



United States
Department of
Agriculture

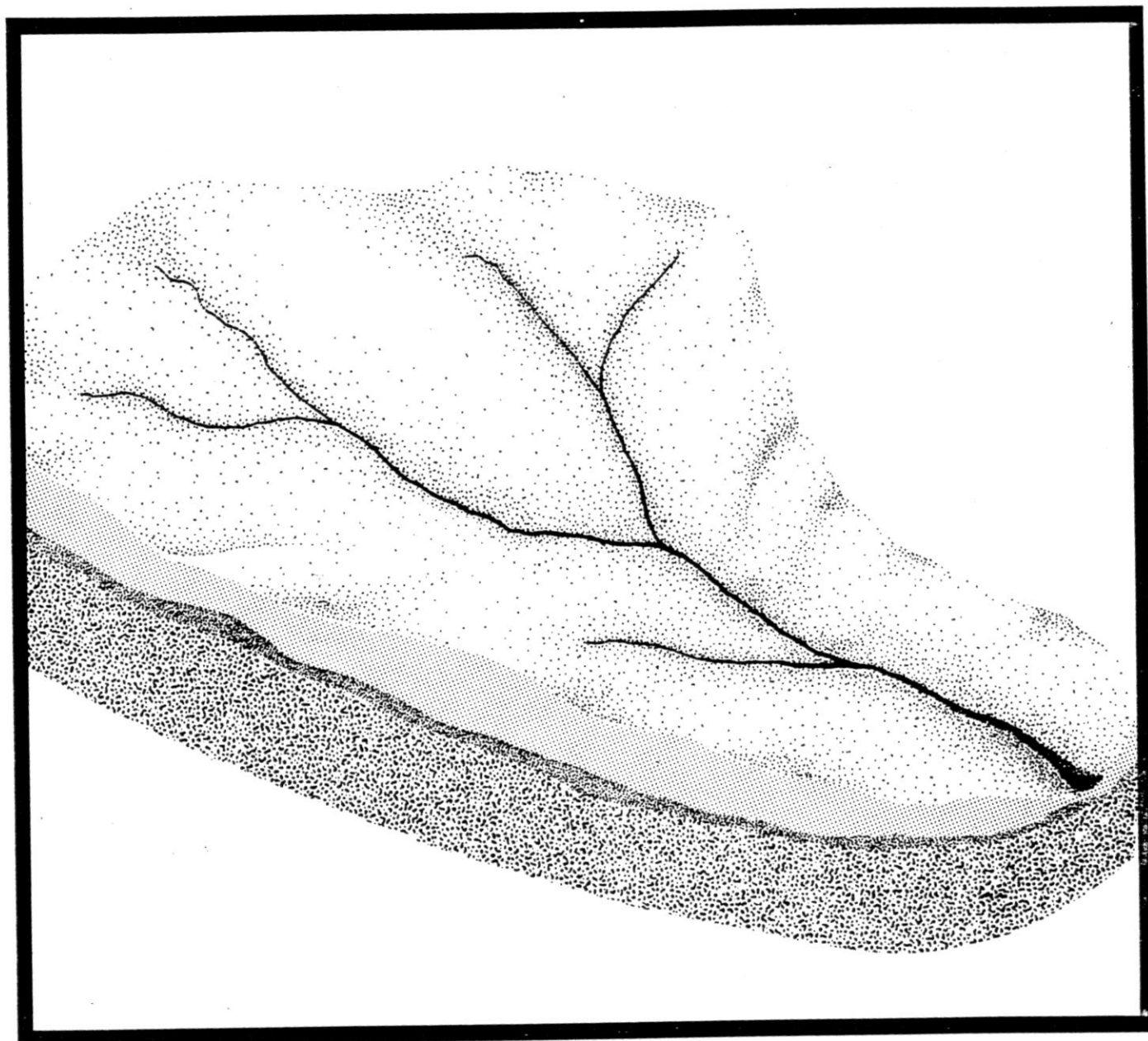
Forest Service

Pacific
Northwest
Region



Erosion and Sedimentation Data Catalog of the Pacific Northwest

38
Sediment
595



SEPTEMBER 1980

Erosion and Sedimentation Data Catalog
of the
Pacific Northwest
September 1980

Prepared for the Forest Service by:

Keith R. Larson and Roy C. Sidle, Department of Forest Engineering,
Oregon State University, under Forest Service Cooperative Agreement
No. 227.

Limited additional copies available from Forest Service, Pacific
Northwest Region, P.O. Box 3623, Portland, Oregon 97208

R6-WM-050-1981

CONTENTS

	<u>Page</u>
Introduction	1
Sediment Yield - Soil Erosion Tables	
Large Basin Sediment Yields	I - III
Small Watershed Sediment Yields	IV - VIII
Erosion Plot Study Results	IX
Forest Road Cut and Fill Slope Erosion	X
Small Watershed Sediment Yields	
Reynolds Creek	2 - 8
Horse Creek Administrative Study	9 - 12
Rock Creek Grazing Study	12 - 13
Zena Creek	14 - 16
Silver Creek-Deep Creek	17 - 18
Alsea Basin Study	19 - 22
Oak Creek	22 - 23
H. J. Andrews Experimental Forest	24 - 27
Coyote Creek Experimental Watersheds	28 - 30
Fox Creek Experimental Watersheds	31 - 32
Clearwater River Basin	33 - 34
Entiat Experimental Forest	35 - 36
Carnation Creek	37 - 38
Caspar Creek	39 - 42
Redwood Creek	42 - 44
Lone Tree Creek	45 - 46
Plat I Reservoir Survey	47 - 48
Cooper Creek Reservoir Survey	48 - 49
SCS Stockpond Sedimentation Survey	49
Erosion Plot Studies	
Erosion Plot Studies - Road Cut and Fill Slopes	50
Siskiyou National Forest Erosion Plot Study	51 - 52
H. J. Andrews Erosion Plot Study	52 - 54
Foresthill Erosion Plot Study	55
Sierra Foothills Erosion Plot Study	56 - 57
Large Basin Characteristics and References	57 - 60
Study Location Maps	61 - 64

INTRODUCTION

Since the late 1950's, numerous studies in the Pacific Northwest have been conducted to quantify sediment yields from small watersheds, determine surface soil erosion rates, and evaluate the effects of various forest management practices on erosion and sedimentation rates. The purpose of this catalog is to compile previously summarized erosion and sedimentation data in a form that is easily accessible and readily used by land planners and soil and water specialists.

Data summaries of several types of studies are contained in the catalog including; 1) sediment yield data from small watershed research studies, 2) sediment yield data from reservoir sedimentation studies, 3) soil erosion data from plot studies conducted on harvested areas and on road cut and fill slopes, and 4) sediment yield data collected by the U.S. Geological Survey on large rivers. Individual data summaries vary with respect to the detail of information provided. An attempt was made to standardize the descriptions of watershed characteristics, study methods, and the presentation of results to facilitate data comparisons and understanding. In some cases this was not possible because information was lacking or study methods and/or design was uncommon.

The natural variability of annual sediment yields from a given watershed and mean annual yields for similar watersheds in a given area are, in many cases, extreme. Any extrapolation of erosion rates or sediment yields to watersheds having similar characteristics should therefore be made with caution. Surface erosion rates reported from plot studies should not be considered as sediment inputs to the stream system. The rate at which soil is routed to the stream system is highly variable and dependant upon many site specific factors. Data collection and analysis techniques differ considerably among the studies reported, resulting in data of varying accuracy. Users of the catalog should consider the methodology utilized in individual studies.

Tables summarizing mean annual sediment yields and soil erosion rates are found at the beginning of the catalog. The locations of the study areas are indicated by numbers on maps found at the end of the catalog.

SUMMARY TABLES

LARGE BASIN SUSPENDED SEDIMENT YIELDS

Map #	River	Location	Watershed area mi ²	Mean Annual Precipitation inches (Regime)	Elevation Range ft	Vegetation, Land Use	Mean Annual Suspended Sediment Yield tons/mi ²	Period of Record Water Year
NORTHERN CALIFORNIA COAST RANGE								
26	Eel R., Rice Fk. Eel R. <u>1</u>	near Hulville	288	48 (2)	1828-7000	Forested, grazing, & timber production <u>5</u>	977	1920 - 59
26	Eel River <u>4</u>	near Scotia	3,113	59 (2)	0-7000	Forested, grazing, & timber production	10,038 <u>4</u>	1958 - 68
25	Middle Fork Eel River	near Dos Rios	753	54 (2)	860-7000	Forested, grazing, & timber production	2,660	1958 - 68
24	Van Duzen	near Carlotta	216	45 (2)	approx. 500-4500	Grassland, forested grazing, timber production	7,208	1958 - 67
23	S. Fork Trinity R.	near Hyampton	898	57 (2)	1000-7000	Forested, Timber production	1,912	1957 - 67
22	East Fork Russian R.	near Ukiah	105	30 - 45 (2) <u>2</u>	approx. 500-4000	Forested, Timber production	355	1965 - 68
22	Russian R.	near Ukiah	99.7	approx. 50 (2)	0-4000	Forested, Timber production	2,640	1965 - 68
21	Dry Creek	near Geyserville	162	approx. 50 (2)	400-2675	40% grazed, slopes 30-80%, Forested	5,770	1965 - 68
20	Big Sulfur Creek	Coast Range near Cloverdale	82.3	approx. 50 (2)	1000-4722	40% grazed, slopes 30-80%, Forested	4,600	1965 - 68
19	N. Fork Cache Creek	near Clear Lake	198	30 - 50 (2) <u>2</u>	1326-4840	Forested, brush, grass	602	1960 - 63
18	Bear Creek	near Clear Lake	96.8	approx. 45 (2)	approx. 1500-3800	Forested	451	1960 - 63
17	Stoney Creek <u>1</u>	Above East Park Res.	102	19 - 60 (2) <u>2</u>	1198-6121	Grass-brush in lower elev., forested in upper elevations	995	1920 - 62
16	Redwood Creek	near Orick	278	approx. 80 (2)	approx. 0-4000	Forested, timber production	7,480	1971 - 76

LARGE BASIN SUSPENDED SEDIMENT YIELDS

Map #	River	Location	Watershed area mi ²	Mean Annual Precipitation inches (Regime)	Elevation Range ft	Vegetation, Land Use	Mean Annual Suspended Sediment Yield tons/mi ²	Period of Record Water Year
15	Walnut Creek	S.F. Bay area, Cal.	79.2	approx. 25-30 (1)	0-1500	Grassland, brush, grazing considerable urban devel.	1,070	1957 - 62
<u>WESTERN WASHINGTON</u>								
28	Deschutes	Cascade Mtn. near Olympia	160	40 - 150 (2) 2	0-3000	78% Forested, 14% crop & range, 8% urban	140	1971 - 73
29	Nisqually	Cascade Mtn. near Nisqually	431	40 - 200 (3) 2	0-14400 3	78% Forested, 14% crop & range, 8% urban	232	1971 - 73
30	Snoqualmie	Cascade Mtn. near Carnation	603	40 - 180 (3) 2	400-8000	Forested, alpine timber production	410	1967 - 69
31	Skykomish	Cascade Mtn. near Monroe	834	40 - 180 (3) 2	400-8000	Forested, alpine timber production	301	1967 - 69
32	Chehalis	Willapa Hills near Doty	1294	45 - 220 (2) 2	approx. 400-8000	94% Forested, timber production 4% cropland	136	1961 - 65
<u>EASTERN WASHINGTON</u>								
37	Palouse	near Hooper Washington	2500	12 - 40 (4) 2	500-5384	At least 50% cropland remainder, forest-range loess soils cultivated	629	1961 - 65
<u>Walla Walla River Basin</u>								
34	Mill Creek	Blue Mtn near Walla Walla	59.6	approx. 35 (4)	1100-5000	Forested; brush-range	440	1962 - 65
33	Walla Walla River	near Touchet	1657	10 - 35 (4)	400-6000	Majority cultivated	2,360	1962 - 65
<u>WESTERN OREGON</u>								
<u>Umpqua River Basin</u>								
11	Elk Creek	near Drain	104	50 (4)	250-2850	Forested, timber production some agriculture in flood plains	730	1956 - 73
11	Steamboat Creek	near Glide	277	60 - 70 (4)	1500-6000	Forested, timber production	800	1956 - 73

LARGE BASIN SUSPENDED SEDIMENT YIELDS

Map #	River	Location	Watershed area mi ²	Mean Annual Precipitation inches (Regime)	Elevation Range ft	Vegetation, Land Use	Mean Annual Suspended Sediment Yield tons/mi ²	Period of Record Water Year
WESTERN OREGON								
11	South Umpqua River	near Brockway	1670	30 - 70 (4)	500-6000	Forested, timber production agriculture in flood plains	1,000	1956 - 73
11	North Umpqua River	At Winchester	1344	40 - 70 (4)	450- 600	Forested, timber production agriculture in flood plains	610	1956 - 73
11	Olalla Creek	near Tenmile	61	45 (4)	800-3000	Forested, timber production agriculture in flood plains	270	1956 - 73
EASTERN OREGON								
8	Bull Run River	near Multnomah Falls	48	90 (2)	-----	Forested, Timber production	249	1978
14	Elliot Creek	Klamath Mtns. near Copper	52	45 (2)	approx. 2000-6000	Forested, Timber production	499	1978
12	Willow Creek	Drains into Columbia R. near Arlington	850	7.5 - 20 (4)	300-6000	10% Forested, 40% cropland 50% rangeland	421 (.01-1913) 6	1964 - 69
13	Bear Creek	near Prineville	205	11 4	3250-6300	Forested, considerable rangeland	626	1978

Footnotes

- All data collected by the U.S. Geological Survey using depth integrated sampling techniques on a daily basis unless otherwise noted.
- Precipitation regimes summarized on page 58.

1 Reservoir sedimentation studies by the U.S.G.S.

2 Range of mean annual precipitation within the watershed.

3 Watershed drains Mt. Rainier.

4 Includes record flood of 1964, sediment production during 1965 water year was over 53,000 tons/mi².

5 "Forested", means the watershed is in various stages of succession following timber harvest, including undisturbed areas.

6 Range in annual sediment yield.

SMALL WATERSHED SEDIMENT YIELDS

Map #	Watershed	Location	Area mi ²	Slope (Mean or Range)	Mean Ann. Precip. inches	Vegetation	Land Use, Experimental Treatment	General Soil Texture	Mean Ann. Sediment Yield tons/mi ²	Period of Record
										Water Year
39	North Fork Caspar Creek	N. California Coast Range	1.96	29	40	Second Growth Redwood	Undisturbed Control	Clay Loam	821 (3)	1963-76
39	South Fork Caspar Creek	N. California Coast Range	1.64	30	40	Second Growth Redwood	Roads, Selec- tive Harvest	Clay Loam	827 (3)	1963-76
27	Lone Tree Creek	N. California Coast	.67	35-80	34	Grass, Brush, Oak, Douglas-fir	State Park, No Roads	Loam, Silt Loam	1791 (3)	1972-74
40	Cooper Creek	Oregon Coast Range	4.4	25-75	40	Hardwood Brush Douglas-fir	Timber Production	Sandy Clay	510 (4)	1968-78
40	Sutherland Creek	Oregon Coast Range	9.0	20	40	Hardwood Brush Douglas-fir, 20% cultivated	Timber Pro- duction, Agriculture	Sandy Clay, Silt Loam	497 (4)	1968-78
<u>Alsea Basin Study</u>										
27	Flynn Creek	Oregon Coast Range	.78	35	100	Douglas-fir Red Alder	Undisturbed Control	Gravelly Loam	281 (1) 8 (2)	1959-73 1978-80
27	Deer Creek	Oregon Coast Range	1.17	50	100	Douglas-fir Red Alder	25% Clearcut, High-Lead, Roads	Gravelly Loam	333 (1)	1959-73
27	Needle Branch	Oregon Coast Range	.27	37	100	Douglas-fir Red Alder	100% clearcut, High-Lead	Gravelly Loam	303 (1)	1959-73
9	Oak Creek	Oregon Coast Range	2.8	30	60	Douglas-fir Oak, Red Alder	<5% Recently Harvested, 8.5 miles road	Clay Loam	33 (1)	1978-80
6	<u>H. J. Andrews Study</u>									
#1	Oregon Cascades 50 miles east of Eugene		.37	63	90	Old-Growth Douglas-fir Western Hemlock	100% clearcut, burned	Clay Loam	73 (3)	1960-68
#2			.23	61			Undisturbed		307 (3)	
#3			.39	53			1.65 miles road, 25% clearcut, burned		7980 (3)	

(1) suspended sediment, (2) bedload, (3) total load, (4) reservoir sedimentation study

SMALL WATERSHED SEDIMENT YIELDS

Map #	Watershed	Location	Area mi ²	Slope Mean or Range)	Mean Ann. Precip.	Vegetation	Land Use, Experimental Treatment	General Soil Texture	Mean Ann. Sediment Yield tons/mi ²	Period of Record
				%	inches					Water Year
<u>H. J. Andrews Study (cont'd)</u>										
6	# 6	Oregon Cascades 50 miles east of Eugene	.05	28	90	Old-Growth Douglas-fir, Western Hemlock	100% clearcut, burned	Clay Loam	29.6 (1)	1972-79
	# 7		.06	31			Shelterwood		7.6 (1)	1972-79
	# 8		.08	30			Undisturbed		31.8 (1)	1972-79
	# 9		.03	60			Undisturbed		9.8 (1)	1969-79
	#10		.04	60			100% clearcut, burned		81.3 (1)	1969-79
<u>Coyote Creek Study</u>										
7	# 1	Oregon Cascades 30 miles south- east of Roseburg	.27	40	48	Mixed Conifer	Roads, shelter- wood cutting	Gravelly Loam	78.1 (3)	1970-79
	# 2		.26	40			Roads, 38% clearcut		59.4 (3)	1970-79
	# 3		.19	40			Roads, 100% clearcut		561.5 (3)	1970-79
	# 4		.19	40			Undisturbed		185.0 (3)	1970-79
<u>Fox Creek Study</u>										
8	# 1	Oregon Cascades 30 miles east of Portland	.23	8	100	Old-Growth Douglas-fir Western Hemlock	Roads, 25% clearcut, broadcast burned	Loam	7.8 (1)	1970-79
	# 2		.98	8			Roads		5.6 (1)	1970-79
	# 3		.27	8			Roads, 25% clearcut		13.2 (1)	1970-79
	Carnation Creek	Vancouver Island, B.C.	3.9	30	125	Old-Growth Western Hemlock	roaded 16% Harvested, High-Lead	Gravelly Loam	188 (1)	1973-77

