4.0.0. RESULTS

4.1.0. Habitat data

4.1.1. Temperature

Water temperatures for streams #11, 15, 25, Sweeney Brook and Upper Vault Brook were measured with Hobo thermographs (for raw data, see Appendix 2). The maximum temperature for the references Sweeney Brook and Upper Vault Brook did not exceed 15.6°C (Table 2). The daily temperature range for Sweeney Brook never exceeded 4°C, and for Upper Vault exceeded 4°C five out of 161 days (3% of the total recorded days) (Table 3). For stream #11, partially cut with a wide buffer strip, the daily temperature range exceeded 4°C three out of 154 days, or 2% of the total recorded days, and the daily maximum temperature exceeded 17°C 5% of the total recorded days. For stream #15, with no buffer, the daily temperature range exceeded 4°C 55% of the total days, and the daily maximum temperature exceeded 17°C, 34% of the total days. The highest maximum temperature recorded on all streams was 23.8°C, on stream #15 (Table 2).

Water temperatures of streams #45, 2, 7, 21, Haley, Dustin, 41, McGee, 40, Cains and the Forks were recorded with maximum/minimum thermometers (See Appendix 3). The 4-5 day range exceeded 4°C more than 80% of the time for streams #45, #41, #40, Dustin, and Haley (cutover in the 1980s), McGee (cutover in 1979), and the reference, Cains; 60% of

Table 2. Monthly temperature records for streams #11, 15 and 25, Sweeney Brook and Upper Vault Brook, with the daily mean, maximum, minimum and mean range (in degrees Celsius).

	June	July	August	September	October	November
STREAM #11 (cut 1984, 1987)						
Mean	12.4	14.6	14.7	12.0	6.9	4.4
Maximum	16.1	18.4	18.0	15.6	10.9	7.7
Minimum	7.2	11.1	8.9	6.8	2.7	1.7
Mean Range	2.4	1.8	2.6	1.8	1.7	1.5
STREAM #15 (cut 1979)						
Mean	10.4	13.8	15.5	12.0	6.5	4.6
Maximum	17.4	21.4	23.8	21.6	11.3	7.5
Minimum	5.2	8.1	1.8	4.6	3.2	2.5
Mean Range	5.1	5.8	9.2	5.8	2.4	1.5
STREAM #25 (cut 1984)						
Mean	12.5	15.5	16.6	13.6	6.5	3.7
Maximum	19.0	22.3	23.6	21.0	10.9	8.1
Minimum	6.8				2.2	0.6
Mean Range	4.4	4.1	5.8	4.1	2.3	2.0
Sweeney Brook (reference)						
Mean	9.3	11.5	12.6	11.0	6.6	4.9
Maximum	12.0	14.1	15.3	14.1	10.2	7.5
Minimum	6.0	8.8	9.7	6.6	4.1	3.0
Mean Range	1.8	1.4	1.9	1.6	1.4	1.0
Upper Vault Brook (reference)						
Mean	9.5	11.8	12.5	10.4	5.8	4.4
Maximum	13.3	14.8	15.6	13.4	9.7	7.5
Minimum	5.5	8.3	9.7	6.2	2.7	1.9
Mean Range	2.8	2.0	2.1	1.9	1.9	1.4

Note: July, August and September thermograph data for Stream #25 were extrapolated using June data and the relative values of other streams

Table 3. Thermograph data, with the proportion of days the temperature range exceeded 4C, and the proportion of days the maximum exceeded 17C. These calculations could not be made for Stream #25 as the thermograph malfunctioned from July to September.

STREAM	#11	#15	Sweeney	Upper Vault
Days Range >4C (%)	2	55	0	3
Days Temp >17C (%)	5	34	0	0

the time for stream #7 (cutover 1982-1989); 40% for #21 (cutover in 1986); 25% for #2 (cutover in 1987); and 10% for the reference, Forks (Table 4). The mean 4-5 day range was greatest for McGee at 9.5°C, with no buffer strip, followed by #40 at 8.1°C, Dustin at 7.8°C, and #41 at 7.7°C. The lowest mean 4-5 day range was recorded on the reference stream, Forks, at 3.1°C, followed by #2 at 3.6°C. Stream temperature did not once exceed 17°C for #21, #2 and the Forks, whereas it was equal to or exceeded 19°C more than 35% of the time for Dustin, #41, #40, and McGee. The highest maximum temperatures recorded were 23°C for McGee, 22°C for #40 and #41, 21°C for Dustin, and 20°C for #45. The lowest maximum temperatures were 13.5°C for the Forks, 14.5°C for #21, and 16°C for #2.

In summary, three of the reference streams (The Forks, Upper Vault, and Sweeney) tended to have smaller fluctuations in temperature and lower maximum temperatures than streams draining clearcuts. Streams draining partially cutover watersheds, or with wide buffer strips along their length, had similar thermal regimes to the reference watersheds (especially stream #2). Where there were no buffer strips (stream #15 and McGee), high maximum temperatures were reached, and diurnal fluctuations were large. Cains, a reference stream, behaved more like the older cuts than the other 3 reference streams, possibly as a consequence of past logging in the 1920s, or some other more

Table 4. Maximum / minimum thermometer data (in degrees Celsius), for streams #45, #2, #7, #21, Haley, Dustin, #41, McGee, #40, and the reference streams, Cains and the Forks.

STREAM	#45	#2	#7	#21	Haley	Dustin	#41	McGee	#40	Cains	Forks
Cutting history	cut 1987	cut 1987	cut 1982, 1986,1989	cut 1986	cut 1984	cut 1983	cut 1984, 1980	cut 1978	cut 1973	reference	reference
Maximum	20.0	16.0	18.0	14.5	19.5	21.0	22.0	23.0	22.0	19.5	13.5
Minimum	5.0	6.0	8.5	5.0	4.5	5.0	5.0	1.5	4.0	5.0	4.5
Mean (May-October)	11.4	11.5	13.5	9.8	12.1	13.2	14.2	13.3	13.7	13.2	9.7
Mean (August)	12.8	12.6	14.5	10.6	13.2	15.2	16.3	15.0	15.5	14.3	11.3
Mean Range	6.2	3.6	4.7	4.4	7.5	7.8	7.7	9.5	8.1	6.8	3.1
Times 4-day Range >4C (%)	84.0	25.0	60.0	40.0	86.0	94.0	95.0	100.0	95.0	90.0	10.0
Times Temp >17C (%)	5.0	0.0	25.0	0.0	27.3	47.4	50.0	60.0	54.6	30.0	0.0

recent disturbance.

4.1.2. Dissolved oxygen

Malfunctioning equipment delayed recording of dissolved oxygen to early September, before the fall rains but after the highest recorded summer temperatures. The lowest O_2 concentrations were observed in streams #41 and #15 (7.7 and 8.2 mg/l, respectively) (Table 5). The latter stream was full of logging slash, which may have obstructed flow, as well as depleted available oxygen. Furthermore, with no overhead canopy cover, #15 reached relatively high water temperatures, further reducing O_2 concentrations. Stream #41, on the other hand, had dried up in many places, except where some deep pools remained. This stream also had poor shading. High temperatures and near absent streamflow could have contributed to the low dissolved oxygen concentrations.

4.1.3. Water chemistry

Total nitrogen (N) in stream water had a strong negative correlation with age of stand, demonstrated by a Pearson $r = -0.80$, $p < 0.001$ (Appendix 4), and a highly significant simple regression (F-ratio = 10.7, $p = 0.006$) (Figure 4). For the four park streams, total nitrogen did not exceed 0.21 mg/l, and the concentrations increased slightly among sampling dates as the growing season progressed (Figure 5). A T-test with separate variances

Table 5. The date, time and water temperature of dissolved oxygen readings, as well as percent saturation.

Stream	45	45	2	11	7	21	Haley	25	Dustin	41	41	15	40	40	Cains	Sween	U.V.
Date	04/09/93	08/09/93	06/09/93	06/09/93	06/09/93	04/09/93	05/09/93	05/09/93	03/09/93	03/09/93	08/09/93	06/09/93	03/09/93	08/09/93	05/09/93	05/09/93	04/09/93
Time	10:15 AM	10:20 AM	10:40 AM	01:30 PM	02:03 PM	10:50 AM	01:10 PM	12:00 PM	04:52 PM	06:15 PM	03:30 PM	05:40 PM	05:30 PM	12:05 PM	01:35 PM	03:05 PM	12:10 PM
Temperature (Celsius)	13.5	11.0	12.0	15.1	15.5	11.4	14.0	12.5	13.0	13.8	16.5	20.2	13.3	15.5	15.5	13.7	12.2
Dissolved Oxygen (mg/l)	9.7	11.1	10.6	9.5	9.4	10.2	9.8	9.2	9.6	7.7	9.0	8.2	10.0	10.4	9.6	9.7	9.8
Saturation (%)	96.0	106.0	101.0	97.0	97.0	97.0	99.0	90.0	95.0	76.0	95.0	92.0	98.0	103.0	100.0	96.0	95.0

Figure 4. Mean nitrogen in stream water for 3 collection dates: July 1, August 4, and September 6, 1993. Streams #45 - #21 drained watersheds clearcut in the mid-late 1980s; Haley - #41 drained watersheds clearcut in the early 1980s; #15 - #40 drained watersheds clearcut in 1970s; and Sweeney - Upper Vault were reference streams.

