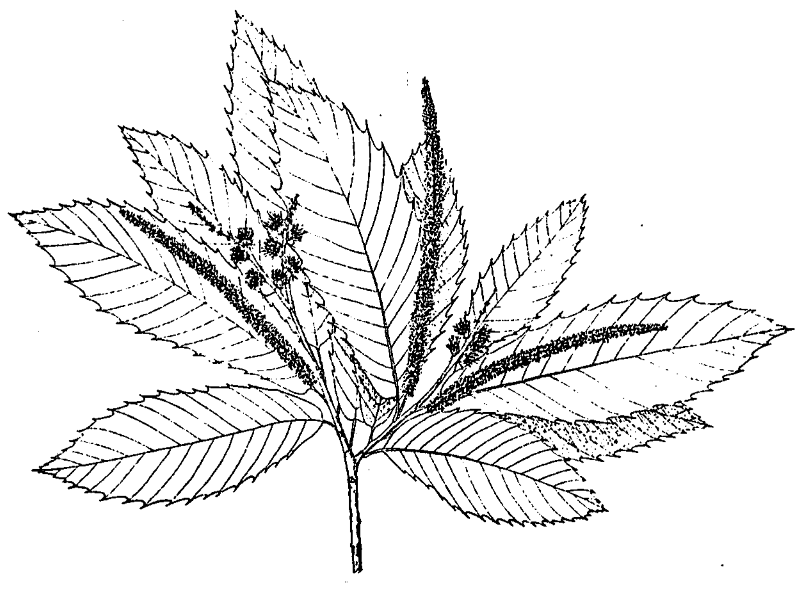

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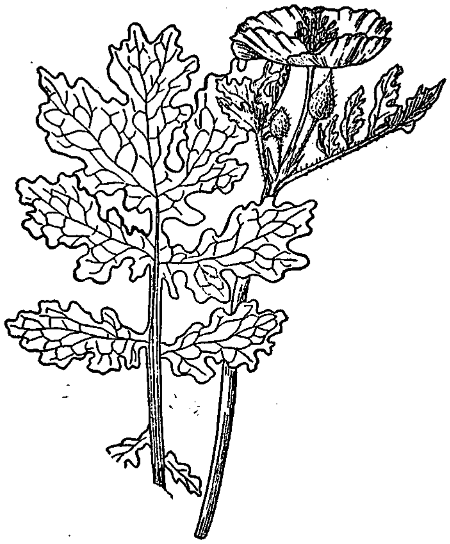
Fig. 19. Trillium pusillum var. ozarkanum; X2/7.
Fig. 20. Cypripedium calceolus var. parviflorum; X2/7.
Fig. 21. Goodyera pubescens; X2/5.
Fig. 22. Castanea pumila var. ozarkensis; X2/7.



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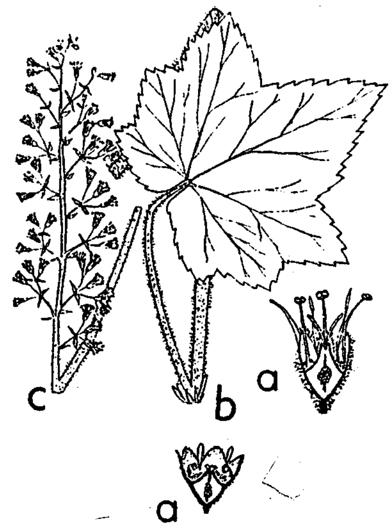

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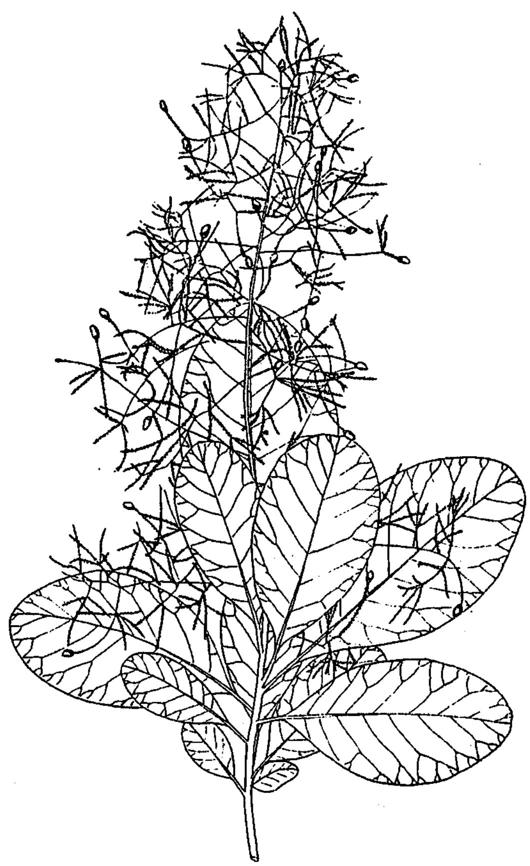

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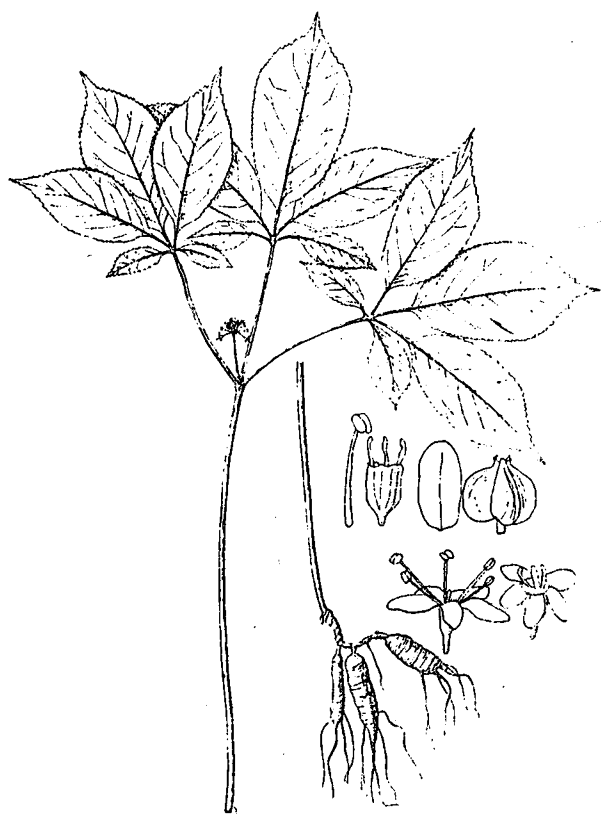

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Fig. 23 Stylophorum diphyllum; X1/2 (from Gleason, 1963).
Fig. 24 Heuchera villosa var. macrorhiza; a = flower X2 2/5, b = basal leaf X2/5, c = inflorescence X 2/5. The var. villosa is similar, but less pubescent.
Fig. 25 Cotinus obovatus; X2/5.
Fig. 26 Panax quinquefolium; X2/7 (enlarged view of flowers and fruit).

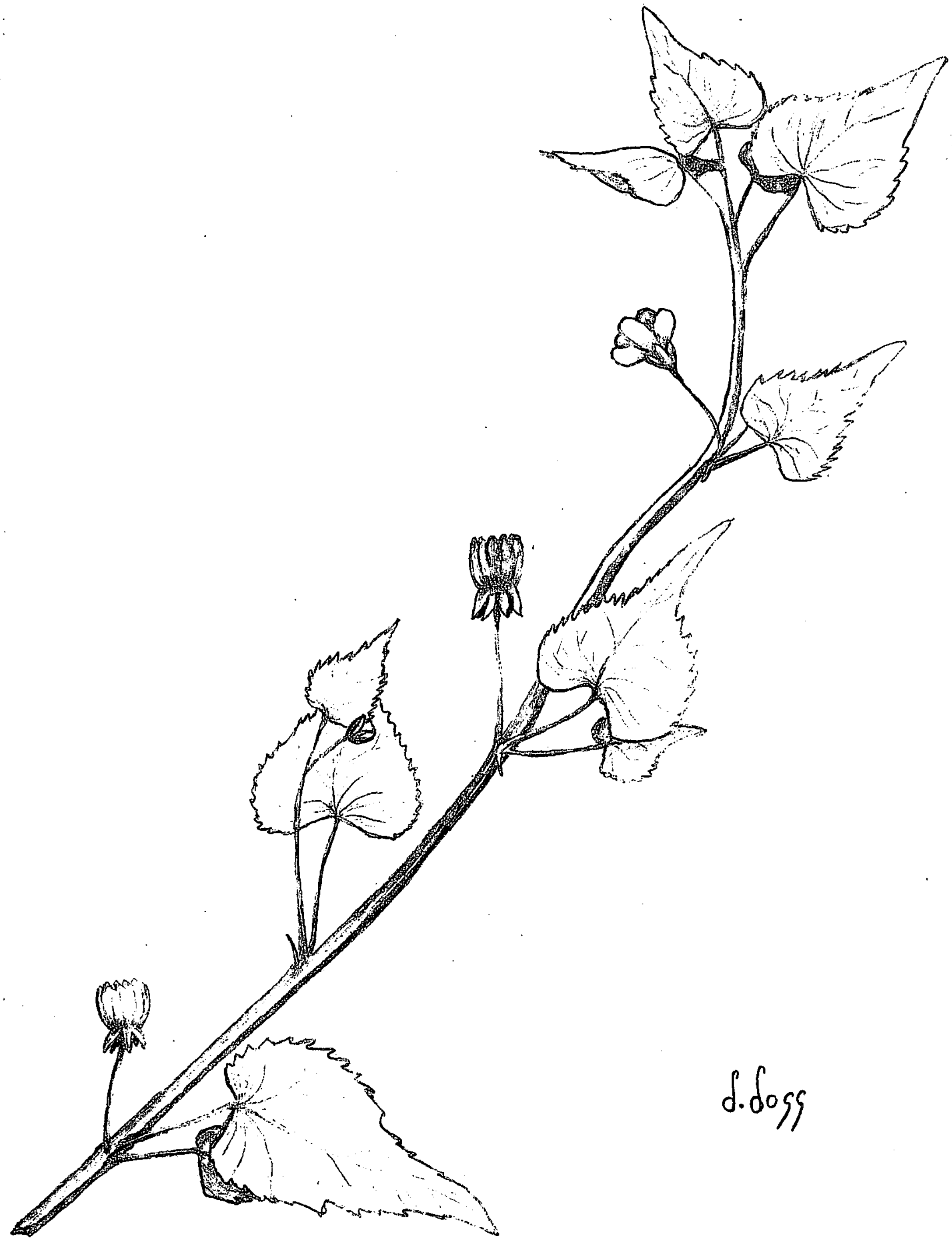

Fig. 27. Abutilon incanum; X1 (original drawing by Debbie Doss).

