INTRODUCTION

In 1961, the cooperative watershed management research program in the Lower Conifer Zone of California was started. Research in the Lower Conifer Zone was designed to obtain information and develop principles to give greater insight into the effect of land management in the Zone upon water quality, floods and sedimentation, water timing, and water yield. The research was conducted by the Pacific Southwest Forest and Range Experiment Station of the U. S. Forest Service with the cooperation of the State of California, Department of Water Resources, and the Division of Forestry. In 1964, the Station entered into a cooperative agreement with the Humboldt State College for joint research on the Caspar Creek Study.

In early 1966, the orientation of the Project's research effort was modified to some extent to give added emphasis to problems associated with floods and sedimentation. Studies concerning water yield which were currently under way, however, are being continued until a logical point of termination is attained.

The current research effort of the Project is enhanced a great deal through cooperative agreements with several agencies. The State of California, Department of Water Resources provides funds and technical guidance for the conduct of all phases of the Project's research program. The Department of Conservation, Division of Forestry, Jackson State Forest conducts the field work for Caspar Creek study. The East Bay Municipal Utilities District provides the use of their land for portions of the study of transmission of solar radiation and for the mass movement study. The University of California at Berkeley provides computer facilities and technical guidance.

This Progress Report will discuss new installations and analysis of data not reported in the three previous Progress Reports.

CASPAR CREEK STUDY

Robert B. Thomas

This study is designed to determine the effects of logging and road building practices on streamflow, sedimentation, and fish life and aquatic habitat in the second growth Redwood-Douglas-fir forest type. The study is located along the North and South Forks of Caspar Creek within the Jackson State Forest near Ft. Bragg (fig. 1). This area is under intensive management by the State Department of Conservation, Division of Forestry.

Instrumentation and technical guidance is provided by the Pacific Southwest Forest and Range Experiment Station of the U. S. Forest Service. Virtually all of the field work is done by personnel of the State of California Division of Forestry located at Ft. Bragg.

The study is planned in three stages. The calibration stage will allow comparison of the characteristics of the two watersheds and will be followed by construction of the major road network required in the South Fork for the logging operation. There will then be several years of record collection to allow evaluation of the effects of road building alone. At the end of this period, the South Fork drainage will be logged and the effects measured. The North Fork will be the control watershed. The study is now nearing the end of the calibration period. (For a more complete description of the study, we refer the reader to the 1963-.64 Progress Report.)

Continuous streamflow and rainfall records have been collected since November 1962, along with suspended sediment samples and annual estimates of bed-load production.

Activities in 1966

Streamflow. Streamflow records are complete for both forks for water year 1966 except for the period from June 8 to July 27, 1966 in the South Fork when the basin was emptied for sediment removal (tables 1 and 2). Total streamflow for water year 1966 was consider ably below that for 1965, but the highest mean daily flows recorded in this study occurred on January 4, 1966.

There is a correction to the 1964 water year streamflow data reported in the 1965 Progress Report. The mean daily flows on February 29, 1964 for the North and South Forks respectively are 0.6756 and 0.5734 cubic ft./sec. (c.f.s.). The annual totals are not affected by this error.