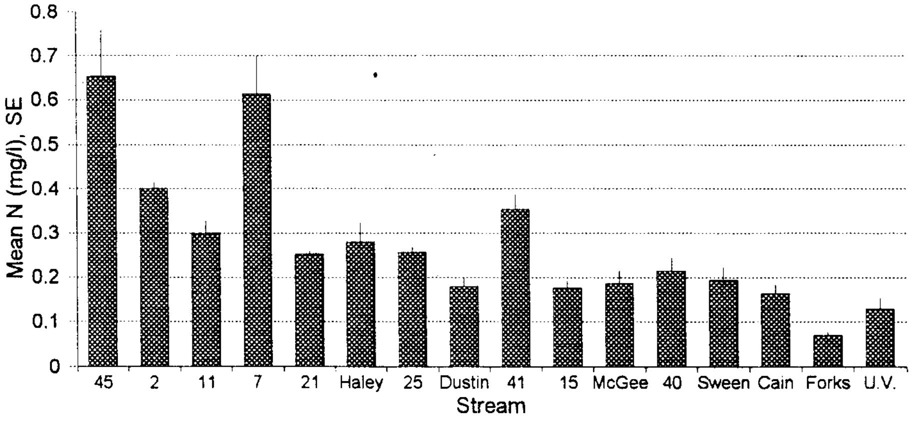
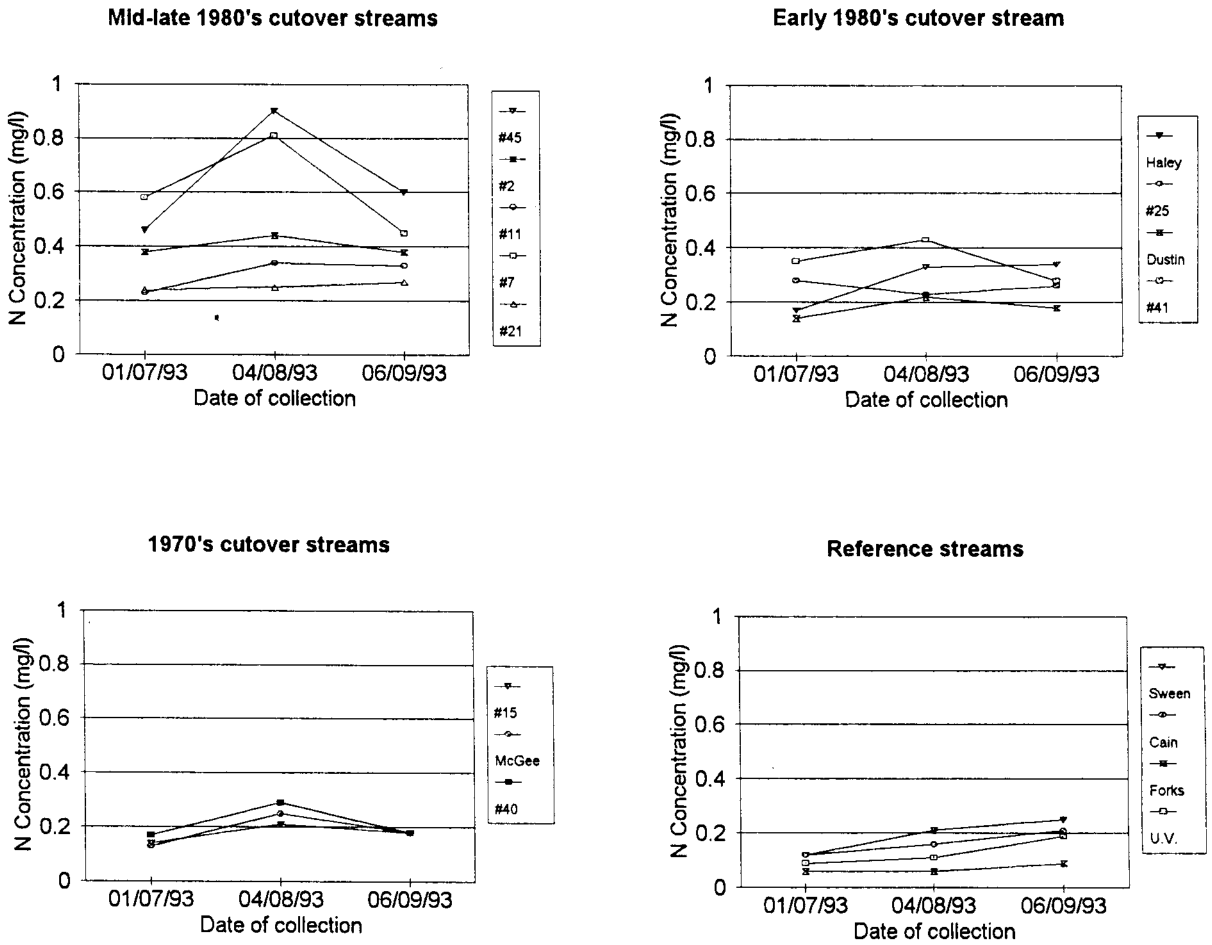


Figure 5. Total nitrogen in stream water for three collection dates: July 1, August 4, and September 6, 1993, for all 16 streams.



indicated a significant difference in N concentrations between the four reference streams and the twelve streams draining clearcuts ($\bar{x}_4$ = 0.14 and $\bar{x}_{12}$ = 0.32; t = 3.4, p = 0.004). The streams draining early 1980s cuts had N concentrations of 0.14 to 0.43 mg/l, with large variations in concentration among sampling dates (Figure 5). The streams draining the five most recent cuts had minimum N concentrations of 0.23 to 0.45 mg/l. Stream #45, cut in 1987, and #7, most recently cut in 1989, had N concentrations of 0.45 mg/l to 0.90 mg/l. Both of these streams had much larger concentrations in early August than in July or September - a pattern shared to various degrees by most of the study streams. Total nitrogen included, and was strongly correlated with nitrate-N (Pearson r = 0.95), and had a similar pattern over the chronosequence of streams (Figure 6).

Magnesium concentration in streamwater was greater in recently disturbed streams (Figure 7) (significant negative correlation with the age of stand; Pearson r = -0.54, p = 0.03), and showed a significant difference in concentration among the four park streams and the twelve cutover streams (independent samples T-test, $\bar{x}_4$ = 0.43 and $\bar{x}_{12}$ = 0.55; t = 2.8, p = 0.014). For the four park streams, Dustin Brook and #11, dissolved Mg did not exceed 0.54 mg/l, and varied little in concentration over the three sampling dates (Figure 8). The streams draining the most recent cuts

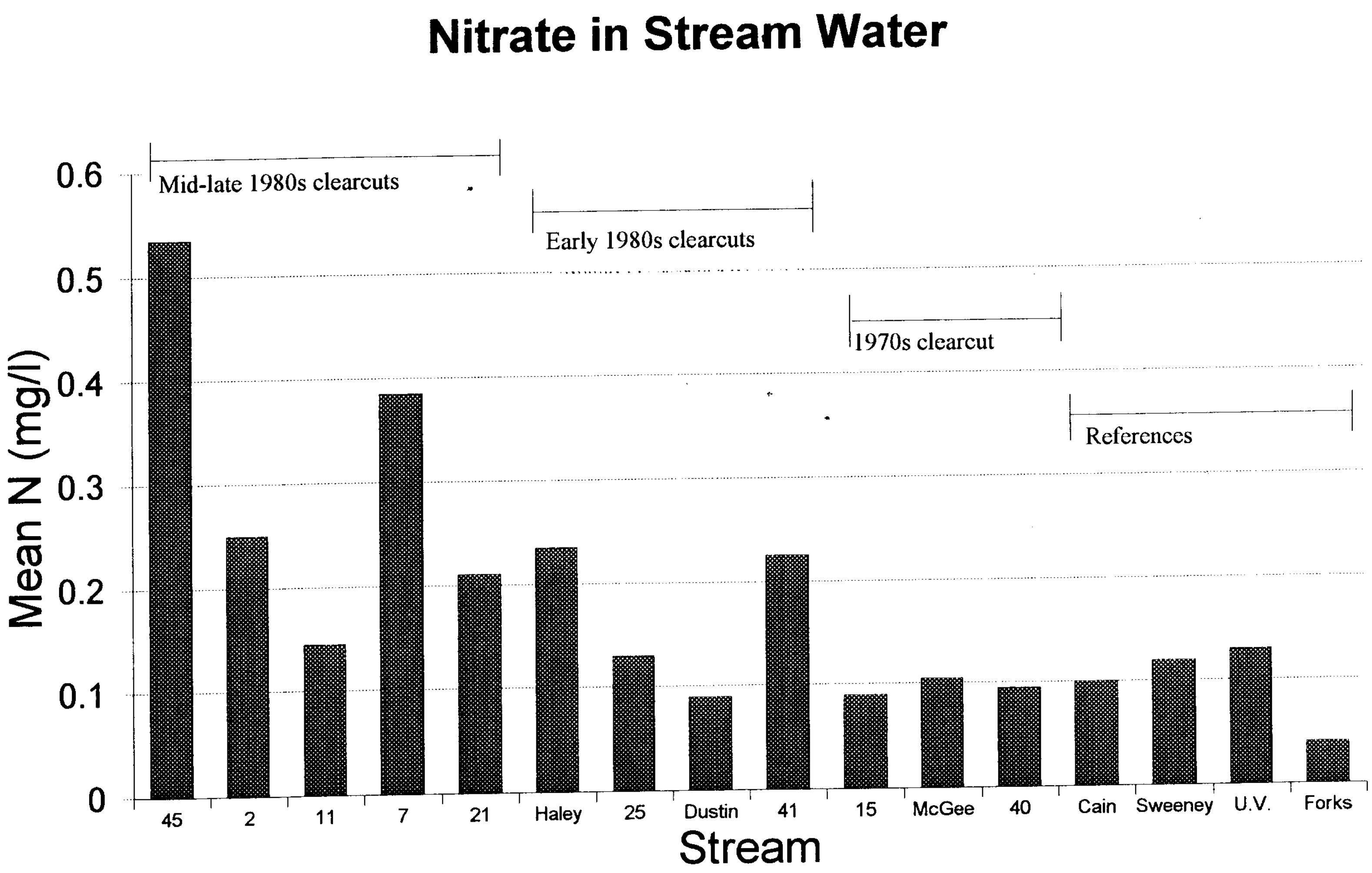


Figure 6. Nitrate concentrations in stream water. Samples collected in July and August, 1993. Stream #45 drained the most recently clearcut watershed, and #40 the oldest clearcut watershed. Cains, Sweeney, Forks and Upper Vault were reference streams.

