THE EFFECTS OF SELECTED GRAZING TREATMENTS ON CHANNEL MORPHOLOGY AND SEDIMENT WITHIN THE RIPARIAN ZONE OF FIFTEEN MILE CREEK

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INTRODUCTION

This is the fourth annual report of 15 Mile Creek research, initiated to investigate the relationship of changes in channel morphology, vegetation, and sediment loading to livestock grazing. Report format remains much the same as previous annual reports, with a few exceptions. For one, the section on the livestock grazing studies, while listed in the table of contents, will be issued as a separate addendum as the bulk of that material forms Clay Miller's thesis for his Masters degree. Secondly, a section which lists the data sets and analyses from the project for 1983 to 1985 has been added. As previously, new methodologies are described in full while those previously used and described are only summarized.

We again express our appreciation to Wyoming DEQ, BLM, and the Wyoming Water Research Center for their support in this research effort. Additionally, we express our appreciation to Jay Matthews for his cooperation and assistance in providing and handling livestock.

MORPHOLOGY/HYDROLOGY

Standard morphology cross-section measurements were taken in all four study areas in the fall of 1985. A summary of the method is as follows:

1) A line is strung between two stakes set at the top of the stream bank on the left and right sides.
2) The line is leveled.
3) Vertical measurements from the line to the channel surface are taken with a surveyor's rod - measurements are to nearest one one-hundredth of a foot (.01).
4) Measurement intervals in the cross-section are at one-tenth (.10) of the top width with additional measurements at the left and right interim banks (low flow banks) and any irregular features of the cross-section.
5) A study reach is composed of five equally spaced standard cross-sections. Meanders are measured along the top of the inside bank between the upstream and downstream thalweg inflection points. Straight reaches are full length subject to a maximum of 200'.

In the course of preparing this report, the data from previous years was re-examined. Due to a programming error, the results previously reported for mean depths in 1982 and 1983 are in error. Corrected means and standard deviations is provided in this report.

Mean Channel Depths

Analysis of morphology data for area mean depths was run for the four study areas. The results indicate that, while individual reaches can be quite variable, overall means remain quite similar. The main channel area, which is the highest order stream in the drainage, had area means which fluctuated only one one-hundredth (.01) of a foot over the four year period. Progressing upstream, the area means become less stable with the Below Exclosure and Exclosure means depths varying by .22 ft. and the Above Exclosure study reach varying by .38 ft. over the four years (Tables 1-4). The attendant standard deviations appear higher in the uppermost (Above Exclosure) study area as compared to lower reaches. However, analysis of means and standard deviations for each reach over the four year period indicate no relationship between the location of a study area in the drainage and the variability of its reaches over time. The Exclosure does have lower area standard deviations indicating a greater degree of depth uniformity in its study reaches. A sharp increase in the area standard deviation in 1985 arose mostly from rapid changes in a few reaches. Analysis of variance of mean depth in the four study areas over four years (1982-85) indicates no differences for any area by year.

Within the Middle Fork exclosure, plots of reach mean depth by year with the Exclosure area mean depth reveals some interesting information (Figures 1-5). In cell one, the ungrazed test cell at the bottom of the exclosure, reach one is apparently undergoing a steady, progressive deepening (Figure 1). Reach two within that same cell has apparently stabilized at a level slightly shallower than the area norm (Figure 1). The mean reach depth in cell two (Figure 2) and three (Figure 3), spring and summer grazed respectively, appear to be converging on the area mean irregardless of their initial relative positions.

Common Point Depth Comparisons

In order to focus upon the location in the channel where depth changes are occurring, a point to point comparison was undertaken from

Table 1. Main channel - mean depths (ft) by reach and year.

REACH	1982	1983	1984	1985	REACH MEAN	REACH STD. DEV.
1-1	3.21	3.98	3.28	4.07	3.64	0.45
1-2	3.38	3.24	3.54	3.20	3.34	0.15
1-3	3.25	3.39	2.76	2.83	3.06	0.31
1-4	4.17	4.44	4.78	4.17	4.39	0.29
1-5	2.06	2.05	2.40	2.47	2.25	0.22
1-6	2.30	2.01	1.87	2.41	2.15	0.25
1-7	3.03	2.84	2.60	2.92	2.85	0.18
1-8	3.10	3.18	3.55	3.38	3.30	0.20
1-9	3.24	3.55	3.36	3.15	3.33	0.17
1-10	3.66	3.45	3.22	2.99	3.33	0.29
1-11	3.42	3.60	3.47	2.69	3.30	0.41
1-12	2.78	--	--	--	--	--
1-13	1.91	2.06	2.87	2.72	2.39	0.48
1-14	2.19	2.34	2.54	2.45	2.38	0.15
1-15	1.55	2.15	2.11	1.85	1.92	0.28
1-16	2.48	2.52	2.47	2.61	2.52	0.06
1-17	3.23	3.43	2.90	2.53	3.02	0.39
1-18	3.73	1.89	2.34	3.78	2.94	0.96
1-19	3.11	2.04	--	--	--	--
1-20	3.33	2.23	--	--	--	--
AREA MEAN	2.94	2.95	2.94	2.95		
AREA STD. DEV.	0.64	0.78	0.70	0.62		

Table 2. Below exclosure -- Mean depths (ft) by reach and year.

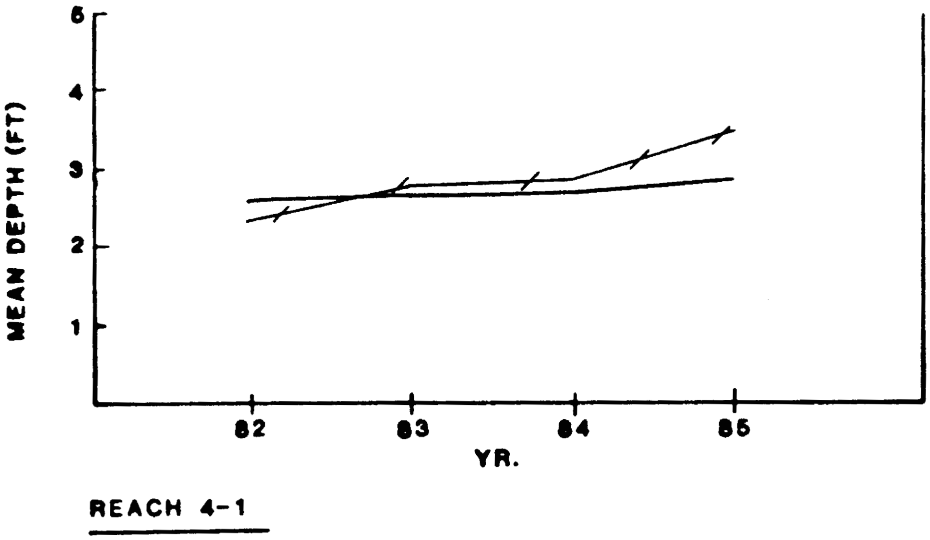
REACH	1982	1983	1984	1985	REACH MEAN	REACH STD. DEV.
2-1	1.84	2.09	1.74	2.14	1.95	0.19
2-2	2.94	3.16	3.11	2.81	3.01	0.16
2-3	0.94	1.65	1.53	1.02	1.29	0.36
2-4	1.65	1.74	1.81	1.60	1.70	0.09
2-5	2.05	2.15	1.97	1.68	1.96	0.20
2-6	2.23	2.11	2.32	2.12	2.20	0.10
2-7	0.88	1.36	0.92	0.95	1.03	0.22
2-8	2.04	1.72	2.15	2.05	1.99	0.19
2-9	2.14	2.36	2.36	2.69	2.39	0.23
2-11	1.83	2.01	2.20	1.82	1.97	0.18
2-13	1.63	2.70	2.44	2.22	2.25	0.46
2-15	1.22	1.23	0.88	1.21	1.14	0.17
2-17	2.05	1.64	2.03	1.95	1.92	0.19
2-19	1.85	1.59	1.75	1.74	1.73	0.11
2-21	0.56	1.36	1.04	1.25	1.05	0.35
AREA MEAN	1.72	1.92	1.94	1.82		
AREA STD. DEV.	0.61	0.53	0.59	0.56		

Table 3. Above exclosure -- mean depth (ft) by reach and year.

REACH	1982	1983	1984	1985	REACH MEAN	REACH STD. DEV.
3-1	2.96	3.25	3.38	3.20	3.20	0.18
3-2	2.63	3.35	3.54	3.54	3.27	0.43
3-3	3.17	3.08	3.04	2.88	3.04	0.12
3-4	3.10	3.70	3.99	3.98	3.69	0.42
3-5	2.42	2.56	2.80	2.79	2.64	0.19
3-7	2.19	2.38	2.36	2.22	2.29	0.10
3-9	0.66	1.19	0.92	1.46	1.06	0.34
3-11	0.86	0.99	1.39	1.21	1.11	0.23
3-13	2.04	2.16	2.24	2.02	2.12	0.10
3-15	1.21	0.85	1.30	0.89	1.06	0.23
3-17	1.37	1.32	1.49	1.32	1.38	0.08
3-19	1.31	1.79	1.93	1.73	0.29	
AREA MEAN	1.99	2.22	2.37	2.28		
AREA STD. DEV.	0.89	0.99	0.99	0.99		

Table 4. Exclosure -- mean depth (ft) by reach and year.