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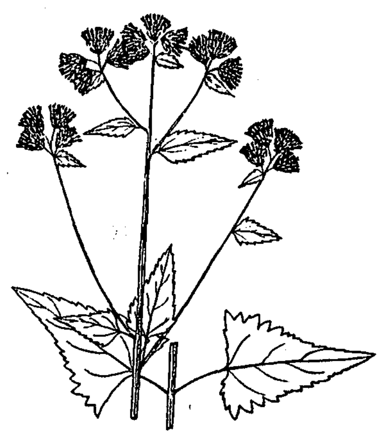

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Fig. 28. Phlox bifida var. bifida; X2/5.
Fig. 29. Lithospermum latifolium; X2/7.
Fig. 30. Mimulus floribundus; plant X1/2, flowers (above) X2; (from Hitchcock et al, 1955).
Fig. 31. Brickellia grandiflora; X2/7.

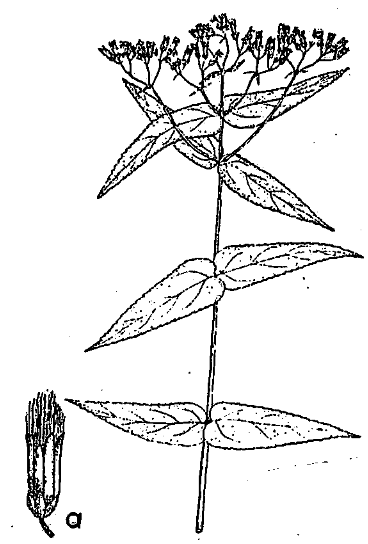

Fig. 32. Eupatorium sessilifolium; plant X2/7, a = head X2 2/7.

HUMAN CARRYING CAPACITY STUDY
ON CAMPING AREAS

Edward E. Dale, Jr., Principal Investigator
Paul M. Kuroda, Graduate Assistant

The rating system devised during 1976 was based primarily on library studies and tested on different types of campgrounds in various parts of Arkansas. The results of this study indicated that some changes in the rating system would improve its usefulness for determining campground conditions. Accordingly, Keith Whisenant, Buffalo National River, suggested changes in the system of rating and in the rating form. One of these changes consisted of assigning different ranges of weight to the items considered in the rating system. For example, campground litter is assigned a lower range of weight than soil erosion because litter is temporary and can be easily removed, but the effects of soil erosion can be serious and the remedy is much more difficult. Also, the number of fire rings present was added to the list of items rated since they give good indication of use. The rating form for use in the field was then modified to fit the revised rating system (Figures 33 and 34).

Ratings were made of 22 camping areas along the river by University of Arkansas personnel. The first rating period was in late June and early July, 1977, the second in August and September, 1977, and the third in March, 1978. Efforts were made to rate these areas at least three times, but some were rated only twice because of difficulty of access. Assistance in rating some areas by Park Service Personnel was very helpful toward adding more information on the campgrounds. Also, this provided a larger

Rating System

A. Ground cover in terms of kind of ecosystem present:

Scale

- 2- Ground cover thick.
- 3- Ground cover generally thick, but with a few thin patches present.
- 4- Ground cover generally thin.
- 5- Ground cover thin with extensive bare areas.
- 6- Ground cover almost entirely absent.

B. Litter-Trash

Scale

- 1- No litter.
- 2- Widely scattered litter.
- 3- Scarce litter, mostly around campsites.
- 4- Litter concentrated around campsites.
- 5- Litter nearly everywhere.

C. Species Present

Scale

- 3- Some rare species or species intolerant to trampling present.
- 4- No rare or intolerant species, but many native forbs and grasses present.
- 5- Mostly grasses present and some forbe. Grasses native or introduced, many species tolerant to trampling, such as bermuda, (*Cynodon dactylon*) goose grass (*Eleusine indica*), poor-jo (*Diodia teres*), etc.
- 6- Mostly grasses and forbs tolerant of trampling, some poison ivy (*Rhus radicans*), catbrier (*Smilax spp.*) or other undesirable vines or shrubs present.
- 7- All species present herbaceous weeds tolerant of trampling or undesirable vines or shrubs.

D. Soil Erosion

Scale

- 3- No soil erosion
- 4- Soil erosion near areas of heavy use only.
- 5- Some soil erosion evident over most of areas.
- 6- Much soil erosion, some exposed tree roots.
- 7- Extensive soil erosion, many tree roots exposed.

E. Paths

Scale

- 3- No unauthorized paths
- 4- Some unauthorized paths in heavily used areas, some ground cover and little compaction.
- 5- Several unauthorized paths in areas behind and between campgrounds.
- 6- Numerous paths and trails, some made by 4-wheel drive vehicles and motorcycles.
- 7- Extensive paths and trails made by vehicles.

FIGURE 33. RATING SYSTEM USED FOR ASSESSING THE RELATIVE IMPACT OF HUMAN USE ON CAMPGROUNDS.

F. Forest litter

<u>Scale</u>

2- Deep, well distributed forest litter.
3- Well distributed forest litter, but thin in some places because of human activity.
4- Well distributed but thin forest litter.
5- Litter in protected places only, such as under shrubs, etc.
6- Little or no litter present.

G. Screening (small trees and shrubs) between campsites

<u>Scale</u>

2- Excellent screening between camps, tables, etc.
3- Good screening, thin in places, a few paths between campsites.
4- Fairly well screened, numerous paths or openings between campsites.
5- Not well screened, a few small trees between campsites, extensive removal of vegetation.
6- No or little screening.

H. Fire rings

<u>Scale</u>

2- No fire rings present.
3- Fire ring was present but has been destroyed by user.
4- One small fire ring present.
5- Two fire rings present.
6- Three or more fire rings present.

FIGURE 33. (CONTINUED)

Campground Rating Form

Name of Area ______________________ Date Visited ______________

Location of Area ___________________ Years in Public Service _____

Vegetation Type ____

Rated by: ______________________

Rating Scale

	1	2	3	4	5	6	7
A. Ground Cover							
B. Litter							
C. Species Present							
D. Erosion							
E. Paths							
F. Forest Litter							
G. Screening							
H. Fire Ring							

Check applicable item using the attached rating scale description.

Comments:

FIGURE 34. CAMPGROUND RATING FORM.

sample so that better indications of consistency in ratings of different people could be obtained.

Since a considerable amount of time is necessary to reach some camping areas along the river and access may be difficult, ratings were made on March 10, 1978 based on observations with binoculars from a light airplane. Results of some of these observations near the upper end of the river were compared with ratings made on March 6, 7, and 8 on the ground.

It became evident during the first sampling period in June that some items on the rating system were not properly applicable to some types of areas. Accordingly, the type of camping areas were grouped into the three categories. These categories are forested camping areas such as those at Buffalo Point on Lost Valley, open camping areas like those at Steel Creek or Woolum, and gravel bars. All items on the rating list were rated at forested camping sites, but items F (Forest Litter) and G (Screening) were omitted from open camp areas in former abandoned fields or areas with a bermuda grass cover. The only items rated on gravel bars were B (Litter), E (Paths) and H (Fire Rings) since none of the others were applicable.

Completed rating forms were collected and the total scores tabulated. These total values were converted to a scale ranging from 0 to 100, with a high score indicating a camping area in relatively good condition and a low score in relatively poor condition.

The scale is calculated for each type of area by first determining the difference between the highest and lowest possible scores for a given type of area. This difference is divided into 100 and the resulting quotient becomes a factor. The factor is multiplied by the score determined from the rating form to obtain the scale value.

For example, an examination of the rating form shows that the worst possible score for a gravel bar (the sum of items B, E, and H, the only items rated on gravel bars) is 6 and the best possible score is 18. The difference between these figures is 12.

Suppose the score for an area is 10.

Factor = $\frac{100}{12}$ = 8.3333

Scale Value = (Total Possible - Score) X Factor

Scale Value = 8 X 8.333 or 66.6664
("Round off" to 67)

The information needed to calculate values for all three types of areas is shown in Table 8.

Results of the study as indicated by an examination of the completed Rating Forms and the compiled data shown in Table 9 are summarized as follows:

1. The rating system reflects the degree of use fairly well.

2. The rating system shows reasonably consistent results when used by different people rating the same area independently.

3. Heavy use of the upper part of the river in spring and the shift to heavy use downstream later in the year is substantiated by the study.

4. Results of assessment of camp areas from a light airplane is a promising method to use in conjunction with ground studies. Air observation can save considerable time and money, and a good correlation is indicated at least tentatively between air observations and ground assessments.

5. The rating scale values provide a quantitative measure useful for determining campground conditions that reflect intensity of human use and serve at least as a partial basis for management decisions.

It is recommended that each type of campground be compared with the same type only.

TABLE 8.

SUMMARY OF FIGURES NEEDED TO CALCULATE SCALE VALUES FOR EACH TYPE OF CAMP AREA

Type of Area	Least Possible	Most Possible	Difference	Factor
Gravel Bar	6	18	12	8.3333
Open Area	14	38	24	4.1667
Forested Areas	18	50	32	3.1250

TABLE 9.

SCALE VALUES OF DIFFERENT TYPES OF CAMPING AREAS*

Camping Area	Type of Area	Intensity of Use	1977 June-July	1977 Aug.-Sept.	1978 March	
Lost Valley	Forest	Heavy	50	44		56
Steel Creek	Open	Heavy	67		58	58
Big Bluff	Bar	Medium	75		50**	75
Kyles Landing	Open	Heavy	56	63		67***
Erbie Ford	Forest	Heavy	19	41	69	69
Ozark Camp	Open	Heavy	54	58	63	71
Little Buffalo	Open	Medium		63		75
Hasty	Open	Medium	29	54		42
Eddings	Open	Medium		63		54
Narrows	Forest	Heavy		50		29
Woolum	Open	Heavy		71		58
	Bar	Heavy	50			58
Coleman	Forest	Light		16		53

* Figures in Parentheses are assumed to be the same as those in comparable areas nearby. These figures were included to assist in estimating use trends during the year. Scale values may represent single ratings or averages of several ratings made about the same time. The list of values on the left side of the column for March, 1978 represent results of rating areas from the ground, and those at the right are ratings made by air observation. Species present(Item C on the rating form) were assumed to be the same as the previous year and assigned the same rating as the previous year when camp area ratings were made from air observations in March, 1978.

** Air observation missed litter!

*** Ground survey indicated fire rings only-but same number as indicated from air.

TABLE 9 continued.

Camping Area	Type of Area	Intensity of Use	1977 June-July	1978 Aug.-Sept.	1978 March
Baker Ford	Forest	Medium	38		56
Red Bluff	Forest	Light	70		56
Maumee	Open	Heavy	42	40	71
	Bar	Heavy	52	25	42
Buffalo Point:					
Panther Creek	Bar	?		53	
Tent Area	Open	Heavy	46	46	75
A Area	Upland Forest	Heavy	(25)	47	
B Area	Lowland For-Open	Heavy	(25)	59	
C Area	Lowland Forest	Heavy	(25)	54	72
D Area	Up-Low Forest	Heavy	(25)	45	
E Area	Lowland Forest	Heavy	28	44	72
Upland Picnic	Oak-Pine	Heavy	39		
Lowland Camp	Open	Heavy	25		72
Upland Camp	Upland-Cedar	Heavy	25		
Toney Bend	Bar	Heavy	100	36	100
Rush	Forest	Heavy			
	Open	Heavy	58	54	71
	Bar	Heavy	50		
Big Creek	Bar	Light	50	29	83

TABLE 9 continued.