Figure 7. Mean magnesium in stream water for 3 collection dates. Streams #45 - 21 drained watersheds clearcut in the mid-late 1980s; Haley - #41 drained watersheds clearcut in the early 1980s; #15 - #40 drained watersheds clearcut in the 1970s; and Cain - Forks were reference streams.

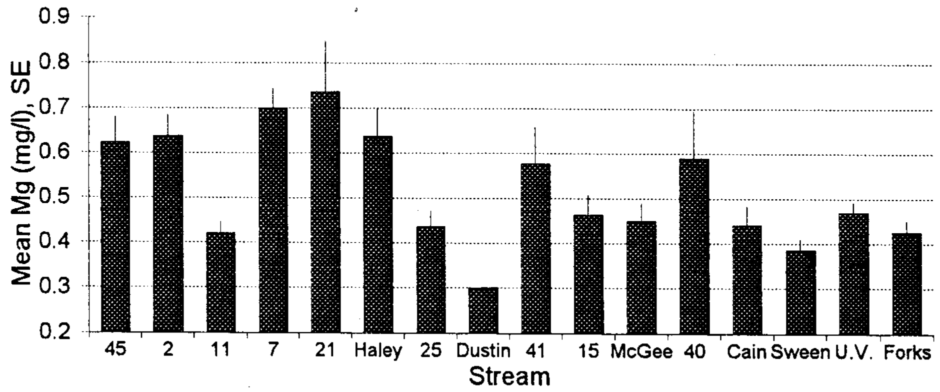
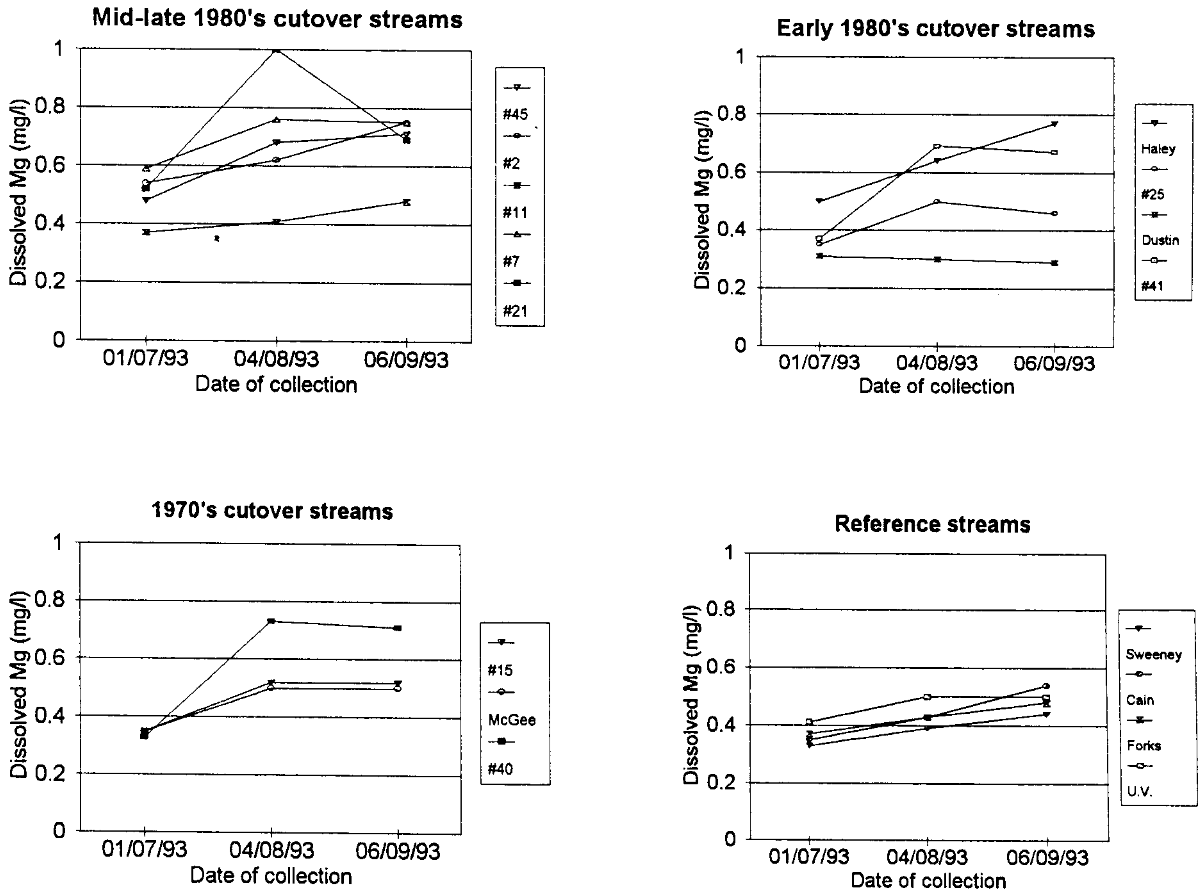


Figure 8. Magnesium in stream water for three collection dates: July 1, August 4, and September 6, 1993, for all 16 streams.



tended to have larger and less stable Mg concentrations. Stream #25, McGee and #15 had comparable concentrations to the reference streams, but they fluctuated more over the three sampling dates. The concentration of dissolved Mg tended to increase over the summer, probably as a consequence of low summer streamflows.

Potassium (K) showed a similar pattern to magnesium and total nitrogen (Figures 9 and 10). Dissolved K had a strong negative correlation with age of stand (Figure 9) (Pearson r = -0.747, p = 0.001), and showed a significant difference in concentration between the park and cutover streams (independent samples T-test, $\bar{x}_4 = 0.14$ and $\bar{x}_{12} = 0.22$; t = 3.4, p = 0.005). The 4 reference streams did not have K concentrations exceeding 0.21 mg/l, and the 5 most recent cuts did not have K concentrations below 0.20 mg/l (Figure 10). The highest potassium concentrations recorded were 0.41 mg/l, on #7. Again, streamwater nutrient concentrations were least variable over the sampling dates for the four reference streams, although the largest concentrations were recorded on the third sampling date.

Mean calcium (Ca), specific conductance, and alkalinity all showed similar patterns among the 16 streams (Figure 11), with an increase in value over the three sampling dates (Table 6). Like total N, the specific conductance and alkalinity of the reference streams fluctuated only slightly from one sampling date to the next. Cains, however, behaved

Figure 9. Mean potassium in stream water for 3 collection dates. Streams #45 - 21 drained watersheds clearcut in the mid-late 1980s; Haley - #41 drained watersheds clearcut in the early 1980s; #15 - #40 drained watersheds clearcut in the 1970s; and Cain - Forks were reference streams.

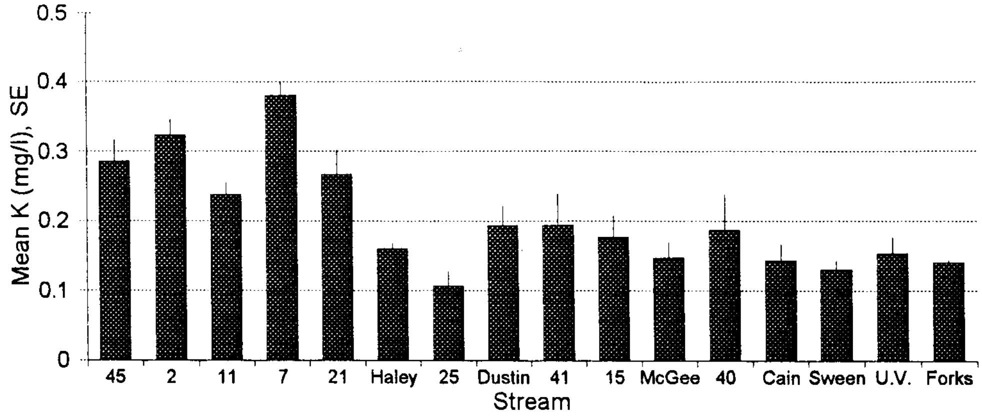


Figure 10. Potassium in stream water for three collection dates: July 1, August 4, and September 6, 1993, for all 16 streams.