REACH	1982	1983	1984	1985	REACH MEAN	REACH STD. DEV.
4-1	2.36	2.80	2.91	3.48	2.89	0.46
4-2	2.67	2.54	2.60	2.70	2.63	0.07
4-3	3.20	2.82	2.92	2.94	2.97	0.16
4-4	2.90	2.76	2.85	2.78	2.82	0.06
4-5	3.25	3.20	3.10	3.16	3.18	0.06
4-6	2.43	2.66	2.76	2.78	2.66	0.16
4-7	2.18	2.35	2.16	1.88	2.14	0.19
4-8	2.34	2.13	3.10	4.20	2.94	0.94
4-9	2.47	--	2.62	2.43	2.51	0.10
4-10	2.29	--	1.93	1.92	2.05	0.21
AREA MEAN	2.61	2.66	2.69	2.83		
AREA STD. DEV.	0.38	0.32	0.39	0.69		



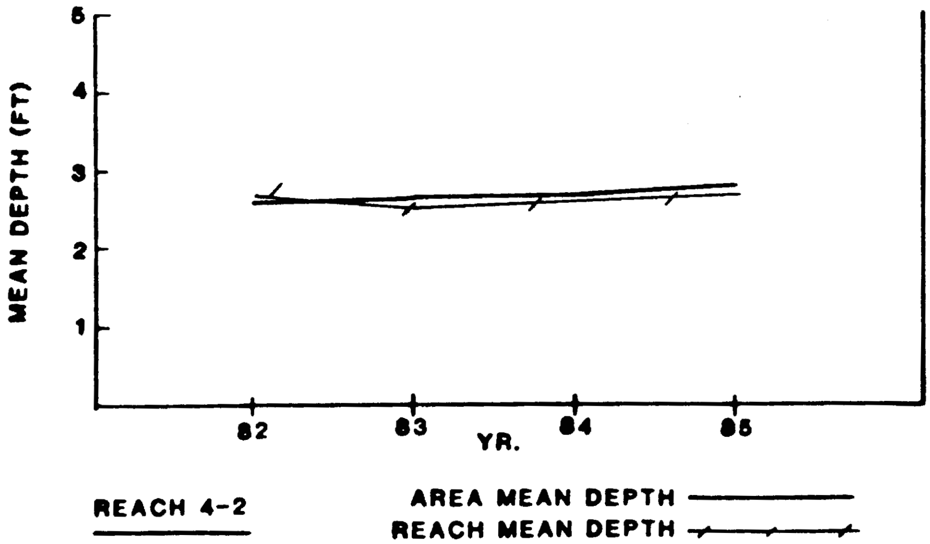
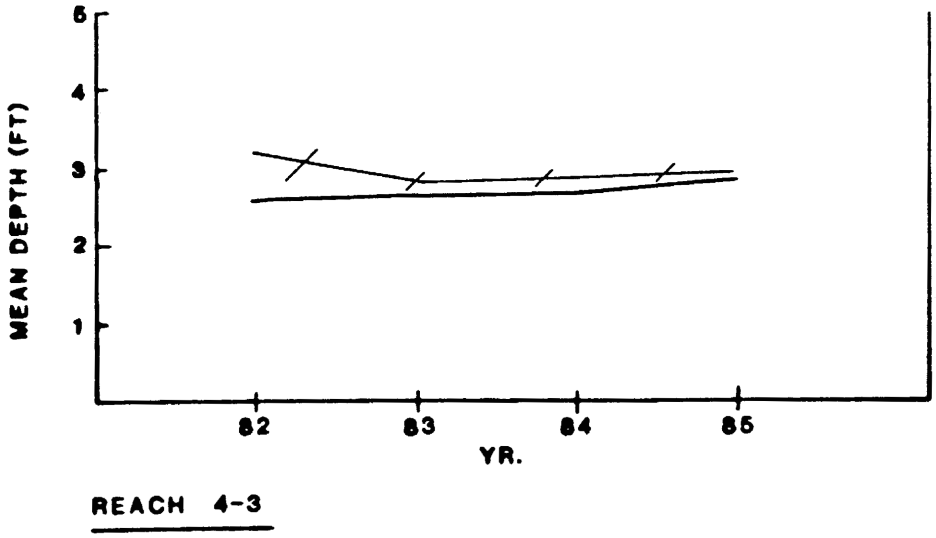


Figure 1. Area mean depth vs. reach mean depth, 1982 to 1985 cell 1.



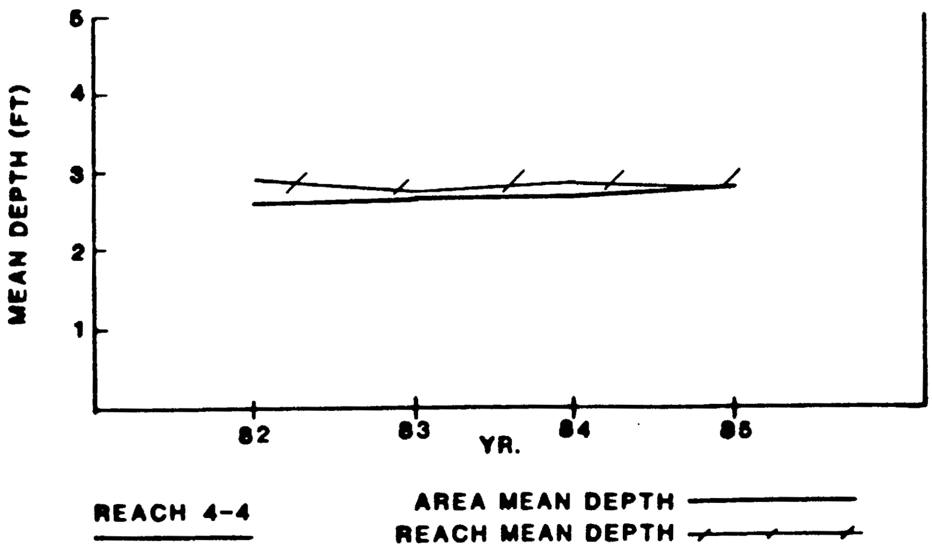
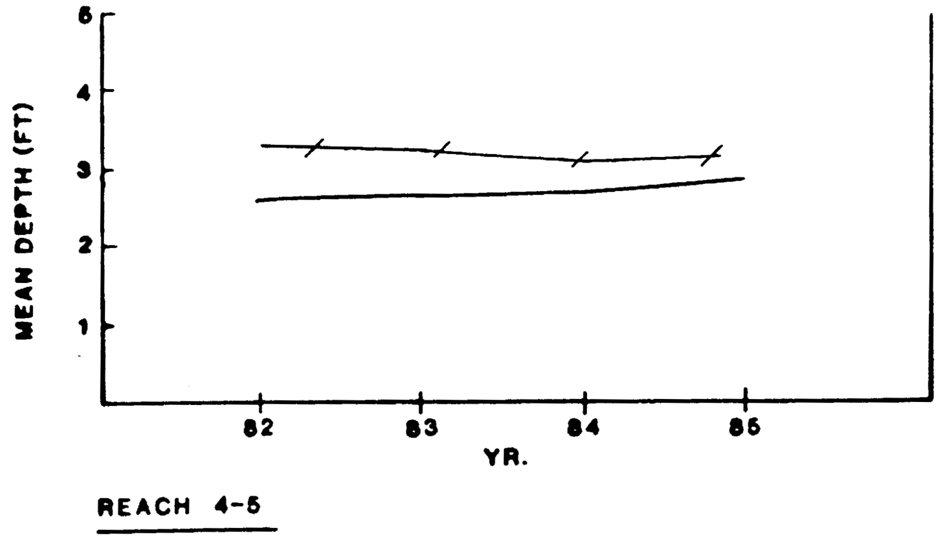


Figure 2. Area mean depth vs. reach mean depth, 1982 to 1985 cell 2.



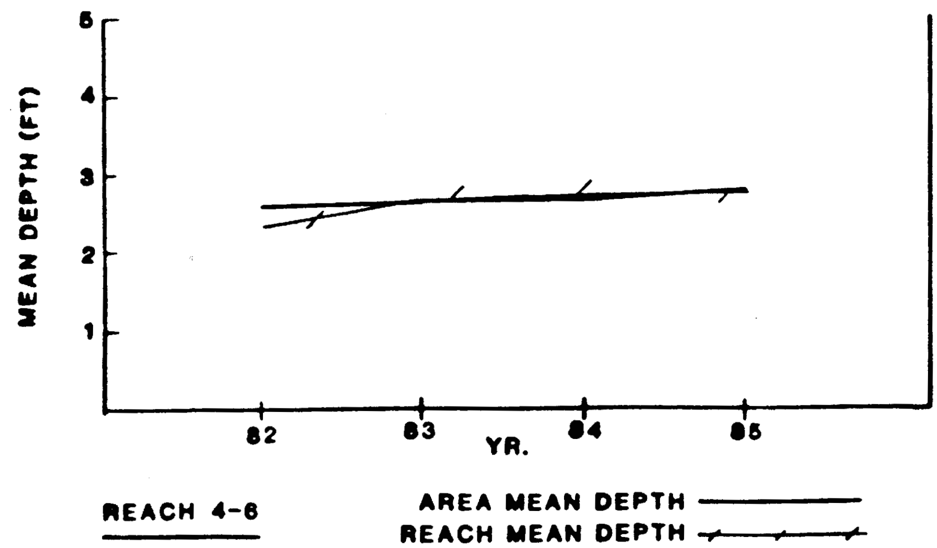
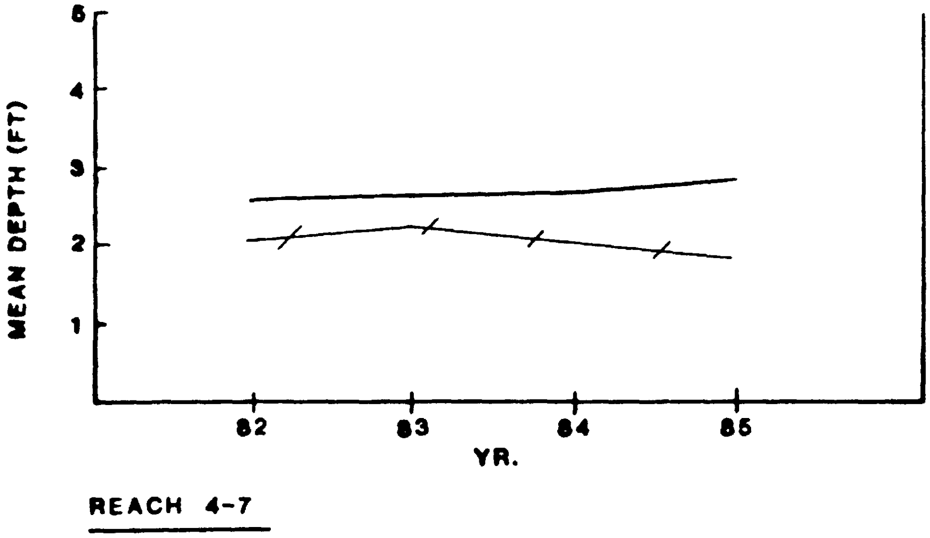


Figure 3. Area mean depth vs. reach mean depth, 1982 to 1985 cell 3.