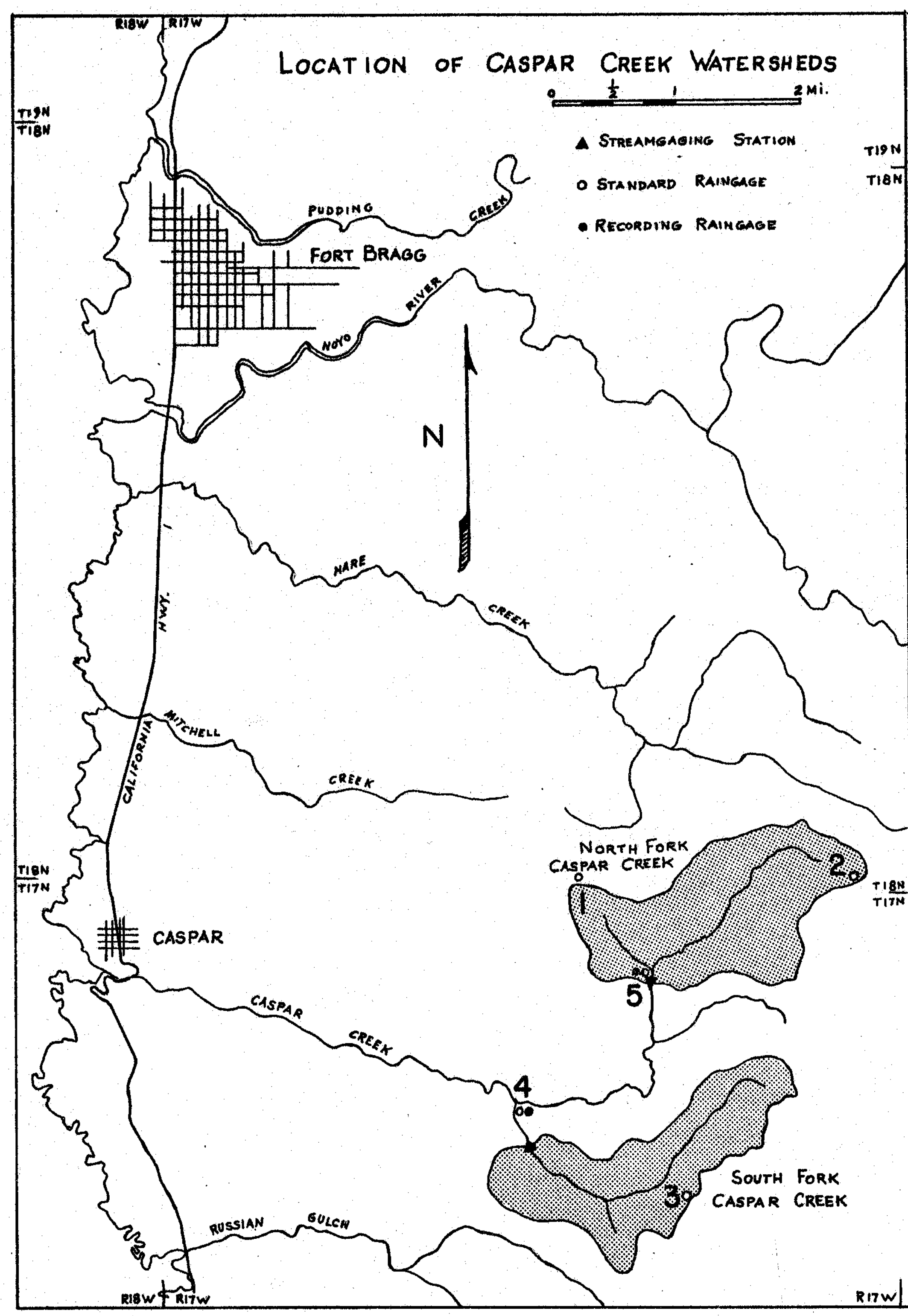

Figure 1.--Map of Caspar Creek area.