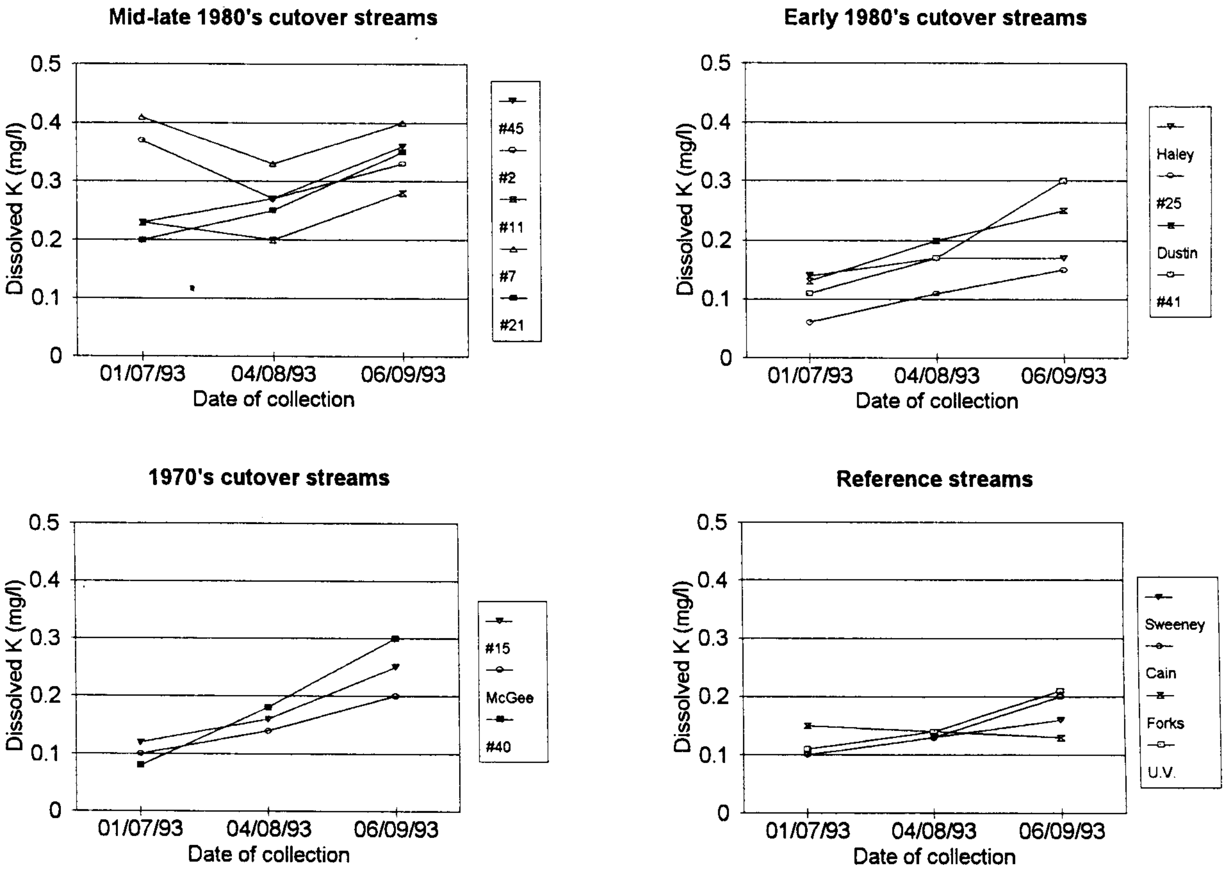
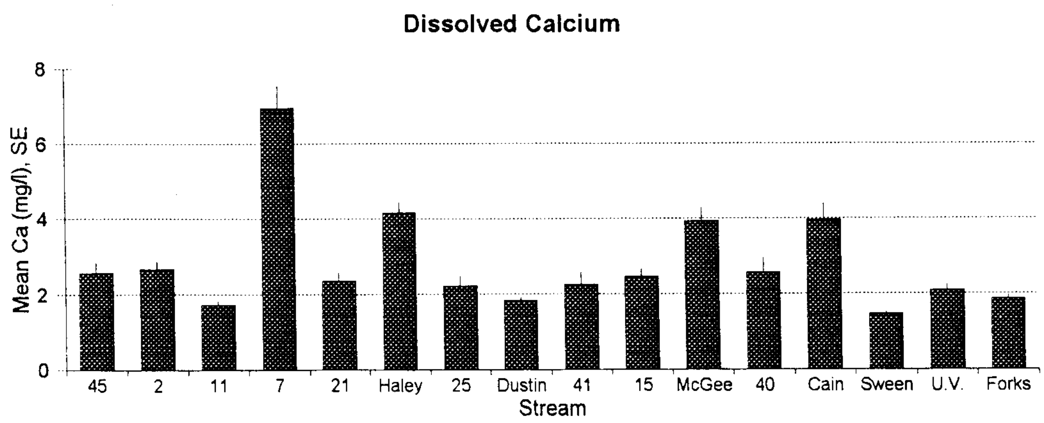
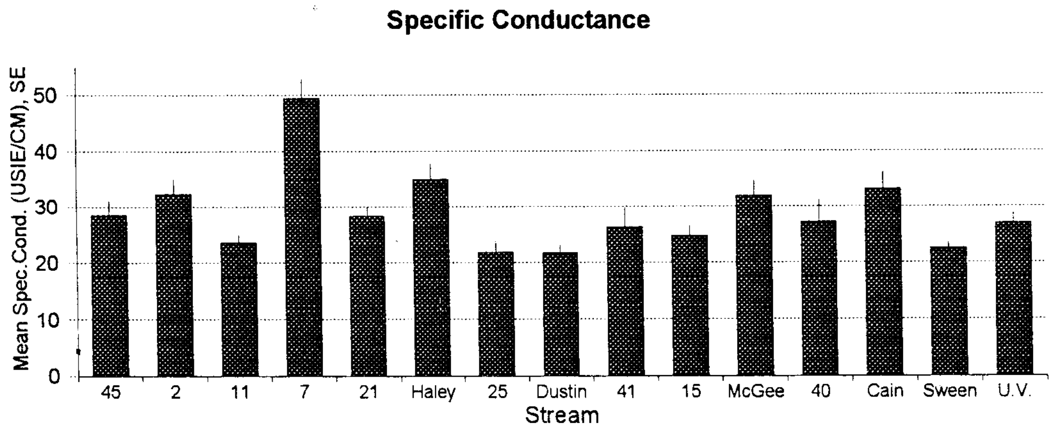


Figure 11(a)-(c). Mean calcium, specific conductance and alkalinity of stream water for three collection dates: July 1, August 4 and September 6, 1993. Streams #45 - 21 drained watersheds clearcut in the mid-late 1980s; Haley - #41 drained watersheds clearcut in the early 1980s; #15 - #40 drained watersheds clearcut in the 1970s; and Cain - Forks were reference streams.

11(a)



11(b)



11(c)

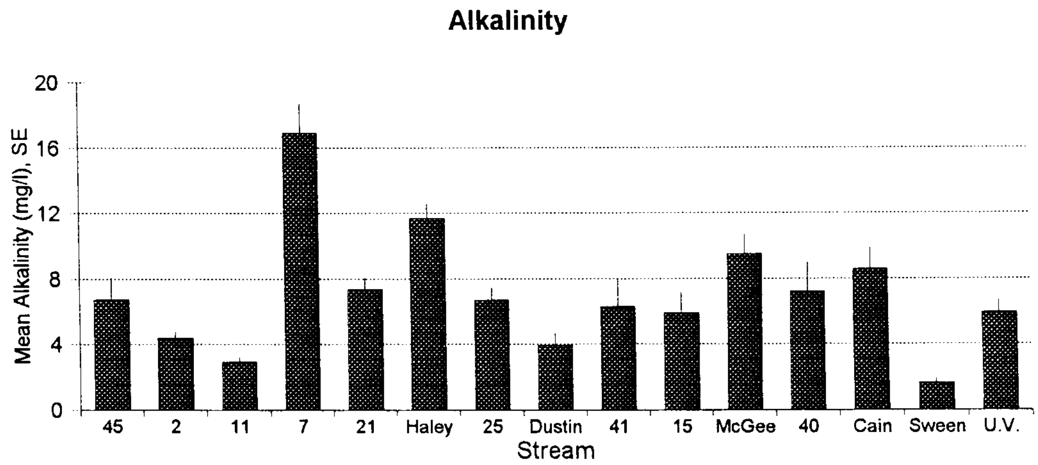


Table 6. Water chemistry measures for the the chronosequence of stands. Samples were collected over three periods: 1. 25/06/93 - 01/07/93 2. 03/08/93 - 06/08/93 3. 03/09/93 - 06/09/93.

STREAM	Date of Collection	Colour	Specific Conductance	Dissolved Organic Carbon	Nitrate	Total Nitrogen	Alkalinity	pH	Sodium	Magnesium	Total Phosphorus	Sulphur	Chloride	Potassium	Calcium	Anions - Cations	Organic Ions
		REL UNIT	USIE/CM	Mg/L	Mg/L	Mg/L	Mg/L	PH UNIT	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	%	ueq/L
45	1	45.00	23.00	3.40		0.46	3.70	6.60	1.60	0.48	0.008	2.30	1.30	0.23	2.00	15.14	32.70
45	2	20.00	28.50	2.50	0.58	0.90	7.10	6.90	2.10	0.54	0.005	2.40	1.40	0.27	2.50	1.15	24.37
45	3	20.00	34.00	2.50	0.49	0.60	9.40	7.00	2.40	0.37	0.005	3.30	1.50	0.36	3.20	0.31	24.46
2	1	45.00	28.40	4.90		0.38	3.70	6.80	2.30	0.59	0.008	4.50	1.90	0.37	2.30	9.72	47.59
2	2	30.00	29.50	4.80	0.25	0.44	4.10	6.60	2.30	0.52	0.006	4.60	2.00	0.27	2.50	5.79	46.17
2	3	15.00	39.00	4.80	0.25	0.38	5.40	6.90	2.90	0.50	0.004	6.60	2.40	0.33	3.20	3.67	46.80
11	1	40.00	21.80	4.40		0.23	2.10	6.40	1.90	0.35	0.013	3.00	2.00	0.23	1.50	9.40	41.81
11	2	40.00	22.00	4.50	0.14	0.34	3.10	6.40	1.90	0.31	0.003	2.70	1.90	0.20	1.90	8.77	42.76
11	3	15.00	27.00	3.80	0.15	0.33	3.60	6.70	2.70	0.37	0.005	3.00	2.30	0.28	1.80	9.51	36.74
7	1	40.00	43.50	4.10		0.58	13.30	7.30	1.90	0.35	0.007	3.00	1.80	0.41	5.80	6.44	40.43
7	2	30.00	46.90	3.60	0.44	0.81	16.40	7.30	2.10	0.35	0.007	2.80	1.60	0.33	6.80	4.06	35.50
7	3	15.00	58.00	3.30	0.33	0.45	21.00	7.60	2.40	0.33	0.008	3.40	1.80	0.40	8.30	2.23	32.71
21	1	35.00	25.00	2.40		0.24	5.90	6.80	1.90	0.33	0.005	2.60	1.50	0.20	1.90	2.54	23.31
21	2	10.00	27.90	1.90	0.20	0.25	7.30	6.90	2.10	0.35	0.002	2.60	1.60	0.25	2.40	7.24	18.52
21	3	5.00	32.00	1.50	0.22	0.27	8.90	7.00	2.30	0.37	0.002	2.70	1.80	0.35	2.80	0.83	14.67
Haley	1	35.00	28.60	3.60		0.17	9.50	7.10	1.80	0.41	0.004	2.70	0.90	0.14	3.60	5.46	35.33
Haley	2	10.00	35.10	3.00	0.17	0.33	13.00	7.10	2.10	0.64	0.002	2.80	0.90	0.17	4.10	0.36	29.44
Haley	3	10.00	41.00	2.20	0.30	0.34	12.60	7.30	2.40	0.77	0.002	3.70	1.50	0.17	4.80	2.38	21.69
25	1	95.00	16.80	7.20		0.28	4.90	6.50	1.20	0.35	0.013	1.10	0.50	0.06	1.60	14.77	68.86
25	2	35.00	22.70	6.40	0.07	0.23	8.00	6.80	1.70	0.50	0.008	1.00	0.70	0.11	2.50	8.34	62.15
25	3	15.00	26.00	5.90	0.19	0.26	7.20	6.80	2.10	0.46	0.005	2.00	1.90	0.15	2.60	1.99	57.30
Dustin	1	60.00	18.40	4.10		0.14	2.00	6.30	1.60	0.31	0.003	2.60	1.60	0.13	1.60	12.43	38.68
Dustin	2	30.00	22.80	3.00	0.08	0.22	4.60	6.80	1.90	0.30	0.002	2.40	1.90	0.20	1.90	1.52	29.13
Dustin	3	10.00	24.00	2.20	0.10	0.18	5.20	6.80	2.20	0.29	0.001	2.40	1.90	0.25	2.00	2.57	21.36