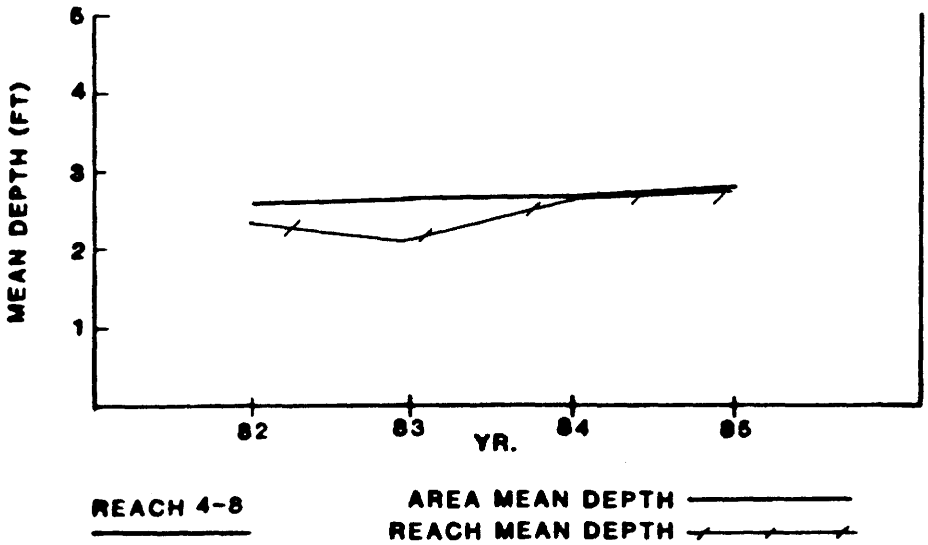
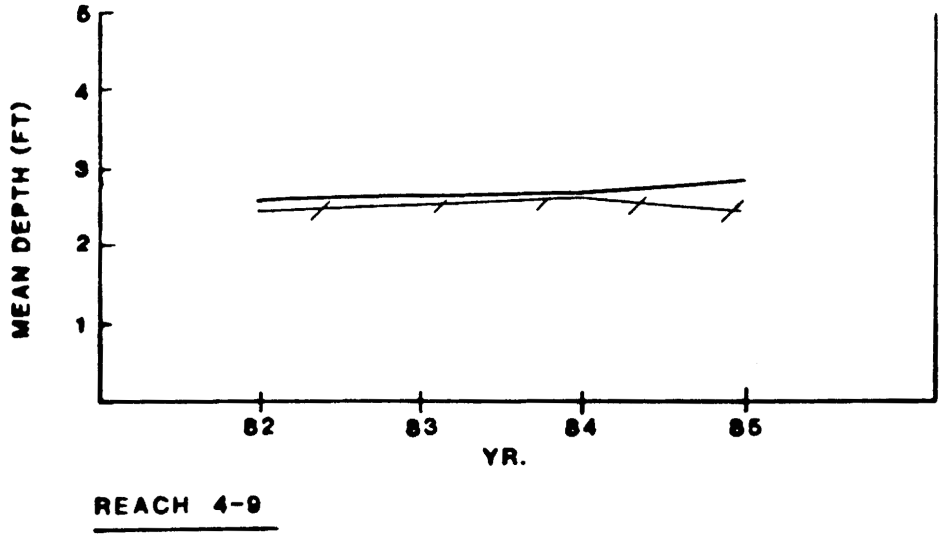


Figure 4. Area mean depth vs. reach mean depth, 1982 to 1985 cell 4.



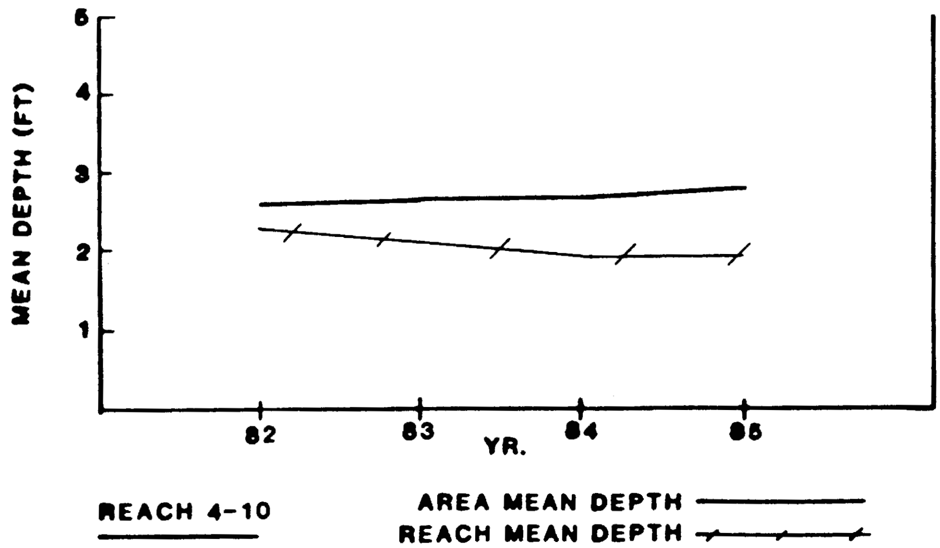


Figure 5. Area mean depth vs. reach mean depth, 1982 to 1985 cell 5.

the reaches in the exclosure for 1984-85 and 1983-85. The procedure used was to determine the differences between years for the specific common points in a given cross-section. These differences were then used to compute means ($\bar{X}$), standard deviations (S), and variances (S^2) for bank sections (i.e., left side bank, interim bank interval, and right side bank) typically producing three datum for each cross-section.

In analyzing the common-point depth changes the following guidelines apply. In cases where the side banks aggrade and the channel floor downcuts, the cross-section oversteepens. In those where the floor aggrades and the side banks deepen, the cross-section flattens. In the case where the channel sections both respond in the same manner (i.e., both aggrade or degrade), the ratio of changes of the sides to changes in the floor becomes key. In the instances when both channel sections aggrade , a ratio of side bank changes to floor changes greater than one indicates steepening while a ratio of less than one indicates shallowing. In mutually deepening cases, side bank to floor ratios greater than one indicate shallowing and ratios less than one indicate steepening.

The means of the depth changes occurring between 1984- and 1985 are summarized in Table 6. F statistics indicate significant differences between cells at the alpha = .05 level. Both reach forms in the upstream control display characteristics of oversteepening, with the interval between interim banks deepening and the side bank building creating a more angular cross-section. In lower cells, the meanders show definite changes associated with the "dishpanning" effect, flattening the the side slope while maintaining or raising the depth of the interval between interim banks. While the straight sections in the

TABLE 6
MEANS AND STANDARD DEVIATIONS OF
MEAN CHANGES (FT) IN DEPTH, SIDE BANKS,
AND INTERIM BANK, EXCLOSURE 1984-85

CELLS

FORM	(1) TEST BANK	(1) TEST INT.	(2) SPRING BANK	(2) SPRING INT.	(3) SUMMER BANK	(3) SUMMER INT.	(4) FALL BANK	(4) FALL INT.	(5) CONTROL BANK	(5) CONTROL INT.
MEANDER										
X	-.04	+.11	-.19	+.18	-.09	+.07	+.12	+.13	+.15	-.03
S	(.27)	(.32)	(.19)	(.18)	(.10)	(.10)	(.33)	(.24)	(.24)	(.35)
STRAIGHT										
X	-.12	-.02	+.11	+.05	-.04	-.11	+.18	+.15	+.04	-.16
S	(.10)	(.10)	(.16)	(.07)	(.10)	(.10)	(.13)	(.08)	(.13)	(.16)

Negative (-) indicates deepening (i.e., 1984 measurement exceeds 1985.

Positive (+) indicates shallowing.

Table 6. Means of depth changes, 1984-85.

grazing cells maintain the oversteepening trend, it is reduced with verticle height change totals of .05 to .07 ft as compared to .20 ft for the control. It is notable also that the straight reaches in the spring and fall pastures shallowed overall even while the bank steepened.

Analysis of variance of the variances of common point channel depths indicate no significant differences between grazing treatments from 1984 to 1985 (Table 7). In all cases, the mean of the point variances of the control cell are greater than those of the seasonal grazing cells and the ungrazed test cell, but F-test statistics indicate an alpha level of less than .50, indicating no differences in variances of depth between cells. In running the same type of test over a two year period (1983 to 1985) definite differences are found. Low F statistics prompts a conclusion of no differences between cell 1 (test) and 5 (control). However, the grazing Cells (2, 3, and 4) all display differences on the meander reaches. In all cases but one, the mean of the variances of depth were less than those of the control cell, the exception being on the straight section in the fall grazing pasture. For an alpha level of .10, we can state that seasonal grazing appears to reduce changes on meanders in the summer and fall pastures. This leads to the conclusion that seasonal use may have promoted increased stability on meanders, which should be the more variable morphological form in those pastures.