TABLE 1

NORTH FORK CASPAR CREEK

DAILY MEAN FLOW IN CUBIC FT./ SEC. WATER YEAR OCTOBER 1965 THROUGH SEPTEMBER 1966

DATE	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.
1	0.0627	0.0508	0.8726	5.6477	6.4686	4.5115	1.2331	0.6616	0.3477	0.1731	0.0931	0.0605
2	0.0596	0.0504	0.7008	4.5116	7.1914	3.5944	1.1578	0.6542	0.3401	0.1715	0.0874	0.0691
3	0.0541	0.0507	0.5948	21.1434*	5.6112	2.7767	1.1006	0.6443	0.3350	0.1663	0.0853	0.0692
4	0.0543	0.0662	0.5109	211.0830*	7.1701	2.3757	1.0470	0.6338	0.3258	0.1637	0.0838	0.0669
5	0.0679	0.0596	0.4625	108.4063*	9.2347	2.1430	1.0247	0.6165	0.3239	0.1580	0.0822	0.0632
6	0.0605	0.0608	0.4291	42.2627	12.9832	2.0447	0.9885	0.6165	0.3290	0.1561	0.0794	0.0600
7	0.0638	0.6990	0.4071	18.1183	12.2454	2.0512	0.9536	0.5864	0.3272	0.1598	0.0775	0.0561
8	0.0658	0.4975	0.3854	11.3000	8.0523	2.2051	0.9140	0.5973	0.3090	0.1574	0.0764	0.0518
9	0.0655	0.2165	0.3730	8.0869	5.3375	11.2952	0.9185	0.6001	0.3034	0.1532	0.0738	0.0469
10	0.0663	0.1600	0.3472	6.2347	3.9628	25.4451	1.5055	0.5946	0.3080	0.1493	0.0699	0.0466
11	0.0982	0.1685*	0.3363	4.7146	3.0249	14.2497	3.1417	0.5493	0.2993	0.1472	0.0687	0.0451
12	0.0723	0.7450	0.3330	3.6391	2.4919	8.7549	6.2853	0.5247	0.2748	0.1493	0.0731	0.0443
13	0.0768	1:8485	0.3105	2.9654	2.0904	7.1802	4.6130	0.5068	0.2566	0.1602	0.0760	0.0443
14	0.0821	1.6816	0.2909	2.4339	1.8584	6.2643	3.4369	0.4916	0.2463	0.1576	0.0771	0.0437
15	0.0787	0.9334	0.2756	2.1193	1.6611	5.9047	2.7177	0.4829	0.2340	0.1422	0.0776	0.0429
16	0.0772	0.5435	0.2687	1.8640	1.4830	5.9883	2.2499	0.4719	0.2290	0.1330	0.0736	0.0424
17	0.0720	0.8606	0.2561	1.6293	1.3837	5.7985	1.9487	0.4524	0.2296	0.1261	0.0668	0.0423
18	0.0716	3.5965	0.2510	1.4913	1.3789	5.2866	1.7217	0.4344	0.2215	0.1222	0.0625	0.0634
19	0.0771	4.4271	0.2413	1.3472	3.6491	4.6724*	1.4652	0.4184	0.2139	0.1215	0.0598	0.0524
20	0.0779	1.6974	0.2317	1.2007	3.1333	3.9077*	1.2311	0.4163	0.2102	0.1192	0.0596	0.0548
21	0.0794	0.9118	0.2316	1.0916	2.7895	3.4993	1.1217	0.4159	0.2086	0.1151	0.0599	0.0551*
22	0.0760	0.6153	0.2252	1.1516	2.8057	3.1013	1.0283	0.4102	0.2118	0.1109	0.0611	0.0534*
23	0.0698	1.0410	0.2155	1.0709	2.9421	2.6998	0.9455	0.3939	0.2139	0.1051	0.0618	0.0519*
24	0.0653	6.9383	1.0957-	1.0013	5.4484	2.3516	0.8726	0.3853	0.2097	0.0987	0.0604	0.0498*
25	0.0600	7.3333	1.4535	0.9428	8.2583	2.0822	0.8370	0.3849	0.1981	0.0960	0.0596-	0.0482*
26	0.0557	5.6901	1.1774	0.8848	10.1156	1.8473	0.8144	0.3917	0.1937	0.0929	0.0596	0.0461*
27	0.0519	4.0716	0.9557	0.8402	8.0778	1.7297	0.7863	0.3877	0.1856	0.0906	0.0575	0.0446*
28	0.0516	2.7930	13.6352	0.7758	5.8925	1.6189	0.7478	0.3823	0.1833	0.0919	0.0565	0.0427*
29	0.0516	1.7848	15.5295	2.3614		1.5118	0.7082	0.3818	0.1798	0.0954	0.0544	0.0412*
30	0.0516	1.2127	8.7807	3.1506		1.4107	0.6747	0.3876	0.1751	0.0970	0.0589	0.0398
31	0.0513		6.6193	2.9250		1.3289		0.3758		0.0975	0.0596	
MEAN	0.0667	1.6935*	1.8644	15.3676*	5.2408	4.8268*	1.6064	0.4920	0.2541	0.1315	0.0694	0.0513*
ACFT	4.102	100.771*	114.640	944.915*	291.058	296.788*	95.586	30.250	15.122	8.088	4.270	3.052*

TOTAL RUNOFF IN ACRE-FEET 1908.642

THE ABOVE DATA IS ACCURATE TO THREE SIGNIFICANT FIGURES ONLY

* FIGURES BASED ON ESTIMATED DATA.