(1) suspended sediment, (2) bedload, (3) total load, (4) reservoir sedimentation study

SMALL WATERSHED SEDIMENT YIELDS

Map #	Watershed	Location	Area mi ²	Slope (Mean or Range)	Mean Ann. Precip. inches	Vegetation	Land Use, Experimental Treatment	General Soil Texture	Mean Ann. Sediment Yield tons/mi ²	Period of Record
2 Horse Creek Study										
	East Fork	Northern Idaho,	5.6	36	45	Lodgepole Pine	Undisturbed	Sandy Loam	9 (3) *	1966-78
	Main Fork	Near Grangeville	6.5	31	45	Grand Fir,	as of 1978		15 (3)	1966-78
	Subwatersheds					Western Larch			48 (3) *	1975-78
	2		.22	--		Engleman Spruce			20 (3) *	1975-78
	4		.54	--					16 (3) *	1974-78
	6		.40	--					28 (3) *	1975-78
	8		.57	--					38 (3) *	1975-78
	9		.09	--					60 (3) *	1975-78
	10		.25	--					32 (3) *	1975-78
	12		.32	--					34 (3) *	1975-78
	14		.24	--					100 (3) *	1974-78
	16		.11	--					40 (3)	1974-78
	18		.33	--						
41 Rock Creek Grazing Study										
	Main	Near Potlatch	52 acres	12	28	Pasture, woodland	Grazed	Silt	103 (3)	
	Control	Idaho	2 acres	6	28	Pasture	Undisturbed	Loam	6 (3)	
3 & 4 Silver Creek - Deep Creek Studies										
	Cabin	Idaho	.40	Approx. 40	Approx. 28	Ponderosa Pine	Undisturbed	Loamy Sand	23.3 (3)	1966-74
	Control	Batholith	.78			Douglas-fir			6.4 (3)	1966-74
	Eggers		.50						14.2 (3)	1966-74
	Ditch		.41						33.8 (3)	1966-74
	C		.75						20.3 (3)	1966-74
	D		.47						21.7 (3)	1966-74
	K-1		.10						27.3 (3)	1966-74
	Tailholt Main		2.54						17.7 (3)	1961-67
	Tailholt A		.84						17.7 (3)	1968-71
	Tailholt B		.61						21.7 (3)	1968-71
	Tailholt C		.56						19.3 (3)	1968-71
	Circle End		1.45						11.7 (3)	1963-71
	Oompaul		1.16						7.8 (3)	1960-62
	Hamilton		.72						14.9 (3)	1962

(1) suspended sediment, (2) bedload, (3) total load, (4) reservoir sedimentation study

* Estimates of total sediment yield arrived at by multiplying original debris basin accumulations by 2. Debris basin trap efficiency has been estimated at 50 percent.

SMALL WATERSHED SEDIMENT YIELDS

Map #	Watershed	Location	Area mi ²	Slope (Mean or Range) %	Mean Ann. Precip. inches	Vegetation	Land Use, Experimental Treatment	General Soil Texture	Mean Ann. Sediment Yield tons/mi ²	Period of Record
1	Reynolds Creek Study									
	Reynolds Outlet	Southeastern Idaho Near Nampa	90.16	17	Precip. ranges from 10 to 45 inches	Forested, sagebrush range	Grazed	Loam	239 (1)	1967-78
	Reynolds Tollgate		21.02	22		Forested, Sagebrush	Grazed	Loam	401 (3)	1966-78
	Salmon Creek		14.05	22		Sagebrush	Grazed	Gravelly Loam	544 (1)	1965-74
	Macks Creek		12.26	18		Sagebrush	Grazed	Gravelly Loam	310 (1)	1967-78
	Summit		.32	23		Sagebrush	Grazed	Sandy Loam	509 (3)	1968-78
	Whisky Hill		.18	27		Forested, Sagebrush	Grazed	Gravelly Loam	30 (3)	1965-78
	Reynolds Mountain		.16	14		Forested Sagebrush	Grazed	Gravelly Loam	87 (3)	1968-78
	Upper Sheep		.09	25		Forested, Sagebrush	Grazed	Gravelly Loam	62 (3)	1970-78
	Nancy Gulch		3.1 acres	10		Sagebrush	Grazed	Gravelly Loam	15 (3)	1972-78
	Flats		2.2 acres	5		Sagebrush	Grazed	Gravelly Loam	19 (3)	1972-78
	Entiat Study									
35	Fox Creek	E. Cascades Washington	1.83	50	23	Prior to Fire Ponderosa Pine Douglas-fir	Burned by Wildfire	Loamy Sand	Pre&Post fire mean 1146 (3)	1967-77
35	Burns Creek	"	2.17	50	23	"	"	"	Pre&Post Fire Mean 597 (3)	1967-77
35	McCree	"	1.98	50	23	"	"	"	Pre&Post Fire Mean 334 (3)	1967-77
Mean For All Watersheds - 692 (3)										1967-77

(1) suspended sediment, (2) bedload, (3) total load, (4) reservoir sedimentation study

COLUMBIA PLATEAU RESEVOIR SEDIMENTATION

Stockpond Name	State, County	Legal Description Sec., Twp., Rng.	Drainage Area acres	Mean Ann. ppt. in.	Depth	Soil Type Texture	Mean Slope %	Sage-brush %	Vegetation			Age at Survey years	Mean Annual Sediment Accumulation yds ² /mi ² tons/mi ² *	
									Ann. %	Grass %	Per. %			
High Valley Wash., #1	Yakima	9 15N 18E	2634	10	shallow	light to medium	15	20	65	15	--	11	35	21.4
High Valley Wash., #2	Yakima	21 15N 18E	118	12	medium	light to medium	35	3	5	92	--	11	61	37.2
High Valley Wash., #3	Kittinas	23 16N 18E	200	11	medium	light to medium	35	22	16	62	--	11	53	32.3
Henry Clark	Wash., Kittinas	1 17N 20E	4143	9	shallow	light to medium	25	20	15	65	--	5	18	11.0
Coffin Sheep Co.	Wash., Yakima	18 16N 17E	309	18	medium	light to medium	20	15	20	65	--	12	44	26.8
A. Anderson	Idaho, Wash.	6 12N 1W	393	17	medium	light to medium	10	67	15	18	--	46	202	121.2
M. Branch	Idaho, Wash.	34 13N 2W	275	16	deep	light to medium	8	29	25	13	--	11	421	256.8
M. Smeed	Idaho, Payette	8 8N 3W	140	11	deep	light to medium	15	--	95	5	--	6	234	142.7
Twin Puddles	Idaho, Ada	36 2N 1E	1032	12	shallow	light to medium	2	45	55	--	--	10	31	18.9
Lamb Kin	Idaho, Elmore	9 2S 6E	124	14	medium	heavy	3	100	--	--	--	10	42	25.6
Mud Springs	Idaho, Elmore	33 15 6E	690	15	shallow	medium	13	21	59	20	--	12	47	28.7
L. Claypool	Oregon, Crook	29 16S 23E	700	15	medium	medium	5	100	--	--	--	5	60	36.6
A. Schmidt	Oregon, Wasco	13 7S 15E	74	9	shallow	medium	5	76	--	24	--	11	42	25.6
Rock Creek Improv. Co.	Oregon, Wasco	14 4S 11E	3600	21	medium	medium	6	--	--	--	100	13	71	43.3
M. Martin	Oregon, Wasco	34 1N 12E	45	20	medium	medium	6	--	51	--	44	7	461	281.2
Hunt Co.	Oregon, Wasco	13 6S 14E	32	10	shallow	medium	5	50	--	50	--	9	355	216.6
J.J. Colton	Oregon, Baker	8 8S 41E	310	10	shallow	medium	5	--	75	25	--	12	68	41.5

* Estimated values calculated assuming average sediment density of 45 lbs/ft³.

SURFACE EROSION MEASURED IN PLOT STUDIES

Map #	Study	Location	Slope Gradient %	Mean Annual Precipitation inches	Vegetation or Soil Cover %	Land Use Treatment	Soil Texture	Soil Loss tons/acre	Period of Record
6	H.J. Andrews	Oregon Cascades 50 miles east of Eugene, Oregon	60	88	5	Clearcut, Skyline,	Loam	So. Asp. 1.77 No. Asp. .18	8-3-67 to 9-10-68
			60		40			So. Asp. .02 No. Asp. .08	
			80		5			So. Asp. 2.94 No. Asp. 1.53	
			80		40			So. Asp. 3.93 No. Asp. .48	
10	Siskiyou National Forest	Siskiyou Mts. near Gold Beach, Oregon	30	103 inches during study period	0	Clearcut, Skyline Burned	Gravelly Loam	SW Asp. 2.8	Dec. 77 through Feb. 78
			50					5.8	
			70					21.8	
38	Foresthill	Sierra Nevada Mts. near Colfax, Ca.	27	64.4 inches during study period	--	Brush Tractor Cleared	Cobbly or Sandy Loam	34.2	Water Year Year 1978
			22					27.1	
38	Sierra Foothills	Sierra Nevada Mts. near Brown's Valley, California	9	23.2 23.2 21.9 21.9	0 100, grass 0 100, grass	Cleared Cleared	Loam Loam Gravelly Loam	48.0 2.0 45.0 1.0	1974-79 1974-79 1974-79 1974-79
3	Zena Creek	25 miles NE of McCall, Idaho	60 to 75	28	--	Clearcut, Jammer	Sandy Loam	.16	Oct. 61 to Oct. 67
						Clearcut Skyline		.43	Oct. 61 to Oct. 67

- Soil loss values are total losses for the period of record -

SURFACE EROSION ON ROAD CUT AND FILL SLOPES

Study Location	Soil Texture	Mean Ann. Precip. (inches)	Road Com- partment	Mean Slope Gradient Aspect	# years since construction	Vegetative cover (%)	Vegetation type	Study Length (years)	Mean Ann. Erosion Tons/acre/yr	Reference
Western Cascades, Oregon	Clay loam Silty clay	90	cut slope	1.4/1	1st year only	0	---	1959	130	1
"	"	"	"	1/1 south	5 when study initiated	near 0	---	1965-72	20.6(1)	2
"	"	"	"	"	"	Approx. 5	grass-legume	1965-75	near 0	"
"	"	"	"	"	1st year when study initiated	0	---	1965-70	11.4(2)	"
"	"	"	"	"	"	70 - 90	grass-legume	1965-70	.1 - .2	"
Idaho Batholith	Loamy sand	Approx. 40	Fill slope	.8/1 southeast	1st year only	0	---	1963	44	3
"	"	"	"	"	"	seeded, fertilized, straw mulch	grass	1963	12	"
"	"	"	"	"	"	seeded, fertilized straw mulch jute netting	grass	1963	.2	"
"	"	"	"	.7/1 southwest	12 when study initiated	0	---	1968-71	5.2	4
"	"	"	"	"	"	seeded, fertilized straw mulch jute netting	grass	1968-71	.5	"
"	"	"	"	"	"	1.5 and 2.5 ft. spacing, straw mulch jute netting	Ponderosa Pine, 2 - 0 seedlings	1968-71	2.6 - 3.4	"
Idaho Batholith Border Zone	Sandy loam	Approx. 45	Fill Slope	NA	1st year only	0	---	1978-79	140 - 193(3)	5

(1) Approximately 25 percent of soil loss occurred the first year of the study.

(2) Approximately 50 percent of soil loss occurred the first year following construction.

(3) Estimates made by inventorying rill and gully erosion and sediment deposition in troughs installed at base of slope. Original volume measurements converted to weight using factor of 45 lbs/ft³ of soil.

REYNOLDS CREEK EXPERIMENTAL WATERSHED

Location

The watershed is located in southwestern Idaho, approximately thirty miles south of Nampa, Idaho. Reynolds Creek drains into the Snake River. Map #1.

Objectives

The project was initiated by the USDA Northwest Watershed Research Center in 1960 with the intent of studying the hydrology and sedimentation characteristics of sagebrush rangelands representative of extensive areas of Idaho and other western states. In addition to the main Reynolds Creek watershed, sediment production has been intensively monitored for three subwatersheds and six small upland source watersheds.

Watershed CharacteristicsSoils and Geology

The watershed is underlain primarily by volcanic rocks of tertiary age. Basaltic rocks underly approximately 38 percent of the watershed. Granitic outcrops, andesites, rhyolites, and alluvium occur in considerably lesser amounts. Over basalt parent material surface soil textures are generally gravelly loam or loam. At the base of granitic outcrops, sandy loams are found. Silty clays have formed over small areas of lake deposits and alluvium. The major soil associations, series, and surface textures for the individual watersheds are listed below. The approximate percentages were obtained from a 1:24000 scale soils map:

Watershed

Summit - 46 percent - Castlevale, gravelly coarse sandy loam
 34 percent - Lolalita, coarse sandy loam
 20 percent - Reywat-Bakeoven, rocky very stony loams,
 stony gravelly loams

Flats and Nancy Gulch

Due to the small sizes of these watersheds, it was impossible to pinpoint them on the soil map. They are both in an area comprised of the Nannyton-Larimer-Ackman Association. Nannyton and Larimer soils have gravelly loam surface horizons. Ackman soils have a loam surface texture.

Whiskey Hill - 66 percent - Genid, gravelly loam
 34 percent - Hormehl and Demast, gravelly loam.
 Gravel comprising 20 to 50 percent of
 the soil by volume.

Upper Sheep - 37 percent - Gabica, Cobbly gravelly loam
 34 percent - Searla, very gravelly loam
 23 percent - Hormehl - loam
 6 percent - very stony land

Reynolds Mountain

- 85 percent - Harmehl, gravelly loam
- 8 percent - Nettleton, gravelly loam
- 7 percent - Gabica, rocky loam

Reynolds at Outlet (Main watershed)

General description given at beginning of soils section.

Salmon Creek

- 75 percent - Bakeoven-Reywat-Babbington Assoc. generally very gravelly loams and stony loams
- 14 percent - Harmehl-Gabica-Demest Assoc. generally loam and gravelly loam
- 6 percent - Farrot-Castleale-Browles Assoc. generally coarse sandy loams
- 4 percent - Glasgow-Lassen Assoc. 90 percent loams, Lassen soils silty clays

Macks Creek

- 63 percent - Bakeoven-Reywat-Babbington Assoc. gravelly loams, stony loams
- 25 percent - Harmehl-Gabica-Demast Assoc. loams and gravelly loams
- 10 percent - Farrot-Castleale-Brown lee Assoc. gravelly coarse sandy loams
- 2 percent - Glasgow-Lassen Assoc. 90 percent loam, approx. 10 percent silty clay

Reynolds at Tollgate

- 57 percent - Harmehl-Gabica-Demast Assoc. loams and gravelly loams
- 22 percent - Takeachi-Kanlee-0/a Assoc. coarse sandy loam and sandy loams
- 18 percent - Bakeoven-Raywat-Babbington Assoc. very gravelly loams and stony loams
- 4 percent - Searla-Bullrey Assoc. very gravelly loams and gravelly loams

Vegetation/Land Use

Vegetation varies from sparse sagebrush cover at low elevations to dense sagebrush associated with grass, forbs, and forest species at higher elevations. Three percent of the Reynolds Creek Watershed is in irrigated feed crops. The remainder of the watershed is grazed by cattle.

Precipitation

Average annual precipitation, occurring as rain and snow, ranges from 10 to 45 inches in the higher elevations. Convection rainstorms whose intensities can reach 10 inches per hour occur during the summer months. Most erosion occurs during these events or during rain-on-snow melt events.

Physical Characteristics

Watershed	Drainage Area mi ²	Average Elev. ft	Average Slope %	Aspect	Vegetative Cover %
Summit	.32	4472	23	W	30
Flats	2.2 acres	3895	5	NW	42
Nancy Gulch	3.1 acres	4682	10	NW	63
Whiskey Hill	.18	5521	27	NE	70
Upper Sheep	.09	6377	25	NE	40
Reynolds Mt.	.16	6826	14	N	70
Reynolds Outlet	90.16	4902	17	N	--
Salmon Cr.	14.05	4869	22	E	76
Macks Cr.	12.26	4931	18	NE	83
Reynolds at Tollgate	21.02	6102	22	N	55

Methods

Streamflow was monitored continuously at specially designed drop-box weirs and V-notch weirs. Automatic pumping samplers were used at selected watersheds to obtain samples during storm events. Depth integrated suspended sediment samples obtained using DH-48 samplers were used to calibrate pumping samplers. Suspended sediment concentrations were plotted on runoff charts and processed by chart reader and computer to determine the time distributed suspended sediment discharges. Composite samples were collected during thunderstorm events at the Summit watershed. Bedload transport at Reynolds Outlet, Salmon Creek, Macks Creek, and Reynolds Tollgate Stations was determined by surveys of weir pond sediment accumulations and by samples obtained using a Helley-Smith bedload sampler. Estimates of annual total sediment yields were based on the assumption that 20 percent of annual sediment yield occurred as bedload.