Camping Area	Type of Area	Intensity of Use	1977 June-July	1977 Aug.-Sept.	1977 March
Other:					
Beistle	Forest			47	
Bear Creek	Forest			59	
Water Creek	Bar			83	

VEGETATION MAP AND NATURAL AREAS SURVEY

Edward E. Dale, Principal Investigator
Paul M. Kuroda, Graduate Assistant

Vegetation Map of the Buffalo National River Area

An aerial photographic map was mounted on stiff paper, divided into segments, put in notebook form, and sent to the Superintendent, Buffalo National River. Also, duplicate negatives of the map as presented in final mosaic form were provided. The negatives and the map referred to below are on file in the Buffalo National River Office.

The aerial photographic map showing major vegetation types includes approximately 50,000 acres of the Buffalo National River area. The scale is 1/24,000, the same as used on USGS 7½ minute quadrangles. Scenic easements and proposed wilderness areas are not included.

The major vegetation communities present were determined from previous field studies by Dale (1973) and Bailey (1976) and observations made during the Summer of 1977. Interrupted belt or line transects were used in selected areas to determine the principal tree species present. Also, observations were made with a 10-40 power telescope to determine changes in the populations on large areas or areas that were difficult to reach. The method consisted of recording tree species present within the field of vision of the telescope at the bottom of a hill or distant area and recording similar observations in successive fields to the top of the hill or boundary of the area in question. The location, direction and date were noted, and each area was photographed. Approximately 25 such observations were made.

Information from ground observations was supplemented by studies of topographic and geologic maps, U.S.D.A. black and white air photographs, and color air photographs. In addition, use was made of high oblique aerial transparencies taken with High Speed Ektachrome and Ektachrome Infrared films from an altitude of approximately 1500 feet. These transparencies were taken on October 12, 1976 when fall color was present in leaves of deciduous trees and on April 14, 1977 when trees showed different stages of leaf initiation. This was done so that the different species could be more easily identified from transparencies. A transparent overlay was placed on each of a series of U.S.D.A. air photographs and the vegetation communities delineated. These were then photographed and an aerial mosaic prepared.

The symbols used to designate each plant community type and a brief description of each type are listed below.

C - Cutover area. This can refer to any forest type. Usually such areas are dominated by dense stands of small trees.

F - Open areas that are cultivated fields, pastures or meadows with few or no trees.

D - Disturbed areas that do not appear to be entirely C or F, or areas that contain cultural features such as buildings, campgrounds, etc.

FL - Floodplain Forest Type composed mostly of american elm (Ulmus americana), green ash (Fraximus pensylvanica), silver leaf maple (Acer saccharinum) or box elder (Acer negundo). These areas are on low, flat places subject to flooding at least once each year. Included also are streamside species such as sycamore (Platanus Occidentalis), black river birch (Betula nigra), black willow (Salix nigra), or cottonwood (Populus deltoides). Cottonwood is largely restricted in distribution to sandy areas behind bars along the lower part of the river. The Gravel Bar Type, dominated by Ward's willow (Salix caroliniana) or sandbar willow (S. interior), is present almost exclusively on the larger gravel or sand bars as narrow strips along the bars. Since the stream-side communities are too narrow and the gravel bar communities generally too small for accurate delineation on the map, they are included with the Floodplain Type. However, the larger areas supporting the Gravel Bar Type, such as the one at Gilbert, are easily discernible as darker strips or patches on the bars.

MH- Mixed Hardwood Type--This type is transitional between Floodplain and Oak-Hickory, Oak-Pine, or Cedar Glade Types. It occurs typically in moister areas on north-facing slopes above the river and along mesic small streams and upland ravines. Such areas are frequently steep-sided and have northerly exposure. Species present in addition to those common on uplands dominated by oak-hickory or oak-pine include american elm, green ash, and silver-leaf maple of the floodplains and sweetgum (Liquidambar styraciflua) white ash (Fraximus americana), bitternut hickory (Carya cordiformis), hackberry (Celtis laevigata), black gum (Nyssa sylvatica), black walnut (Juglans nigra), Shumard oak (Quercus Shumardi), and other lowland species. White oak (Quercus alba), a mesic species of the uplands, frequently occurs in these transitional zones on the upper slopes.

OH- Oak Hickory Type--This is the most extensive of all types present, occurring principally on south-facing slopes, hilltops, and dry, upper north exposures. Common species on the drier sites of this type include post oak (Quercus stellata), blackjack oak

(*Quercus marilandica*), black oak (*Q. velutina*), or mockernut hickory (*C. tomentosa*). The more mesic areas, particularly on north-facing or protected slopes, are usually dominated by white oak (*Quercus alba*), black oak or mockernut hickory. Dogwood (*Cornus Florida*) frequently dominates the high understory.

OP- Oak Pine Type--This type occurs locally in patches and most extensively on soils derived from sandstones or shales on uplands. The oaks (upland species) usually dominate this type, although short-leaf pine (*Pinus echinata*) can occur locally in almost pure stands. Generally, pine occupies from 10 to 40 percent of the total species composition. In some instances, the pure or nearly pure stands of pine have been planted.

CG- Cedar Glade Type--Cedar glades are present almost exclusively on soil derived from limestone or dolomite. They occur as narrow bands on the tops or steep sides of the limestone or dolomite bluffs in dry areas along most of the entire length of the river. Also, they can occur along the sides of tributary ravines with thin soils, and red cedar (*Juniperus virginiana*) frequently invades and becomes established in abandoned fields near the river. Glades have a highly variable vegetation composition. The drier areas support a few cedar trees and prairie grasses if relatively undisturbed, or weedy grasses and forbs if heavily grazed. The more mature glades support oak-hickory forests with little cedar. White cedar (*Juniperus Ashei*) occurs with red cedar in some areas.

BE- Beech Type. This type is found almost exclusively on north-facing slopes and moist ravines mostly in the western part of the river area. The Beech (*Fagus grandifolia*) Type is highly restricted in its distribution. The only two areas mapped as the Beech

Type are in Leatherwood Creek and Lost Valley, although small patches occur in Indian Creek and Hemmed-in-Hollow. However, these areas were too small to show on the map. It is possible that larger "pockets" of this type will be discovered later.

It should be pointed out that some plant communities have species present that occur as dominant in several types. Examples include black oak and mockernut hickory, which may dominate singly in Oak-Hickory, Oak-Pine or Mixed Hardwood Types, thus, the lines drawn on the map indicating separate communities of these types may indicate in actuality the approximate center of transition zones. However, the separation between some of the other community types are more distinct, such as between Floodplain and Cedar Glade Types, or between the Gravel Bar and Floodplain Types.

Finally, note that very small areas of a vegetation type adjacent to or surrounded by a different type are not indicated on the map.

Natural Areas Survey

Seven sites along the river were examined during the summer of 1977 to determine their quality as natural areas. These areas were Lost Valley, Leatherwood Creek, Snead area, Hemmed-in-Hollow, Indian Creek, Richland Creek, and the Bluffs at Gilbert.

Leatherwood Creek is the only one recommended as a Research Natural Area at present. This area is unique because it supports an excellent example of an outlier of flora typical of the southern Appalachians. It contains the best stand of beech (*Fagus grandifolia*) within the boundary of the National River and several uncommon and at least one rare and endangered plant species occur in the area. Also, the slopes support typical oak-hickory and oak-pine, and typical examples of the mixed hardwood type occur along Leatherwood Creek and its tributary ravines. It is doubtful that the forests are virgin, but extensive disturbance has not occured in many years over most of the area.

Stands of beech are present at Hemmed-in-Hollow, Lost Valley, and Indian Creek, but these areas have been subjected to much more disturbance in the past. Consequently, these areas are not as high quality as potential natural areas as Leatherwood Creek.

All other areas examined represent good examples of the vegetation types present, but none of them are outstanding.

RECREATIONAL RIVER STRESS USING TIME-LAPSE PHOTOGRAPHY

M. D. Springer, Principal Investigator
Sharon McBride, Graduate Assistant
Manuel Barnes, Research Assistant

The objectives of the study were threefold:

1. To determine the effect of certain relative variables on the density of canoes at selected points on the Buffalo River.
2. To obtain regression functions for estimating the number of canoes as a function of these variables. Specifically, the variables are:
   (a) Low temperature (X_1), measured in degrees Fahrenheit.
   (b) High temperature (X_2), measured in degrees Fahrenheit.
   (c) Month (X_3). The month was identified in the usual manner by a number 1-12 (1 for January, 12 for December).
   (d) Weekend (X_4). $X_4 = 1$ indicates that the day being considered is a weekend; $X_4 = 0$, that it is not.
   (e) Holiday (X_5). ($X_5 = 1$ or 0, according as the day under consideration is or is not a holiday.)
   (f) Water flow (X_6), measured in cubic feet per minute.
   (g) Rainfall (X_7), measured in inches.
3. To obtain numerical estimates of canoe densities at selected river reaches.

Data were obtained by mounting cameras at six locations: Ponca, Hasty, Tyler Bend, Maumee, Tony Bend and Hy 14 bridge. The data covered the months of March through mid-November, including four holidays: Easter, Memorial Day, Fourth of July, and Labor Day. The multivariate normal regression model was used, based on the aforementioned seven variables, not all of which were involved in each regression model. The use of a multivariate linear regression model enables one to determine confidence statements for the various estimates of canoe densities.

Statistical analysis was carried out on six sets of data, one set for each of the above six locations. Tony Bend involved 185 days; Maumee, 188 days; Tyler Bend, 168 days; Hasty, 113 days; Ponca, 35 days; and Highway 14, 135 days.

Other observations were included in a set which did not have a canoe count but which did have values for all other variables. Such observations were used to estimate the canoe density once regression equations were found.

Correlation and Regression Analysis

Regression functions for each camera location were obtained by SAS procedures. The best regression model was chosen in which each variable was significant at the 0.05 level. At Tony Bend, this regression function is given by

$$Y = -7.088 + 1.316X_2 - 8.122X_3 + 36.133X_4 + 61.708X_5$$

where Y is the canoe density, X_2 is the high temperature for the day, X_3 denotes the month during which the observation is taken, X_4 indicates whether or not the observation is made on a weekend, and X_5 indicates whether or not the observation is taken on a holiday. Thus, of seven variables considered, only five have a significant effect on the number of canoes per day at Tony Bend for the 7 month period from May to mid-November. The multiple correlation coefficient for this period is 0.627.

The mean number of canoes per day for this time period was estimated to be 52.735, while the estimated standard deviation was 55.325. The estimated number of canoes to pass this camera location from May to mid-November was 10,876 with 90% confidence that it was between 10,597 and 11,155.

The regression function for estimating the number of canoes per day at Maumee is

$$Y = 76.219 - 0.436X_1 - 5.294X_3 + 8.620X_4 + 33.839X_5,$$

which is a function of low temperature, month, weekend, and holiday. The multiple correlation coefficient was $R = 0.649$. The mean number of canoes per day for the period May to mid-November was estimated to be 10.43, while the standard deviation estimate was 18.83. Finally, the estimated number of canoes to pass this camera location for the period May to mid-November was 1,795, with 90% confidence that it was between 1,712 and 1,878.