TABLE 2

SOUTH FORK CASPAR CREEK

DAILY MEAN FLOW IN CUBIC FT./ SEC.   WATER YEAR OCTOBER 1965 THROUGH SEPTEMBER 1966

DATE	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.
1	0.0780	0.0766	0.7115	5.9352	8.9405	3.2677	0.9337	0.5866	0.3395*	0.2193*	0.1222*	0.1003
2	0.0755	0.0771	0.5658	3.8551	7.4212	2.5519	0.8811	0.5812	0.3402*	0.2157*	0.1217	0.0962
3	0.0766	0.0764	0.4829	18.0854	4.8828	1.9731	0.8428	0.5795	0.3329	0.2106*	0.1226	0.0897
4	0.0792	0.1168	0.4159	192.9665*	6.6134	1.7119	0.8043	0.5691	0.3270	0.2068*	0.1186	0.0875
5	0.1273	0.0926	0.3749	83.0375	7.9600	1.6032	0.8043	0.5512	0.3289	0.2034*	0.1149	0.0864
6	0.1027	0.0855	0.3516	31.1125	11.2591	1.5760	0.8023	0.5545	0.3361	0.1999*	0.1139	0.0864
7	0.0975	0.9859	0.3330	11.9599	9.6973	1.7660	0.7836	0.5334	0.3254	0.1965*	0.1093	0.0875*
8	0.0950	0.5519	0.3110	8.0265	5.7653	1.9333	0.7349	0.5427	0.3132*	0.1932*	0.1053	0.0826
9	0.0969	0.2019	0.2975	6.1984	3.6238	10.9684	0.7592	0.5434	0.3099*	0.1898*	0.0989	0.0768
10	0.0991	0.1563	0.2745	4.5717	2.6757	20.9999	2.3558	0.5394	0.3055*	0.1865*	0.0983	0.0769
11	0.0978	0.1485	0.2701	3.2779	2.0152	9.3434	5.6264	0.5076	0.3011*	0.1833*	0.1024	0.0743
12	0.0925	0.9952	0.2664	2.4912	1.6561	5.4494	10.1048	0.4837	0.2967*	0.1800*	0.1069	0.0719
13	0.0898	2.6174*	0.2489	1.9956	1.4103	5.3251	5.4107	0.4682	0.2924*	0.1755*	0.1092	0.0757
14	0.1095	2.8141*	0.2327	1.6443	1.2649	5.0500	3.4750	0.4492	0.2881*	0.1721*	0.1132	0.0750
15	0.1062	1.8766*	0.2201	1.4364	1.1410	4.8631	2.5081	0.4418	0.2839*	0.1690*	0.1086	0.0698
16	0.0921	1.0610*	0.2143	1.2583	1.0279	5.5587	1.9723	0.4326	0.2877*	0.1659*	0.0994	0.0681
17	0.0856	1.2909*	0.2134	1.0936.	0.9751	5_3697	1.6276	0.4228	0.2782*	0.1629*	0.0973	0.0684
18	0.0914	4.6023	0.2105	1.0078	0.9898	4.3517	1.4225	0.4174	0.2714*	0.1599*	0.0914	0.1177
19	0.1070	4.4251	0.2009	0.9165	6.6485	3.6214	1.1887	0.4055	0.2673*	0.1569*	0.0913	0.0956
20	0.1018	1.4989	0.1963	0.8304	4.8118	2.8812	1.0055	0.4049	0.2632*	0.1540*	0.1014	0.0844
21	0.0977	0.9146	0.1961	0.7707	3.4929	2.5010	0.9236	0.4034	0.2592*	0.1511*	0.1077	0.0767
22	0.0902	0.8576	0.1909	0.8355	3.0949	2.1822	0.8642	0.3955	0.2553*	0.1482*	0.1087	0.0738
23	0.0819	1.6532	0.1829	0.7777	3.7485	1.8925 .	0.7876	0.3809	0.2496*	0.1441*	0.1030	0.0733
24	0.0761	8.1113	1.2955	0.7278	8.7580	1.6433	0.7382	0.3794	0.2455*	0.1411*	0.0970	0.0746*
25	0.0717	9.0765	2.4347	0.6961	10.3048	1.4572	0.7185	0.3898	0.2416*	0.1384*	0.0944	0.0713*
26	0.0681	6.4534	1.5728	0.6631	10.7633	1.3160	0.6962	0.3939	0.2378*	0.1357*	0.0922	0.0677*
27	0.0681	5.2968	1.1501	0.6321	6.7064	1.2440	0.6629	0.3858	0.2340*	0.1330*	0.0879	0.0642*
28	0.0686	2.9468	24.6310	0.5953	4.7257	1.1815	0.6373	0.3760	0.2303*	0.1345	0.0861	0.0608*
29	0.0732	1.6509	17.1197	3.2199		1.1087	0.6121	0.3752	0.2266*	0.1374	0.0851	0.0565*
30	0.0755	1.0337	8.2801	3.7951		1.0527	0.5925	0.3809	0.2229*	0.1377	0.0929	0.0535
31	0.0755		8.5536	3.0953		0.9902		0.3669*		0.1300	0.0999	
MEAN	0.0887	2.0582*	2.3226	12.8229*	5.0848	3.7656	1.7092	0.4594*	0.2831*	0.1688*	0.1033*	0.0781*
ACFT	5.452	122.471*	142.809	788.447*	282.396	231.539	101.706	28.250*	16.843*	10.378*	6.351*	4.648*