Interim Bank Interval

Another analysis method that can provide insight into changes occurring in stream morphology is the changes in the width of the channel floor (i.e., the interval between interim banks). Analysis of variance of these changes in channel floor width for 1984-85 indicates

TABLE 7
MEANS AND STANDARD DEVIATIONS OF BANK SECTION VARIANCES
AND SIGNIFICANCE LEVEL FOR TESTING FOR DIFFERENCES FROM CONTROL

ANALYSIS PERIOD	REACH FORM	CELL (CELL NO.)	TREATMENT MEAN	CONTROL MEAN	SIGNIFICANCE LEVEL(1-alpha)
1984-85	MEANDER	TEST(1)	0.029	0.047	.50
1984-85	STRAIGHT	TEST(1)	0.014	0.047	.50
1984-85	MEANDER	SPRING(2)	0.027	0.047	.50
1984-85	STRAIGHT	SPRING(2)	0.039	0.047	.50
1984-85	MEANDER	SUMMER(3)	0.010	0.047	.50
1984-85	STRAIGHT	SUMMER(3)	0.008	0.047	.50
1984-85	MEANDER	FALL(4)	0.024	0.047	.50
1984-85	STRAIGHT	FALL(4)	0.013	0.047	.50
1983-85	MEANDER	TEST(1)	0.106	0.188	.50
1983-85	STRAIGHT	TEST(1)	0.017	0.169	.50
1983-85	MEANDER	SPRING(2)	0.053	0.188	.82
1983-85	STRAIGHT	SPRING(2)	0.048	0.169	.655
1983-85	MEANDER	SUMMER(3)	0.013	0.188	.90
1983-85	STRAIGHT	SUMMER(3)	0.059	0.169	.60
1983-85	MEANDER	FALL(4)	0.036	0.188	.90
1983-85	STRAIGHT	FALL(4)	0.175	0.169	.95

Table 7. Means and standard deviations of bank section height variances in exclosure.

no significant differences on the pasture or reach level. The means do follow a pattern similar to the 1983-1984 data (Table 8) with a general trend of the channel floor to widen slightly. It must be cautioned that the locating of interim banks is a highly subjective process strongly influenced by size of the most recent flow event, and any judgements of effect must be carefully evaluated in light of other information.

Bank Angle

Changes in the angle of incidence between the interim banks and side bank presents another means of detecting morphological changes in the stream. Two methods of determining angles were used. The first, following the method established in supplementary analysis last year, was the use of cross-sectional plots to determine the "contact point" of a straight line originating at the interim bank. The angle of that line is then calculated by trigonometric formula. The results obtained by this method are summarized in Table 9. Analysis of variance on the 1984-1985 changes indicates that the mean angle changes in eight of the ten reaches were not different from one another. The two exceptions were in the meander in cell number one (Test), and the straight section in the third cell (Summer). No pattern of change is evident which can be associated with the application or withholding of grazing pressure. The second means of analyzing changes in angle of incidence is a direct measurement method first employed in 1985. This technique is being tested as an alternative to the more time consuming method of cross-section analysis. It employs a long straight edge and an abney level. The straight edge is used to determine the "mean line" (sometimes a chord, sometimes a tangent depending on bank form) of the major planes of the side bank. The angle is measured with the abney and height of the inter-

TABLE 8
EXCLOSURE INTERIM BANK INTERVAL CHANGES

TREATMENT CELL (CELL #)	'83 - '84 $\bar{x}$	'83 - '84 s	'84 - '85 $\bar{x}$	'84 - '85 s
TEST (1)	-0.30	0.64	-0.75	0.34
SPRING (2)	-0.29	0.84	-0.15	0.71
SUMMER (3)	-0.53	0.81	+0.02	0.30
FALL (4)	+0.95	1.01	-0.58	0.66
CONTROL (5)	-1.26	3.83	-0.48	1.42

Positive (+) indicates narrowing.
Negative (-) indicates widening.

Table 8. Means and standard deviations of changes in interim bank intervals, 1983, 1984, and 1985.

TABLE 9
CALCULATED MEAN CHANGES IN REACH BANK ANGLE BY YEAR

REACH FORM	TREATMENT CELL	1983-84		1984-85	
		$\bar{X}$	s	$\bar{X}$	s
STRAIGHT	TEST(1)	-0.15	3.60	-3.48	5.05
	SPRING(2)	-3.50	2.42	-5.02	7.73
	SUMMER(3)	+1.35	14.02	-10.68	21.71
	FALL(4)	+0.40	8.90	-1.43	2.37
	CONTROL(5)	-1.50	3.33	-3.09	5.73
MEANDER	TEST(1)	-1.95	5.07	+9.62	12.41
	SPRING(2)	-1.20	8.92	-2.66	8.77
	SUMMER(3)	-0.17	4.64	-3.06	6.18
	FALL(4)	-2.15	2.91	+2.32	6.22
	CONTROL(5)	-5.40	9.54	+1.24	9.17

(-) indicates increase in mean reach angle.

(+) indicates decrease (flattening).

Table 9. Means and standard deviations of calculated angle changes in exclosure by year.

sections of major planes of the cross-section above the channel floor noted (See Figure 6). The preliminary statistics, summarized in Table 10, indicate no discernable effects between the treatments in the first time interval. The second measurement interval has stronger differences but still doesn't display significant differences at acceptable alpha levels. In any case, the differences do not appear to be associated with the presence or absence of grazing. Given the high standard deviations, more standardization of the technique is needed.

Cross-Sectional Area

Channel cross-sectional areas, calculated using the morphology data, were computed for all reaches (Table 11). These were used to develop area means for each area by year. Analysis of variance of the changes in these means over the four years indicates that the mean changes in cross-sectional area of the four study areas over the four years are not different. In other words, apparently no area is changing in its mean channel cross-section area in a manner inconsistent with the others.

Standard morphology measurements were taken prior to and following grazing trial in the treatment and control cells. Analysis of variance on the changes in cross-sectional area occurring in that time was run to check for differences between the control and the grazed cell. The F statistics indicted no significant differences in channel area changes between grazed and ungrazed cells.

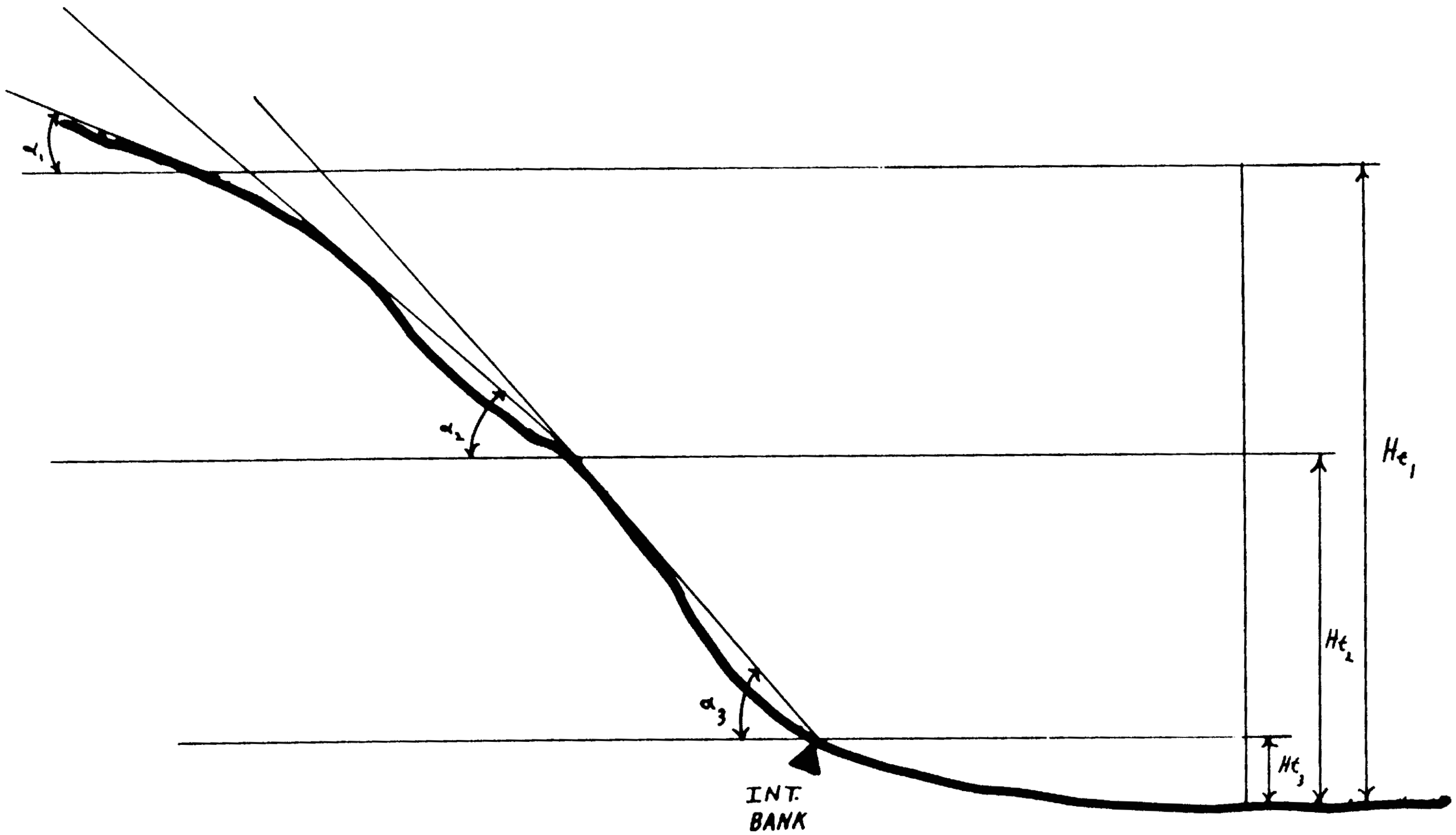


Figure 6. Schematic of data collected by bank angle direct measurement technique.