Results

Annual sediment yields are given in the tables on the following pages. Note that reported yields for some watersheds are total sediment yields while only suspended sediment yields are supplied for other watersheds.

Maximum Suspended Sediment Concentrations - mg/L

<u>Watershed</u>	<u>Concentration</u>
Summit	143,000
Flats	1,413
Nancy Gulch	900
Upper Sheep	5,000
Reynolds Mountain	1,380

References

Johnson, Clifton W. and C.L. Hanson. 1978. Sediment sources and yields from sagebrush rangeland watershed, in Proceedings, 3rd Federal Interagency Sedimentation Conference, March 22-25, 1976, p. 1-71-1-80.

Johnson, Clifton W. and J.P. Smith. 1978. Sediment characteristics and transport from northwest rangeland watersheds. Transactions of the ASAE, Vol. 2, No. 6, pp. 1157-1168.

Johnson, Clifton W. 1979. Written and oral communications.

Tables on Following Pages

ANNUAL SEDIMENT YIELD

Reynolds Mountain Watershed - .16 mi²

Water Year	Precipitation (in)	Annual Sediment Yield		
		Suspended	Bedload	Total
		----- tons/mi ² -----		
1968	31.9	24.0	11.3	35.3
1969	37.4	72.1	36.6	108.8
1970	39.8	141.5	57.9	199.4
1971	57.9	68.0	48.0	116.0
1972	50.4	74.8	42.5	117.3
1973	31.0	44.5	15.8	60.3
1974	45.6	49.6	16.0	65.7
1975	51.6	55.2	35.9	91.1
1976	42.5	54.2	25.0	79.3
1977	21.1	3.7	2.6	6.3
1978	----	-----	----	78.5
Mean	<u>40.9</u>	<u>58.8</u>	<u>29.2</u>	<u>87.1</u>

Reynolds at Tollgate Watershed - 21.02 mi²

Water Year	Annual Sediment Yield		
	Suspended	Bedload	Total
	----- tons/mi ² -----		
1973	140.1	8.2	148.4
1974	283.2	58.8	342.1
1975	733.5	236.3	969.9
1976	284.4	29.3	313.8
1977	128.5	0	128.5
1978	---	---	247.8
Mean	<u>314.0</u>	<u>83.2</u>	<u>362.9</u>

- Mean annual total sediment yield, water years 1966-74 = 428.8 tons/mi²/year
- Mean annual total sediment yield, water years 1966-78 = 400.5 tons/mi²/year

ANNUAL SUSPENDED SEDIMENT YIELD

Reynolds Outlet Watershed - 90.16 mi²

<u>Water Year</u>	<u>Suspended Sediment Yield</u> tons/mi ²
1967	240.0
1968	77.0
1969	699.2
1970	273.2
1971	509.1
1972	664.8
1973	42.9
1974	102.4
1975	109.4
1976	16.0
1977	36.0
1978	91.7
Mean	238.5

- Estimated mean annual total sediment yield, water years 1963-74 = 326.4 tons/mi²/year*
- * Bedload sampling discontinued 1974
- * Sampling has shown suspended sediment to be 80-90% of total yield.

Macks Creek Watershed - 12.26 mi²

<u>Water Year</u>	<u>Suspended Sediment Yield</u> - - - tons/mi ² /yr - - -
1967	----
1968	51.2
1969	827.8
1970	477.6
1971	762.6
1972	707.7
1973	165.2
1974	158.6
1975	158.8
1976	52.8
1977	.5
1978	45.1
Mean	309.8

- Estimated mean annual total sediment yield, water years 1966-73 = 448.0 tons/mi²/year*
- * Bedload sampling discontinued 1974.
- * Sampling has shown suspended sediment to be 80-90% of total yield.

Salmon Creek Watershed - 14.05 mi²

<u>Water Year</u>	<u>Suspended Sediment Yield</u> - - - - tons/mi ² - - - -
1968	43.2
1969	974.0
1970	576.6
1971	570.2
1972	1405.0
1973	166.5
1974	138.4
Mean	553.4

- Mean annual total sediment yield, water years 1965-74 = 544.0 tons/mi²/year*
- * Sampling discontinued 1974.

ANNUAL SEDIMENT YIELD

Summit Watershed - .32 mi²

Water Year	Total Sediment Yield
	--- tons/mi ² ---
1968	771.0
1969	712.5
1970	0
1971	0
1972	3.4
1973	10.3
1974	0
1975	670.5
1976	0
1977	3428.5
1978	0
Mean	508.7

Upper Sheep Creek Watershed - .09 mi²

Water Year	Sediment Yield		
	Suspended	Bedload	Total
	---	---	---
	tons/mi ²		
1970	1.7	13.2	114.9
1971	28.1	115.2	142.3
1972	14.0	56.2	70.3
1973	29.5	133.5	163.0
1974	5.0	113.8	18.9
1975	---	81.8	---
1976	---	---	9.3
1977	---	---	2.4
1978	---	---	8.4
Mean	15.7	85.6	62.0

- Mean annual total sediment yield, water years 1970-78 = 62.0 tons/mi²/year*

- Estimated total yield based on 81% trap efficiency.

* No suspended sediment samples taken 1975-78.

Source Area Watersheds

Water Year	Total Sediment Yield		
	Flats	Watersheds Nancy	Whisky Hill
	---	---	---
	tons/mi ²		
1965	-	-	4.3
1966	-	-	5.3
1967	-	-	47.5
1968	-	-	14.2
1969	-	-	47.4
1970	-	-	49.9
1971	-	-	83.7
1972	37.8	33.7	90.8
1973	3.1	2.2	1.1
1974	0	4.5	10.0
1975	0	2.2	16.6
1976	3.1	11.2	1.1
1977	85.0	33.7	.5
1978	3.1	0	2.3
Mean	18.9	14.6	30.3

HORSE CREEK ADMINISTRATIVE STUDY

Location

The Horse Creek Watersheds are located within the Selway River drainage in north-central Idaho, approximately 35 miles east of Grangeville, Idaho. The study area is comprised of two main watersheds, the Main Fork (6.51 mi²) and the East Fork (5.56 mi²) of Horse Creek. These watersheds have been instrumented since 1966. Within the Main Fork watershed, on its south facing slope, are ten subwatersheds ranging in size from .09 to .56 mi (58-364 acres). Map #2.

Objectives

The study, initiated in 1966 by the Forest Service Intermountain Forest and Range Experiment Station in cooperation with the University of Idaho, is intended to collect baseline water quality data, and to evaluate the effects of various forest management practices on sedimentation and other water quality parameters.

Watershed Characteristics

Soils and Geology

The watersheds are located on the border of the Idaho Batholith, a 16,000 mi² expanse of granitic bedrock. The watersheds are underlain by sedimentary and metasedimentary rocks, primarily gneiss. The most commonly occurring soil type is a moderately deep, well drained sandy loam. The other main soil type is a similar texture but shallower. Surface layers of loessal silt loams ranging from 15 to 30 inches deep cover extensive areas of the watersheds. These soils are approximately 40 percent silt and 20 percent clay.

Vegetation

The watersheds are almost completely forested. The predominant tree species are grand fir, western red cedar, western larch, Engleman spruce, and lodgepole pine. Understory vegetation includes willow, serviceberry, ceanothus, mountain maple, and pacific yew. All watersheds were in an undisturbed state as of 1978.

Precipitation

Mean annual precipitation is approximately 45 inches with 60 to 70 percent occurring as snow during the winter months. Annual streamflow is approximately 40 percent of the annual precipitation with peak flows normally occurring during the spring snowmelt period.

Physical Characteristics

Watershed	Area	Elevation mean or range	Median Slope	Aspect	Drainage Density
	mi ² (acres)	ft.	%		mi/mi ²
Main Fork	6.51(4166)	4100 - 5700	31	E	---
East Fork	5.56(3558)	4100 - 6000	36	E	---
2	.223(143)	4966	--	S	3.38
4	.544(348)	4980	--	S	3.74
6	.40 (256)	4950	--	S	4.61
8	.569(364)	5005	--	S	2.22
9	.091(58)	4790	--	S	5.11
10	.252(161)	4985	--	S	5.49
12	.323(207)	5190	--	S	4.34
14	.241(154)	5230	--	S	4.44
16	.109(70)	5438	--	S	4.06
18	.333(213)	5458	--	S	4.41

- The watersheds have convex side slopes often exceeding 65 percent.

Methods

Debris basins designed to trap bedload sediment were constructed at the mouth of each watershed. The volume of sediment deposited in the basins is measured annually, during summer low flows using a sag tape cross sectioning technique. From 1975 to 1977, bedload measurements were taken on the subwatersheds using a Helley-Smith sampler. Streamflow measurements are taken at the time of sediment sampling. Sampling frequency ranged from biweekly during snowmelt runoff to monthly during periods of low flow. However, sampling was not initiated until the time of the snowmelt hydrograph peak. Using depth integrated suspended sediment samples collected above and below the debris basins, the average debris basin trap efficiency of five subwatersheds was calculated to be 49 percent. That is, 100 percent of the bedload was trapped while an estimated 23 percent of the suspended load was retained.

Results and Discussion

The weight of sediment trapped in debris basins is shown in the following table. These values were calculated from the original volume measurements using a conversion factor of 43 lbs/ft² of sediment. This value was determined from sediment core sample taken from the debris basins.

SEDIMENT TRAPPED IN DEBRIS BASINS

Horse Creek Watersheds - tons/mi²

Water Year	Drainage/Subdrainage												Sub- watershed mean
	East Fk	Main Fk	2	4	6	8	9	10	12	14	16	18	
66	1.99	2.27											
67	5.26	6.15											
68	1.47	2.24											
69	2.68	4.04											
70	4.23	4.47											
71	6.55	12.55											
72	10.13	16.69											
73	1.32	3.27											
74	3.64	13.21			9.24						31.33	20.06	
75	5.34	9.27	18.40	10.70	6.74	10.64	22.60	55.38	17.78	8.11	147.30	19.04	33.13
76	6.82	10.44	44.84	16.97	12.67	20.27	18.99	33.35	25.01	17.64	21.07	20.91	27.43
77	2.32	3.43	4.14	5.00	1.60	4.39	5.29	4.26	2.99	12.73	4.63	6.22	5.70
78	6.05	9.12	27.28	5.72	8.63	19.53	28.20	26.18	18.64	28.65	44.97	26.81	24.98
Mean	4.45	7.47											

* Original volume measurements converted to weight by using a factor of 43 lb/ft³.

- Sediment trap efficiency estimated at 49 percent of total sediment yield (100 percent bedload and 23 percent of suspended sediment load).

References

King, J.G. 1979. Water Quality Characteristics of the Horse Creek Watersheds in North Central Idaho, Unpublished Manuscript.

Young, Michael E. 1979. Personal communication.

ROCK CREEK GRAZING STUDY

Location

The study watersheds are located on the north slope of the Moscow Mountain area of the Palouse Range, approximately 4 miles south of Potlatch, Idaho. Map #5.

Objectives

The objective of the study, conducted by the University of Idaho in cooperation with the USDA-SEA Agricultural Research Unit in Pullman, Washington, was to obtain baseline water quality data on surface runoff from typically managed pastures.

Watershed Characteristics

Soils and Geology

The soils of the watersheds are generally a loess derived silt loam overlying decomposed granite at a depth of 40 inches or more. The soils are primarily of the Taney and Santa series.

Vegetation/Land Use History

Fifty-seven percent of the area of the main watershed is in open pasture. This area was originally cleared in the early 1900's and rotationally farmed or pastured. It has not been farmed since 1968. Thirty-three percent of the watershed is presently in woodland. This area was logged during the initial farm development and has been grazed since that time. The remaining ten percent of the area was logged in the past and has had limited grazing by horses. The control watershed is entirely pasture land on an old ridge top field.

Precipitation

Mean annual precipitation is approximately 28 inches, 60 percent of which occurs during the November to April period, predominantly in the form of snow.

Physical Characteristics

Watershed	Area acres	Mean Elevation ft	Average Slope %	Aspect
Main	52	940	12	East
Control	2.2	930	5	NE

Methods

The control watershed was fenced to exclude cattle during the study period. The Main watershed was grazed during the May 1st to October 1st period at a rate of 50-55 animal units.

Streamflow was measured with a broad crested V-notch wier on the main watershed and with a small precalibrated flume on the control watershed. Water samples were obtained on each watershed using PS-69 automatic pumping samplers. Samples were taken hourly during high flows and at 6 to 12 hour intervals during low flows. Suspended sediment concentration was determined using the filtration method.

Results

	Water Year		
	1977	1978	1979
Precipitation(in.)	14.6	26.6	20.3
Sediment Yield	- - - - - tons/mi ² - - - - -		
Main Watershed	11.0	131.2	167.1
Control Watershed	4.9	8.1	3.9

The average sediment concentration during the study period for main (grazed) watershed was 424 mg/L with a maximum of 12,700 mg/L. The maximum concentration observed for the control watershed was 2105 mg/L. The marked differences in sediment concentrations and yields between the grazed and control watershed were attributed to the presence of cattle on the main watershed. Several cow trails intercepted surface runoff becoming flowing channels during runoff events.

Reference

Fortier, D. H., M. Molnau, and K.E. Saxton. 1980. Sediment from a small summer grazed watershed. In Proceedings of the ASCE Watershed Management Symposium, July 21-23, 1980, Boise, Idaho.

ZENA CREEK

Location

The study area is located in north central Idaho approximately 25 miles northeast of McCall, near the confluence of the Secesh River and the South Fork of the Salmon River. Map #3.

Objectives

The study was initiated by the Forest Service Intermountain Forest and Range Experiment Station to evaluate the effects of jammer and skyline logging on erosion and sedimentation.

Watershed Characteristics

Soils, Geology, and Physical Characteristics

The study is in the Idaho Batholith, an area of acid, granitic rocks. Quartz monzonite is the predominate mineral type. The soils of the study watersheds are coarse textured, ranging from sandy loams to loamy sands. Soil depths average about 16 inches with little or no B-horizon development. Mean slope gradients range from 60 to 75 percent. The average elevation of the study area is approximately 5000 ft.

Vegetation

Ponderosa pine and Douglas-fir are the dominant tree species.

Precipitation

Mean annual precipitation is 28 inches. Approximately 60 percent occurs during the winter months as snow and about 15 percent as rain during the June through August period.

Methods

Eight small ephemeral drainages ranging from 1 to 5 acres in size were monitored for sediment production and on-site erosion. Sediment dams and erosion plots were constructed in November 1960 and September 1961. Eight 1/100 acre erosion plots were constructed in each unit. A sediment dam was constructed at the outlet of each drainage. Because of the coarse textured nature of the soils in this area, most sediment movement occurs as bedload. The trap efficiency of the sediment dams has been estimated at 80 to 90 percent. Sediment accumulations behind dams were surveyed twice annually. All material caught in erosion plots troughs was weighed in the laboratory.

Treatments

In October 1961, roads were constructed in the 3 drainages to be jammer logged. Twenty-one percent of the total area of these watersheds was disturbed by roads. In October and November, 1962, both the jammer and skyline units were logged. Following logging, the jammer roads were water-barred and seeded.

Results and Discussion

Erosion plot data are shown in Table 1. An analysis of variance showed no significant differences between the two logging methods with respect to on site erosion. Skyline yarding, in most situations, would result in less erosion than jammer methods. Maximum log ground clearance is attained when a skyline system is used on concave slopes. The slopes on the study area, however, varied from straight to convex. Also, logs were skidded downhill which is contrary to normal skyline procedures. These factors probably resulted in more soil disturbance than is normally associated with skyline yarding.

Sediment deposition behind debris dams is documented in Table 2. Prior to road construction and logging, both units had no measurable sediment deposition. Sediment production in the jammer unit increased greatly following road construction. Sediment production in the skyline unit increased following logging. Sediment deposition was considerably higher on the jammer unit than on the skyline unit during the first three periods following logging, reflecting the added influence of road erosion. Prior to December, 1964, all sediment deposited behind dams was derived from sheet and rill erosion on road prisms and skid trails. A severe rain-on-snow storm event in December, 1964, resulted in many landslides on logged and undisturbed lands in the area. Another severe rainstorm in April, 1965 resulted in a road failure and debris torrent that destroyed one of the sediment dams in the jammer unit.

Table 1. AVERAGE EROSION FROM PLOTS ON THE JAMMER AND
SKYLINE LOGGING UNIT

Measurement Period	<u>Jammer Unit</u>		<u>Skyline Unit</u>	
	Mean Erosion tons/mi ²	Number of Plots	Mean Erosion ton/mi ²	Number of Plots
9/61 - 5/62	---	8	---	8
5/62 - 9/62	5.8	4	25.1	7
9/62 - 5/63	6.1	5	18.6	8
5/63 - 9/63	7.8	5	17.3	8
9/63 - 5/64	5.3	5	17.7	8
5/64 - 9/64	32.4	5	21.2	8
9/64 - 5/65	9.8	4	43.6	5
5/65 - 9/65	22.2	3	46.1	7
9/64 - 5/66	2.8	5	30.9	8
5/66 - 10/66	8.0	5	32.8	8
10/66 - 5/67	2.4	5	21.0	8
5/67 - 9/67	1.3	4	0.3	7

Table 2. SEDIMENT ACCUMULATIONS BEHIND DEBRIS DAMS

Measurement Periods	Elapsed Time days	<u>Jammer Unit</u>		<u>Skyline Unit</u>	
		Sediment Yield ton/mi ²	For Period tons/mi ² /yr	Sediment Yield tons/mi ²	For Period tons/mi ² /yr
11/60 - 6/61	232	0	0	0	0
6/61 - 6/62	372	5,424	5,321	0	0
6/62 - 10/62	121	402	1,213	0	0
10/62 - 11/62	21	Period of logging on both units - no measurements			
11/62 - 5/63	196	440	819	4	7
5/63 - 9/63	114	224	717	38	122
9/63 - 5/64	252	34	49	1	2
5/64 - 10/64	129	0	0	5	14
10/64 - 6/65	253	17,492	25,235	13	19
6/65 - 9/65	105	58	202	0	0
9/65 - 6/66	259	340	479	0	0
6/66 - 9/66	101	0	0	0	0
9/66 - 5/67	220	61	101	0	0
5/67 - 9/67	121	180	543	4	12

* One dam in jammer unit destroyed by debris torrent on 4/23/65.