TOTAL RUNOFF IN ACRE-FEET   1741.290

THE A80VE DATA IS ACCURATE TO THREE SIGNIFICANT FIGURES ONLY

* FIGURES BASED ON ESTIMATED DATA.

During the past year, Donald Seegrist, a biological statistician with the Station, reviewed the correlation between the mean daily flows in the North and South. Forks. The following remarks report his work:

We want to develop a prediction equation for the mean daily flow in the South Fork, y_t, from the mean daily flows in the North Fork. The annual hydrographs for the two forks indicate that the daily flows in the South Fork rise and delete faster than the daily flows in the North Fork as a result of a storm. Therefore we used as independent variables the mean daily flows in the North Fork for the same day x_t, the previous day x_{t-1}, and two days previous x_{t-2}. We also included the squares and cross products of the x_t's.

Our model is:

$$y_t = a + b_1 x_t + b_2 x_{t-1} + b_3 x_{t-2} + b_4 x^2_t$$
$$+ b_5 x^2_{t-1} + b_6 x^2_{t-2} + b_7 x_t x_{t-1}$$
$$+ b_8 x_t x_{t-2} + b_9 x_{t-1} xt_{-2}.$$

With a little less than 3 complete water years we had 1051 observations on the daily flows in the two forks. The estimate of the constant term was a = -0.00044 c.f.s. The estimated regression coefficients, in the order that they entered the stepwise regression, are:

$b_1 = 1.27417$
$b_2 = -0.39659$
$b_4 = -0.00060$
$b_5 =$ 0.0o658
$b_8 = 0.00214$
$b_6 = 0.00307$
$b_9 = -0.00537$
$b_7 = -0.00415$
$b_3 = 0.01932$

The correlation, between y_t and x_t is 0.98120. The correlation drops to 0.74284 for y_t and x_{t-1}, and to 0.526 for y_t and x_{t-2}. The correlation between y_t and x^2_t was 0.84626. The correlation between y_t and each of the remaining dependent variables ranged from 0.742 to 0.391.