TABLE 10
MEASURED MEAN BANK ANGLE CHANGES, 1985

CELL (CELL NO.)	6/19-7/02 $\bar{x}$	6/19-7/02 s	7/02-8/01 $\bar{x}$	7/02-8/01 s
TEST(1)	-1.07	2.95	-0.60	1.42
SPRING(2)	+0.67	3.00	-1.50	4.20
SUMMER(3)	+1.07	2.76	-1.27	4.76
FALL(4)	-0.13	4.06	+1.44	3.14

(-) negative indicates steepening.

(+) positive indicates flattening.

Table. 10. Means and standard deviations of measured bank angle changes in exlcosure.

TABLE 11

MEANS AND STANDARD DEVIATIONS (ft^2) OF CHANGES IN CHANNEL AREA IN THE EXCLOSURE BY TREATMENT AND ANALYSIS PERIOD.

PERIOD	CONTROL		SPRING GRAZING		SUMMER GRAZING		FALL GRAZING	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
1984-85	+0.88	3.16	-0.97	3.28	-0.45	3.50	+2.18	7.16
1983-84	-2.81	5.62	+0.22	7.18	+0.15	1.47	+2.77	6.27
1982-83	-3.04	3.02	-0.38	5.93	-0.38	15.50	-0.71	14.40

Table 11. Means and standard deviations of changes in channel cross-sectional area by treatment and analysis period.

Precipitation

Precipitation gages were installed at the three previously established sites in the Middle-Fork drainage in early May. Some difficulties were experienced this year with gage clocks and pen travel resulting in less complete records than previous years.

The three year precipitation record on Middle Fork is summarized in Table 12. The catchment records show 1985 to have been significantly drier than either of the previous two years, with both precipitation amounts and storm frequency quite low. The overall pattern indicates a dearth of generalized area-wide storms and leads to the presumption that almost all precipitation emanated from convective storms.

Gradient

A survey of the stream gradient of the Middle Fork was undertaken in early August. The survey originated about 7,000 ft upstream of the upper exclosure boundary and was run to the confluence with South Fork. The survey encompassed all of the Exclosure and Above Exclosure study areas on the Middle Fork. In the course of the survey, the locations of the study reaches and topographical control features were noted. The resulting profile (Figure 7) showed the Middle Fork to be a relatively uniform channel which tails off sharply at its confluence with South Fork. There is a sharp discontinuity approximately 17,000 ft above the channel mouth which suggests this channel is currently undergoing a gradient adjustment, probably reflecting a lowering of some gradient control in the past. Using the elevation differences at 15% and 85% of channel length, channel slope is calculated as .33% throughout most of the study areas. The channel slope above the discontinuity appears to be similar to that below it, displaying an adjustment of approximately 3 ft. at the discontinuity.

TABLE 12
PRECIPITATION SUMMARY FOR 15-MILE CREEK WATERSHED AREA*

YEAR	MONTH	SQUAW TEATS	MIDDLE	EXCLOSURE
1983	April	0.75	0.85	0.60
	May	1.70	1.25	1.40
	June	3.20	1.75	1.40
	July	0.50	0.75	0.65
	August	1.50	1.05	1.30
	September	0.70	0.30	0.55
	October	0.75	0.60	0.20
	Total	9.30"	6.55"	6.10"
1984	May	0.65	0.40	0.20
	June	1.17	1.36	1.25
	July	0.38	0.70	1.10
	August	0.72	0.16	0.10
	September	1.09	1.62	1.65
	October	0.14	***	0.00
	Total	4.15"	4.24"	4.30"
1985	May	0.40	0.30	0.15
	June	T	0.80	0.90
	July	F	0.35	0.50
	August	1.70	1.15	0.05
	September	***	0.00	0.25
	Total	2.10"	2.70"	2.55"

* - (Note: all figures in inches).

*** - Missing data.

T - Trace.

F - Gage failure.

Table 12. Precipitation summary.

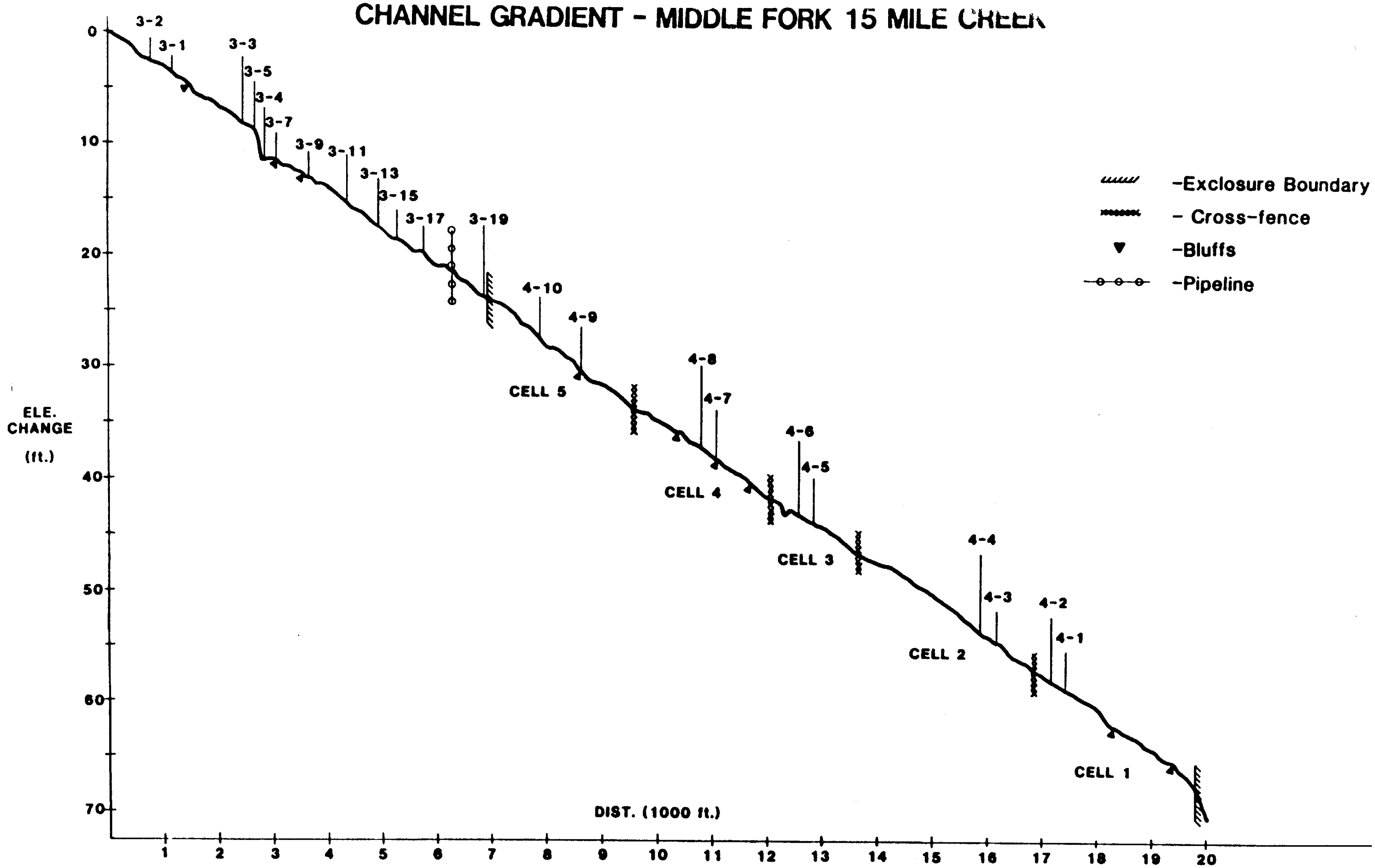


Figure 7. 15 Mile creek, Middle Fork stream gradient.

The stream gradient through the study reaches is summarized in Table 13. Slope through the reaches in the lower cells is very consisent at .003 ft/ft. Channel slope through the reaches in the control cell are higher with the straight secton at .005 ft/ft and the meander at .006 ft/ft. As a whole channel slope in the straight sections is more consistent than the meanders which have reaches containing both the highest and lowest slopes reported.

Bank Soil Texture

Bank soil texture was sampled in 1984 using a design much like that used in root biomass sampling. This sampling pattern develops three transects on either side of a study reach at the low, mid, and upper bank slope positions. Actual sampling points are offset from cross-section centerlines by a fixed distance and direction. Texture analysis was performed by the Bouyukos method. This utilizes a known weight of soil mixed into a known volume of water. Fluid density is monitored at times determined by the theoretical settling rate of various soil particle sizes. Measuring the fluid density at 40 seconds and two hours with a calibrated hydrometer gives a direct reading of the soil remaining in suspension after the sands and silts, respectively, have settled out of the water column. The residual materials in suspension are the clays. Gravels are previously removed by screening and weighed to determine their percentage of sample composition.

Analysis factors included in the ANOVA procedures were 1) study reach, 2) grazing cell, 3) reach form (meander or straight) and 4) meander bank form (concave or convex). Variance analysis indicated that only the clay fraction of the soil composition varied in occurrence by reach and cell at an alpha level of .05. Grouping the data by reach

TABLE 13

CHANNEL SLOPE IN REACH (ft/ft)

FORM	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5
Meander	.003	.003	.002	.004	.006
Straight	.003	.003	.003	.003	.005

Table 13. Channel slope by grazing cell and reach form.

form produced no significant differences at the .05 level. Data grouping by meander concave and convex banks confirmed that the convex banks of the meanders had higher percentages of sand and lower percentages of silt and clay than the concave banks at a .05 alpha level.