At the Highway 14 location, the regression function was

$$Y = 90.144 - 9.128X_3 + 36.442X_4 + 91.608X_5 + 11.494X_7$$

where X_3 denotes the month, X_4 and X_5 indicate, respectively, whether the canoe count occurred on a weekend or holiday, and X_7 denotes the amount of rainfall. The estimates of the mean and standard deviation of the number of canoes per day were, respectively, $\bar{X} = 26.64$ and $S = 35.51$. The multiple correlation coefficient was $R = 0.627$. The estimated number of canoes to pass this point on any given day from June to mid-November was 4,683, with 90% confidence that the actual number was between 4,428 and 4,938.

For the Tyler Bend location the regression equation is

$$Y = 62.455 - 9.375X_2 - 3.999X_3 + 3.595X_4 + 28.965X_5$$

The multiple correlation coefficient was $R = 0.626$. Estimates of the mean and standard deviation of the number of canoes per day which passed the point were, respectively, $\overline{X} = 6.127$ and $S = 12.842$. The results here are quite similar to those at Maumee, except that the number of canoes on a specific day is correlated with high temperature at Tyler, rather than with low temperature as was the case at Maumee. The estimated number of canoes to pass this point during the entire period from March to November was 1,653, with a confidence of 0.90 that the actual number was between 1,560 and 1,746.

At Hasty, the regression equation is a function of only two independent variables: weekend and holiday. Specifically,

$$Y = 7.729 + 28.371X_4 + 80.574X_5,$$

with a multiple correlation coefficient of $R = 0.574$ and estimates $\overline{X} = 31.818$ and $S = 50.582$, respectively, for the mean and standard deviation of the number of canoes per day. The estimated number of canoes to pass this point during the 5 month period from March through July was 2,834 with a 90% confidence interval of 2,478 to 3,190.

At Ponca, only one variable (weekend) had a significant effect on canoe density, as indicated by the regression equation

$$Y = 13.44 + 31.56X_4$$

The multiple correlation coefficient was $R = 0.407$, while $\overline{X} = 22.457$ and $S = 35.509$ were estimates of the mean and standard deviation, respectively, of the number of canoes per day passing this point. Finally, the estimated number of canoes to pass this point during the entire period from March to mid-May was 1,545, with a 90% confidence that the actual number was between 1,215 and 1,875.

Table 10 gives the best estimates of the number of canoes passing each of six river segments per month, based on statistical data, concessionaire's records, and consultation with rangers and Park Service Personnel.

Cluster Analysis

It was desired to find some measure of how the canoes were spaced out over the day. Specifically, were most of the canoes together or evenly distributed over the day? One measure which was used was the following: on each day, in addition to the count of the canoes for the day, the number of canoes in each group was counted. A group was defined to be all canoes with less than five empty frames separating them (5-7 mins.). Groups of fewer than four canoes were not counted. As could be expected, on days when the total canoe count was small, the maximum group size was small. On days when the canoe count was over 100, some very large groups were observed, indicating that very little empty space existed on the river for a large part of that day. A plot of the maximum group size vs the total canoe count for the day was made at each location. The first plot shown is an example. All of the example plots are from Tony Bend. The second plot shown is a plot of the total number of canoes observed in all groups of four or more as the total canoe count for the day. It is obvious, however, that it is impossible for more canoes to be observed in groups than are observed for the day. The linearity of

TABLE 10

SUMMARY OF MONTHLY CANOE DENSITY ESTIMATES FOR SIX SPECIFIC RIVER SEGMENTS

Camera Location Designation	River Segment	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total for Season
Ponca	Ponca-Kyles	626	1692	712	← Low Water Level →						3030
	Kyles-Pruitt	← No Data →									
Hasty	Pruitt-Hasty	222	925	1239	140	308	← Low Water Level →				2834
Tyler Bend	Wollum-Tyler Bend	(154)	(502)	1017	217	94	112	104	88	21	2309*
Tyler Bend	Tyler Bend-Gilbert	(154)	(502)	1017	217	94	112	104	88	21	2309*
Maumee	Gilbert-Maumee	(103)	(334)	557	609	168	198	140	82	38	2229
Hiway 14	Maumee-Buff. Pt.	(122)	(712)	(1150)	1481	972	1156	700	273	101	6667
Tony Bend	Buff. Pt.-Rush	(225)	(1240)	2063	2681	2704	2066	894	346	122	12341
											29410

Note: The numbers in parentheses involve no observed data but are best estimates available.

* These are the same canoes -- there is not yet a take-out at Tyler Bend.

this plot (and similar plots at other locations), then, might be due to this limitation. In order to avoid this, a plot was made of the percentage of canoes observed in groups vs the total canoe count for the day. At all locations a general trend can be observed: when the total canoe count for the day is small (under 50), many days had very few or no groups and the percentage of canoes in groups tended to be small; when the total canoe count was large (over 100) all days had many groups observed and the percentage of the total canoes observed in groups tended to be large. One interpretation which might be placed on these results is that when the total canoe count is small, the groupings represent choice since there is plenty of empty space on the river; when the canoe count is large, however, the larger percentage is groups may simply represent the lack of empty space on the river.

Another measure of the spacing of the canoes suggested was a comparison of the canoes counted in the morning vs the afternoon. At Tony Bend, for example, it was found that on the average, about as many canoes were seen in the morning as in the afternoon. In fact, except for the early morning and late evening, the number of canoes per hour seemed fairly constant over the day. That is, no one time seemed to be a peak hour. At Ponca, however, more canoes were observed in the first half of the day than the last half (60% vs 40%). At all locations, on even the most crowded days, the early morning hours had few canoes.

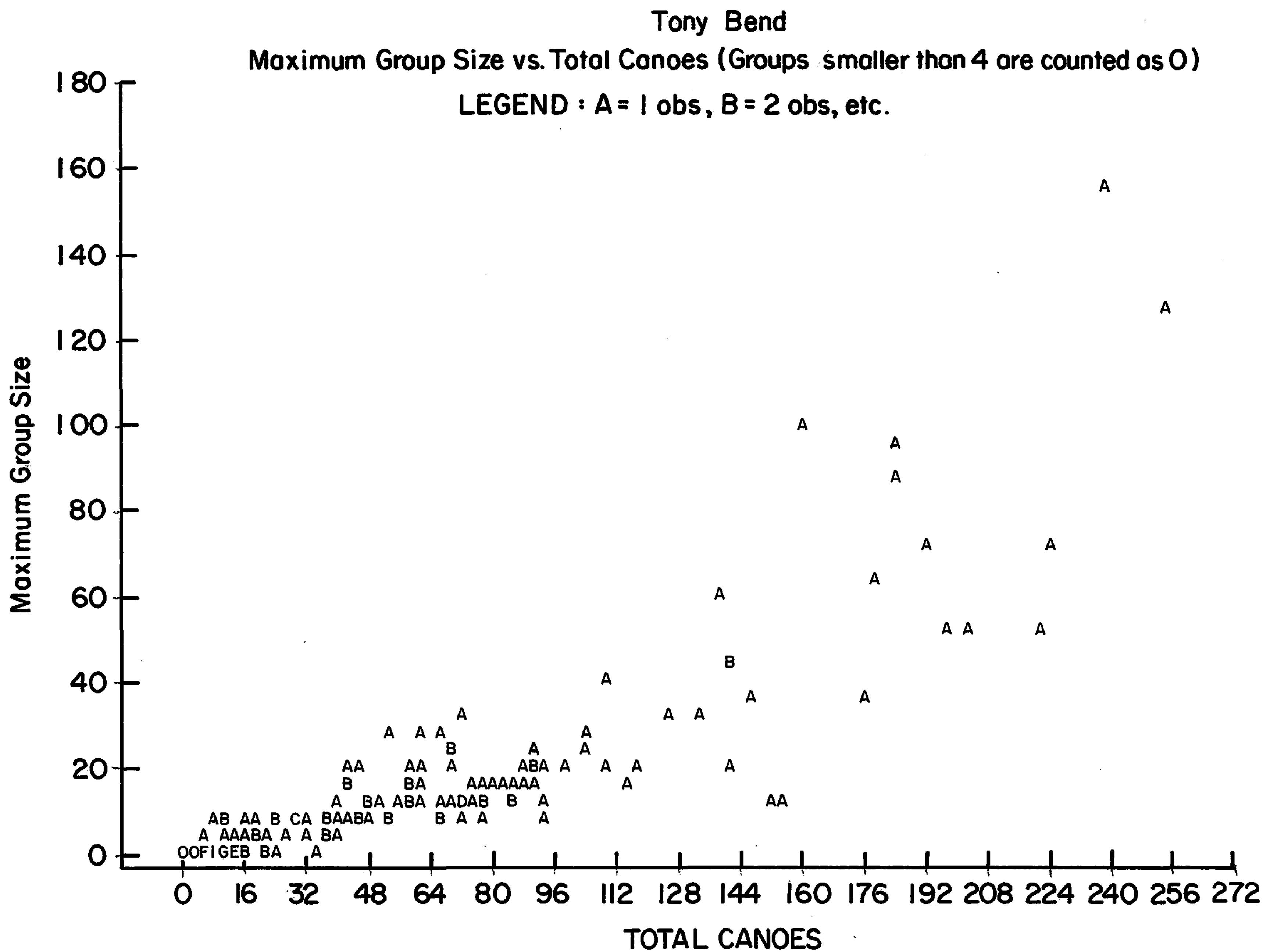
Tony Bend
Maximum Group Size vs. Total Canoes (Groups smaller than 4 are counted as 0)
LEGEND : A = 1 obs, B = 2 obs, etc.
Maximum Group Size
0
20
40
60
80
100
120
140
160
180
TOTAL CANOES
0
16
32
48
64
80
96
112
128
144
160
176
192
208
224
240
256
272