The proportion of the variance in y_t accounted for by regressing on the independent variables was $R^2 = 0.9929$. The standard error about the regression line was 0.98621 c.f.s. The average of the 1051 mean daily flows was 2.95 and 2.60 c.f.s. in the South and North Forks respectively.

In order to have a valid estimate of the error in regression, the residuals from the regression line must be independent of each other. It is obvious that the original observations y_t, y_{t+1}, y_{t+2}, etc. are highly correlated among each other. This is called serial correlation. One of the reasons for choosing the particular set of independent variables was to introduce independence among the residuals. The Durbin-Watson statistic, which is used to test for serial correlation, was calculated and we accept the hypothesis that the first-order serial correlation among the residuals is 0. We apparently have a valid estimate of the error of regression.

The error of the regression (Sy.x) is the square root of the sum of the deviations squared divided by the degrees of freedom. A deviation is the observed value of y_t minus the predicted value y^*_t. The estimated error of our regression is 0.98621 c.f.s. We have a 95 percent confidence that a future mean daily flow (Y'_t) for a water year of 365 days will be within 4 percent of the predicted flow (y^*_t). A confidence interval of ± 0.04 (y^*_t) seems well within the expected increase in mean daily flow in the South Fork following logging. We feel we have calibrated the North and South Fork of Caspar Creek in terms of mean daily flows.

As mentioned above, the flows in the South Fork change faster during a storm than the flows in the North Fork. With minor modifications of the existing streamflow program, we can find the length of time-between start of rise to the peak-in both forks. Also, we will find the correlation between these times, and the correlation between peak flows, for individual storms.

<u>Precipitation</u>. The precipitation network (fig. 1) was not altered during the year. We have complete records from the North and South Fork intensity gages (tables 3 and 4), and from the five non-recording gages.

<u>Sedimentation</u>. As reported in the 1965 Progress Report, the North Fork sediment basin was cleaned out in early summer 1965. The estimate of debris removed, based on a count of dump-truck loads required, was 2,502 cubic yards. The volume was also

Table 3 -- DAILY PRECIPITATION AT CASPAR CREEK STATION 4

October 1965 - September 1966

(All entries in inches)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1				0.91	0.06							
2				0.87		0.13						
3				1.70	0.60							
4	0.22	0.21		4.91	0.38	0.23						
5	0.05			0.78	0.38	0.03		0.09				
6				0.09	0.48	0.33						
7		1.86		0.03		0.06						
8		0.02		0.37		0.24						
9						0.90	0.20					
10		0.05	*	0.01	0.10		1.35					
11		0.22	*		*		0.68					
12		1.00	*		*	0.47	0.07					
13		1.10	*		*	0.04						
14	0.17	0.60	0.10*		0.04*	0.14						
15		0.01				0.37						
16						0.25						
17		0.96										
18		0.98				0.30						0.18
19	0.08	0.07			0.38	0.05						0.13
20					0.68							
21				0.01		0.05						
22				0.25	0.41							
23		1.28	0.03		0.37							
24		o.66	1.33.		0.48							
25		0.73	0.15		0.54							
26		0.41										
27			0.02									
28			2.50									
29			0.20	1.34								
30			0.47	0.25							0.12#	
31			0.16	0.08								
Monthly Totals	0.52	10.16	4.96	10.69	5.75	3.65	2.30	0.09	0.00	0.00	0.12#	0.31

Total Annual Precipitation 38.55 inches

* Indicates missing record - value at last* is total for period
# Indicates a total in question due to missing record