An estimated 6,030 ft² of material moved down the channel.

References

Megahan, W.F. 1975. Sedimentation in relation to logging activities in the mountains of central Idaho, in Present and Prospective Technologies for Predicting Sediment Yields and Sources. ARS-S-40, pg. 74-82.

Megahan, W.F. 1972. Effect of logging roads on sediment production rates in the Idaho batholith. U.S.D.A. Forest Service Research Paper INT-123.

SILVER CREEK - DEEP CREEK

Location

The Silver Creek study area (watersheds 1-7) is located in the Middle Fork of the Payette River drainage near Crouch, Idaho. The Deep Creek study is located approximately 25 miles northeast of McCall, Idaho, near the confluence of the Secesh River and the South Fork of the Salmon River. Silver Creek, Map #4; Deep Creek, Map #3.

Objectives

The objective of the studies, initiated in 1967 by the Forest Service Intermountain Forest and Range Experiment Station, is to collect sediment yield data for undisturbed forested watersheds typical of the high erosion hazard areas of the Idaho batholith. Data collection is continuing on all watersheds except numbers 13 and 14.

Watershed Characteristics

Soils and Geology

The watersheds are underlain by acid granitic bedrock. Quartz monzonite is the predominate mineral type. Soils are shallow (16 to 25 inches) with little or no B-horizon development. Soil textures are coarse ranging from sandy loams to loamy sands. Cohesion is very low because of the low silt and clay contents, typically 10 and 15 percent respectively.

Vegetation

The dominant tree species are ponderosa pine and Douglas-fir. All watersheds were in an undisturbed condition throughout the study period.

Precipitation

Average annual precipitation at the 5,000 foot level in these areas is approximately 28 inches, with about 60 percent occurring during the winter months as snow.

Physical Characteristics

Methods

In these watersheds of coarse textured soils, most stream sediment movement is in the form of bedload. Sediment collection dams were constructed at the mouth of each watershed. The volume of sediment deposited was measured twice annually using a network of closely spaced cross sections. A sediment trap efficiency of 80 percent was calculated for one of the dams by comparing suspended-sediment data obtained at the spillway with the total sediment deposited behind the dam.

Results

MEAN ANNUAL TOTAL SEDIMENT YIELD*

Watershed	Range of Annual Sediment Yield	Mean Annual Sediment Yield	Period of Record
	tons/mi ² **	tons/mi ² **	Water Year
1) Cabin	.5 - 54	23	1966-74
2) Control	1 - 34	6	1966-74
3) Eggers	2 - 31	14	1966-74
4) Ditch	4 - 109	334	1966-74
5) C	.7 - 43	20	1966-74
6) D	3 - 60	22	1966-74
7) K-1	.6 - 85	27	1966-74
8) Tailholt Main	.2 - 55	18	1961-67
9) Tailholt A	1 - 46	22	1968-71
10) Tailholt B	4 - 54	19	1968-71
11) Tailholt C	4 - 37	12	1968-71
12) Circle End	.7 - 21	7.8	1963-71
13) Oompaul	---	15	1960-62
14) Hamilton	---	18	1962

* Estimates are conservative because debris basin trap efficiencies are approximately 80 percent.

** Original volume measurements converted to mass using a factor of 60 lbs/ft³. (Approximate density of sediment deposits, personal communication, W. F. Megahan.)

- Watersheds 1-7 located in Silver Creek study area, Watersheds 8-14 in Deep Creek Area.

References

Megahan, W.F. 1976. Sediment storage in channels draining small forested watersheds in the mountains of central Idaho, in Proceedings of the Third Federal Inter-agency Sedimentation Conference, Denver, Colorado, March 1976: 4-115 to 4-126.

Megahan, W.F. 1975. Sedimentation in relation to logging activities in the mountains of central Idaho, in Present and Prospective Technologies for Predicting Sediment Yields and Sources, ARS-S-40, pg. 74-82.

Megahan, W.F. 1972. Effect of logging roads on sediment production rates in the Idaho batholith. U.S.D.A. Forest Service Research Paper INT-123.

ALSEA BASIN STUDY

Location

The study area is located in the Alsea River basin of the Oregon Coast Range, 8 miles south of Toledo, Oregon, approximately 10 miles from the Pacific Ocean. Map #27.

Objectives

The purpose of the original study, initiated in 1958 by Oregon State University in cooperation with the U.S. Geological Survey and other agencies, was to examine the effects of logging on water quality and the fishery resources of three small coastal watersheds. Bedload sampling was initiated on the Flynn Creek watershed in 1977, by the Oregon State University Forest Engineering Department. The objective of this research is to gain knowledge of basic sediment transport processes. Bedload data collection is continuing.

Watershed Characteristics

Soils and Geology

The watersheds are underlain by the Tye sandstone formation. Over 80 percent of the watershed soils are of the Slickrock or Bohannon series. Slickrock soils are moderately deep gravelly loams formed over sandstone colluvium. Bohannon soils, shallow gravelly loams, are formed over sandstone residuum.

Vegetation

Prior to logging, the watersheds were forested primarily with Douglas-fir and red alder.

Precipitation

Mean annual precipitation is 100 inches with the majority occurring in the form of rain during the November - April period.

Physical Characteristics

Watershed	Area	Elevation Range	Average Slope	Aspect
	mi ²	ft	%	
Flynn Creek	.78	600-1450	35	S
Deer Creek	1.17	600-1650	50	S
Needle Branch	.27	400-1250	37	S

Treatments

Logging roads were constructed into the Deer Creek and Needle Branch watersheds during the summer of 1965. Roads covered 4 percent and 5 percent of the respective watersheds. Roads entered the watersheds from the ridges and were carefully located and constructed in an attempt to minimize erosion and mass wasting. High lead cable logging took place during the March to November period of 1966. The Deer Creek watershed was 25% clear-cut in three units. The Needle Branch watershed was fully clear-cut. Buffer strips were left along streams in two of the Deer Creek cutting units. No buffer strip was left along the Needle Branch stream channel. Slash was burned on the Needle Branch watershed and on one unit of the Deer Creek watershed in October, 1966. The Flynn Creek watershed remained undisturbed.

Methods

Streamflow was continuously monitored at concrete V-notch weirs. Depth integrated suspended sediment samples were obtained at the weirs daily. During storms samples were obtained more frequently, with up to several samples taken per hour. Changes in annual sediment yields were estimated using an averaging technique which reduces the variation in sediment associated with a changing streamflow regime. This technique uses a long term average flow duration curve and assumes the flow each year following treatment is equal to the long-term average (Harper, 1969).

During water year 1978, bedload samples were obtained using a vortex tube. During water years 1979 and 1980, samples were obtained using a Helley-Smith bedload sampler. All major storm events were sampled intensively, with sampling frequencies of up to 20 samples per hour.

Results and Discussion

Annual suspended sediment and bedload yields are given in the tables on the following page. Road building significantly increased sediment yields at the 95% confidence level in Deer Creek and Needle Branch during the first year following construction. One road slide produced an estimated 40 percent of the sediment yield from Deer Creek in water year 1966. No large failures occurred in Needle Branch. In 1967, the first year after logging, the sediment yield increase for Deer Creek was significant at the 95% level. The sediment yield of Needle Branch in 1967, the first year after logging and slash burning, increased to 3-4 times the pre-treatment levels. This increase however, was not significant at the 90% level because of an upward movement of the sediment-discharge relationship for the control watershed in the same year, most likely a result of the floods of January 1965.

The maximum suspended sediment concentrations recorded were 2050 mg/L for Flynn Creek, 6460 mg/L for Deer Creek, and 7670 mg/L for Needle Branch.

ANNUAL SUSPENDED SEDIMENT YIELD

Water Year	Flynn Creek		Deer Creek		Needle Branch	
	Normalized	Actual	Normalized	Actual	Normalized	Actual
	-----tons/mi ² -----					
1959	92	88	114	82	74	49
1960	--	65	---	91	--	41
1961	172	258	193	286	98	180
1962	136	84	178	97	201	115
1963	212	127	285	160	161	115
1964	223	209	231	199	181	187
1965	337	1237	308	1040	129	422
Mean	195	295	218	279	141	158
			Road Construction			
1966	246	300	577	740	270	365
			----- Logging -----			
1967	136	137	251	213	570	904
1968	92	59	101	84	372	490
1969	123	139	162	162	279	517
1970	---	121	---	147	---	232
1971	---	189	---	211	---	415
1972	---	1103	---	1411	---	519
1973	---	88	---	131	---	132
Post Treatment						
Mean		267		387		447
Mean for all years		281		333		303

ANNUAL BEDLOAD YIELDS - FLYNN CREEK

Water Year		
1978	1979	1980
-----tons/mi ² -----		
8.3	6.5	8.5

- The above bedload yields are conservative estimates because several minor storms were not sampled.

References

- Beschta, Robert L. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range, Water Resources Research. 14 (6), 1011-1016.
- Beschta, Robert L. 1980. Unpublished data.
- Brown, G.W., and J.T. Krygier, 1971. Clear-cut logging and sediment production in the Oregon Coast Range, Water Resources Research. 7 (5), 1189-1198, 1971.
- Edwards, Richard Earl, 1979. Sediment Transport and Channel Morphology in a Small Mountain Watershed in Western Oregon, M.S. Thesis, Ore. State Univ., Corvallis.
- Harris, D.D. 1977. Hydrologic changes after logging in two small Oregon coastal watersheds. U.S. Geological Survey Water-Supply Paper 2037, 31p.

OAK CREEK

Location

The Oak Creek watershed is located in the Oregon Coast Range approximately 6 miles northwest of Corvallis, Oregon. Oak Creek drains into the Willamette River. Map #9.

Objectives

The purpose of the research study, being conducted by the Oregon State University Water Resources Research Institute and the Department of Forest Engineering, is to gain knowledge of basic sediment transport processes. Data collection is continuing, including sampling of bedload transport.

Watershed Characteristics

Soils and Geology

Basalt of the Mary's Peak Intrusian formation underlies the majority of the watershed. Clay loam soils of the Dixonville, Price-Ritner, and Jory series are the predominant soil types.

Vegetation/Land Use

The watershed is forested with 50-150 year-old Douglas-fir, red alder and Oregon white oak. Less than 5 percent of the watershed has been clearcut in recent years. There are approximately 8.5 miles of rocky road in the watershed.

Precipitation

Mean annual precipitation is approximately 60 inches with the majority occurring during the November-April period in the form of rain.

Physical Characteristics

Area mi ²	Elevation Range ft	Average Slope %	Aspect
2.8	480-2178	25	South

Methods

Suspended sediment samples were obtained during all major storms using an ISCO automatic pumping sampler. Samples were generally a composite of two samples taken at ½ hour intervals. The annual suspended sediment yields listed in the following table should be considered conservative estimates because minor storms and periods between storms were not sampled.

Results

Suspended Sediment Yield

Water Year			
1978	1979	1980	Mean
----- tons/mi ² -----			
51	23	24	33

References

Beschta, Robert L. 1980. Unpublished data.

Paustian, Steven J. and R. L. Beschta. 1979. The suspended sediment regime of an Oregon Coast Range stream. Water Resources Bulletin, Vol. 15, No. 1.

H. J. ANDREWS EXPERIMENTAL FOREST

Location

The study area is located in the western Oregon Cascades approximately 45 miles east of Eugene, Oregon. Map #6.

Objectives

The objective of the study, conducted by the Forest Service Pacific Northwest Forest and Range Experiment Station, was to evaluate the impacts of timber harvest and road construction on water quality and quantity. Data collection is continuing.

Watershed CharacteristicsSoils and Geology

The watersheds are underlain by the Little Butte formation. Ridge tops are underlain by basalt and andesite flows. The majority of the watersheds are underlain by tuffs and breccias. Soils are, in general, shallow loams and clay loams. Soils over much of the watersheds, however, have developed on deep deposits of unconsolidated, highly weathered regolith.

Vegetation

Prior to logging, the study watersheds were forested with old-growth Douglas-fir and western hemlock.

Precipitation

Mean annual precipitation is approximately 90 inches, the majority of which occurs during the November to April period primarily in the form of rain. Above an elevation of 3000 feet, shallow short-lived snowpacks occasionally accumulate. Peak streamflows frequently occur as a result of rain-on-snow events.

Physical Characteristics

Watershed	Area acres	Elevation Range ft	Mean Slope %	Aspect
1	237	1450-3325	63	NW
2	149	1725-3500	61	NW
3	250	1575-3500	53	NW
6	32	2700-3800	28	S
7	38	2700-3800	31	S
8	53	2700-3800	30	S
9	22	1400-2350	60	NW
10	27	1450-2200	60	NW

Methods

Streamflow was continuously monitored at concrete trapezoidal flumes. From 1957 to 1968, vertically integrated suspended sediment samples were obtained in wide-mouthed milk bottles at the end of each flume during storm events on watersheds 1, 2, and 3. Suspended sediment yields were calculated using the sediment discharge rating curve method. From 1968 on, samples were obtained using an automatic pumping sampler. Sampling frequency is determined by streamflow, with samples taken more frequently at high streamflow. The suspended sediment concentration of a composite sample is then applied to the total volume of streamflow during the sampling period to obtain suspended sediment yield. Suspended sediment yields for watersheds 6, 7, 8, 9, and 10, were obtained in the same manner. Estimates of annual bedload yields were made surveying the volume of material trapped in debris basins downstream of the flumes.

Treatments

In the spring of 1959, 1.65 miles of rocky road (14 foot roadbed) were constructed in watershed #3. All cut and fill slopes were seeded with grass, fertilized, and mulched with straw before the onset of the winter rains. During the winter of 1962-63, 25 percent of the area of watershed #3 was clear-cut in three small patch-cut units. Yarding was done with a high-lead system. Logging slash was broadcast burned in September 1963.

Watershed #1 was 100 percent clearcut from 1962 to 1966. Yarding was done with a skyline system. No roads were built in the watershed. Slash was broadcast burned in September 1966. Watershed #6 was 100% clearcut and high-lead yarded during the summer of 1974. Slash was broadcast burned the spring of 1975. A shelterwood cutting was done on watershed #7 the summer of 1974. The lower 1/3 of the watershed was high-lead yarded while the upper portion of the watershed was tractor logged. Slash was broadcast burned the summer of 1975. Watershed #10 was 100 percent clearcut and skyline yarded in 1975. Slash was not burned. Watersheds #2, 8, and 9 were left in the undisturbed condition.

Results and Discussion

Sediment yields are shown in Tables 1 and 2 on the following pages. During the first fall storm following road construction (watershed #3), suspended sediment concentrations were 250 times greater than undisturbed levels. During winter storms, concentrations had declined to approximately 10 times pre-treatment levels.

In December 1964, a storm with a return interval estimated at 100 years resulted in several road and slope failures and a debris torrent that scoured the Watershed #3 stream channel to bedrock. This event resulted in an estimated total sediment yield of 70,200 tons per square mile. During the three years following this event, suspended sediment concentrations remained an average of nine times higher than undisturbed concentrations.

During the first two years of logging in watershed #1, there was little or no change in sedimentation. Landslides during January of 1965 delivered an

estimated 800 cubic yards of soil to the stream channel. A modest rise in sedimentation was noted following this event. In the two years following slash burning, mean suspended sediment concentrations were 67 and 28 times the undisturbed levels. This considerable rise was attributed to the release of sediment that had been stored by logging debris in the channel.

Total sediment yield from watershed #3 (patchcut with roads) during the 1960-68 period was 109 times that of the control watershed. Ninety-nine percent of the total sediment yield from watershed #3 during this period occurred during water year 1965. Total sediment yield from watershed #1 (clearcut, no roads) during the 1960-68 period was 3.3 times the yield from the control watershed.

No analysis of sediment yields from watersheds 6, 7, 8, 9, and 10 is available at this time.