Figure 35

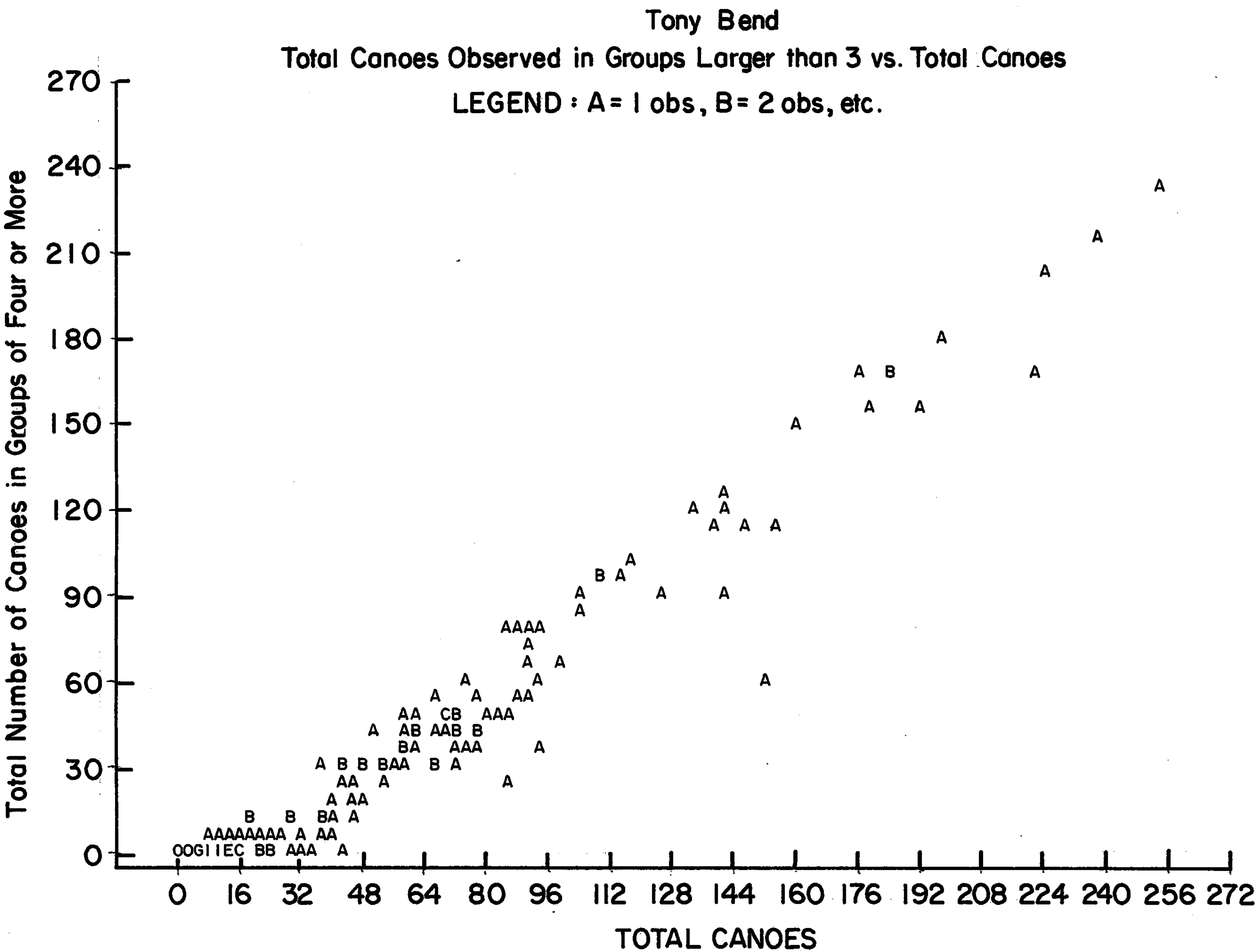
Tony Bend
Total Canoes Observed in Groups Larger than 3 vs. Total Canoes
LEGEND : A= 1 obs, B= 2 obs, etc.
Total Number of Canoes in Groups of Four or More
0
30
60
90
120
150
180
210
240
270
0 16 32 48 64 80 96 112 128 144 160 176 192 208 224 240 256 272
TOTAL CANOES

Figure 36

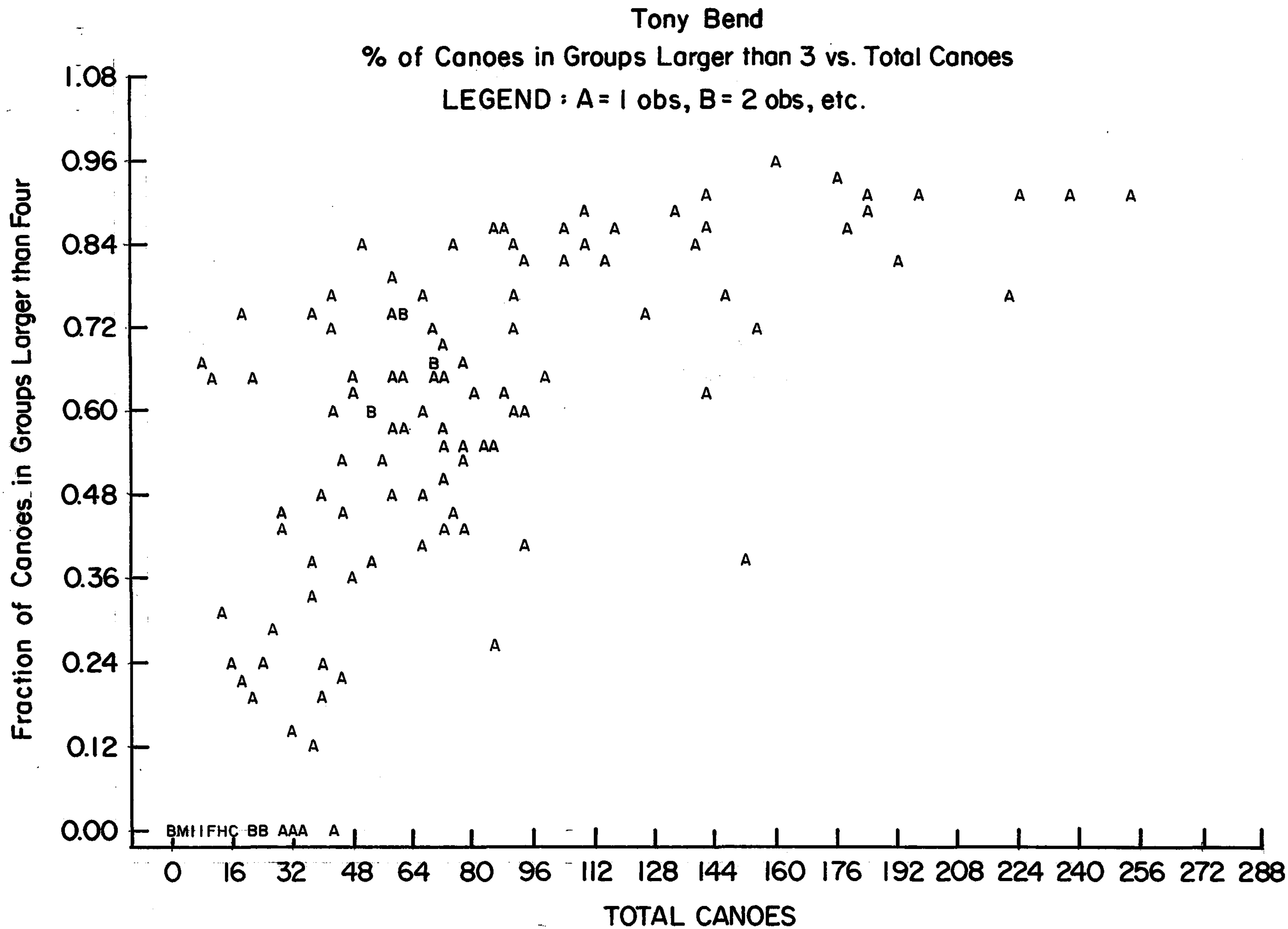
Tony Bend
% of Canoes in Groups Larger than 3 vs. Total Canoes
LEGEND : A = 1 obs, B = 2 obs, etc.
Fraction of Canoes in Groups Larger than Four
1.08
0.96
0.84
0.72
0.60
0.48
0.36
0.24
0.12
0.00
0 16 32 48 64 80 96 112 128 144 160 176 192 208 224 240 256 272 288
TOTAL CANOES

Figure 37

EFFECTS OF CATTLE GRAZING ON WATER QUALITY

Dave Parker, Principal Investigator
Ray Strain, Graduate Assistant

Introduction

Previous water quality studies on the Buffalo National River have identified the presence of some fecal coliform contamination in the river. This contamination appears to generally be of non-human origin and usually in compliance with Arkansas Water Quality Standards for primary contact recreational water. However, some samples taken during the last three years have exceeded maximum fecal coliform levels as specified in the standards. One source of this fecal contamination is known to be cattle grazing near and in some cases with direct access to the waters of the Buffalo National River. The quantity and quality of cattle manure runoff is influenced by factors such as feed composition, soil and vegetation characteristics, density of cattle, previous weather conditions, topography of the area, intensity and amount of rainfall, and temperature. Soil and vegetation characteristics are extremely important. Runoff flowing over grass or other vegetation will be reduced in volume by soil percolation and evapotranspiration, and in pollutional characteristics by solids removal from settling and oxidation of organic matter in the stubble or grass. For example, a study conducted in Maryland (Doyle, R. C., et. al., 1975) showed that runoff from land spread with manure could not be distinguished from run off from land without fecal waste after traveling through a forest for 3.8 meters.

The test for total coliforms has long been used as a measure of water quality. Current standard methods exclude coliforms that occur naturally on plants and soil, thereby testing for fecal coliforms that are members of the coliform group associated only with the feces of warm blooded animals, including man. The predominate member of the fecal coliform group is escherichia coli (Ecoli). Ecoli represent 90 percent of the coliforms discharged in fecal matter. The presence of fecal coliforms in water specifically indicates fecal waste contamination by warm blooded animals, and therefore is generally considered to be an indicator of the presence of pathogenic organisms.

Fecal streptococcus tests include intestinal streptococci present in all warm blooded animal fecal waste. This includes S. faecalis, S. faecalis var. liquefaciens, S. faecalis var. zymogenes, S. durans, S. feacium, S. bovis and S. equinus. Most species of fecal streptococcus tend to survive longer than fecal coliforms. However, two species, S. faecalis and S. liquifaciens, live and multiply for exceptionally long periods of time on soil and plants.

The Fecal coliform to Fecal streptococcus ratio (FC/FS) for fresh fecal matter is about 4.4 for man and less than 1.0 for all animals. This and the fact that fecal coliform tend to die faster than fecal streptococcus has led many investigators to use a FC/FS ratio of 2 or more to indicate human contamination and ratios of less than 1 to indicate animal contamination of water. However, many factors may effect the FC/FS ratio once these organisms leave the intestinal track of their host.

Studies show that indicators survive longer than pathogens in most environments. Some of the factors that effect the survival of indicator organisms in water are temperature, stream velocity, tubidity, sunlight, PH, organic matter, frequency of recontamination, competing or antagonistic organisms, chemical constituents, nutrient level, and stream size. Higher indicator counts are known to exist when animals are allowed direct access to the stream. The initial number of indicators present is three times as large in warm weather as cold. Subsequent increases and decreases are larger and more rapid in warm weather. Indicator counts tend to increase with high turbidity. When velocities and stream flow permit, sedimentation bacteria are apparently absorbed by turbidity and carried to the bottom. Increases and decreases in indicator counts occur more rapidly in small streams. High velocities and shallow depths on riffles assure frequent contact of water with biological masses. Biological masses join with predators to rapidly consume the bacteria.

The Arkansas State Board of Health has set the following bacteria standard for waters delineated as outdoor bathing places for body contact recreation. Based on a minimum of not less than 5 samples taken over not more than a 30 day period, the fecal coliform content shall not exceed a log mean of 200/100ml nor shall more than 10 percent of total samples during any 30 day period exceed 400/100ml.

Several studies show that pasture land can be a source of bacterial pollution. However it is reported (Gifford, et. el., 1976) that for semiarid watersheds with gentle slopes there is little danger of significant bacterial contamination from livestock grazing unless the feces are deposited in or adjacent to a stream bed.