Table 4 -- DAILY PRECIPITATION AT CASPAR CREEK STATION 5
October 1965 - September 1966
(All entries in inches)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1					0.83	0.05						
2				0.92		0.12						
3				2.07	0.67							
4	0.22	0.21		5.94	0.56	0.22						
5	0.05			1.01	0.40	0.05		0.11				
6				0.13	0.48	0.35						
7		2.15		0.04		0.05						
8		0.06		0.37		0.34						
9					0.03	1.54	0.19					
10		0.08	*	0.02	0.06		1.33					
11		0.18	*		*		0.78					
12		1.29	*		*	0.51	0.09					
13		1.16	*		*	0.04						
14	0.21	0.58	0.11*		0.04*	0.13						
15		0.01				0.50						
16						0.08						
17		1.12										
18		1.37				0.30						0.11
19	0.15	0.07#			0.33	0.10						0.26
20		*			0.81	0.02						
21		*		0.01#		0.08						
22		*		0.24*	0.42							
23		*			0.36							
24		2.20*	1.51		0.54							
25		0.60	0.10		0.54							
26		0.42										
27			0.03									
28		2.50	0.01									
29		0.23	1.32									
30		0.42	0.30								0.12	
31		0.24	0.12									
Monthly		#		#								
Totals	0.63	11.50	5.14	12.50	6.07	4.48	2.39	0.11	0.00	0.00	0.12	0.37

Total Annual Precipitation 43.31 inches

* Indicates missing record - value at last * is total for period

# indicates a total in question due to missing record

estimated by the surveying procedure which measures changes in the sediment surface between surveys. This latter estimate was 2,697 cubic yards which is within 8 percent of the former figure. During the summer of 1966, the California Division of Forestry removed sediment accumulation in the South Fork in a similar manner. The survey estimate of debris removed was 1,130 cubic yards. No estimate of volume by dump-truck loads was made.

Sediment deposition was not reported in the 1965 Progress Report, so we have included a summary of sedimentation for the entire study to date in this report (table 5).

The collection of hand and fixed suspended sediment samples has continued as before.

Table 5 - Summary of Sediment Deposition and Removal in the Caspar Creek Basins

Watershed	Water year	Total Sediment (cu.yds.)	Sediment (cu.yds./ sq. mile)	Cumulative Total (cu. yds.)	Sediment Removed (cu.yds.)
North Fork					
(1.92 sq.mi.)	1963	122	64		
	1964	132	69		
	1965	1317	686	1571	2697
	1966	1521	793		
South Fork					
(1.63 sq.mi.)	1963	141	87		
	1964	73	45		
	1965	365	224		
	1966	314	193	893	1130

STREAM ECOLOGY PHASE OF THE CASPAR CREEK STUDY

John W. DeWitt (Humboldt State College)

Emphasis in July, August, and September was on the measuring of stream and air temperature and solar radiation along both the South and North Forks of the Caspar Creek. In addition, the detailed South Fork stream bed map, prepared in 1965, was field checked for accuracy and stream bed and bank changes were noted; numerous photographs of stream sections and floral canopy were taken; the make-up of both forks in terms of the proportions of dry, pool, riffle, and "run" areas was measured; quantitative sampling of insects dropping to the water surface was continued; and preliminary work on establishing "standard" bottom aggregate types for benthos sampling as well as other work was undertaken.

Little field work was done after September. The principal office and laboratory work done from October to December included: compilations and calculations of radiation meter chart data; compilations and calculations of thermograph chart data; and routine keying and enumeration of insects taken in "drop-box" collectors. One of the most conspicuous effects of the logging to be done along the North Fork may be reduction in the floral canopy over the stream. Based on the light available in the general area (hillside station data) it is obvious that the amount of light reaching and being absorbed in the stream could be markedly increased by canopy removal.

Such increased light absorption in the stream could, of course, have greatly significant effects on the ecology of the stream.

The approximate proportions of dry, pool, riffle, and "run" areas in the study areas in both forks, measured using tentative criteria, were as follows in September, 1966:

		North fork (6000-foot stretch)-	South fork (7700-foot stretch)-
dry	-	19 (percent)	13 (percent)
pool	-	14 "	24 "
riffle	-	33 "	25 "
run	-	34 "	38 "

Mr. James Andrews, student, was employed full-time on the project from July 1 to about September 15, and about one-third time from September .15 to December 31. A small additional amount of student assistance was utilized. Project supervision was passed back to John DeWitt from Richard Ridenhour on October 20.