Table 6. Continued.

STREAM	Date of Collection	Colour	Specific Conductance	Dissolved Organic Carbon	Nitrate	Total Nitrogen	Alkalinity	pH	Sodium	Magnesium	Total Phosphorus	Sulphur	Chloride	Potassium	Calcium	Anions - Cations	Organic Ions
		REL UNIT	USIE/CM	Mg/L	Mg/L	Mg/L	Mg/L	PH UNIT	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	%	ueq/L
41	1	30.00	18.30	3.40		0.35	2.30	6.40	1.40	0.37	0.005	2.50	1.20	0.11	1.50	12.46	32.31
41	2	5.00	27.80	1.70	0.25	0.43	7.90	7.10	2.00	0.69	0.003	2.50	1.40	0.17	2.50	1.05	16.68
41	3	5.00	33.00	2.50	0.20	0.28	8.70	6.70	2.30	0.67	0.010	3.30	1.70	0.30	2.80	0.33	24.17
15	1	60.00	20.10	4.10		0.14	3.00	6.50	1.50	0.35	0.007	2.70	1.80	0.12	2.00	8.32	39.21
15	2	45.00	26.20	3.00	0.05	0.21	6.50	6.80	1.90	0.52	0.005	2.60	2.00	0.16	2.60	3.06	29.13
15	3	30.00	28.00	3.80	0.13	0.18	8.20	6.90	2.10	0.52	0.008	2.80	2.00	0.25	2.80	1.31	37.05
McGee	1	50.00	25.60	3.20		0.13	6.80	7.00	1.60	0.35	0.007	3.10	1.30	0.10	3.20	4.75	31.31
McGee	2	40.00	31.70	3.60	0.10	0.25	9.80	7.00	1.90	0.50	0.006	2.90	1.40	0.14	3.90	3.08	35.22
McGee	3	25.00	38.00	2.50	0.11	0.18	11.80	7.10	2.10	0.50	0.009	3.00	1.60	0.20	4.70	2.90	24.53
40	1	65.00	18.00	4.50		0.17	2.80	6.40	1.40	0.33	0.008	2.20	1.40	0.08	1.60	9.34	42.76
40	2	30.00	29.80	3.40	0.10	0.29	9.00	7.00	1.90	0.73	0.012	2.40	1.70	0.18	2.80	0.39	33.26
40	3	20.00	34.00	2.60	0.09	0.18	9.80	7.10	2.30	0.71	0.008	2.90	1.90	0.30	3.30	2.27	25.51
Cains	1	40.00	26.90	3.10		0.12	5.80	6.80	1.60	0.35	0.002	3.40	1.70	0.10	3.10	4.32	30.11
Cains	2	25.00	32.20	2.80	0.09	0.16	8.50	7.00	1.90	0.43	0.002	3.50	1.70	0.13	3.90	3.09	27.39
Cains	3	15.00	40.00	2.50	0.11	0.21	11.40	7.10	2.20	0.54	0.003	4.10	2.00	0.20	4.90	1.62	24.53
Sweeney	1	35.00	20.60	2.80		0.12	0.90	6.10	1.90	0.33	0.005	3.20	2.50	0.10	1.30	6.87	25.96
Sweeney	2	40.00	21.90	3.30	0.10	0.21	2.10	6.20	2.20	0.39	0.003	3.00	2.60	0.13	1.50	5.54	30.88
Sweeney	3	20.00	25.00	3.60	0.14	0.25	2.00	6.30	2.30	0.44	0.003	3.80	2.60	0.16	1.60	4.31	33.96
Forks	1	10.00	22.10	1.30		0.06	2.40	6.50	1.70	0.37	0.002	3.70	2.30	0.15	1.70	0.91	12.43
Forks	2	5.00	23.20	1.90	0.03	0.06	3.10	6.60	1.90	0.43	0.001	3.80	2.30	0.14	1.80	0.86	18.28
Forks	3	5.00	25.00	1.40	0.05	0.09	3.80	6.70	2.10	0.48	0.001	3.70	2.20	0.13	2.10	4.49	13.54
Upper Vault	1	40.00	23.60	2.30		0.09	4.60	6.80	2.00	0.41	0.004	2.80	1.90	0.11	1.70	1.15	22.34
Upper Vault	2	10.00	26.40	1.20	0.11	0.11	5.70	6.90	2.40	0.50	0.004	2.90	2.10	0.14	2.20	3.53	11.70
Upper Vault	3	10.00	31.00	1.10	0.15	0.19	7.60	7.00	2.30	0.50	0.012	2.70	2.00	0.21	2.40	1.62	10.76

less like the other park streams and more like the cutover streams. The highest values of all 3 variables were observed from watershed #7, which was most recently cut in 1989.

Total phosphorus (P) concentrations in stream water were extremely variable amongst streams, and tended to fluctuate considerably from one sampling date to the next (Figure 12a, Table 6). In general the park streams appeared to have smaller, more stable phosphorus concentrations, except for a sudden increase of P in Upper Vault on the September sampling date. No consistent pattern in concentration over the three sampling dates was observed.

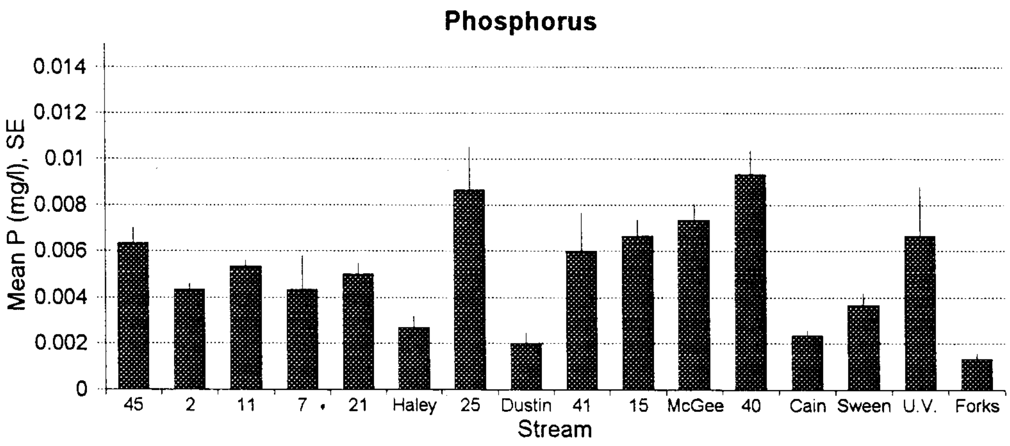
Dissolved chloride (Cl) concentrations are shown in Figure 12b. The three streams sites closest to the Fundy coast (Sweeney, #2 and #11) (Figure 2), had some of the largest chloride concentrations, suggesting that the sea had some influence on stream ion content.