Some studies that show significant bacterial pollution from pasture lands show all other pollution parameters to be very low and not distinguishable from background sources. Some of the conclusions from pasture land studies are as follows: 1) Stream bacteria counts are sometimes 50 or more times higher after rains. 2) Direct access of animal waste to surface waters should be prohibited. 3) Points of animal concentration should be located away from streams and away from hillsides leading directly to streams. 4) To intercept any contaminant, vegetation should be provided between areas of animal concentration and drainage paths or surface waters.

Methods and Procedures

The water quality parameters evaluated in the study were fecal coliform, fecal streptococcus, turbidity, ammonia nitrogen, nitrate nitrogen, phosphorus, and temperature. Samples were taken at four locations on the Buffalo National River itself, and at sixteen additional sites on five different tributaries. All of these sampling stations are located on the upper end of the Buffalo River between Boxley and Pruitt.

The samples that were used for turbidity and bacterial examination were collected in autoclaved polypropylene bottles and stored in an ice chest which did not contain ice. These samples were processed within 24 hours after sampling. The dissolved oxygen samples were fixed in the field and processed upon their return to the lab. BOD samples were collected in polypropylene bottles and stored in an ice chest containing ice. Upon the return to the lab these samples were stored in a refrigerator. BOD samples were processed within 48 hours after sampling.

NH_3-N, NO_3-N, and total phosphorus samples were collected in acid washed polypropylene bottles and stored in an ice chest containing ice until they were returned to the lab where they were stored in a refrigerator. The PH of these samples was reduced to below 2 with concentrated sulfuric acid immediately after collection. NH_3-N and NO_3-N was measured within 72 hours after sampling. Total phosphorus was measured within 96 hours after sampling. Water temperature was measured in the field.

Fecal coliform densities were measured according to the membrane filter technique as set forth in section 909C of Standard Methods (American Public Health Association, 1976).

Fecal streptococcus densities were measured according to the membrane filter technique set forth in section 910B of Standard Methods (American Public Health Association, 1976).

Turbidity was measured using a model 2100A Turbidimeter manufactured by the Hach Chemical Company. This unit measures turbidity using Nephelometric Turbidity Units (NTU).

Dissolved oxygen was calculated according to the procedure set forth for the Azide Modification Method in section 422B of Standard Methods (American Public Health Association, 1976). The dissolved oxygen deficit was calculated using table 422:I in Standard Methods (American Public Health Association, 1976) assuming zero mg/l chloride concentration in the water.

The five day biochemical oxygen demand was calculated according to the procedures set forth in section 507 of Standard Methods (American Public Health Association, 1976).

Ammonia Nitrogen (NH_3-N) concentrations were measured according to the Nesslerization Method set forth in Section 418B of Standard Methods (American Public Health Association, 1976). A Colman 124 double beam spectrophotometer was used for photometric measurement.

Nitrate-Nitrogen (NO_3-N) concentrations were measured according to the Ultraviolet Spectrophotometric Method set forth in section 419A of Standard Methods (American Public Health Association, 1976). A Colman 124 double beam spectrophotometer was used for photometric measurement.

Phosphorus samples were digested according to the Persulfate Digestion Method set forth in section 425C III of Standard Methods (American Public Health Association, 1976). Total phosphorus was then measured according to the Stannous Chloride Method as set forth in section 425E of Standard Methods (American Public Health Association, 1976). A Colman 124 double beam spectrophotometer was used for photometric measurement.

Sample Site Description

Four sampling locations on the Buffalo River itself and 16 sites on 5 different tributaries were selected for this analysis. All of these sampling stations were located on the upper end of the Buffalo River between Boxley and Pruitt. The stations located on the tributaries of the Buffalo River are divided into four classification: 1) Stations where livestock have direct access to stream within 100' above sampling site; 2) Stations where livestock are present within 1500' upstream but do not have direct access to the stream; 3) Stations where livestock have direct access to the stream but are not present within 5000' above the sampling site; and 4) Stations with no livestock in drainage area.

The stations within each of the 4 classifications are further described by: 1) the average number of cattle meeting the access and stream distance requirements of that classification; 2) the approximate minimum stream distance between the sample site and the cattle upstream; 3) the approximate minimum distance runoff must travel to reach the stream.

These sites were selected in consultation with park services personnel and selection was based on the classifications listed above as well as practicality due to travel fund limitations.

Discussion of Results

In the following analysis, all data is categorized as either wet or dry weather data according to weather conditions that existed prior to sample collection. Data from samples collected within 36 hours after a rain of 0.5 inches or more is labled wet weather data. All other data is categorized as dry weather data.

Fecal Coliform (FC) - Dry Weather

The highest log mean for any individual station for dry weather fecal coliform was 150 fecal coliforms per 100 ml, which is below the limit for Arkansas primary contact waters. Figure 38 is a plot of FC vs. stream distance from the cattle grazing point. Figure 38 shows a definite decrease in FC counts between a stream distance of 100 feet and 5000 feet for those stations with direct access. The increase in FC counts from

1 foot to 10 feet is not surprising because within less than ten feet of the point source of contamination insufficient mixing would occur. Also, one would expect the coliform growth rate to increase the count until the die-off rate and delution become dominant. Figure 38 did not show FC counts to be lower for stations without direct access. Figure 39, a plot of FC vs. the numbers of cattle, does not show a correlation between the number of cattle and the FC count. Possible reasons for this are: 1) all fields had 80 or fewer cows (this is consistent with cattle grazing patterns on the upper end of the Buffalo River) and 2) the density of cattle was not always higher for fields with more cattle.

Fecal Coliform (FC) - Wet Weather

All stations with direct access within 100 feet had a log mean of 910 or greater. Figure 40is a plot of FC vs. stream distance for wet weather. Figure 40 shows the following: 1) for stations with direct access, the log mean dropped from 910 at a stream distance of 100 feet to 64 at a stream distance of 5000 feet; 2) FC counts for stations without direct access were consistently lower than those for stations with direct access; 3) stations without direct access also showed a decrease with increased stream distance. The plot of FC vs. number of cattle, Figure 41, again fails to show a correlation between the number of cattle in a field and the FC count.

Fecal Coliform: Buffalo River - Tributary Comparison (for the upper section of the Buffalo)