Table 1. SUSPENDED SEDIMENT YIELD

Water Year	Watershed 1			Watershed 2			Watershed 3		
	SS	Bed	Tot	SS	Bed	Tot	SS	Bed	Tot
	- - - - - tons/mi ² - - - - -								
1957	30.0	29.0	59.0	29.0	32.8	61.8	34.0	18.9	63
1958	54.6	17.6	72.2	62.3	44.1	106.4	88.0	29.0	117
1959	5.2	0	5.2	8.7	7.6	16.3	10.0 ⁽²⁾	3.9	13.9
1960	3.9	1.3	5.2	5.4	2.5	7.9	28.0	10.0	38.0
1961	22.2	2.5	24.7	26.5	22.7	49.2	90.0	40.0	130
1962	17.4 ⁽¹⁾	15.1	32.5	17.2	7.6	24.8	702	272	974
1963	4.4	1.3	5.7	6.2	8.8	15.0	40 ⁽³⁾	32.5	72.5
1964	4.6	1.3	5.9	4.9	1.3	6.2	35 ⁽⁴⁾	20.0	55
1965	407	70.0	477	246	278	524	11700	73300	85000
1966	60 ⁽⁴⁾	20.0	80	6.2	52.0	58.2	95	82.5	177.5
1967	457	332	789	6.1	0	6.1	86	90.0	176
1968	223	408	631	8.6	1.3	9.9	61	70.0	131
1969	319	475	794	20.9	13.9	34.8	1198	222	1046
1970	98	140	238	14.2	13.9	28.1	171	125	296
1971	---	402	---	--	23.9	--	--	50	---
1972	1241	750	1991	78.5	5.0	83.5	665	205	865
1973	218	460	678	2.6	5.9	8.5	50	30	80
1974	1133	490	1623	15.5	.5	16.0	173	50	223
1975	443	482	925	9.3	6.0	15.3	29	28	57
1976	552	488	1040	40.6	67.7	108.3	110	69	179
Mean	227	231	458	32	30	62	809	3737	4546

- (1) 100% clearcut
 (2) Road Construction
 (3) 25% clearcut
 (4) Broadcast burned

SS - Suspended Sediment Yield
 Bed - Bedload Yield
 Tot - Total Sediment Yield

*Sediment yields listed above are unpublished. Any publication of this data is prohibited without the consent of R. L. Fredricksen, Forest Service Pacific Northwest Forest and Range Experiment Station.

Table 2.

SUSPENDED SEDIMENT YIELD

Water Year	Watershed				
	6	7	8	9	10
	----- tons/mi ² -----				
1969				11.6	19.7
1970				6.4	10.9
1971				6.6	10.6
1972	44.7	13.2	92.2	18.8	84.8
1973	9.6	2.5	7.1	1.6	2.8
1974	7.9	5.7	20.0	---	---
1975	27.8 ⁽¹⁾	10.6 ⁽³⁾	8.5	8.4	34.8
1976	55.4 ⁽²⁾	9.9 ⁽²⁾	67.6	33.0	406.2 ⁽¹⁾
1977	2.9	2.3	1.1	1.1	4.0
1978	80.7	14.1	52.0	5.7	193.4
1979	7.9	2.1	5.6	5.2	46.1
Mean	29.6	7.6	31.8	9.8	81.3

(1) 100% clearcut

(2) Broadcast burned

(3) Shelterwood Harvest

* Sediment yields listed above are unpublished. Any publication of this data is prohibited without the consent of R. L. Fredricksen, U.S.F.S. Pacific Northwest Forest and Range Experiment Station.

References

Fredricksen, R. L. 1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. U.S.D.A. Forest Service Research Paper PNW-104. Pacific NW For. and Range Exp. Sta., Portland, Ore.

Fredricksen, R. L. 1980. Personal communication of unpublished data.

COYOTE CREEK EXPERIMENTAL WATERSHEDS

Location

The study area is located in the South Umpqua River drainage of the western Oregon cascades approximately 30 miles southeast of Roseburg, Oregon. Map #7.

Objectives

The objective of the study, initiated in 1962 by the Forest Service Pacific Northwest Forest and Range Experiment Station, is to determine the effects of road construction, shelterwood cutting, and small patch clearcutting on the quantity and quality of streamflow. Data collection is continuing.

Watershed CharacteristicsSoils and Geology

The watersheds are underlain by the Little Butte formation, consisting of welded and non-welded tuffs with andesite and basalt common on ridges. Two main soil series are found on the watershed. Dumont soils are gravelly loams at least 60 inches deep and are derived from reddish breccia parent material. Strait soils are similar but are only 20 to 40 inches deep.

Vegetation

The study area is in the mixed conifer zone. Prior to logging, the watersheds were forested with Douglas-fir, ponderosa pine, sugar pine, incense-cedar, western hemlock and grand-fir.

Precipitation

Mean annual precipitation is approximately 48 inches, the majority of which occurs in the form of rain during the October to March period. In most years, a shallow short-lived snowpack forms in the upper elevations of the watersheds. Rain-on-snow melt events have resulted in the highest recorded streamflows.

Physical Characteristics

Watershed	Area mi ²	Elevation Range ft	Slope Range %	Aspect
1	.27	2047-2867	Approx. 40	E
2	.26	2000-2890		NE
3	.19	1990-2605		NE
4	.19	1990-2540		N

Methods

Streamflow is continuously monitored at 120-degree sharp-crested V-notch

weirs. Suspended sediment samples are obtained using an automatic pumping sampler. Sampling frequency is determined by streamflow, with samples taken more frequently at higher streamflows. The suspended sediment concentration of a composite sample is then applied to the total volume of streamflow during the sampling period to obtain suspended sediment yield. Estimates of bedload yield were arrived at by measuring the volume of sediment deposited in the weir stilling pond.

Treatments

During the summer of 1970, permanent rocked roads were constructed in watersheds 1, 2, and 3. During construction, 6.4 percent, 7.6 percent, and 1.6 percent of the respective watersheds were cleared. Road cut banks and fill slopes were seeded, fertilized, and mulched in late September, 1970. The watersheds were logged during the summer of 1971. In watershed 1, 50 percent of the total basal area was harvested in a shelterwood cut. Yarding was done by tractor. In watershed 2, timber was harvested in 20 small patch cuts totaling about 38 percent of the total watershed area. About half the area was tractor yarded while a high-lead system was used on the steeper slopes. In the tractor logged units, slash was piled. Watershed 3 was completely clearcut. Seventy percent of the watershed was clean-logged using a high-lead system while slash on the remaining area was piled by tractor. Watershed 4 was left undisturbed.

Results

Sediment yields are listed in the table on the following page.

References

- Fredricksen, R. L. 1980. Personal communication of unpublished data.
- Harr, R. Dennis. 1979. Changes in streamflow following timber harvest in southwestern Oregon. USDA Forest Service Research Paper PNW-249. Pacific Northwest Forest and Range Experiment Sta., Portland, Oreogn.
- Swanson, Frederick J. and D. N. Swanson. 1977. Complex mass-movement terrains in the western cascade range, Oregon. In, Reviews in Engineering Geology, Vol. III, Geological Society of America.

SEDIMENT YIELD - COYOTE CREEK WATERSHEDS

Water Year	Watershed 1			Watershed 2			Watershed 3			Watershed 4		
	SS	Bed	Tot	SS	Bed	Tot	SS	Bed	Tot	SS	Bed	Tot
	----- tons/mi ² -----											
1966	--	8.3	--	--	5.1	--	--	23.8	--	--	15.2	--
1967	--	.6	--	--	.4	--	--	3.0	--	--	1.3	--
1968	--	2.4	--	--	.6	--	--	3.4	--	--	3.9	--
1969	--	.4	--	--	.2	--	--	1.3	--	--	1.5	--
1970	13.4	2.8	16.2	14.9	.6	15.5	27.3	8.1	35.4	34.9	6.8	41.7
1971	98.6 ⁽²⁾	31.9	130.5	108.6 ⁽²⁾	25.5	134.1	322.7 ⁽²⁾	133.3	456.0	178.5	99.5	278.0
1972	236.8 ⁽¹⁾	92.2	329.0	149.7 ⁽³⁾	58.6	208.3	1254.0 ⁽⁴⁾	428+	1682+	443.1	192.0	635.1
1973	17.1	1.7	18.8	19.2	.6	19.8	43.3	19.7	63.0	30.9	2.6	33.5
1974	91.2	4.7	95.9	65.4	2.8	68.2	1737.0	282.5	2019.5	172.2	96.7	268.9
1975	34.2	1.5	35.7	31.3	.4	31.7	160.3	47.1	207.4	76.6	16.7	93.3
1976	49.6	6.8	56.4	38.0	1.5	39.5	236.2	88.4	324.6	224.2	53.3	277.5
1977	6.0	.3	6.3	7.9	.3	8.2	25.5	2.8	28.3	11.2	.3	11.5
1978	45.6	10.3	55.9	30.4	1.1	31.5	494.3	15.2	509.5	78.7	7.7	86.5
1979	33.8	2.5	36.3	37.0	.6	37.6	178.7	110.8	289.5	79.6	44.8	124.4
Mean	62.6	11.8	78.1	50.2	7.0	59.4	447.9	83.4	561.5	133.0	38.7	185.0

SS = Suspended Sediment, Bed = Bedload, Tot = Total Load

(1) 50% partial cut, (2) road construction, (3) 100% clearcut, (4) 38% clearcut

* Sediment Yields listed above are unpublished. Any publication of this data is prohibited without the consent of R. L. Fredricksen, U.S.F.S. Pacific Northwest Forest and Range Experiment Station.

FOX CREEK EXPERIMENTAL WATERSHEDS

Location

The Fox Creek experimental watersheds are located in the Bull Run River drainage of the western Cascades approximately 30 miles east of Portland, Oregon. Map #8.

Objectives

The objectives of the study, initiated in 1958 by the Forest Service Pacific Northwest Forest and Range Experiment Station, is to evaluate the impacts of timber harvesting and road construction on streamflow and water quality. Data collection is continuing.

Watershed CharacteristicsSoils and Geology

The watersheds are underlain primarily by flow andesite and basalt. The majority of soils within the watershed are moderately deep loams.

Vegetation

Prior to timber harvesting, the watersheds were forested primarily with old-growth Douglas-fir.

Precipitation

Mean annual precipitation is approximately 100 inches, the majority of which occurs as rain during the November to April period. Shallow short-lived snowpacks accumulate in the upper elevations of the watersheds. Peak streamflows are often a result of rain-on-snow melt events.

Physical Characteristics

Watershed	Area mi ²	Mean Slope %	Elevation Range ft	Aspect
1	.23	8	2680-3200	W
2	.98	8	2680-3200	W
3	.27	8	2680-3200	W

Methods

Streamflow is continuously monitored at concrete V-notch weirs. Suspended sediment samples are obtained with automatic pumping samplers. Sampling frequency is determined by streamflow, with samples taken more frequently at higher streamflows. The suspended sediment concentration of a composite sample is then applied to the total volume of streamflow during the sampling period to obtain sediment yield.

Treatments

Watersheds 1 and 3 were 25 percent clearcut in small patch cuts in 1970 and 1972 respectively. Access roads covered 2 percent of watershed 1 and about 1 percent of the area of watershed 3. Yarding was done with a high-lead cable system on both watersheds. Slash was broadcast burned the summer of 1971 on watershed 1. Slash was not burned on watershed 3. Access roads covered .4 percent of the area of watershed 2. No timber was harvested in watershed 3.

Results

Suspended Sediment Yield Fox Creek Watersheds

Water Year	Watershed		
	1	2	3
	----- tons/mi ² -----		
1970	4.7 ⁽¹⁾	4.7	4.9
1971	7.0 ⁽²⁾	6.1	8.2
1972	12.0	6.6	8.1 ⁽¹⁾
1973	8.7	7.7	7.7
1974	11.3	9.1	9.9
1975	6.8	6.5	11.4
1976	5.9	4.5	4.6
1977	3.2	1.3	4.2
1978	7.5	5.9	7.7
1979	11.3	3.5	9.0
Mean	7.8	5.6	13.2

(1) - 25% clearcut and road construction

(2) - broadcast burned

* Sediment yields listed above are unpublished. Any publication of this data is prohibited without the consent of R. L. Fredricksen, Forest Service Pacific Northwest Forest and Range Experiment Station.

Reference

Fredricksen, R. L. 1980. Personal communication of unpublished data.

CLEARWATER RIVER BASIN

Location

The basin is one of the major drainages of the western Olympic Peninsula in Washington State. Map #36.

Objective

The objective of the study, conducted by the University of Washington, was to provide hydrologic data in support of fisheries research. Data was collected only for the 1974 water year.

Watershed Characteristics

Soils and Geology

The basin is underlain by intensely folded and deeply weathered interbedded sandstones and siltstones. In general, surface soil textures are silty clay loams over gravelly subsoils. The upper portion of the watershed has been more recently glaciated, thus soils are shallower and less weathered than in the lower watershed. All drainages monitored lie in the upper watershed with the exception of the Miller Creek, Christmas Creek, and Snahapish River drainages.

Vegetation

The basin is forested primarily with sitka spruce, western hemlock, western redcedar and Douglas-fir.

Precipitation

Mean annual precipitation varies within the basin from 140-180 inches. Precipitation varied from 150-205 inches within the basin during the 1974 water year.

Methods

Five of the streams monitored were equipped with continuous water level recorders. At the remaining stations, staff gauges were read periodically and readings correlated with data from the continuous recording stations to obtain stage and discharge. Suspended sediment samples were taken at 2 hour intervals using ISCO automatic samplers. For several stations, suspended sediment concentrations were obtained from sediment-discharge rating curves derived from limited sediment samples.

Results

SUSPENDED SEDIMENT YIELDS CLEARWATER RIVER BASIN

Watershed	Area mi ²	Miles of Road miles	Area Harvested %	Suspended Sediment Yield tons/mi ²
Hurst Cr.	2.49	2.7	4	174
Iska Cr.	.83	2.1	26	130
Lower Miller	12.8	33.4	29	782
Christmas	5.86	12.2	17	602
Prairie Deception	4.53	12.3	41	164
Bull Cr.	2.30	4.4	23	167
Kloochman Cr.	2.50	.6	0	250
W. Fk. Kunamakst	2.63	3.8	15	101
E. Fk. Wilson	.61	1.7	10	123
Upper Clearwater	14.98	7.3	3	330
Shale Cr.	6.09	8.1	9	437
Upper Miller	4.06	8.7	24	245
Lower Christmas	8.05	23.2	33	436
Upper Christmas	4.23	7.4	16	273
E. Fk. Snahapish	13.05	28.5	23	155
Stequaleho	9.75	9.9	17	415
Upper Solleks R.	7.73	.9	0	337
W. Fk. Wilson	.89	1.2	24	787
Dingaling Cr.	1.17	1.4	7	294

References

Wooldridge, David D., A. G. Larson, and A. R. Wald. 1974. Hydrologic Data Summary Clearwater River Basin, Water Year, 1973-1974. State of Washington Water Research Center.

Wooldridge, David D. 1980. Personal Communication.

ENTIAT EXPERIMENTAL FOREST

Location

The forest is located in the Entiat River basin, on the east slope of the Cascade Mountains northwest of Wenatchee, Washington. Map #42.

Objectives

Three small research watersheds were instrumented in 1961 by the Forest Service Forest Hydrology Laboratory in Wenatchee. The original purpose of the study was to evaluate the effects of timber harvest on the quantity, quality, and timing of streamflow. The watersheds were uniformly and severely burned by wildfire in July and August of 1970. The study's objective was then changed to that of evaluating the impacts of fire on the hydrology and climate of east Cascade forests.

Watershed Characteristics

Soils and Geology

The watersheds are underlain primarily by granodiorite and quartz diorite bedrock. During glaciation large deposits of water transported glacial material accumulated in the lower section of each watershed. Soil profiles also show several pumice and ash layers originating from Glacier Peak to the northwest. Choral and Rampart series are the two major soils found in the watersheds. Both series are coarse textured, well drained, and have high infiltration capacities.

Vegetation

Prior to the fire, ponderosa pine with an understory of bitterbrush and blue-bunch wheatgrass were the predominant species in the lower elevations. Douglas-fir with a snowbush ceanothus understory was more prominent in the upper elevations.

Precipitation

Mean annual precipitation is 23 inches, 70 percent of which falls as snow from November to May.

Physical Characteristics

Watershed	Area mi ²	Elevation Range ft	Average Slope %	Aspect	Mean Channel Gradient %
McCree	1.98	2121-7049	50	SW	29
Burns	2.17	2761-7069	50	SW	27
Fox	1.83	1980-7102	50	SW	27

Treatments

Following the fire, McCree and Burns Watersheds were seeded with a mixture of grasses and fertilized. Fire-killed timber was logged in the McCree and Burns watersheds under rigid controls. The majority of yarding was done by helicopter. Tractor skidding was allowed only on slopes less than 30 percent. Three and three-tenths miles and 4.7 miles of logging roads were built in the McCree and Burns watersheds, respectively.

Methods

Streamflow was calculated from stage-discharge relationships at sharp crested V-notch weirs. In 1972, Parshall flumes were placed in McCree and Fox Creek after weirs were destroyed by debris torrents. Prior to 1972, estimates of total sediment production were obtained by weighing the sediment deposited in weir ponds. These values should be considered conservative estimates because it is likely that some sediment was not trapped or flushed through the ponds. Beginning in 1972, grab samples were obtained using wide mouthed bottles at locations where turbulent water spilled over rocks. Thus these samples contained suspended sediment and some bedload material. Sediment concentrations obtained in this manner were thought to be conservative estimates of total sediment load. The frequency of sampling ranged from several times a day during snowmelt runoff to monthly during low flow periods. In computing total sediment production, it was assumed that samples were representative of total runoff during the period which included one-half the time since the previous sample and one-half the time to the next sample. Total runoff was computed for that time period and the sediment concentration applied to that volume.

Results

Water Year	TOTAL ANNUAL SEDIMENT YIELD		
	Watershed		
	Fox	Burns	McCree
	-----tons/mi ² -----		
1967	121.7	17.4*	13.9*
1968	173.8	17.4*	13.9*
1969	123.4	17.4*	13.9*
1970	36.5	17.4*	13.9*
Pre-Fire Mean Annual Yield	113.9	17.4*	13.9*
1971	700.5	455.4**	206.9**
1972	6606.4	3212.3**	2452.7**
1973	-----no data collected-----		
1974	-----no data collected-----		
1975	334.4	754.4	121.7
1976	1199.4	587.5	123.5
1977	518.0	295.5	43.5
Post-Fire Mean Annual Yield	1971.7	1061.0	589.7

* - Average values based on ten-year accumulation removed in 1970.

** - These values do not include large amounts of material lost during debris torrents.

References

Helvey, J. D. 1979. Effects of a North Central Washington Wildfire on Runoff and Sediment Production. Unpublished manuscript.