4.1.4. Sedimentation

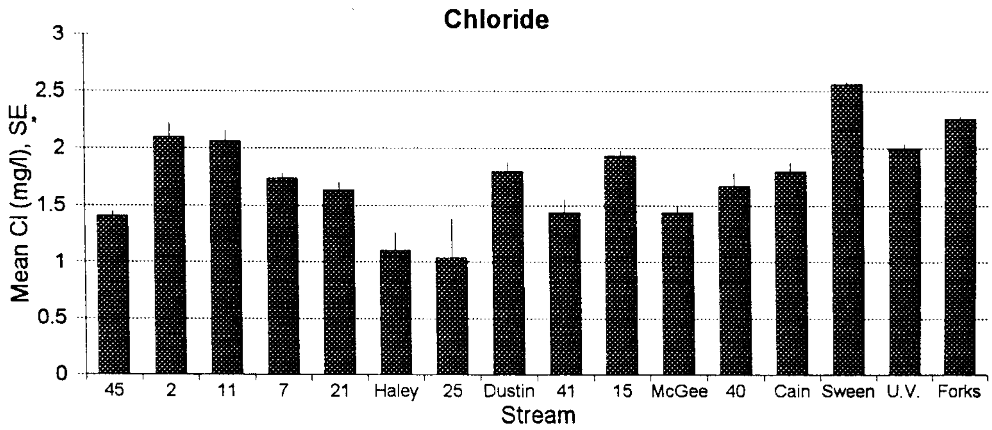
Some of the sediment pots buried into the stream bottom were not found again, presumably because they were covered by substrates, or possibly dislodged during the heavy autumn flows. Three pots, one each from Haley, #15 and #40, were found empty on the streambank beside where they had been buried - presumably emptied by curious passers-by. Where it was known that pots had been removed, the remaining pots

Figure 12(a)-(b). Mean phosphorus and chloride of stream water for three collection dates: July 1, August 4 and September 6, 1993. Streams #45 - 21 drained watersheds clearcut in the mid-late 1980s; Haley - #41 drained watersheds clearcut in the early 1980s; #15 - #40 drained watersheds clearcut in the 1970s; and Cain - Forks were reference streams.

12(a)



12(b)



were used to estimate the rate of sedimentation. Three lost pots in #25, and one lost pot in McGee and #40 were assumed full, and assigned an approximate weight based on the known weight of full pots.

The highest rates of sedimentation were recorded on #2 (478 g/pot), #40 (437 g/pot), #25 (400 g/pot), #7 (177 g/pot), McGee (180 g/pot), and #45 (118 g/pot) (Figure 13). The latter had a particularly large proportion of fines (<3.3 mm). The sampling reaches of streams #2, #40, #7 and #45 were located below road crossings. Medium rates of deposition were observed on streams #41 (65.9 g/pot) and Haley (40.2 g/pot). The greatest quantity of sediment recorded in any reference stream was from Cains, in which one pot had accumulated more than 28 g (21.7 g >3.3 mm; 6.4 g <3.3 mm) between June and October (Figure 13). The other park streams had no more than 7.5 g of sediment in any one pot.

T-tests for the deposition of sediment <3.3 mm and >3.3 mm showed significant differences between the cutover streams and the park streams ($t = 3.1$, $p = 0.01$ for <3.3 mm; $t = 2.6$, $p = 0.025$ for >3.3 mm). The Pearson correlation matrix also showed a significant negative relationship between the deposition of fines (<3.3 mm) and the age of stand (inverse transformed) ($r = 0.62$, $p = 0.011$), and a simple regression showed a significant linear relationship between the amount of sediment (<3.3 mm) and the age of the

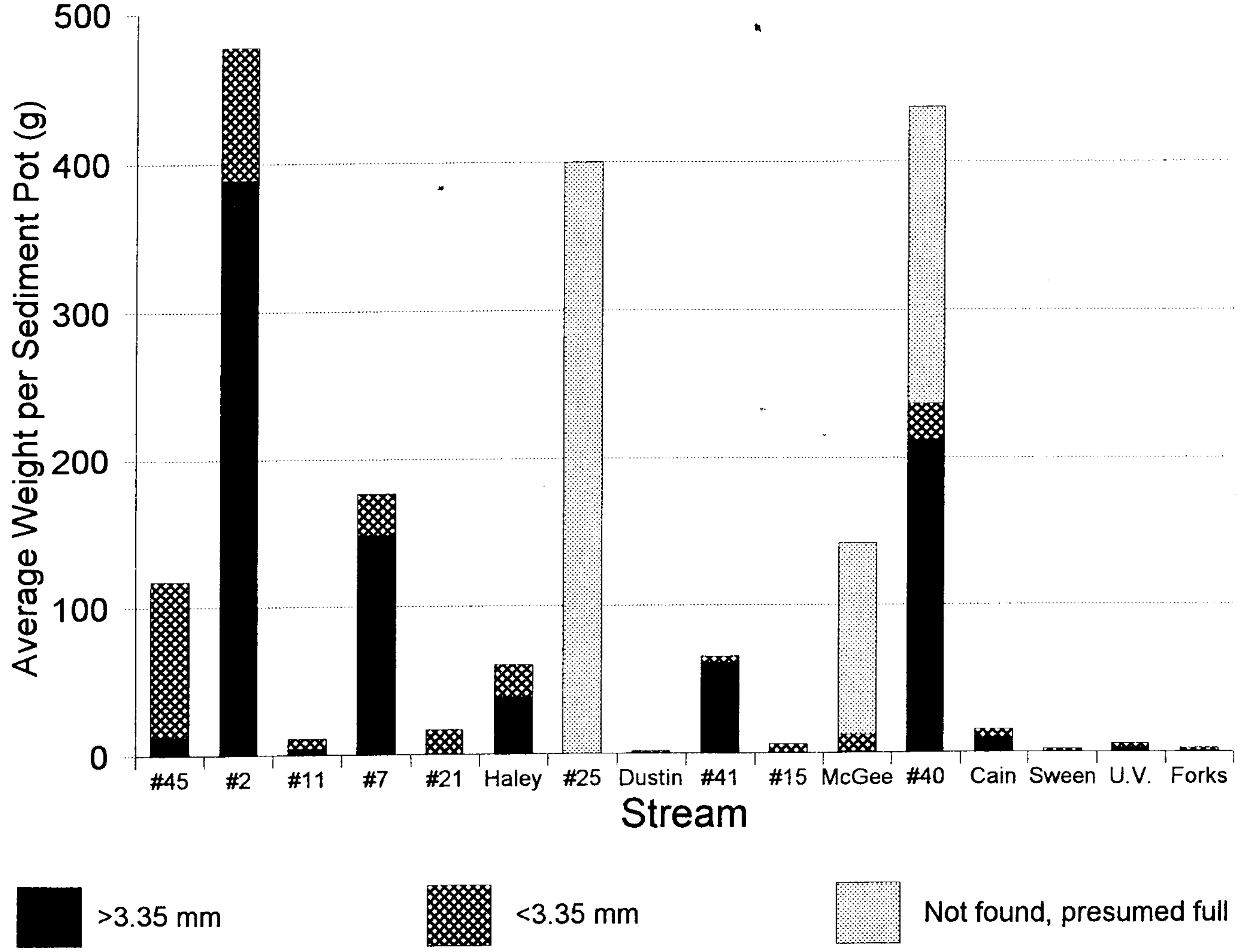


Figure 13. Sedimentation (deposition of materials <4.5 cm) measured with sediment pots placed in each stream from June to Ocober, 1993. Streams #45 - 21 drained watersheds clearcut in the mid-late 1980s; Haley - #41 drained watersheds clearcut in the early 1980s; #15 - 40 drained watersheds clearcut in the 1970s; and Cains - Forks were reference streams. Lost bottles were assumed to have been buried and were assigned the weight of full pots.

stand (F = 9.2, p = 0.009).

4.1.5. Streambed composition

The results of the substrate core analysis showed that medium and very coarse gravels, small cobbles, and bedrock were the dominant substrates (Figure 14a-d). Of the four reference streams (Figure 14d), Cains appeared to be anomalous, with no exposed bedrock and a relatively large proportion of fines (12.4%), and medium and very coarse gravels being the most dominant substrate sizes. Upper Vault had a total of 7% fines and 35% bedrock. Sweeney and the Forks had smaller proportions of fines and of bedrock.

McGee (Figure 14c) and stream #21 (Figure 14b) had similar substrate size distributions to that of Cains (Figure 14d), with a low proportion of bedrock (7.2% and 0%), a high proportion of medium and very coarse gravels (10.2%), and a relatively high proportion of fines (20%). The high proportion of fines for stream #21 (Figure 14b) was mostly due to an exceptionally high percentage of coarse sands. The lowest proportion of fines (<3.3 mm) was measured in Dustin (2.3%), followed by #11 (2.5%), and #40 (2.8%). Overall, there was no pattern found with the proportion of streambed fines and the age of stand.

The highest proportion of bedrock was measured in stream #45, with 65.6%; followed by #2, with 51.1%; Dustin Brook, 45.1%; #40, 43.7%; and #11, 39.2%.

Figure 14(a). The range of particle sizes in the 1993 substrate cores taken from the sampling reaches of streams draining watersheds clearcut in the mid-late 1980s.