The upper Buffalo River had consistently lower FC counts

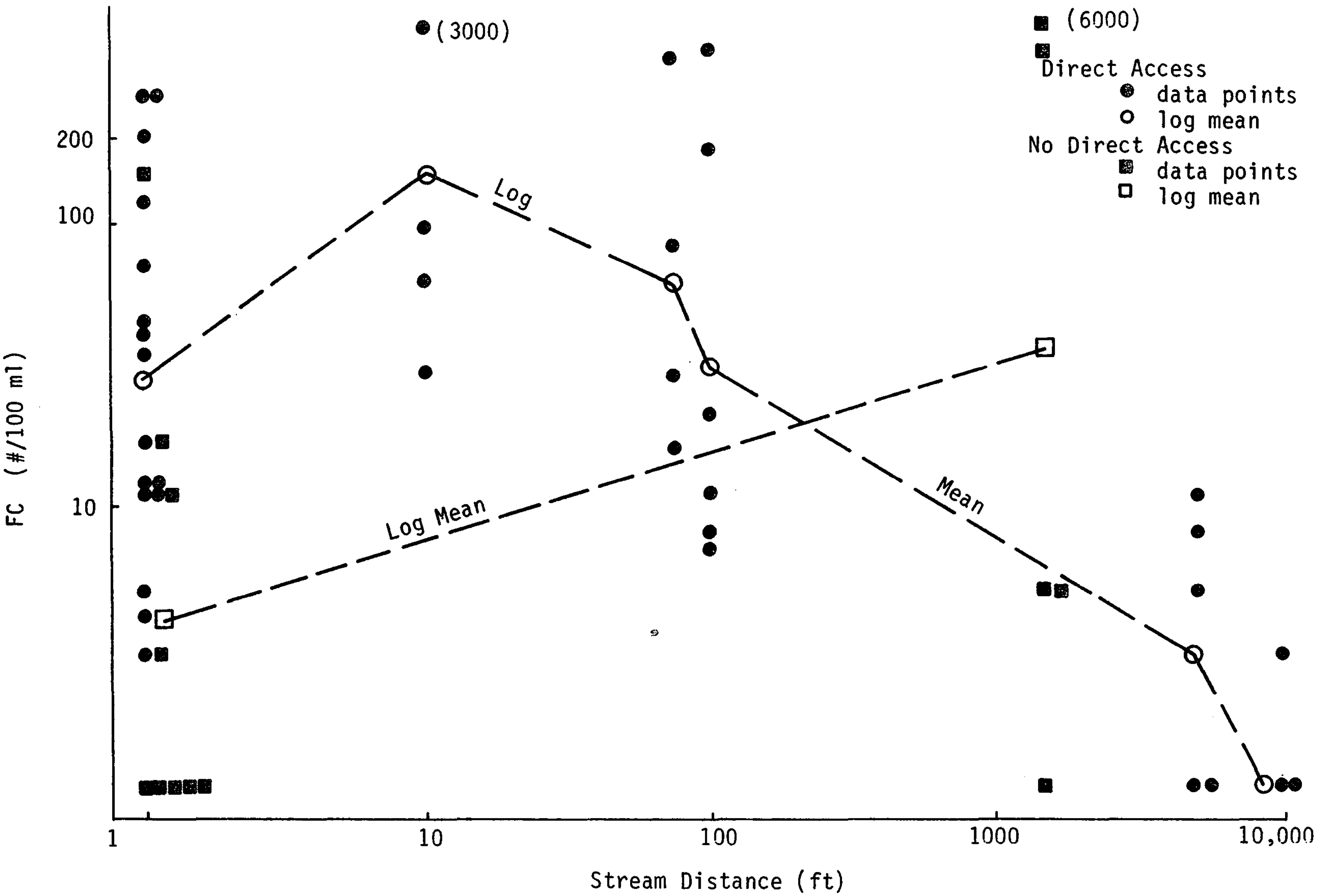

Figure 38. Stream Distance vs. FC for Dry Weather

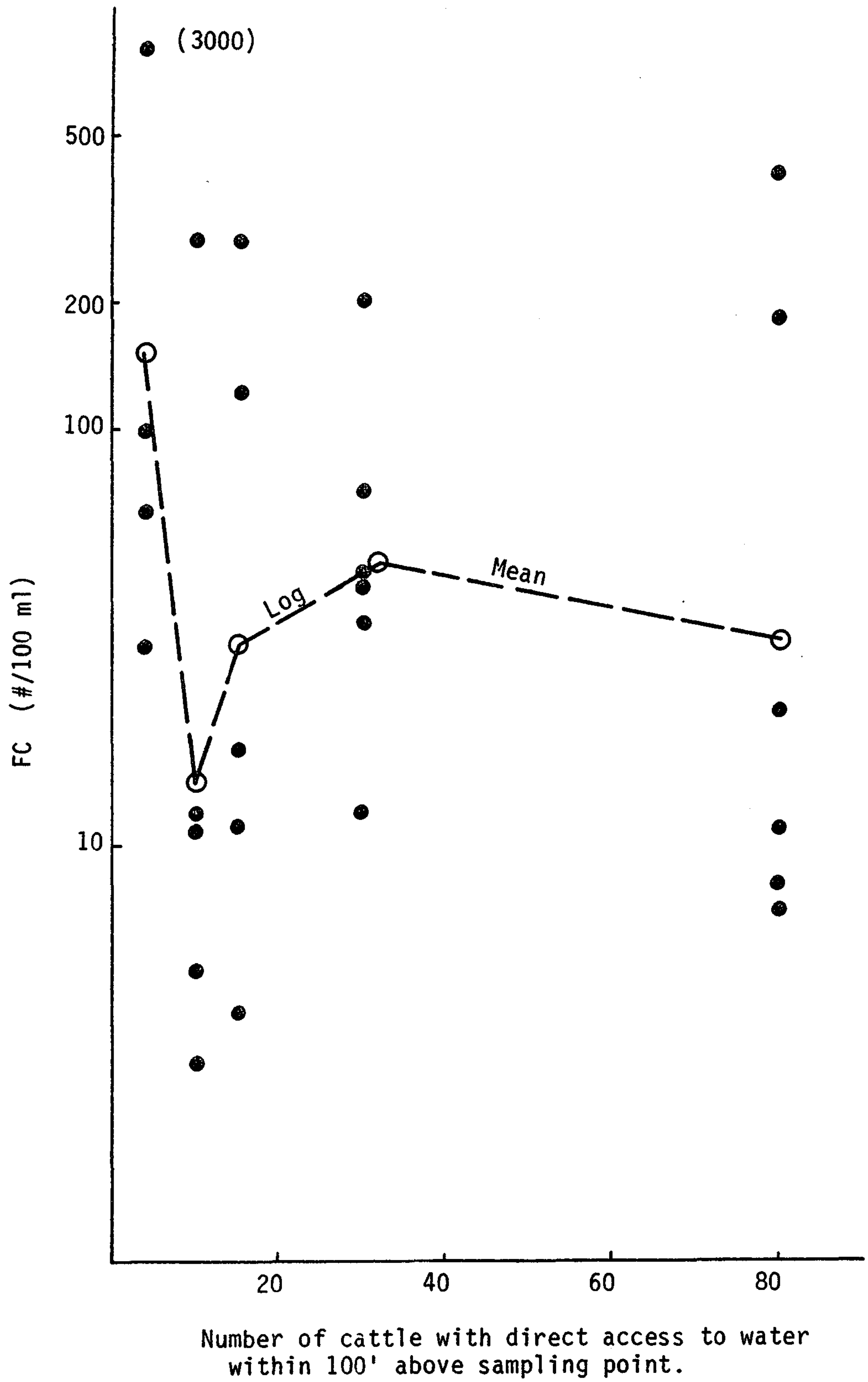

Figure 39. Number of Cattle vs. FC for Dry Weather

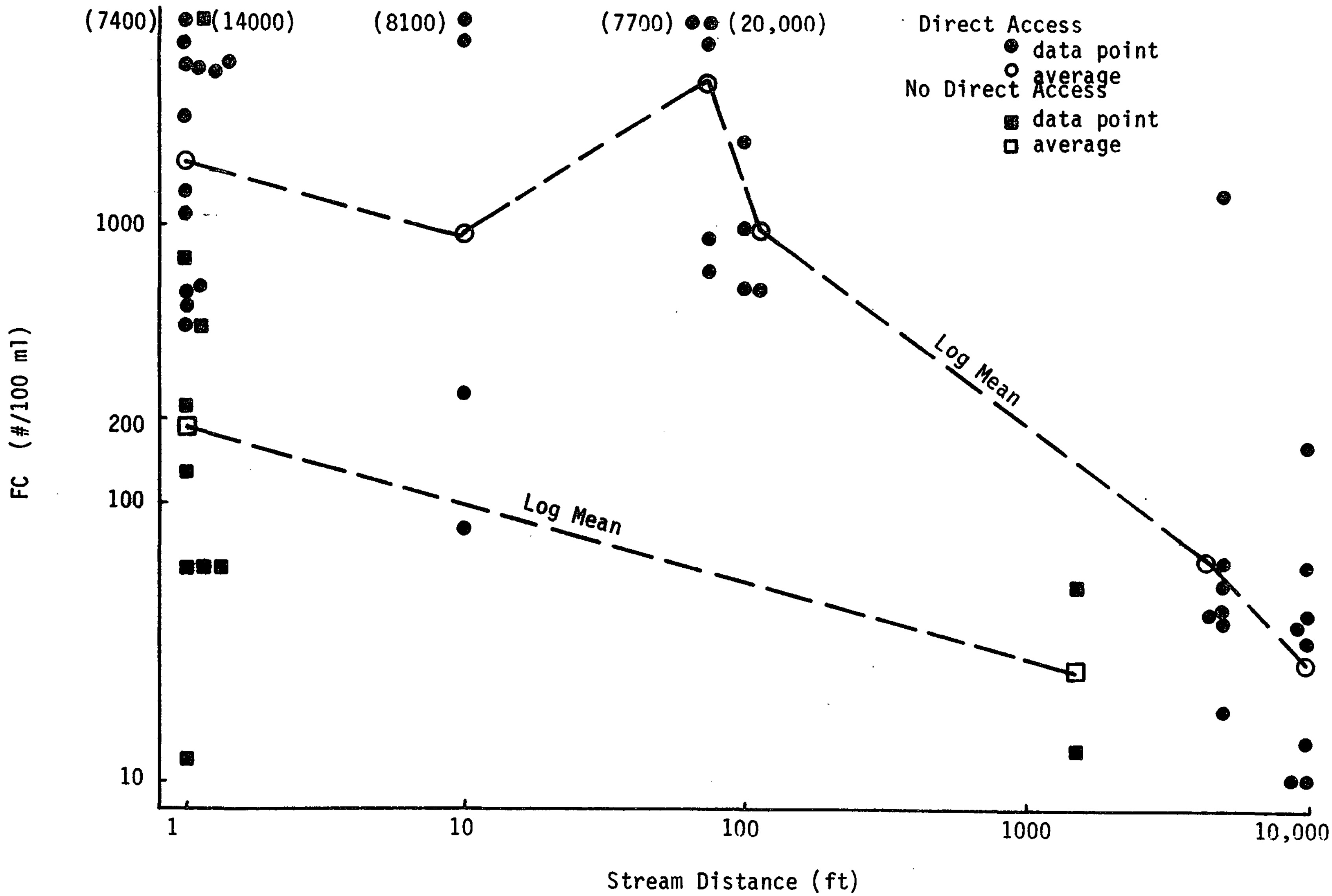

Figure 40. Stream Distance vs. FC for Wet Weather

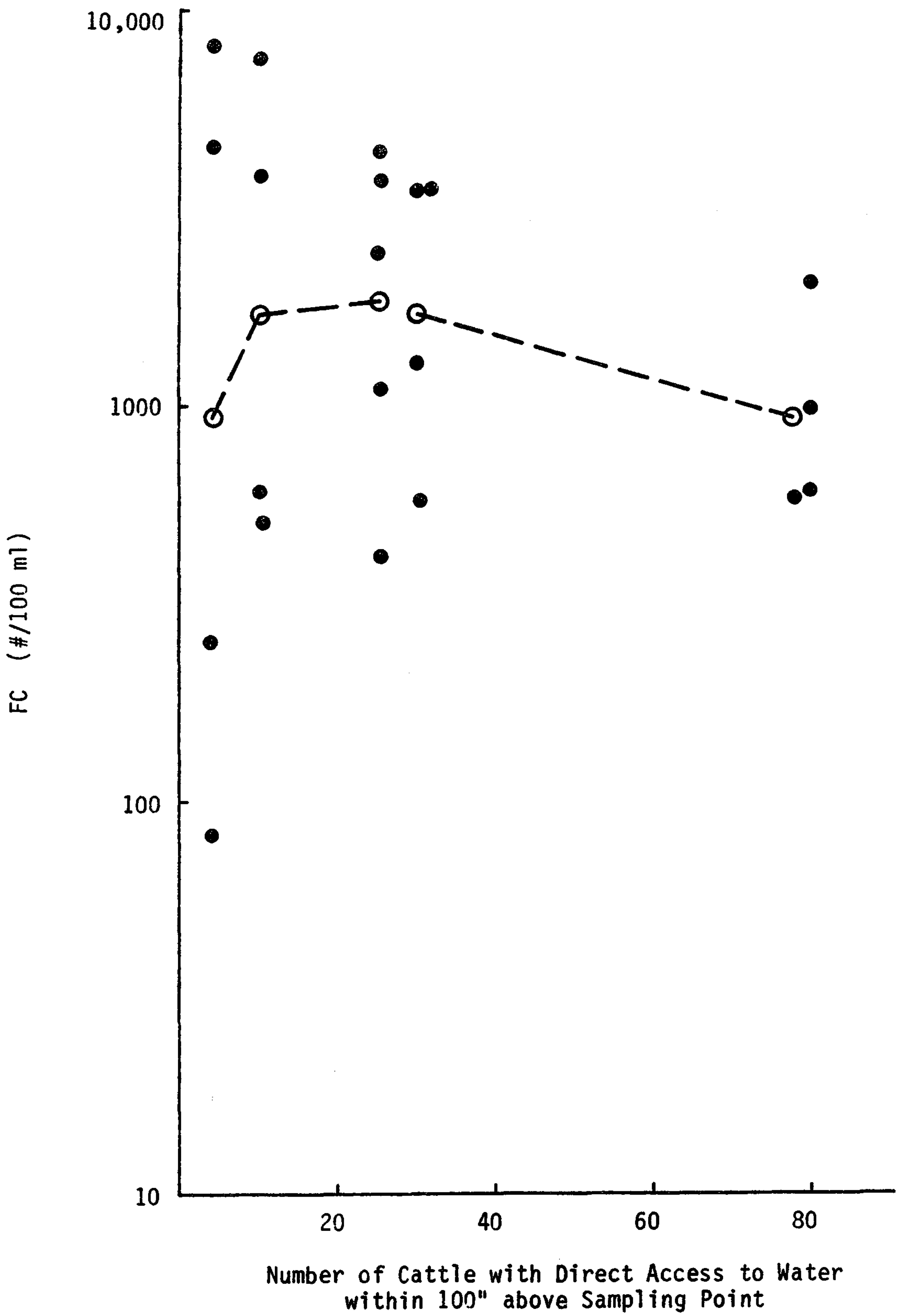

Figure 41. Number of Cattle vs. FC for Wet Weather.

than its tributaries that have cattle on its lower sections and consistently higher counts than its tributaries without cattle on its lower sections.

Fecal Streptococcus Ratio (FC/FS)

Figures 42 and 43 show the FC/FS data. Several stations had average FC/FS ratios above 1 and most stations had some samples with ratios above 4.

As was pointed out in the literature review: a FC/FS ratio of 4 or more is usually considered an indication of human contamination; a FC/FS ratio of 1 or less is usually considered an indication of animal contamination; and FC/FS ratio of 1 to 4 is usually considered an indication of both animal and human contamination. However, the FC/FS ratios were not consistently higher at sampling sites below houses or outdoor toilets. Some of the reasons for the high FC ratios may be: 1) undetected sources of human contamination; 2) higher die-off rates for FS than for FC, either before or after sample collection (FC die-off rates are usually higher); 3) FC/FS ratios in collected samples that were not representative of the total population; and 4) errors in bacteria tests or counts.