SOIL MOISTURE

In evaluating soil moisture measurements over the three year period, 1983-1985, we attempted to identify differences in soil moisture related to 1) position relative to the stream, 2) location in the exclosure (cell) and 3) seasonal variations. The sampling design to monitor these factors had two major elements which were used on both meander and straight reaches (Figure 8). To monitor and characterize the overall area a "full-floodplain" access tube arrangement was used. This employs six tubes that span the floodplain on the study reach, two on the floodplain/upland edge on either side of the valley, two at stream edge on either side, and the two mid points. A more intensive study of the relationship between soil moisture and proximity to the stream was examined utilizing a "near stream" distribution of tubes which consists of three tubes on either side of the stream spaced at three, six, and twelve feet from the bank edge.

All measurements of soil moisture, taken with a neutron soil moisture probe, were recorded in kg/m^3. The analysis unit used was the total moisture content at each tube. A long-term record of probe standards indicates no significant instrument drift over the three years. Although not calibrated to obtain absolute values, the probe values for soil moisture present excellent information on relative changes occurring over time.

The contribution of the stream to soil moisture was examined using tube number (which corresponds to position relative to the stream) and moisture content in an analysis of variance. The data was grouped by tube arrangement ("full-floodplain" and "near-stream") prior to analysis.

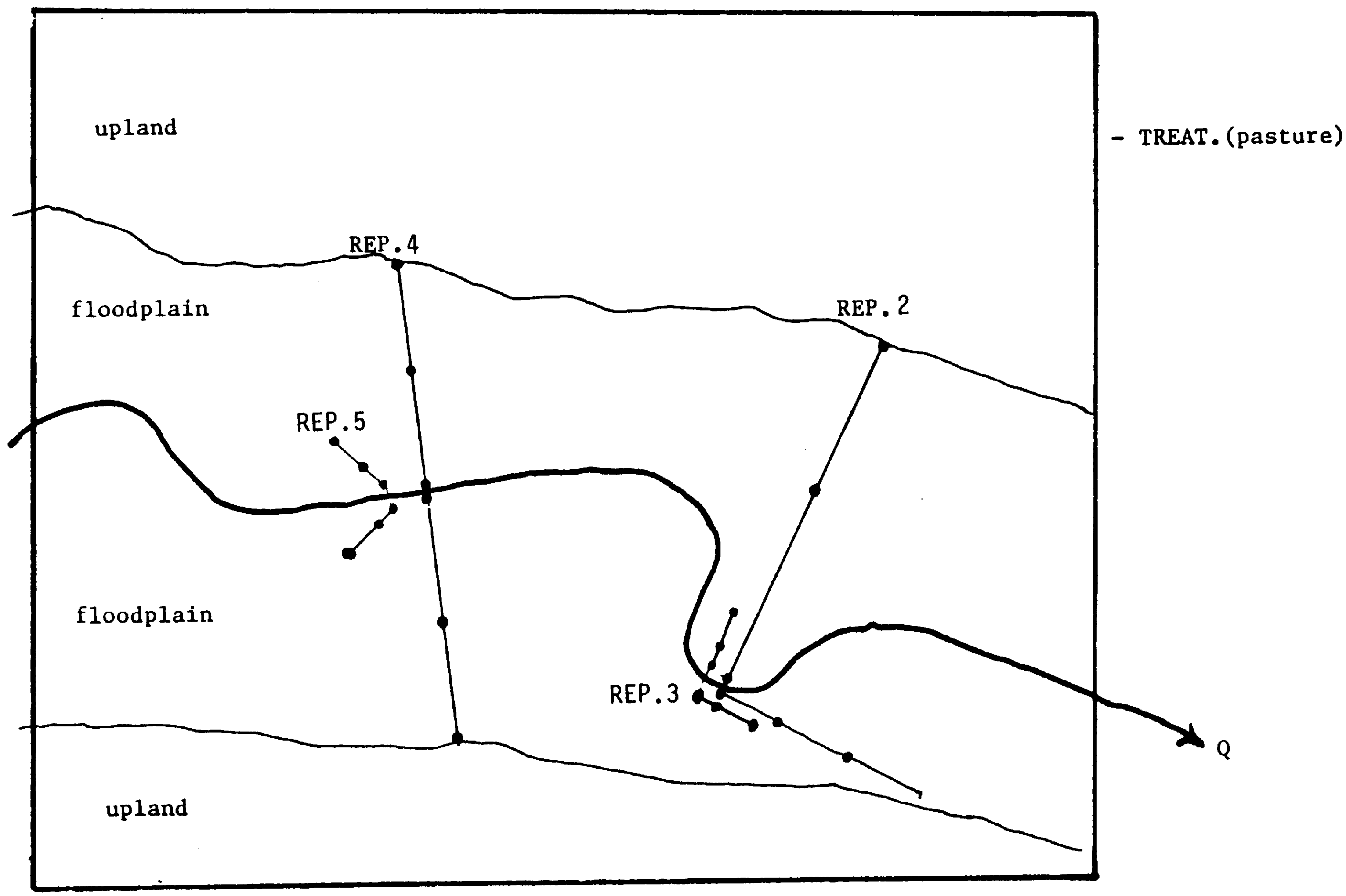


Figure 8. Soil moisture access tube arrangement by cell.

The results indicate that the moisture content of the upper eight feet of soil was enhanced by stream proximity only in 1983, which had frequent stream flow events due to its high precipitation (Table 14). In both 1984 and 1985, no enhancement of soil moisture content was observed. A more surprising result is the identification of the near-stream meander arrangement as consistently displaying the lowest overall soil moisture content of the four tube distributions (Table 15). At present, the only explanation offered in the sandy nature of the soils at these locations, particularly on the meander point bars, which would contribute to poor water storage characteristics. The near-straight tube clusters also tended to have lower soil moisture content, but did not necessarily differ from the full floodplain arrangements at statistically significant levels.

Analyses of variance of soil moisture levels relative to position in the exclosure indicated the control cell to be consistently higher in soil water content than the lower four cells (Table 16). It was noted in 1982 during access tube installation that the locations in cell five were generally wetter, with some free water being encountered in the locations nearest the stream. Additionally, exploration wells drilled in 1983 in cell four located water at a level of 13 to 16 feet while none was found in cell two. This information suggests a condition at the upstream end of the exclosure which forces and/or retains groundwater at levels high enough in the profile to influence soil moisture probe readings, irregardless of grazing activity.

The variation of the soil moisture level in response to the month displayed an expected pattern (Table 17). Soil moisture generally declined as the season progressed. In the two drier years (1984 and

TABLE 14
VARIATION OF SOIL WATER CONTENT (Kg/m^3 BY
RELATIVE POSITION AND YEAR

YEAR	FLOODPLAIN POSITION (TUBE NO.)	MEAN WATER CONTENT
1983	(1) Edge	37.83
	(2) Mid-Left	31.11
	(3) L. Stream	43.39
	(4) R. Stream	39.27
	(5) Mid-Right	30.10
	(6) Edge	34.28
1984	(1) Edge	42.75
	(2) Mid-Left	31.68
	(3) L. Stream	25.70
	(4) R. Stream	28.10
	(5) Mid-Right	23.51
	(6) Edge	21.51
1985	(1) Edge	44.36
	(2) Mid-Left	34.72
	(3) L. Stream	28.07
	(4) R. Stream	29.43
	(5) Mid-Right	23.84
	(6) Edge	23.11

Table 14. Variaion of soil water content by position and year.

TABLE 15
SOIL MOISTURE CONTENT (Kg/m^3) BY TUBE ARRANGEMENT

YEAR	MEAN SOIL MOISTURE (kg/m^3) FULL MEANDER (2)	NEAR MEANDER (3)	FULL STRAIGHT (4)	NEAR STRAIGHT (5)
1983	36.10	28.36	35.65	32.19
1984	27.71	23.14	28.60	25.15
1985	29.45	24.81	30.37	31.78

Table 15. Soil Moisture content by tube arrangement and year.

TABLE 16
SOIL MOISTURE CONTENT (Kg/m^3) BY CELL AND YEAR

YEAR	CELL	MEAN WATER CONTENT
1983	TEST(1)	34.34
	SPRING(2)	28.28
	SUMMER(3)	30.65
	FALL(4)	32.28
	CONTROL(5)	43.47
1984	TEST(1)	28.88
	SPRING(2)	22.42
	SUMMER(3)	24.97
	FALL(4)	25.88
	CONTROL(5)	31.02
1985	TEST(1)	30.18
	SPRING(2)	28.09
	SUMMER(3)	27.50
	FALL(4)	27.31
	CONTROL(5)	34.79

Table 16. Soil moisture content by cell and year.

TABLE 17
SOIL MOISTURE CONTENT (Kg/m^3) BY MONTH AND YEAR

YEAR	MONTH	MEAN WATER CONTENT
1983	May	35.06
	June	33.86
	July	34.59
	August	31.86
	September	33.79
	October	32.32
1984	May	27.50
	June	28.30
	July	24.73
	August	25.41
1985	May	30.66
	June	30.34
	July	28.26
	August	27.67

Table 17. Soil moisture content by month and year.

1985), July appeared to be a critical month, showing an especially sharp drop in soil moisture compared to the previous readings. 1983 was an inordinately wet year and, although there was a trend towards decreasing moisture as the year progressed, it was not as well defined as in the other two years. In fact, analysis of variance procedures did not determine any differences between months at acceptable F levels in the 1983 data.