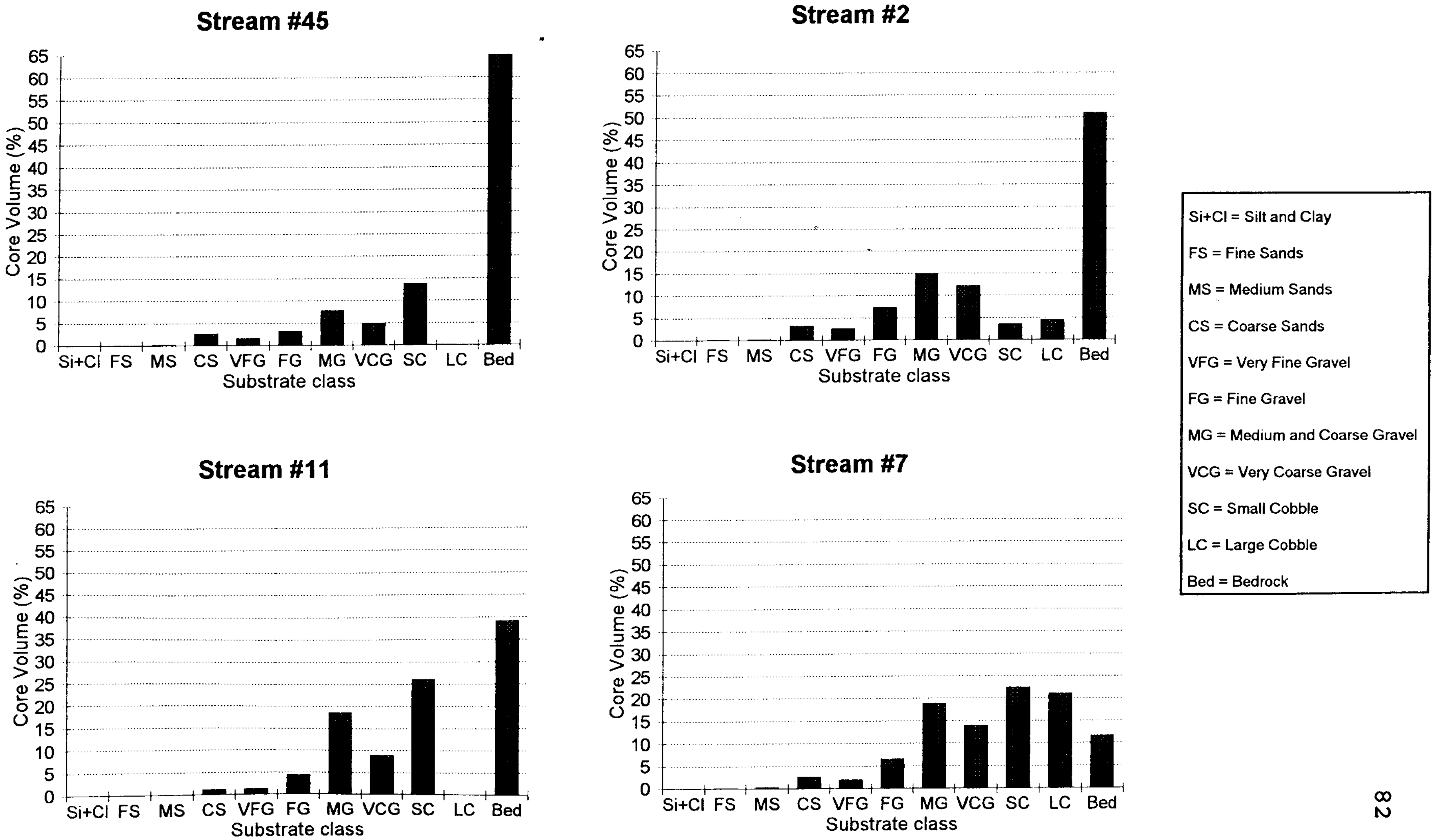


Figure 14(b). Substrate cores cont'd. Streams #21, #25, Haley and Dustin drained watersheds clearcut in the early 1980s.

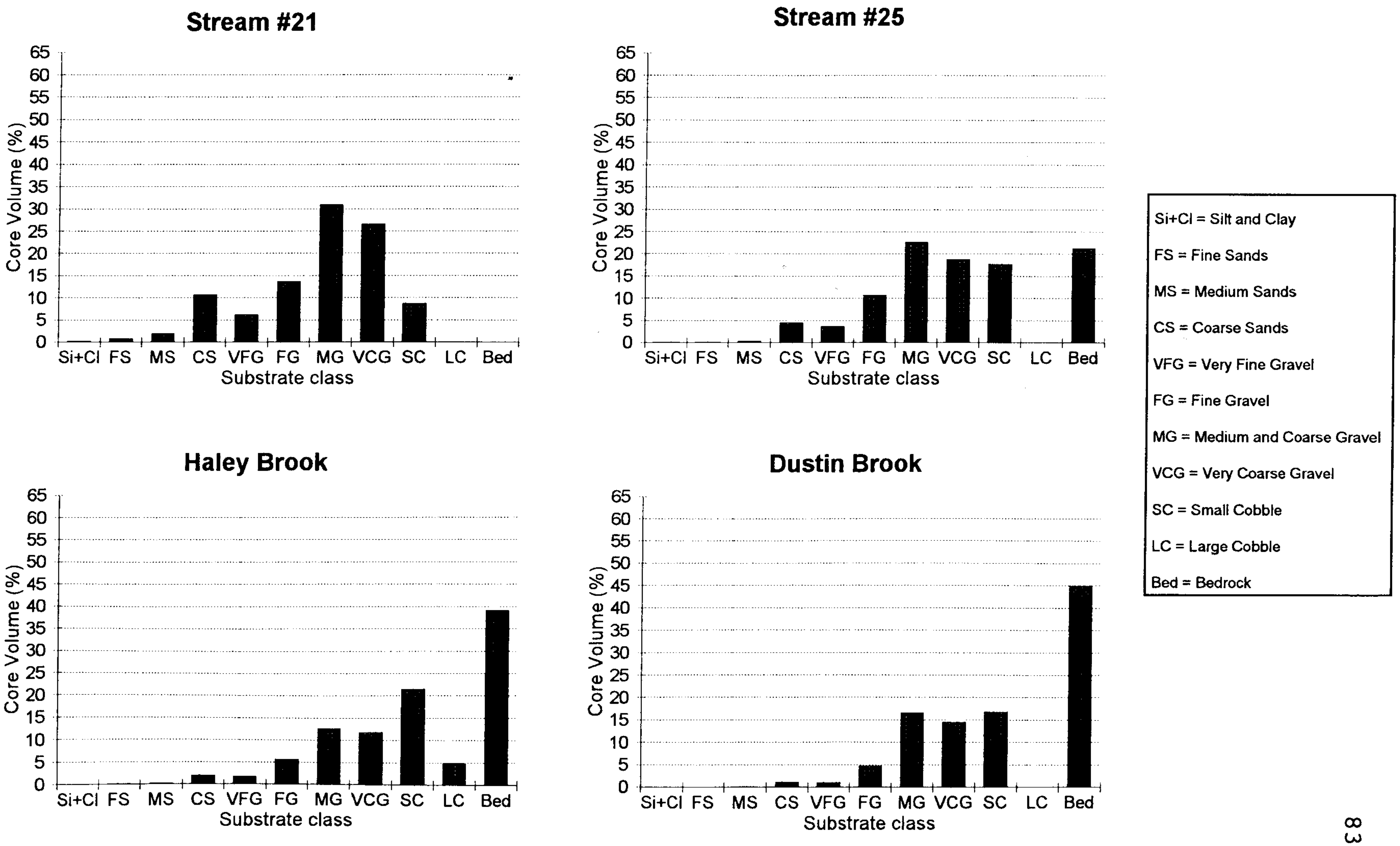


Figure 14(c). Substrate cores cont'd. Stream #41 drains a watershed clearcut in the early 1980s, and streams #15, #40, and McGee drain watersheds clearcut in the 1970s.