Summary of Results

The only parameter which consistently exceeded recommended or required water quality limits during the study was the fecal coliform concentration. Therefore, this parameter will be discussed in detail below.

Rainfall

Water samples collected within 36 hours after a rain of 0.5 inches or more generally had much higher fecal coliform concen-

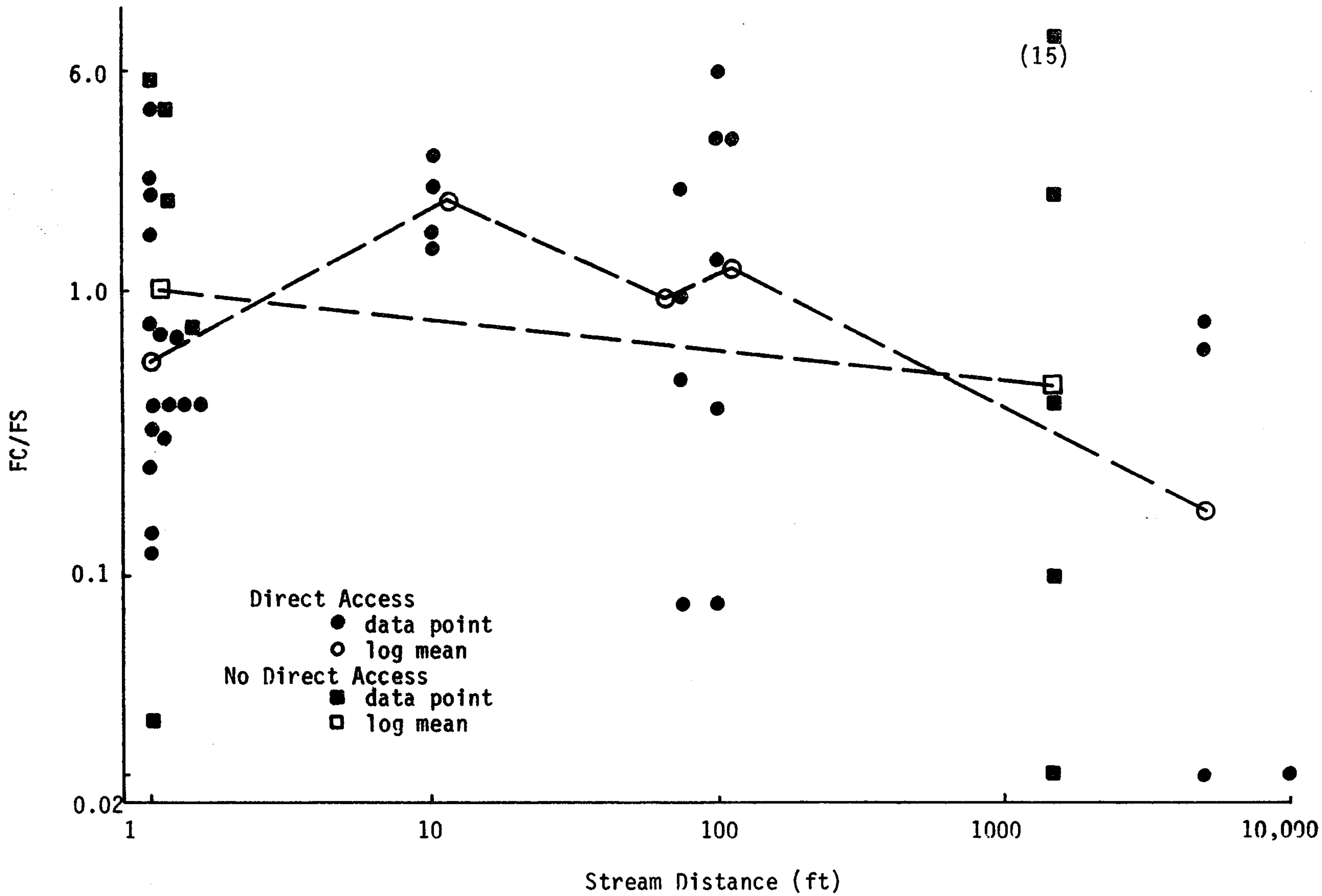

Figure 42. Stream Distance vs. FC/FS for Dry Weather

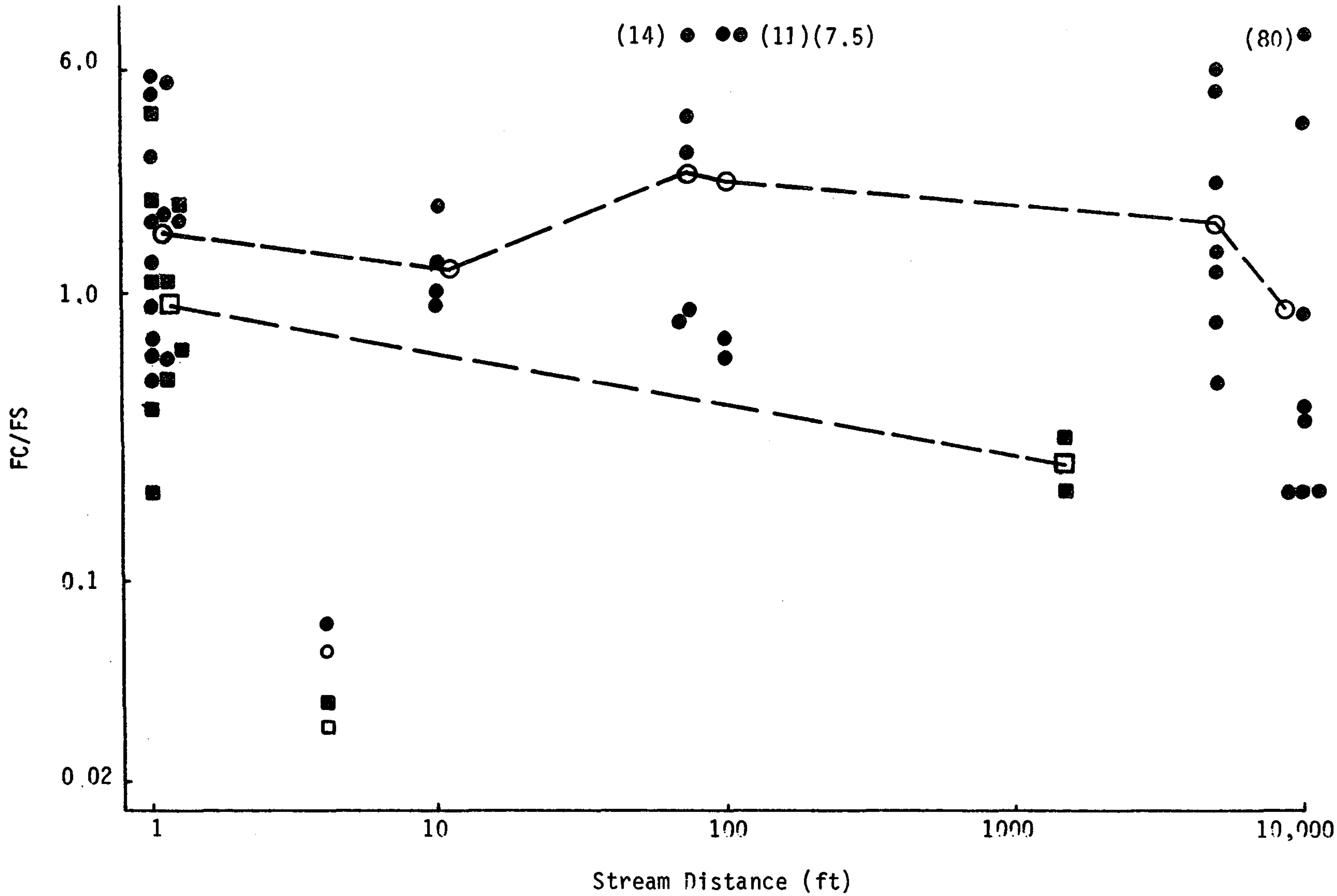

Figure 43. Stream Distance vs. FC/FS for Wet Weather

trations than samples collected during dry weather. The log mean concentration for every station sampled during dry weather was below 200 fecal coliforms per 100 ml, which is below the Arkansas water quality limit for primary contact recreational water, while many of the stations sampled after a rain had log mean concentrations above 200. Some individual dry weather samples did have concentrations above 200. These high count dry weather samples were always downstream from areas where cattle had direct access to the water and, therefore, probably were caused by waste being deposited directly into the water.

Access to the Stream

Water samples collected from areas where cattle had direct access to the stream generally had much higher coliform concentrations than samples collected from areas where cattle were kept at least 50 feet away from the stream. This trend is particularly apparent during wet weather when high coliform concentrations are present. For all stations where cattle did not have direct access to the stream, the log mean of the samples for each station were all less than 200 coliforms per 100 ml and only a few individual samples had concentrations above 200. Where cattle had direct access to the stream within 100 feet upstream from the sampling site, the fecal coliform concentrations usually exceeded 200 organisms after a rain.

Stream Distance

The stream distance between the sample site and the cattle upstream had an effect on the concentrations of fecal coliform concentrations. Generally, the longer the stream distance, the lower the coliform concentrations in a sample. Samples collected where cattle were not present within 5000 feet upstream had log mean fecal coliform concentrations less than 200 even during wet weather.

Fecal coliform organisms, like the pathogenic organisms they are supposed to indicate, tend to die off or be physically removed in a natural stream. This reduction process was probably responsible for the decreasing concentrations observed in this study.

Presence of Cattle

Water samples, collected from areas where no cattle were present or did not have direct access to the stream within 5000 feet upstream from the sample site, contained relatively few fecal coliform organisms.

The number of cattle present in the study area was small and was generally less than 100 cows per location. This pattern is generally consistent with cattle grazing in the Buffalo River valley, however, if cattle density were greater, the coliform concentrations in the water would probably also be proportionately larger.

Buffalo River - Tributary Comparison

The Buffalo River in the study area had consistently lower fecal coliform concentrations than its tributaries with cattle and consistantly higher concentrations than its tributaries without cattle. The relative high coliform concentrations in the tributaries with cattle tend to increase the coliform concentrations in the Buffalo River.

Human Contamination

The contribution of fecal coliforms from humans was not considered to be significant in this study because of the few people present in the study areas and the low fecal coliform to fecal streptococcus ratios found during the study.

However, in some situations humans can contribute fecal contamination to a river. Furthermore, human contamination is usually much more dangerous than non-human contamination.

Interpretation of Results

The following is a list of observations about the results which may be helpful in planning for cattle grazing on Buffalo National River Park Land.

1. Fecal coliform concentrations were found to often exceed state water quality standards after rainfalls of 0.5 inches or greater at stations within 100 feet below areas cattle had direct access to the stream.
2. Fecal coliform concentrations were generally found to be within state water quality standards at stations below areas where cattle were kept at least 50 feet from the stream.
3. Fecal coliform concentrations were generally found to be within state water quality standards at stations where cattle do not have direct access to the stream within 5000 feet upstream from the sampling station.

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