VEGETATION

Standard vegetation sampling on permanent vegetation transects was undertaken in early July of 1985. Sampling protocol involved estimating standing crop on permanent plots on each transect, and estimating and harvesting the standing crop on temporary plots offset from the permanent transects (double sampling method). Results are based on clipped and estimated plots and are expressed in grams per square meter (gm/m^2).

Middle Fork

Table 18 shows the standing crop of grasses and forbs for three years (1983-85) in three broad landform types on the Middle Fork Channel. Previous to 1984 sampling in the channel was of a preliminary nature and this data is not included. The table displays two production figures for each cell in the floodplain landform class. The first is from the short transects in the floodplain. These are the transects most proximate to the channel running from bank edge to 50 feet out on either side. The second figure is for the long transects in each cell which run from 60 feet out from the bank edge to the floodplain/upland interface.

Overall, vegetation production appeared higher in 1983 than in 1984 and 1985 in both the uplands and floodplains. Comparable data for channel production in 1983 is not available. This production history corresponds well with the precipitation record and with observations by on-site personnel.

In evaluating the productivity of the various landforms, the most productive in terms of grasses and forbs is the channel. The channel is two to seven times as productive as the floodplains or uplands. Within

TABLE 18
MEAN PRODUCTION (g/m^2) BY YEAR

SITE	1983	1984	1985
Upland			
U1	21.48	10.88	11.32
U2	29.20	12.76	15.61
U3	24.09	21.94	14.91
U4	21.35	9.08	9.80
Floodplain +			
F1	9.61/13.53	5.36/22.41	4.68/8.04
F2	7.41/5.58	3.33/4.03	10.83/5.79
F3	12.04/15.26	16.98/8.80	19.18/18.10
F4	30.89/16.87	13.13/6.12	13.80/6.98
F5	28.22/16.01	5.33/8.77	7.30/7.24
Channel			
C1	**	4.194	35.97
C2	**	30.75	24.04
C3	**	51.74	32.92
C4	**	24.67	19.91
C5	**	34.96	26.71

Table 18. Middle Fork mean production (g/m^2) grasses and forbs - 1983-1985.

** no data
+ first no. = channel adjacent / second no. = channel distant

the channel the low slope position, adjacent to the channel floor and characterized by a high incidence of wildryes (Elymus spp), was the most productive zone. As one moves up the bank slope, production generally decreases. Production figures for the upper bank are very similar to those for the near channel floodplain in drier years (Table 19).

Second in production was the upland landform, which is dominated by blue grama (Bouteloua gracilis). Comparisons by cell for this land form indicate it to have the most uniform production of the three types between the cells. The floodplains were generally lowest in grass and forb production of the three landforms. In most cases, near-stream production exceeds that of the areas further from the channel. The only consistant exception to this trend arose in cell one, which had the sections of the floodplains further out from the channel producing more vegetation in all three years.

North Fork

Permanent vegetation transects monitor vegetative standing crop on the three major vegetative types found in the North Fork pastures. These are: 1) seeded grass, 2) shrublands and 3) saline uplands. Table 20 shows the means of the standing crop of grasses and forbs. 1984 is shown to have been a poor year in regards to vegetative production. This again corresponds to low precipitation occurring in the area in that year. 1985 production figures are surprising in that production increased in a year that, based on Middle Fork records, was drier than the preceeding one. In all liklihood, precipitation on the North Fork drainage was probably greater and/or more timely in nature as compared to Middle Fork.

TABLE 19

SITE	BANK POSITION	MEAN PRODUCTION 1984	MEAN PRODUCTION 1985
CI	Upper	7.61	24.66
	Middle	22.33	49.99
	Lower	77.97	48.51
C2	Upper	5.08	16.41
	Middle	15.57	24.59
	Lower	51.53	52.83
C3	Upper	10.15	4.85
	Middle	51.78	38.96
	Lower	65.46	111.55
C4	Upper	16.18	158.04
	Middle	9.68	16.34
	Lower	55.28	43.20
C5	Upper	7.83	10.00
	Middle	20.20	9.95
	Lower	51.83	85.28

Table 19. Standing crop (g/m^2) - channel vegetation - 1984 and 1985.

TABLE 20

MEAN PRODUCTION (g/m^2) BY YEAR

SITE	1983	1984	1985
Shrub			
S1	2.86	0.70	2.25
S2	5.43	2.30	20.85
S3	9.57	4.52	23.68
Upland			
U1	7.03	0.29	14.70
U2	8.32	2.18	12.02
U3	5.80	0.70	17.27
U4	4.38	1.77	22.15
U5	5.34	2.05	20.22
Grass			
G1	166.05	81.70	170.88
G2	50.45	37.00	53.11
G3	115.87	29.50	90.56

Table 20. North Fork mean production (g/m^2) - grasses and forbs - 1983-1985.

The most consistently productive vegetation type over the three year period was the seeded areas. The enhanced productivity stems from the species composition and the benefits derived from the advantageous positioning in the water spreading network. Production on the shrub dominated sites and uplands was lower and roughly equal. These sites are much more variable due to their dependence on local precipitation without the water augmentation of the dike system. An important species in the uplands not included in the grass and forbs in Nuttal Saltbush (Atriplex nuttalli). Production figures for Atriplex are summarized in Table 21. Production is very stable, with no significant differences in standing crop between years.

Belowground Biomass

Because of its vital role in stabilizing channel banks, the response of root biomass to grazing is of particular importance. Additionally, variations in its position and extent can provide insights into morphological responses of the channel. Preliminary sampling of belowground biomass was undertaken on the Middle Fork in 1983. Intensive sampling was begun within the exclosure in 1984 and continued in 1985.

Belowground biomass sampling was performed in 1985 in accordance with the general sampling design described in the 1984 report recapped as follows:

> Three 2.5 inch cores - one each at the upper bank, mid bank, and low bank slope positions - were taken at cross-sections in the study reach. The coring locations were offset a fixed interval from transect center lines to avoid influencing other measurements. This sampling arrangement forms three transects on each bank

TABLE 21

MEAN PRODUCTION (g/m^2) BY YEAR

SITE	1983	1984	1985
U1	8.77	11.96	17.61
U2	10.26	7.14	6.17
U3	14.35	7.28	13.07
U4	20.84	14.49	12.16
U5	18.01	11.15	9.51

Table 21. North Fork mean production - Atriplex nuttalli 1983-1985.

parallel to the stream at the upper, mid, and lower bank slope positions.

In 1985, sampling was somewhat reduced in that the number of observations per sample was lower and samples were only taken in the top 6 inches.

Standard analysis of belowground biomass involves the separation of the gross biotic and mineral fractions of the sample, then ashing the biomass to separate out its mineral component. Initial separation is performed using a root washing technique which utilizes water to separate the components, catching the biomass on screens. The biomass is then oven dried, weighed, ashed at 500° C, and reweighed. The weight difference is the biomass of the sample.

Analysis of variance of the mean root biomass data for 1984 and 1985 (Table 22) indicates that root biomass differed by reach and year at an alpha level of .05 while slope position only narrowly overran the selected alpha level. However, multi-factor analysis indicated the only factor interactions at the alpha = .05 level to be between slope position and year. Results indicate that the mid and upper slope positions experienced a decline in mean belowground biomass in 1985 as compared to 1984, while samples from the low bank position show an increase in mean biomass. This was especially apparent on the less uniformly vegetated meanders.

The lack of significant differences in interactions between year and study reach indicates no grazing related changes in root biomass from 1984 to 1985. Currently, the period of record of root biomass data does not permit the extrapolation of these results to predict long-term or cumulative effects. Additional data would be required to insure that these results are not anomalous.

Table 22. ANOVA, n-way interaction results - mean biomass (g/m^2) by year, slope position, and reach.

FACTOR	MS	MSE	F	Sig.(α)
Year	1.769		4.1	.031
Slope Position	1.129	.360	3.132	.051
Reach	1.388		3.853	.001
Interactions				
YR/slope position	2.003		5.56	.006
YR/Reach	.212		.589	.801
Slope Position/Reach	.552		1.532	.111

LIST OF DATA SUMMARIES AND ANALYSES

The appended list details the data sets and analyses from the 15 Mile Creek project for the summer of 1982 through 1985. Data sets and analysis summaries are on file at the Range Mangement Department and on the University of Wyoming computer systems.

A. Vegetation

1. Vegetation standing crops ($g/m^2 \pm SD$), on floodplain long and short transects, in cells of 15-Mile Creek Middle Fork study area 1985.
2. Vegetation standing crop ($g/m^2 \pm SD$), on channel transects, in cells of 15-Mile Creek Middle Fork study area 1985.
3. Vegetation standing crop ($g/m^2 \pm SD$), on upland transects, in cells of 15-Mile Creek Middle Fork study area 1985.
4. Vegetation standing crop ($g/m^2 \pm SD$), on shrub transects in 15-Mile Creek North Fork study area 1985.
5. Vegetation standing crop ($g/m^2 \pm SD$), on upland transects in 15-Mile Creek North Fork study area 1985.
6. Vegetation standing crop ($g/m^2 \pm SD$), on grassland transects in 15-Mile Creek North Fork study area 1985.
7. Vegetation standing crop ($g/m^2 \pm SD$), on upland transects in cells of 15-Mile Creek Middle Fork study area 1984.
8. Vegetation standing crop ($g/m^2 \pm SD$), on floodplain long and short transects in cells of 15-Mile Creek Middle Fork study area 1984.
9. Vegetation standing crop ($g/m^2 \pm SD$), on channel transects in cells of 15-Mile Creek Middle Fork study area 1984.
10. Vegetation standing crop ($g/m^2 \pm SD$), on grassland transects of 15-Mile Creek North Fork study area 1984.
11. Vegetation standing crop ($g/m^2 \pm SD$), on upland transects of 15-Mile Creek North Fork study area 1984.