CARNATION CREEK

Location

Carnation Creek flows into Barkley Sound on the southwestern side of Vancouver Island, British Columbia. Not on map.

Objectives

The study was initiated in 1970 with the purpose of evaluating the effects of forest management practices on the fisheries resource. Resource agencies involved in the project include the Canadian Forestry Service, Water Survey, and the Department of Fisheries. Data collection will continue through 1984.

Watershed CharacteristicsSoils and Geology

The soils of the upland areas developed on colluvial material or bedrock, primarily of volcanic origin. The soils of the floodplain were derived from recent alluvium. The majority of the soils are coarse textured, ranging from gravelly loam to loamy sand, although minor areas have a silt loam or clay loam surface horizon.

Vegetation

Vegetation consists primarily of old-growth western hemlock and amabilis fir with minor amounts of western red cedar, Douglas-fir and sitka spruce. Red alder and broadleaf maple are found in stream bottoms.

Precipitation

Annual precipitation ranges from 110-140 inches. The majority of precipitation occurs during the November-April period in the form of rain, although occasional snow accumulations occur in the higher elevations.

Physical Characteristics

Area	Elevation	Average	Aspect
mi ²	Range	Slope	
	ft	%	
3.9	0 - 2295	30	SW

Treatments

By November 1977, approximately 7.4 miles of logging road had been built in the watershed. In the spring of 1977, a clearcut unit of 236 acres was harvested. This treatment exceeded then current Canadian logging regulations in that no buffer strip was left along the main stream channel. The unit was broadcast burned. In November 1977, a 141 acre unit was harvested near the head of the watershed. A buffer strip was left standing. Another 16.5 acre unit was harvested in December 1977. All yarding was done with a high lead system. Additional logging is planned for 1979 through 1981.

Methods

Streamflow is measured at a concrete rectangular weir. Suspended sediment samples are obtained automatically by a pumping sampler. Sampling intervals are regulated by streamflow (i.e., at high flows samples are taken more frequently). Mean daily streamflow and sediment concentration are used to compute daily loads. Bedload production is estimated by measuring sediment deposition in the weir basin. Bedload data is currently not summarized.

Results

<u>Calendar Year</u>	<u>Suspended Sediment - tons/mi²/year</u>
1973	707 - no data for January and February
1974	78
1975	79
1976	33
1977	41

References

Narver, David. W. and T.W. Chamberlin. 1976. Carnation Creek -- an experiment toward integrated resource management. Fisheries and Marine Service of Canada, Circular No. 104.

Oswald, E.T. 1973. Vegetation and soils of Carnation Creek watershed. Pacific Forest Research Center, Canadian Forestry Service, Internal Report BC-43.

Symons, P.E.K., ed. 1977. Carnation Creek project annual report for 1977.

Sediment Data - Canadian Rivers, Published by the Water Survey of Canada, 1973-77.

CASPAR CREEK

Location

The Caspar Creek watersheds are located along the northern California coast approximately seven miles southeast of Fort Bragg, California. Caspar Creek drains directly into the Pacific Ocean. Map #39.

Objectives

This paired watershed study, initiated in 1960, is a joint investigation of the Pacific Southwest Forest and Range Experiment Station and the California Department of Forestry to assess the impacts of road building and selective timber harvest on streamflow, sedimentation, and fish habitat. Data collection is continuing in conjunction with plans for the evaluation of future harvest treatments.

Watershed CharacteristicsSoils and Geology

Sedimentary rocks of the cretaceous age underlie most of both the North and South Fork watersheds. Soils of the Hugo and Mendicino series comprise most of the area. The Hugo soils have developed over hard sandstone and shale which are moderately weathered, coarse grained and deeply fractured. Surface texture is clay loam and erosion hazard is high. The Mendicino soils are associated with more highly weathered sandstone. Surface texture is loamy with very clayey subsoils.

Vegetation

Vegetation consists of second-growth redwood-Douglas-fir type with lesser amounts of grand fir, hemlock, and bishop pine. Both watersheds were clear-cut and burned in the late 1880's.

Precipitation

Average annual precipitation is 40 inches, concentrated during the October-April period in the form of rain.

Physical Characteristics

Watershed	Area mi ²	Elevation Range ft	Average Slope %	Aspect
South Fork	1.64	120-1040	29	West
North Fork	1.96	280-1000	30	West

Treatments

The North Fork watershed was left in its undisturbed condition as the control. During the summer of 1967, 4.2 miles of roads were built in the South Fork drainage, 3.7 miles of which were within 200 feet of the stream channel. Most of the streambed was disturbed during construction, with 360 feet of the streambed disturbed by tractor operation directly into the stream. Fill slopes were seeded with rye grass. After the effects of road building had been evaluated, the South Fork was logged during the 1971 - 1973 period.

Description of timber harvest in the South Fork of Caspar Creek.

	1967	1971	Year Logged		Avg.	Total
			1972	1973		
Area harvested (acres)	47	249	316	435	---	1047
Total stand/acre (MBF)	85.1	69.9	62.7	51.3	61.3	---
Harvest/acre (MBF)	85.1	41.4	43.0	33.1	39.2	---
Road Construction (acres)	47	5.0	1.2	1.7	---	54.9
Skid trails (acres)		21.7	27.6	38.0	---	87.3
Landings (acres)		8.7	3.3	9.0	---	21.0

Methods

Beginning in 1962, continuous stream discharge measurements were obtained at V-notch weirs. Suspended sediment samples were obtained weekly using a DH-48 sampler and also by stage triggered samplers. During storm events, samples were taken more frequently. Automatic sediment samplers were installed in 1967. Total sediment deposition was measured in large debris basins located upstream from the weirs.

For the years 1963-1967, annual suspended sediment yields were computed using the normalizing technique described by Anderson (1971). For the subsequent years, while the South Fork was being disturbed by road building and logging, sediment rating curves were developed for each year to guard against the possibility that the sediment-discharge relationship was changing.

Results and Discussion

An event occurred during the course of this study which complicated interpretation of the data. A dam on the South Fork that had been storing sediment for 80 years failed in December, 1967, releasing an estimated 925 cubic yards of sediment into the stream. To compensate, in part, for an underestimation of erosion during the construction of the stream crossing, the splash dam failure was considered a result of road construction.

For the South Fork, two regression equations were computed which predicted potential sediment production had the watershed not been impacted. These equations were then used to estimate changes in sediment yield due to logging.

Suspended sediment production in 1968, following road construction, was 3.7 times that predicted by regression equations. In 1971, the increase was more than four times the predicted value. This large increase was attributed to exceptionally high flows that had the ability to move the heavier fractions of splash dam sediment that was released in 1968. Negative debris basin accumulations were measured in 1972, an extremely dry year. This was due to small sediment yields and settling of sediment. Negative values were considered zeros in computing total sediment production and averages.

Logging affected suspended sediment discharges more than debris basin accumulation. Using prediction equations adjusted to smooth out the landslide events of 1972 and 1974, a total sediment yield increase due to logging of about 4739 tons/mi² was estimated for the four year post-logging period.

ANNUAL SEDIMENT YIELD - CASPAR CREEK WATERSHEDS

Hydroi. Year	NORTH FORK (Control)			SOUTH FORK		
	Suspended Sediment	Deb. Bas. Accumul.	Total Sediment	Suspended Sediment	Deb. Bas. Accumul.	Total Sediment
----- tons/mi ² -----						
1963	100.1	55.8	155.9	159.3	86.2	246.1
1964	93.9	63.4	157.3	128.0	44.6	172.6
1965	606.4	678.6	1285.0	476.8	231.7	708.5
1966	736.6	819.2	1555.8	407.2	191.3	598.5
1967	136.9	59.6	196.4	204.8	108.3	313.1
AVERAGE	334.6	335.3	669.9	275.4	130.4	405.8
ROAD CONSTRUCTION - SUMMER 1967						
1968	67.0	53.2	120.2	541.6	132.4	674.0
1969	386.1	390.3	776.4	560.3	231.9	792.2
1970	383.3	224.9	608.2	309.0	145.7	454.7
1971	485.2	368.1	853.3	590.3	414.4	1004.7
AVERAGE	330.4	259.1	589.5	500.3	231.1	731.4
LOGGING - 1971-1973						
1972	50.6	-79.2	50.6	197.1	-148.3	197.1
1973	323.1	178.0	501.2	1875.9	236.3	2112.2
1974	(595.1)* 2680.4	(567.8)* 1206.9	(1162.9)* 3887.4	2368.6	344.0	2712.6
1975	389.1	335.7	624.8	1156.4	101.4	1257.4
1976	52.3	-34.8	52.3	283.3	47.5	330.8
AVERAGE	699.1	301.3	1000.4	1176.3	116.2	1292.5
14 Yr. AVERAGE	513.6	369.5	821.1	661.3	178.1	826.8

* Values in parenthesis adjusted for landslide.

References

Anderson, Henry W. 1971. Relative contributions of sediment from source areas and transport processes. Proc. Symp. Forest Land Uses and Stream Environment, Corvallis, OR. pp. 55-63.

Krammes, J.S., and David M. Burns. 1973. Road Construction on Caspar Creek Watersheds. 10-year report on impact. USDA Forest Serv. Res. Paper PSW-93, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

Rice, Raymond M., F.B. Tilley, and P.A. Datzman. 1979. A watershed's response to logging and roads -- the South Fork of Caspar Creek, 1967-1976. USDA Forest Service Research Paper PSW-146.

REDWOOD CREEK

Location

The study was conducted in the Redwood Creek unit of Redwood National Park. Redwood Creek is a coastal drainage in northern California near Orick. Map #16.

Objectives

The study was initiated in September 1973 by the U.S. Geological Survey, at Menlo Park, Ca. to evaluate the geomorphic processes active in the basin and to assess the impacts of intensive timber harvesting practices in the area. Suspended sediment yields presented here are for those watersheds sampled frequently enough to permit estimations of annual sediment yields.

Watershed Characteristics

Soils and Geology

The soils of the watersheds are primarily of the Hugo and Melbourne series developed on fractured and sheared shales and sandstones of the Franciscan formation. Relatively noncohesive soils occupy the steeper portions of the watersheds with deeply-weathered clayey soils found in broad gently sloping ridgetop locations. Hillslope soils are highly conducive to both surface and mass erosion. Harry Wier, Miller, and Hayes Creeks could be generally characterized as having non-cohesive soils while Little Lost Man and Lost Man Creeks could be characterized as having cohesive soils.

Vegetation

The watersheds were forested primarily with old-growth and advanced-second-growth redwood dominated forest prior to recent logging. Small isolated prairies and brush fields are scattered throughout the basin.

Precipitation

Annual precipitation averages approximately 80 inches, occurring primarily as rainfall during moderately intense winter storms.

Physical Characteristics

Watershed	Area mi ²	Elevation Range ft	Mean Slope %	Aspect	Mean Channel Gradient %
Harry Wier	2.96	120-2650	29	SW	8
Miller	1.36	80-2150	31	W	33
Hayes	.58	80-1610	33	W	15
Lost Man	3.97	300-2275	41	NW	1
Little Lost	3.46	80-2280	38	NW	6

Logging History

Watershed	Tractor Logged Since 1968	Cable Logged Since 1968	Tractor Logged Since 1968
	- - - - - % of total watershed area - - - - -		
Harry Wier	42	2	--
Miller	76	1	--
Hayes	--	--	4
Lost Man	--	--	87
Little Lost Man	--	--	8

Methods

Flow duration curves were synthesized from daily flow records at Little Lost Man Creek for the remaining 4 watersheds. Instantaneous suspended-sediment and discharge measurements were obtained for each watershed under a wide range of hydrologic conditions, with greatest emphasis placed on sampling during periods of high streamflow. Sediment transport curves were developed for each site using mean daily values developed from individual storm events and low flow averages based on summertime sampling. Synthesized sediment discharge curves were then constructed using the synthesized flow duration data together with the appropriate sediment transport curve for each site. Periodic bedload measurements were taken with a Helley-Smith bedload sampler during selected storms. Bedload data have not been summarized in terms of annual production.

Results and Discussion

Watershed	Mean Annual Suspended Sediment
	Yield - Water Years 1975 and 1976 tons/mi ²
Harry Wier	435
Miller	700
Hayes	40
Lost Man	155
Little Lost Man	75

During a six year period of record (1971 - 1976), Redwood Creek at Orick transported an average annual suspended-sediment load of 7480 tons/mi . Although the smaller contributing watersheds cited in this summary exhibited lower sediment yields per unit area, this remains one of the most actively eroding areas in North America. The sediment yields cited for water years 1975 and 1976 are probably considerably lower than long-term averages for these watersheds because precipitation during 1976 was approximately 25 percent below normal. The impacts of timber harvesting activities on sedimentation in the Harry Wier and Miller Creek basins are apparently significant.

References

Janda, R. J. 1977. Summary of watershed conditions in the vicinity of Redwood National Park, California. U.S.G.S. Open-File Report 78-25. 79 pp.

Janda, R. J., K. M. Nolan, and D. R. Harden. 1975. Graphic and Tabular Summaries of Water and Suspended-Sediment Discharge During Eight Periods of Synoptic Storm Sampling in the Lower Drainage Basin of Redwood Creek, Humboldt County, Calif. U.S.G.S. Open-File Report.

LONE TREE CREEK

Location

The Lone Tree Creek watershed lies on the southwest slope of Mt. Tamalpais, approximately 8 miles northwest of San Francisco, California. It drains directly into the Pacific Ocean. Map #35.

Objectives

The objective of the study, conducted by the Department of Geology, University of California, Berkeley, was to construct a sediment budget for the watershed.

Watershed CharacteristicsSoils and Geology

The watershed is underlain by greywacke melange of the Franciscan Assemblage. The formation is composed of sheared greywacke and shale in which are inbedded isolated blocks of greenstone, chert, altered rhyolite, and metamorphic rocks. The soils of the watershed are generally thin, stony, and poorly developed. B-horizons are weak or non existant. Both soil and collivial parent material are texturally loam or silt loam.

Vegetation

Three vegetation types are present, including grass, brush, and oak-laurel-Douglas-fir. Annual grasses with some forbs comprise approximately 50 percent of the watershed. Brushland, composed primarily of Baccharis, sagebrush, and poison oak covers about 30 percent of the watershed. Forest species are found in creek bottoms and on north facing slopes.

Land Use

The watershed was grazed from the mid 1800's until 1967, when it was incorporated into Mt. Tamalpais State Park. There are no roads within the watershed.

Precipitation

The watershed has a mediterranean climate moderated by sea-fog that covers much of the area during the summer. Mean annual precipitation is 34 inches, approximately 90 percent of which falls as rain during the November to April period. The maximum one hour rainfall during the study period (October 71 to October 74) was .79 inches occuring during a storm on January 12, 1973, which also produced the maximum 24-hour rainfall of 6.5 inches. This event resulted in a 15-20 year flood. Precipitation during water years 73 and 74 was far below average, however, several storms of high intensity did occur during these years.

Physical Characteristics

Area mi ²	Elevation Range ft	Slope Range %	Aspect	Channel Gradient %
.67	340-1398	35-80	SW	17.3

Methods

Streamflow was measured during nearly all major storms and about half of all minor ones.

Suspended sediment concentrations were determined from depth integrated samples taken at the gaging site using a DH-48 sampler. Time between successive samples during a storm ranged from 5 minutes to 6 hours, depending on the rate of stage and turbidity changes. Suspended sediment discharge was computed by the concentration graph method during storms and by the flow duration curve-rating method for periods of evenly declining flow.

Because extensive bedload sampling was physically impractical on this stream, only six bedload samples were obtained using a Helley-Smith sampler. Estimates of bedload discharge were computed using the flow duration - bedload rating curve method. The accuracy of the bedload estimates is thought to be 50 percent (Lehre).

Results and Discussion

Suspended sediment concentrations measured ranged from 1 - 16,000 mg/L. Concentrations during storms are typically 200 - 1000 mg/L.

Annual Sediment Yield

Water year	1972	1973	1974	Average
	----- tons/mi ² -----			
Suspended load	44	3178	1492	1572
Bed load	18	500	140	220
Total	62	3678	1632	1791

Although precipitation during water year 1972 was high, the lack of high intensity storms and extreme flows prevented the flushing of mobilized sediment from the watershed. During the next two years, intense storms and high streamflows were more frequent, resulting in high sediment yields.

Reference

Lehre, Andre K. 1979. Sediment Budget of a Small Mountain Catchment in North-Central California, Paper presented at Sediment Budget Conference, Oregon State University, Corvallis, Oregon.

PLAT I RESERVOIR SURVEY

Location

The Plat I reservoir is located within the Sutherlin Creek Watershed, (in the Umpqua River drainage), approximately 3 miles from the City of Sutherlin, in Douglas County, Oregon. Map #40.

Objective

The objective of the survey, conducted in 1976, by the Soil Conservation Service, was to determine the rate of reservoir sedimentation and capacity at the time the survey was conducted.

Watershed CharacteristicsSoils and Geology

The watershed is underlain by marine sedimentary rocks of the Umpqua formation, including sandstones, shales, and siltstones. Upland soils are of the Willakenzie series. They are moderately deep, well drained, sandy clays. The soils of the nearly level floodplain in the lower portion of the watershed are of the Coburg and Yoncalla series, consisting of silt loams, silty clay loams, and heavier clay soils.

Vegetation/Land Use

A large portion of the watershed's upper slopes are recently cut over timber lands supporting primarily brush species. Large areas of mature Douglas-fir forests occupy the steeper slopes. Gently sloping bottomland supports a mixed hardwood (Oak, Maple, Madrone) forest. Approximately 20 percent of the watershed is nearly level and in hay, grains, and orchards. Approximately 5 miles of logging road was constructed in late 1975. The mileage of older roads present in the upper portions of the watershed is unknown.