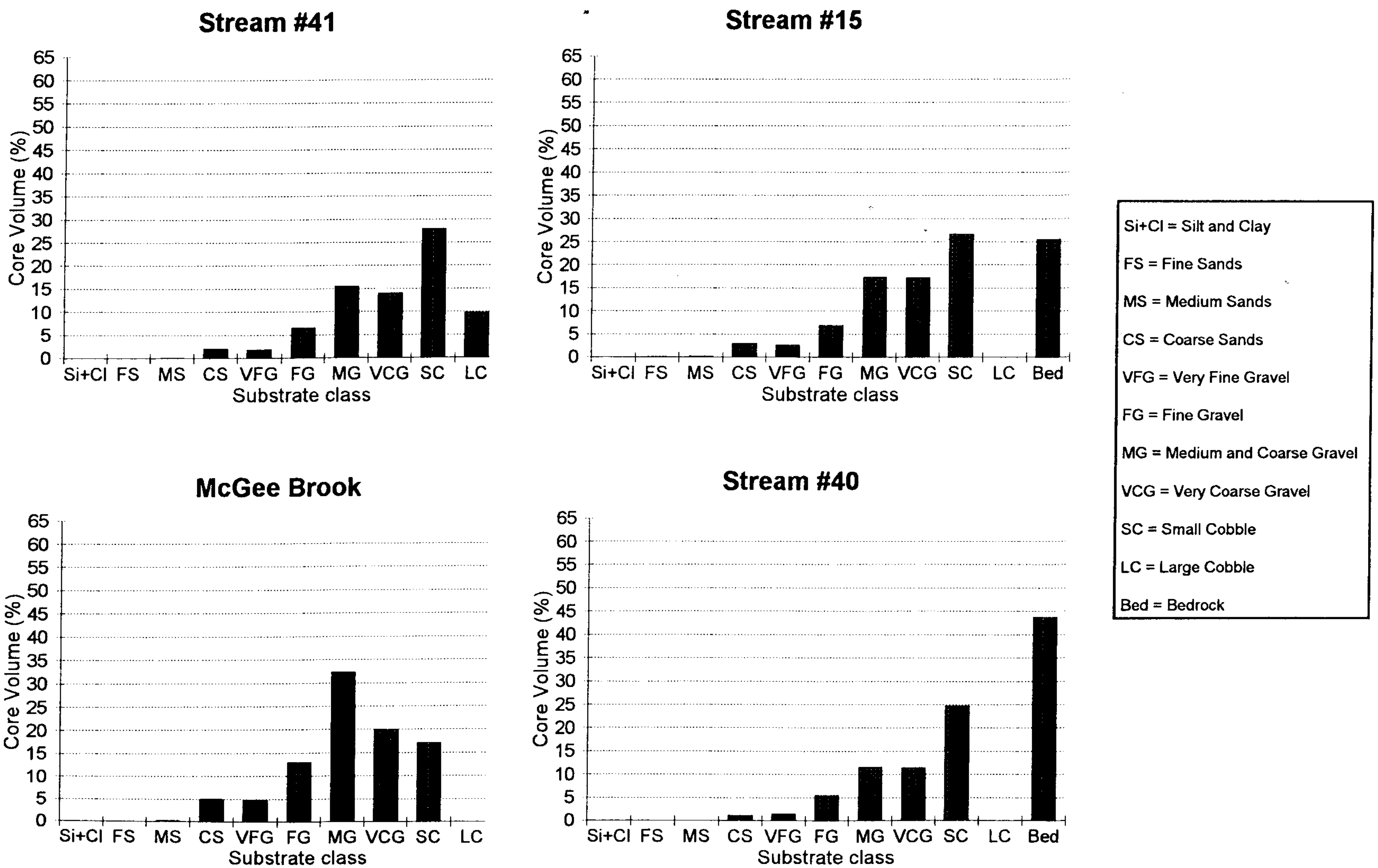
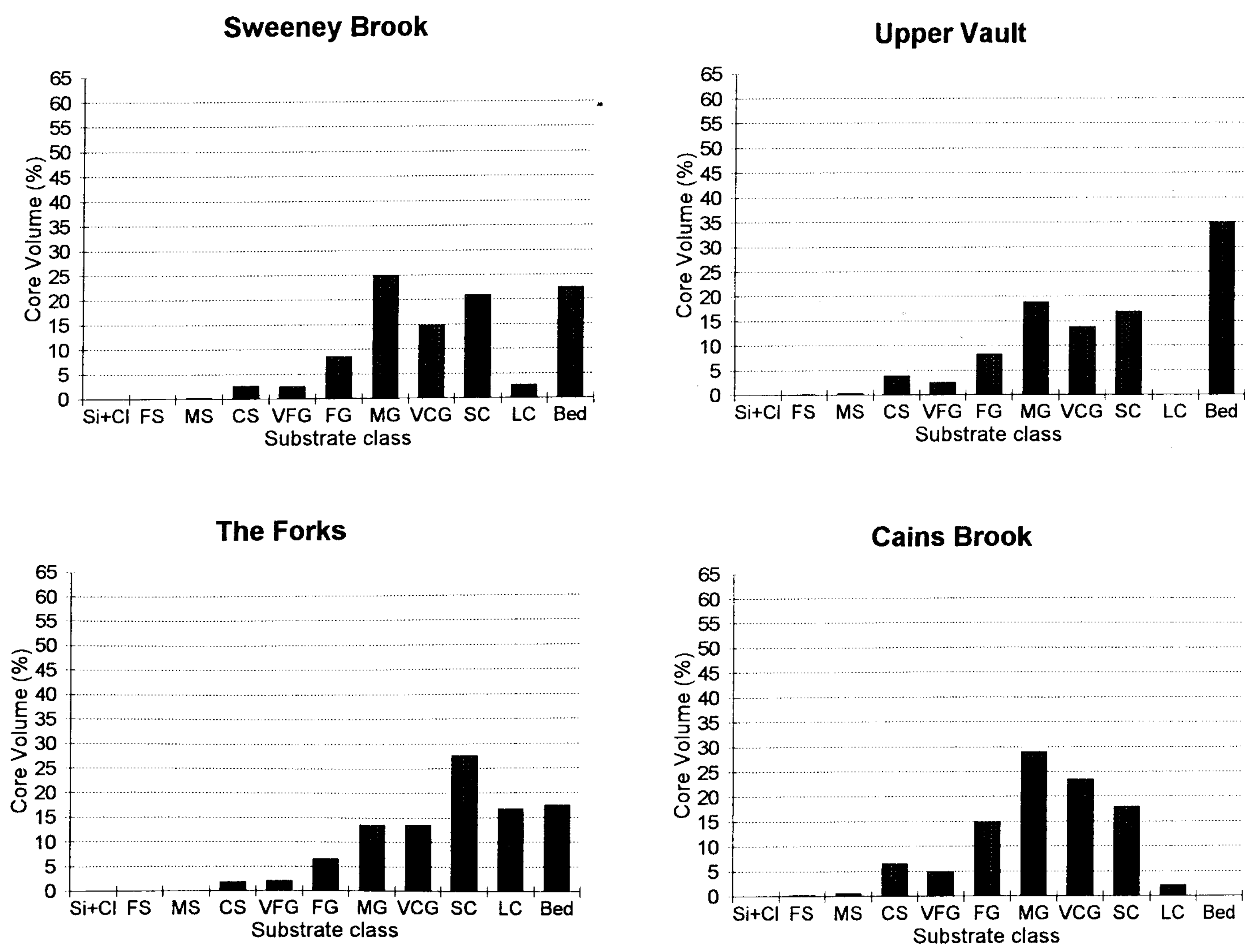


Figure 14(d). Substrate cores cont'd. Sweeney, Upper Vault, The Forks and Cains were reference streams.



- Si+Cl = Silt and Clay
- FS = Fine Sands
- MS = Medium Sands
- CS = Coarse Sands
- VFG = Very Fine Gravel
- FG = Fine Gravel
- MG = Medium and Coarse Gravel
- VCG = Very Coarse Gravel
- SC = Small Cobble
- LC = Large Cobble
- Bed = Bedrock

Results of the analyses for organic carbon in substrates are given in Figure 15. No trend was evident. The three streams with relatively high organic carbon, Forks, Dustin, and #11, also had very large standard error bars, indicating considerable variance within the sites. Streams #15 and #25 had moderately uniform amounts of organic carbon from one sample to the next. The low concentrations of organic carbon in streams #15 and #21 were somewhat surprising, considering that the former was choked with logging slash and coated by a layer of dark organic silt, and the streambed of the latter had a dark-black, mucky consistency.

4.1.6. Surface substrates

The differences between the two techniques for estimating streambed substrates - core sampling and surface estimation - gave rise to some dissimilar results for each stream. In particular, bedrock was less frequently reported as a surface substrate. In the four most recently cutover streams (Figure 16a), bedrock was often the most dominant or subdominant substrate, but in the other streams (Figure 16b-d), surface exposures of bedrock were nearly absent. There was a significant Pearson correlation between surface bedrock and age of stand ($r = 0.7$, $p = 0.004$). The Forks was the only other stream with a noticeable proportion of bedrock (Figure 16d), no doubt due to its high gradient and

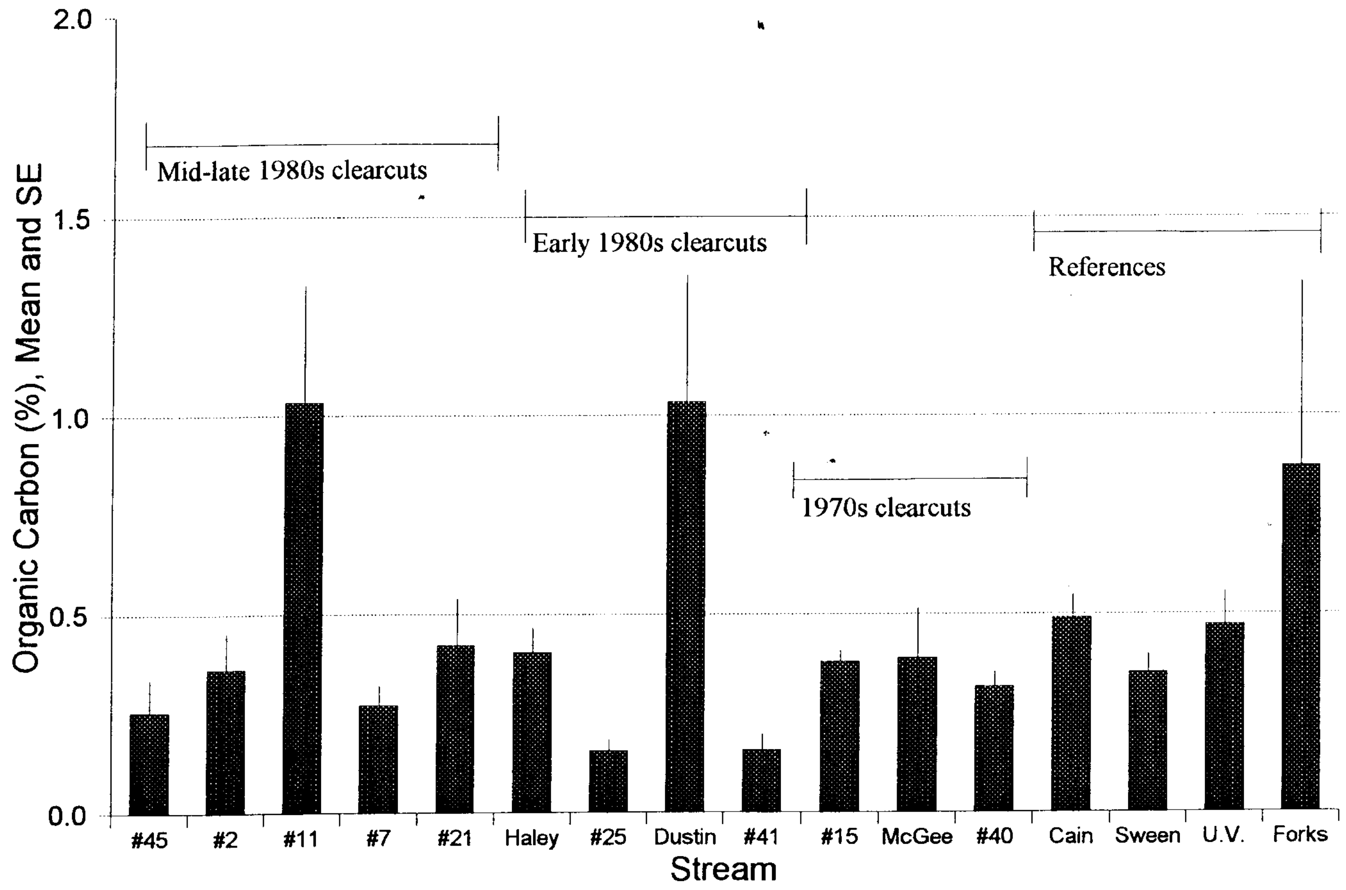


Figure 15. Organic carbon concentration of streambed substrates.