12. Vegetation standing crop (g/m^2±SD), on shrubland transects of 15-Mile Creek Middle Fork study area 1983.
13. Vegetation standing crop (g/m^2±SD), on floodplain long and short transects in cells of 15-Mile Creek Middle Fork study area 1983.
14. Vegetation standing crop (g/m^2±SD), on upland transects in cells of 15-Mile Creek Middle Fork study area 1983.
15. Vegetation standing crop (g/m^2±SD), on shrubland transects in 15-Mile Creek North Fork study area 1983.
16. Vegetation standing crop (g/m^2±SD), on grassland transects in 15-Mile Creek North Fork study area 1983.
17. Vegetation standing crop (g/m^2±SD), on upland transects in 15-Mile Creek North Fork Study area 1983.
18. Vegetation standing crop (g/m^2±SD), on floodplain long and short transects in cells of 15-Mile Creek Middle Fork study area 1982, base line year.
19. Total vegetation standing crop (g/m^2±SD), on channel transects in cells of 15-Mile Creek Middle Fork study area 1984 and 1985.
20. Root biomass (g/m^2) 15-Mile Creek Middle Fork study area, stream channel transects 1984.
21. Root biomass (g/m^2) 15-Mile Creek Middle Fork study area, stream channel transects 1985.
22. (Comparisons between reaches, cells, meander-straights, and banks 1-Way Anovas) for root biomass (g/m^2) 15-Mile Creek Middle For study area, stream channel transects 1984 and 1985.
23. Simultaneous comparisons cells x reaches, cells x years, meanders x years, straights x years (2-Way Anovas) for root biomass (g/M^2 surface 15 cm) Creek Middle Fork study area, stream channel transects 1984 and 1985.

24. Simultaneous comparisons of year x reach x bank x slope position with interactions (N-Way Anovas) of root biomass 15-Mile Creek Middle Fork study area, stream channel transects 1984 and 1985.

25. Continualtion (N-Way Anovas) root biomass, 15-Mile Creek Middle Fork study area, stream channel transects 1984 and 1985.

26. Shrub density (individuals/100ft^2) of channel transects, 15-Mile Creek Middle Fork study area, stream channel transects 1984 and 1985.

27. Soil particle size distribution (% gravel, % sand, silt, clay without gravel) for stream channel reaches 15-Mile Creek Middle Fork study area 1984.

28. Comparisons between reaches, cells, meander-straight, concave-convex bank (1-Way Anova) of soil particle size distribution for stream channel reaches 15-Mile Creek Middle Fork study area 1984.

29. Correlation coefficients for selected shrub species and total stem density with soil texture components 15-Mile Creek Middle Fork study area.

B. Livestock Grazing Distribution

1. Percent of animals observed in channel, first terrace and upland habitats in large allotments encompassing Middle Fork and main channel of 15-Mile Creek, Spring-Fall 1982-1985.

2. Percent of animals observed in various activities (e.g., feeding, traveling, resting) in large allotments, Spring-Fall, 1982-1985.

3. Percent of animals observed in channel, first terrace and upland habitats in Spring, Summer and Fall grazing cells of Middle Fork study area, 1984-1985.

4. Percent of animals observed in various activities (feeding, traveling, resting) in habitats in Spring. Summer and Fall cells of Middle Fork study area, 1984-1985.
5. Analysis of variance and T-tests comparing season of grazing and preferences for habitats in Middle Fork grazing cells.
6. Percent of animals in habitats and in activities in relation to length of time in stocking rate pastures on North Fork 15-Mile Creek, 1984-1985.
7. Analyses of variance and T-tests comparing habitat selection and activity as stocking pressure increases in North Fork pastures.
8. Utilization levels of potential forage species in Spring, Summer and Fall grazing cells on Middle Fork study area, 1983-1985.
9. Analysis of variance comparing utilization between seasons and between plant species in Middle Fork study area.
10. Crude protein and succulence of potential forage species in Spring, Summer and Fall grazing periods in Middle Fork study area, 1984-1985.
11. Analysis of variance comparing crude protein and succulence between seasons and between species in Middle Fork study area.
12. Utilization, crude protein and succulence of potential forage species at intervals during grazing periods in North Fork 15-Mile Creek stocking rate pastures.
13. Analysis of variance of utilization, crude protein and succulence of forage species comparing habitats, species, and time in grazing period.

C. Morphology/Hydrology

1. Mean channel depth - 1 way ANOV area mean depth by year

2. Mean channel depth - 1 way ANOV study area reach mean depth changes by year.
3. Channel x-section area - 1 way ANOV's
   - study area mean x-sect, area by year
   - reach x-sect. changes by year
   - study area x-sect. changes by year
4. Common point depth changes: 1983-84, 1984-85, 1983-85, 1 way ANOV's.
   - bank section mean depth change by grazing treatment
   - bank section mean depth change by reach form
   - variances of bank section depth changes by grazing treatment
   - variances of bank section depth changes by reach form
5. Bank angle - 1 way ANOV's
   - changes in angle (calc.) by grazing treat.
   - change in angle (calc.) by reach
   - change in angle (meas.) by grazing treat.
   - change in angle (meas.) by time
6. Interim bank interval width changes - 1 way ANOV's
   - changes in width by grazing treat.
   - changes in width by reach
7. Soil moisture (total) - 1983, 1984 & 1985 - 1 way ANOV's
   - water content by grazing treatment
   - water content by tube arrangement
   - water content by tube position (relative to stream)
   - water content by time
8. Precipitation - yearly summaries 1983, 1984 & 1985
9. Stream gradient - 1985 Middle Fork profile

10. Extended cross-section surveys (1983-84) - 1 way ANOV
    - x-sectional area by grazing treat.
11. Permanent photo-point surveys - 1983 to 1985 - annual record
12. Low-level aerial photographs-Middle Fork and North Fork, 15 Mile Creek.

APPENDIX: 1
BUDGET SUMMARY

The attached summary sheet from the UW Financial Records System shows the project account balence as of January 1986. The records do not reflect subsequent commitments for travel, mileage and salaries. Operating budget for the 1986 field season prior to July 1 will be adequate to cover travel costs for essential crew.

DATE RUN 02/06/86
TIME RUN 17:32:17
FB4090 - A1

UNIVERSITY OF WYOMING
FINANCIAL RECORDS SYSTEM
STATEMENT OF ACCOUNT FOR 01/31/86
REPORT DESTINATION = 10008

REPORT PAGE 1137
PROGRAM ID FBM092
ACCOUNT PAGE 1

ACCT: 5-38689
DEPT: 00208 RANGE MANAGEMENT

WY DEQ EFFECT OF SELECTED GRAZING TREAT SKINNER

TO: SKINNER
AG BLDG

START	END-DT	IC RATE1	IC BASE1	IC RATE2	IC BASE2	TECH-DT	FISC-DT	INVT-DT	RNWL-DT	PRIOR FISC YR	ORIG AWD AMT
030182	063086	20.0	2	AIC		000000	000000	000000	000000	202,936.11	284,800.00

SUB CODE	DESCRIPTION	BUDGETS ORIGINAL	BUDGETS REVISED	ACTUAL CURRENT MONTH	ACTUAL FISCAL YEAR	ACTUAL PROJECT YEAR	OPEN COMMITMENTS	BALANCE AVAILABLE	PERC USED
0999	ABR POOL 2 EXPEND	114,361.17	26,780.85					26,780.85	0
1220	FT STAFF-PROF		18,528.00	1,544.00	10,808.00	10,808.00	7,720.00		100
1230	PT STAFF-GENERAL		2,488.58			2,488.58			100
1240	PT-STUDENTS		4,559.54		2,839.54	4,559.54			100
1401	GRADUATE ASSISTANTS		20,025.00	1,890.00	9,450.00	14,985.00	5,040.00		100
1901	BENEFITS-STATE RET		814.94	116.42	814.94	814.94			100
1902	BENEFITS-SOC SEC		937.70	110.40	763.50	937.70			100
1906	BENEFITS-HEALTH INS		673.46	102.00	600.00	673.46			100
1909	BENEFITS-LIFE INS		45.78	6.54	39.24	45.78			100
	PERSONAL SERVICES		48,073.00	3,767.36	25,315.22	35,313.00	12,760.00		100
2021	OTHER EQUIP REPAIRS		363.75			363.75			100
2074	REGISTRATION/CONF		215.00		130.00	160.00	55.00		100
2102	PHOTOGRAPHY		26.40		26.40	26.40			100
2203	COPY CHARGES		120.18		38.50	120.18			100
2204	PHOTO/MICROFILM SUP		310.23		31.99	310.23			100
2205	OTHER OFFICE SUPPL		347.51		134.75	347.51			100
2270	EDUC & INSTR SUPPL		4,876.95	145.00	186.52	4,876.95			100
2277	BOOKS		44.87		40.37	44.87			100
	SUPPORTIVE SERVICES		6,304.89	145.00	588.53	6,249.89	55.00		100
3003	TIS-PER DIEM-STAFF		4,641.65	56.00	2,685.26	4,391.65	250.00		100
3011	TIS-PER DIEM-GUEST		13,277.45	228.25	3,336.97	13,277.45			100
3012	TIS-OTHER FEES-GUEST		1,040.60			1,040.60			100
3101	TOS-COM CARR-STAFF		20.00		20.00	20.00			100
3104	TOS-PER DIEM-STAFF		387.63		387.63	387.63			100
3112	TOS-MLG PD-GUEST		215.88			215.88			100
	TRAVEL		19,583.21	284.25	6,429.86	19,333.21	250.00		100
9212	LITERATURE		1,200.00			1,200.00			100
9535	INDIRECT COST-FED-UW		12,419.22	839.32	6,466.72	12,419.22			100
	NET ACCOUNT TOTAL	114,361.17	114,361.17	5,035.93	38,800.33	74,515.32	13,065.00	26,780.85	76