Precipitation

Mean annual precipitation is approximately 40 inches, primarily in the form of rain during the November to April period.

Physical Characteristics

Area - 9.0 mi²

Elevation - 590-1900 ft.

Slope Gradients - Approximately 60% of the watershed consists of 25-70 percent slopes, the remainder of the watershed is level to gently sloping.

Survey Methods

A total of 27 ranges, each 200 feet apart, were established both east-west and north-south across the reservoir (area - .5 mi²). Sediment depths were determined by probing and extending original bottom contours. The area-contour method was used to compute sediment volumes. Sediment samples were obtained to determine sediment density.

Results

The average annual sediment deposition in the reservoir during the 9 year period from 1968 (year of construction) to 1976 was approximately 467 tons/mi²/year.

Reference

High, Robert D. 1978. Unpublished Report, Soil Conservation Service, Portland, Oregon.

COOPER CREEK RESERVOIR SURVEY

Location

The Cooper Creek reservoir is located in the Umpqua River drainage approximately 1.5 miles southeast of the city of Sutherlin, in Douglas County, Oregon. Map #40.

Objective

The objective of the survey, conducted by the Soil Conservation Service in 1978 was to determine the rate of reservoir sedimentation and the reservoir's capacity.

Watershed Characteristics

Soils and Geology

The watershed is underlain by marine sedimentary rocks of the Umpqua Formation, comprised of sandstones, shales, and siltstones. The watershed's upland soils are of the Willakenzie series. They are moderately deep, well drained, sandy clays. The nearly level flood plain (approximately 20% of the watershed) is composed of soils of the Drain-Anlauf series. These soils are silt loams, silty clay loams, and other heavier clay soils.

Vegetation/Land Use

Approximately 80 percent of the watershed is composed of moderately steep to very steep terrain supporting either hardwood-brush (cut over timberland) or mature Douglas-fir timber on the steeper slopes. The remaining portion of the watershed is gently sloping or nearly level and supports hardwoods (Oak, Maple, Madrone) and brush. The mileage of older roads present in the watershed is unknown.

Precipitation

Mean annual precipitation is approximately 40 inches, primarily in the form of rain during the November to April period.

Physical Characteristics

Area - 4.4 mi²
 Elevation - 590-1914 ft.
 Slope gradients - 25-75 percent

Survey Methods

Shortly after construction of the dam in 1968, 19 ranges were established across the reservoir at right angles to incoming streamflow and depths established. The same ranges and sample points were used in the 1977 survey when depths were established using a fathometer.

Results

The average annual sediment deposition in the reservoir during the 10 year period following construction was 838 yd³/mi²/year. If one assumes an approximate sediment density of 45 lbs/ft³ the mass of sediment deposited annually was 510 tons/mi².

Reference

High, Robert D. 1978. Unpublished report, Soil Conservation Service, Portland, Oregon.

SCS STOCKPOND SEDIMENTATION SURVEY - COLUMBIA PLATEAU

Location

The stockponds surveyed were located throughout the Columbia Plateau Physiographic Province in the states of Washington, Oregon, and Idaho.

Objectives

The objective of the survey, conducted by the Soil Conservation Service in 1951, was to determine the potential reduction in sedimentation achievable through the application of conservation practices.

Survey Methods

Spillway contour and range lines were established by plane table and telescopic alidade methods. Water and sediment depth measurements were obtained with the use of a spud in submerged pond areas and by a screw type auger where sediment was exposed. Measurements were taken along range lines and were located by plane-table intersection. Water and sediment volumes were computed with the modified prismoidal formula explained on pages 158-161 of USDA Technical Bulletin 524, SILTING OF RESERVOIRS. Watershed characteristics were determined in the field and using aerial photographs.

Results

See table on page VIII in the first section of the catalog.

References

Flaxman, Elliot M., and Robert L. Hobbs. 1955. Some Factors Affecting Rates of Sedimentation in the Columbia River Basin, in Transactions, American Geophysical Union, Vol. 36, No. 2, pg. 293-303.

DATA NOT IN SUMMARIZED FORM

Data from several watershed research studies in progress was not in a summarized form at the time of this publication.

Three small watersheds (280-750 acres) in the Hoh River drainage of the Western Olympic Peninsula have been monitored for suspended sediment production since 1975 by the Forest Hydrology Department at the University of Washington. Timber was harvested on two of the watersheds during the summer of 1980. Data collection will continue for several years to evaluate the effects of timber harvest on sediment yields.

Sediment yields of the High Ridge Barometer Watersheds have been monitored since 1970 by the U.S.F.S. Pacific Northwest Forest and Range Experiment Station. The four small watersheds (approximately 40 to 80 acres) are located in the Umatilla River drainage of the Blue Mountains east of Pendleton, Oregon. Timber was harvested on three of the watersheds in 1970. Data collection is continuing.

EROSION PLOT STUDIES - ROAD CUT AND FILL SLOPES

Several studies have been conducted to quantify surface erosion on unvegetated road cut and fill slopes, and to evaluate the effectiveness of various revegetation practices in reducing erosion. The results of these studies are summarized on page X in the first section of the catalog.

References

- 1) Wilson, Robert L. 1963. Sources of Erosion on Newly Constructed Logging Roads on the H.J. Andrews Experimental Forest. Unpublished Manuscript.
- 2) Dryness, C.T. 1975. Grass-legume mixtures for erosion control along forest roads in western Oregon. Journal of Soil and Water Conservation, Vol. 30 (4), p. 169-173.
- 3) Bethlahmy, Nedavia, and W. Joe Kidd, Jr. 1966. Controlling soil movement from steep road fills. USDA Forest Service Research Note INT-45, 4 p.
- 4) King, J.G. 1979. Fill slope erosion from forest roads. Paper Presented at the Thirty-Forth Annual Meeting, Pacific Northwest Region, American Society of Agricultural Engineers, Red Lion Inn, Boise, Idaho, October 3-5.
- 5) Megahan, Walter F. 1974. Deep-rooted plants for erosion control on granitic road fills in the Idaho Batholith. USDA For. Ser. Res. Pap. INT-161. 18 p.

SISKIYOU NATIONAL FOREST EROSION PLOT STUDY

Location

The study area is located along the Oregon Coast in the Pistol River drainage of the Siskiyou Mountains, approximately 15 miles south of Gold Beach, Oregon. Map #10.

Objectives

The objective of the study, conducted by the Siskiyou National Forest, is to determine surface erosion rates for slopes of varying steepness on sites that have been clearcut and broadcast burned. Data collection is continuing.

Site Characteristics

The soils of the study area are derived from the Dothan formation composed of marine sandstones and siltstones. Surface soil texture is very gravelly loam. Prior to logging, the area was forested primarily with old-growth Douglas-fir. Slope gradients range from 30 to 70 percent. The study area was located at an elevation of approximately 2600 feet. Mean annual rainfall is over 100 inches, the majority of which occurs in the form of rain during the November to April period. Vegetative cover on the plots during the study period was essentially zero.

Methodology

Erosion plot sites were located prior to logging in the summer of 1976. The unit was clearcut, skyline yarded, and broadcast burned in the fall of 1976. Following logging, a total of 12 plots, each measuring 4 x 7 feet (1/2500th acre) were established on slopes of 30, 50 and 70 percent (4 plots on each slope category). Soil and water runoff was collected in 55 gallon drums at regular intervals. Collected soil material was oven dried and weighed. Data collection was continuing as of January 1980.

Results

Precipitation during the winter of 1976-77 was extremely low and essentially, no water runoff or erosion was measured. During the three month period from 11/20/77 to 2/23/78, approximately 103 inches of rainfall was recorded at the study area. Soil erosion recorded for the plots during this period is presented in the following table. These values should be considered conservative estimates because the collection drums overflowed several times during the study period. Rill and sheet erosion (overland flow) were observed on the study plots. Hanson (1980) feels that the soil losses recorded at this site are higher than losses that would normally be expected on similarly managed sites in the area. This site has a southwest exposure that is susceptible to driving winds.

Erosion	
%	- tons/acre -
30	2 - 4.0, mean 2.8
50	2.5 - 7.5, mean 5.8
70	9.5 - 34, mean 21.8

Reference

Hanson, William. 1980. Personal communication.

H. J. ANDREWS EROSION PLOT STUDY

Location

The study took place in watershed #2 of the H. J. Andrews Experimental Forest, located in the MacKenzie River drainage of the Western Cascades, 50 miles east of Eugene, Oregon. Map #6.

Objectives

The objective of the study, conducted by the Forest Service Pacific Northwest Forest and Range Experiment Station, was to quantify soil erosion following clearcut logging and slash burning.

Site Characteristics

The majority of the soils within the watershed have developed from tuff and breccia, with minor areas of andesitic bedrock and colluvium. The soils generally have a loamy A horizon and are shallow, stony and extremely permeable. Average annual precipitation is 88 inches, the majority of which falls as rain during the October-April period. Rainfall intensities are rarely high enough to cause overland flow. Shallow, short-lived snowpacks do occur in the upper elevations of the watershed. Prior to logging, the watershed was forested with old-growth Douglas-fir and western hemlock. The average slope gradient of the watershed is 61 percent, including slopes exceeding 100 percent. Vegetative cover on bare plots at the initiation of the study averaged about 5 percent. Cover on vegetative plots averaged 30-40 percent. By the end of the 1968 growing season cover averaged 50 percent on bare plots and 75 percent on vegetated plots.

Methodology

The watershed was skyline logged from 1962 to 1966. Slash was broadcast burned in the fall of 1966. The burn was termed about average for the region. In July, 1967, two soil collection boxes, 8 feet long by 1½ feet wide were constructed in each of five slope/soil condition classes - one on a north facing slope and one on a south facing slope. The five classes were: 1) 80 percent slope, soil bare with obvious movement; 2) 80 percent slope, soil disturbed, but with some vegetation; 3) 60 percent slope, soil bare and moving; 4) 60 percent slope, soil disturbed, but with some vegetation; and 5) 80 percent talus slope composed of platy fragments of andesite or welded tuff. To estimate total soil movement in the watershed, the total area within each sampled class was estimated using a planimeter on aerial photographs.

Results and Discussion

Estimated rates of soil movement are shown in Tables 1 and 2. Soil movement was considerably higher on 80 percent slopes than on 60 percent. During the first growing season after slash burning, about 50 percent more soil moved on bare plots than on vegetated plots. By the end of the second growing season, plant cover averaged 50 percent on bare plots and 75 percent on vegetated plots. Little soil movement occurred during this period.

Soil losses on south slopes averaged 87.3 ft²/acre (approximately 2.17 tons/acre) compared to 23.0 ft²/acre (approximately .57 tons/acre) on north slopes. Thus, dry ravel appears to be a major surface erosion process on these soils, occurring during the summer months when the soils are dry and cohesiveness is at a minimum. Soil movement on bare south slopes surpassed that on vegetated north slopes by eight times. On 80 percent south slopes, 26 times as much movement occurred as on 60 percent north slopes.

Table 2 shows the estimated soil movement within the entire watershed and the various classes (includes only 73 percent of the watershed). Total soil movement was 12,378 ft² (approximately 1.77 tons/acre). Almost 75 percent of the estimated soil movement originated from talus slopes, emphasizing the extremely unstable nature of these areas.

References

Merserseau, R. C. and C. T. Dryness. 1972. Accelerated mass wasting after logging and slash burning in western Oregon. *Journal of Soil and Water Conservation*, Vol. 27, No. 3.

Table 1 - Cumulative Surface Erosion Over an 18-Month Period in H. J. Andrews Watershed #2,
Values are in ft³/acre and tons/acre in parenthesis

Collection Date	80-Percent South		80-Percent North		60-Percent South		60-Percent North		80-Percent Talus	
	Bare	Vegetated	Bare	Vegetated	Bare	Vegetated	Bare	Vegetated	Bare	Vegetated
8-3-67	32.0(.79)	33.5(.83)	5.0(.12)	5.0(.12)	22.7(.56)	0	4.4(.11)	2.1(.05)	34.8(.86)	95.2(2.36)
9-13-67	73.8(1.83)	54.4(1.35)	50(1.24)	11.7(.29)	40.9(1.01)	0	4.4(.11)	2.1(.05)	45.2(1.12)	289.6(7.18)
10-26-67	95.9(2.38)	71.2(1.77)	54.0(1.34)	11.7(.29)	52.3(1.29)	0	4.4(.11)	2.1(.05)	55.6(1.38)	332.1(8.24)
2-13-68	111.9(2.76)	113.7(2.82)	58.5(1.64)	13.3(.33)	63.3(1.57)	.7(.02)	7.4(.18)	3.2(.08)	83.4(2.06)	400.9(9.94)
4-10-68	116.8(2.90)	144.2(3.58)	61.2(1.52)	14.9(.37)	71.2(1.77)	.7(.02)	7.4(.18)	3.2(.08)	107.7(2.67)	453.7(11.25)
5-8-68	118.0(2.93)	148.3(3.68)	61.7(1.53)	16.2(.40)	71.2(1.77)	.7(.02)	7.4(.18)	3.2(.08)	112.9(2.80)	477.5(11.84)
6-19-68	118.0(2.93)	152.4(3.78)	-	16.2(.40)	71.2(1.77)	.7(.02)	7.4(.18)	3.2(.08)	116.3(2.88)	490.7(12.17)
9-10-68	118.6(2.94)	158.6(3.93)	-	19.5(.48)	71.2(1.77)	.7(.02)	7.4(.18)	3.2(.08)	116.3(2.88)	502.7(12.47)

- Original Measurements Taken in ft³, tons/acre Values Computed Assuming Soil Bulk Density of .8 -

Table 2 - Watershed Area and Estimated Total Surface Soil Moved in the Experimental Watershed by Sampled Class,
July 1967 to September 1968

Slope/Aspect/Condition Class	Watershed Area(ac)	Volume (cu ft)
80% south-bare	5.1	604
80% south-vegetated	9.4	1,494
80% north-bare	5.1	314
80% north-vegetated	9.4	184
60% south-bare	6.5	468
60% south-vegetated	58.3	41
60% north-bare	6.5	49
60% north-vegetated	58.3	187
80% talus	14.6	9,037
TOTAL	173.2	12,378

FORESTHILL EROSION PLOT STUDY

Location

The study area is located in the foothills of the Sierra Nevada Mountains of California on the Foresthill District of the Tahoe National Forest near Colfax, California. Map #38.

Objectives

The objectives of this study, conducted by the Department of Land, Air, Soil and Water Resources, University of California (Davis), in cooperation with the California Agricultural Experiment Station, are 1) to give District forest managers information on the erodibility of steep slopes in areas cleared for replanting and 2) to check the validity of curves prepared to estimate the effect of steep slopes on soil loss.

Site Characteristics

The soils of the study area are of the McCarthy series, developed over andesitic conglomerate. Surface textures of the study soils are a cobbly loam or sandy loam. Prior to initiation of the study, Manzanita was the principal brush species present. Erosion plots were established on areas where brush species had been mechanically cleared to prepare the site for tree planting. Slope gradients of the two study areas are 21.6 and 27.0 percent. Precipitation during the study period (1978) was 64.4 inches.

Methodology

Two sets of four erosion plots, each measuring 72.6 feet long by 6 feet wide were established in 1977.

Results

Water Year 1978	Avg. Slope %	Soil Loss tons/acre
South Set	27.0	34.2
North Set	21.6	21.1

During water year 1979, the majority of precipitation at the sites was in the form of snow or sleet, hence little over-land flow or erosion occurred. Data collection is continuing.

Reference

Huntington, Gordon, L. 1979. Annual report to western regional research committee, W-125.

SIERRA FOOTHILLS EXPERIMENTAL RANGE EROSION PLOT STUDY

Location

The Sierra Foothills Experimental Range is located in the western foothills of the Sierra Nevada Mountains near Brown's Valley, California.

Objectives

The purpose of the study, conducted by the Department of Soil, Air, and Water Resources at the University of California, Davis is to evaluate the erodibility of several soils typical of the Sierra Nevada foothills and to determine soil engineering properties critical to estimating erosion potentials. Only the erosion plot phase of the study is summarized here.

Site Characteristics

The soils of the study area have developed over meta-volcanic rock. Surface soil textures of the three soil series are 1) Argonaut Series - gravelly loam (34 percent gravel), 2) Auburn Series - loam (10 percent gravel), and 3) Sobrante Series - loam (15 percent gravel). Vegetative cover on the natural vegetation plots approaches 100 percent, and consists primarily of wild oats, soft chess, and ripgut brome. The plots are located on slopes of 9 percent gradient.

Methodology

Eighteen erosion plots were established on three soil types at elevations of approximately 1000 feet. Four bare cultivated plots and two natural vegetation plots were established on each soil. The plots, measured 72.6 feet long by 6 feet wide.

Results

Soil	Year	Precipitation inches	Erosion	
			Bare tons/acre	Vegetated
Auburn	1974-75	24.6	10.9	1.1
	1975-76	14.3	.5	.3
	1976-77	12.2	.3	.3
	1977-78	36.4	15.0	.3
	1978-79	28.4	21.2	.0
	Mean	23.2	9.6	.4
Argonaut	1975-76	8.1	.3	.3
	1976-77	11.7	.3	.3
	1977-78	39.2	7.9	.2
	1978-79	28.5	27.5	.03
	Mean	21.9	9.0	.2
Sobrante	1975-76	7.3	.3	.3
	1976-77	14.3	.3	.3
	Mean	10.8	.3	.3

Sobrante plots were abandoned because of operational problems.

Reference

Singer, Michael J. 1979. Engineering and pedological properties of soils as they affect soil erodibility. California Water Resources Center Publication No. 166, Davis, California.

LARGE BASIN SEDIMENT YIELDS

Annual suspended sediment yields of selected large basins are provided to facilitate the comparison of sediment yields from watersheds of varying geology, climate, and land use. In addition, this data will enable the reader to view the erosion and sediment transport system as a whole, providing a context in which erosion plot data and sediment yields from small watersheds may be more meaningful. Sediment yields are found in tables on pages I - III.

BASIN GEOLOGY

Eel River

Primarily Franciscan Formation, a complex assemblage of marine sedimentary rocks and mafic marine volcanic material, with local masses of serpentine. Predominant rock type is sandstone chiefly graywacke.

Russian River

Predominantly Franciscan Formation (see Eel River), outcrops of volcanic rocks occur throughout basin.

South Fork Trinity River

Franciscan Formation primarily (see Eel River); outcrops of strongly metamorphosed and granitic rocks occur sporadically.

North Fork Cache Creek, Bear Creek, Upper Stoney Creek, and Redwood Creek

Franciscan Formation (see Eel River).

Deschutes River, Nisqually River

Underlain predominantly by igneous rocks (basalt, andesite, granite) above 2500 feet; lowland soils developed over glacial deposits.

Snoqualmie River, Skykomish River

Above 2500 feet, soils have developed over sedimentary, igneous, and metamorphic rocks; lowland soils developed over glacial deposits.

Chehalis River

Underlain predominantly by sedimentary rocks or glacial deposits; a few small igneous bodies are present.

Palouse River

Underlain by 1) flow basalt, 2) metamorphic and intrusive igneous rocks, and 3) loess deposits.

Walla Walla River

Columbia River basalt and unconsolidated clay deposits or gravel alluvium.

Umpqua River

Underlain primarily by the Little Butte Formation, consisting of pyroclastic rocks (welded and non-welded ash-flow tuffs with andesite and basalt common on ridges). Marine sedimentary rocks underly the basin in the Coast Range Province.

Bull Run River

Underlain by Columbia River basalt flows and more recent andesite flows.

Elliot Creek

Underlain by metamorphosed sedimentary and volcanic rocks.

Bear Creek

Underlain by the Clarno Formation, composed of lava flows, mud flows, volcanic breccias and beds of volcanic ash.

Precipitation Regimes

- (1) Majority of precipitation occurs as rain during the winter months, very dry summers (mediterranean climate).
- (2) Majority of precipitation occurs during winter months, rain in lower elevations, snow in higher elevations, limited and short-lived snowpack, very dry summers.
- (3) Majority of precipitation occurs during winter months, rain in lower elevations, snow in higher elevations with deep long-lived snowpack, limited summer precipitation.
- (4) Majority of precipitation occurs during winter months as rain or snow in higher elevations with deep long-lived snowpack, limited summer precipitation in the form of convective storms.

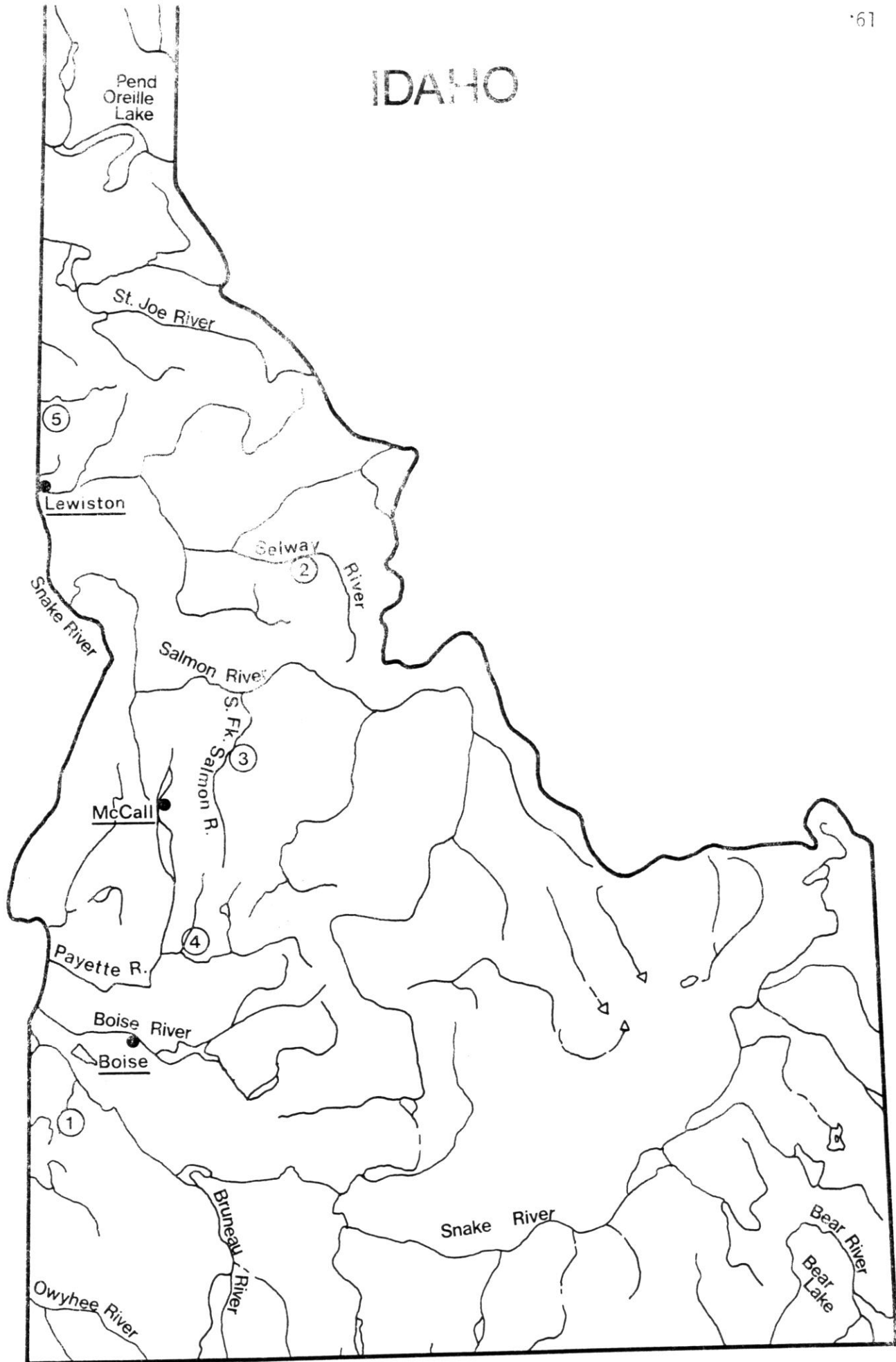
LARGE BASIN REFERENCES

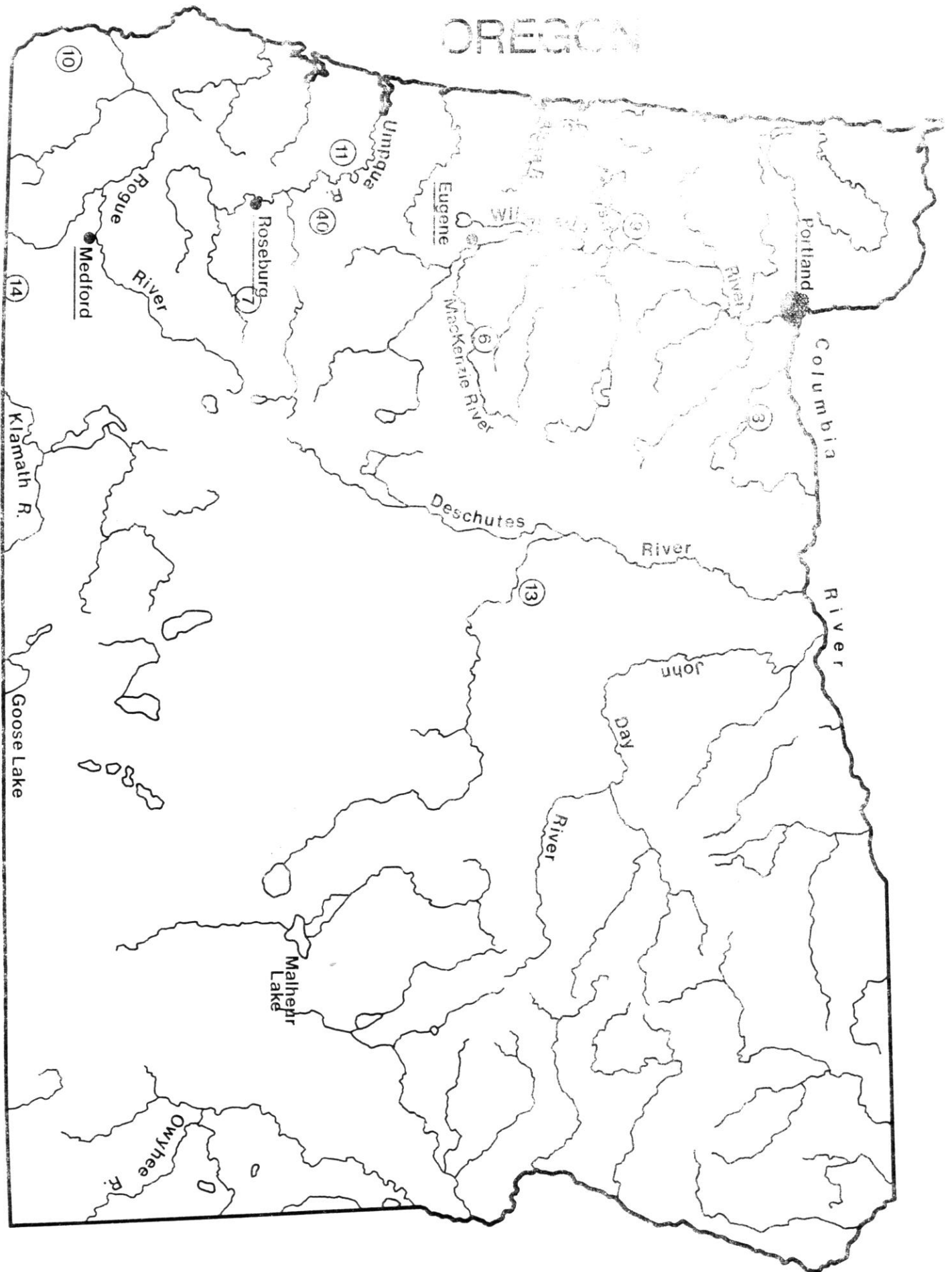
- Eel River, Rice Fk. Eel River - Porterfield, G. and C.A. Dunham, 1964. Sedimentation of Lake Pillsbury Lake County California, U.S.G.S. Water Supply Paper 1619-EE.
- Eel River, Van Duzen River - Brown, William M. III, and John R. Ritter, 1971. Sediment Transport and Turbidity in the Eel River Basin, California, U.S.G.S. Water Supply Paper 1619-EE.
- Middle Fk. Eel River - Knott, J.M., 1971. Sedimentation in the Middle Fork Eel River Basin, California, U.S.G.S. Open File Report, Menlo Park, California.
- S. Fk. Trinity River - Knott, J.M., 1974. Sediment Discharge in the Trinity River Basin, California, U.S.G.S. Water Resources Investigations 49-73.
- Russian River Basin - Ritter, John R., and W. M. Brown III, 1971. Turbidity and Suspended - Sediment Transport in the Russian River Basin, California, U.S.G.S. Open File Report 72-316.
- N. Fk. Cache Creek, Bear Creek - Lustig, Lawrence K., and R. D. Busch, 1967. Sediment Transport in the Cache Creek Drainage Basin in the Coast Range West of Sacramento, California, U.S.G.S. Professional Paper 562-A.
- Stoney Creek - Knott, J.M., and C.A. Dunham, 1969. Sedimentation in Upper Stoney Creek Basin, Eastern Flank of the Coast Ranges of Northern California, U.S.G.S. Water Supply Paper 1798-F.
- Walnut Creek - Porterfield, George, 1972. Sediment Transport and Deposition, Walnut and Pacheco Creeks Contra Costa County, California, August 1965-April 1970, U.S.G.S. Open File Report 72-302.
- Deschutes River Nisqually River - Nelson, Leonard M., 1974. Sediment Transport by Streams in the Deschutes and Nisqually River Basins, Washington, U.S.G.S. Open File Report, Tacoma, Washington.
- Snoqualmie River Skykomish River - Nelson, Leonard M., 1971. Sediment Transport by Streams in the Skykomish River Basin, Washington, U.S.G.S. Open File Report, Tacoma, Washington.
- Chehalis River - Glancy, P.A., 1971. Sediment Transport by Streams in the Chehalis River Basin, Washington, October, 1961 to September, 1965, U.S.G.S. Water-Supply Paper 1798-H.

- Palouse River - Boucher, P.R., 1970. Sediment Transport by Streams in the Palouse River Basin, Washington and Idaho, July 1961 - June 1965, U.S.G.S. Water-Supply Paper 1899-C.
- Walla Walla River Basin - Mapes, B.E., 1969. Sediment Transport by Streams in the Walla Walla River Basin, Washington and Oregon, July 1962 - June 1965, U.S.G.S. Water-Supply Paper 1868.
- Willow Creek - Koelliker, James K., 1974. Evaluation of Suspended Sediment Discharge from the Willow Creek Basin, Water Resources Research Institute, Paper #60, Oregon State University, Corvallis.
- Umpqua River Basin - Curtis, D.A., 1975. Sediment Yields of Streams in the Umpqua River Basin, Oregon. U.S.G.S. Open File Report, Portland, Oregon.
- Elliot Creek - Water Resources Data for Oregon, Water Year 1978.
Bull Run River U.S. Geological Survey Water-Data Report OR-78-1.
Bear Creek

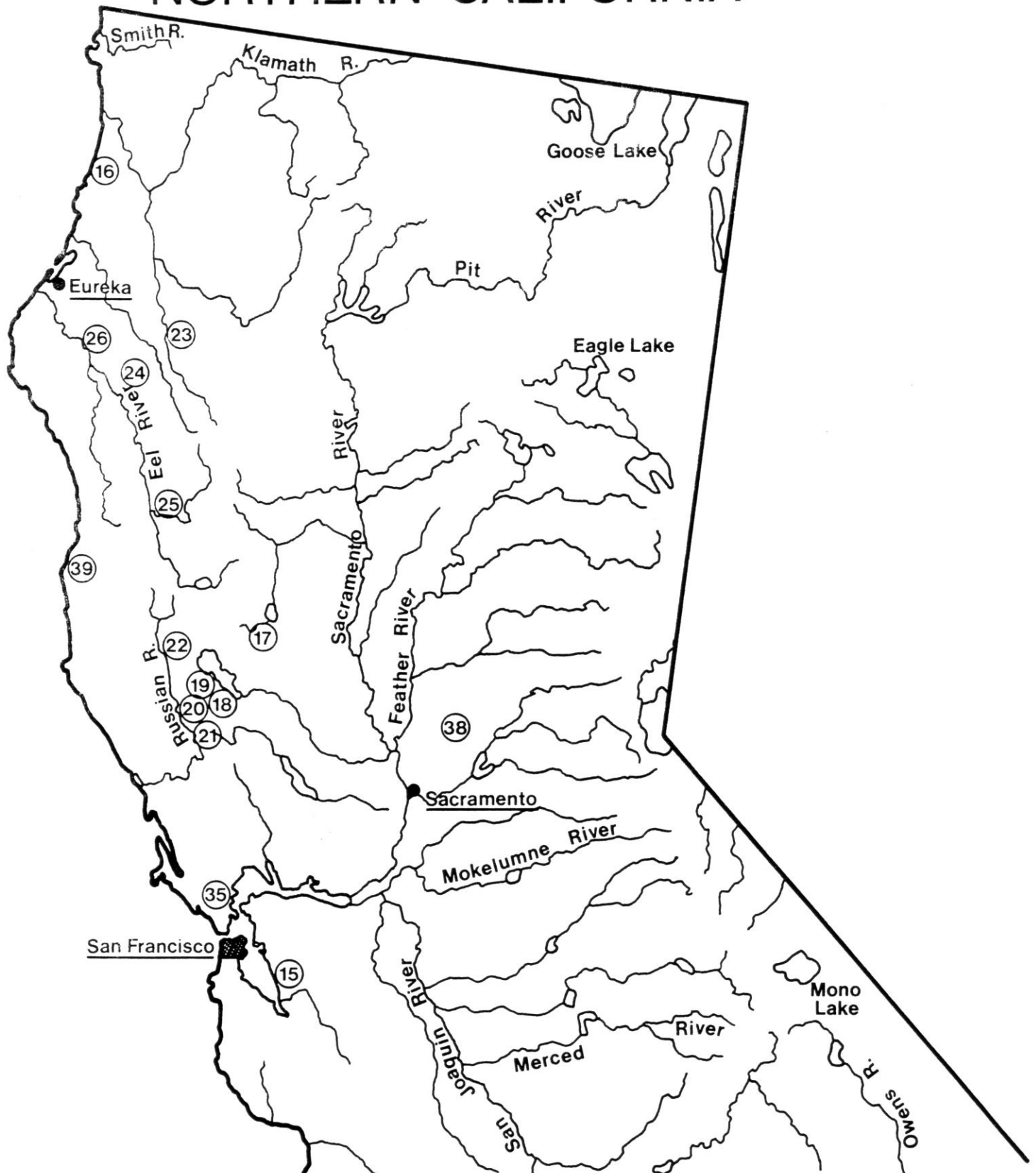
- Mean annual suspended sediment yields are listed in the tables on the following pages.

IDAHO





NORTHERN CALIFORNIA



WASHINGTON

