CHANGES IN PEAK STREAMFLOWS

FROM MANAGED AREAS OF THE WILLAMETTE NATIONAL FOREST

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Pacific Northwest Region

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WILLAMETTE NATIONAL FOREST

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Willamette National Forest, January 1981

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I. SUMMARY

Records of annual peak streamflows dating back to the early 1900's were examined. Changes in the magnitude were revealed. During the last 40 years, timber management activity has increased. In the western Cascades the larger flows are due at least partially to the contribution of water from snowmelt. An implication from the data examined is that timber management has contributed to higher peak flows because of the effect upon hydrology - particularly snowmelt.

II. INTRODUCTION

The purpose of this report is to examine changes in peak streamflow that may have been influenced by timber harvest and associated activity. It relates available research information and other data that are applicable to the Willamette National Forest.

There are several questions that are important to address: (1) what changes have occurred; (2) how does activity affect streams and water resources; (3) what levels of management are detrimental or unacceptable; (4) does recovery occur after an activity; (5) what are the important characteristics related to recovery; (6) how long does recovery take? Those questions have been asked by various Willamette National Forest personnel including the Assistant Forest Supervisor for Resources, the Assistant Forest Supervisor for Planning and the Oakridge District Ranger.

Complete answers to the questions are not available. Although using available information, I feel it is possible to gain an insight about conditions and make inferences about causes and effects. The following items also relate to the questions above, but were not addressed in this paper: (1) water temperatures; (2) mass soil movement; (3) seasonal low flows; (4) soil erosion; and (5) sedimentation.

III. BACKGROUND

Importance

The issue of water resources and land use is important for the Willamette National Forest. Some reasons are:

-- Over the past years maximum water temperatures in Salmon Creek have been increasing.

-- In some streams there appears to be an increase in bedload sediment. Two examples of increased sediment are the Upper Middle Fork of the Willamette River and Blowout Creek, a tributary in the North Santiam basin.

-- Flood damage is also important. In 1977, high flows in November had a recurrence interval, depending on location, of only approximately 5 to 25 years on the Willamette National Forest; yet, the amount of damage to roads, drainage structures, and watershed areas was estimated at 1.5 million dollars.

-- Water flowing from the Willamette National Forest is used by nine cities and towns. There are eleven reservoirs and eight fish hatcheries that depend on water from the Forest. The Willamette River system farther downstream is influenced in part by quality and quantity of water produced from the National Forest.

Research

In an early publication on Western Oregon conditions, Anderson and Hobba (1959) documented changes in peak flows in several large drainage basins which had timber harvest. The flows in the harvested basins were compared to nearby uncut basins. As an example of what they found, a 56 percent increase in the magnitude of flood peaks was noted in the Mollala River drainage (11 percent logged) compared to the uncut Clackamas River Basin. They also reported increases in peak flows from four other watersheds that had from 3 to 11 percent increases in basin area harvested. Anderson and Hobba also recognized the importance of rain-on-snow events in producing floods and showed flood potential by elevation zone. Snowmelt will be discussed later in more detail.

In recent years, research (Rothacher 1965, 1970. 1973; Harr, 1976) from the small watersheds in the H.J. Andrews Experimental Forest within the Willamette National Forest has indicated that the size of average peak flows is increased after logging because the soil moisture is higher in harvested areas and less of a moisture deficit has to be made up from precipitation. The effect is most profound during the first significant storm in the fall or early winter after the dry summer. Rothacher felt that there is little effect of timber harvesting upon the largest floods.

Three conditions have been identified that seem to contribute to an increase in peak flows (Rothacher 1973; Harr 1976; Harr, Fredriksen, Rothacher, 1979).

1. Exceptionally large quantities of precipitation at the end of a dry season.

2. A rain-on-snow storm event that coincides with rapid melt of accumulated snow. Harr (1979) indicated that out of the floods in the Upper Willamette Basin with the return period greater than 6 years, 88 percent of them were associated with rain-on-snow events.

3. Soil compaction and road building in 10-12 percent of a watershed.

Runoff and Snowmelt

Watersheds in the Western Oregon Cascades respond quickly. During extreme storm periods (long duration and low intensity) runoff rates approach 80 percent of the average rate of precipitation the previous 12 to 24 hours (Rothacher, Dyrness and Fredriksen, 1967).

In one study of a small (25 acre) watershed, Harr and McCorison (1979) found that after harvest, peak flows from rain and snowmelt were delayed several hours and were about one-third smaller. During the post treatment periods studied there were only small amounts of snowfall and little or no antecedent snowpack on the ground. Differences were due to snow caught and melted earlier in the tree crowns of the forested area compared to the opening.

As previously mentioned, the majority of the floods of any consequnce, were caused at least partly by rain-on-snow events. Snowpacks in the Western Oregon Cascades are termed warm, which require little increase in energy to initiate melt (Harr, in press). Water input to the soil from snowmelt alone can be up to about two inches per day (Harr, 1978; George, 1979).

Assuming an exisiting snowpack and using snowmelt models developed by the Corps of Engineers, Harr (1978) demonstrated that soil water input from melt would be greater in open areas. The increase in snowmelt is due to changing the transfer of energy and water vapor to the snow surface. The warm snowpacks characteristic of Western Oregon respond rapidly to any increased energy. Harr showed that a soil water input event with a two-year return period could be increased (by more snowmelt in a clearcut) to an event of a magnitude that would occur with a 10-year return period. A 10-year event could be increased in size to that of a 25-year event. Small increases in soil water input can increase the storm runoff.

Elevation is an important factor in snowmelt. The most important zone of snow accumulation and melt in the Oregon Cascades is about 4,000 feet and lower (Anderson and Hobba, 1959; Fredriksen, 1978). During warm periods, and particularly rain-on-snow storms, part or all of the snowpack can melt rapidly (Harr, 1979). The freezing level influences where snow will be and where snow will be melting.

Another influence on snow accumulation and melt is a "thermal cover" effect of trees. The value of thermal cover or insulation by tree canopy has been recognized as important to big game during both hot and cold periods (Harshman, 1977; Edgerton and McConnell, 1976). The trees also store snow on branches under certain conditions. Dennison (1979) reported that winter and summer air temperatures in conifer canopies are 1.3 degrees centigrade warmer than at ground level. The presence or absence of the thermal cover can affect the storage of snow and rate of melt.

Locally only a limited amount of documentation is available for winter conditions during storms. It is during those periods of snow, rain, and rain-on-snow that microclimate is influenced by vegetation and is of interest.

Channel Hydraulics

Hydraulics in natural channels is complex and difficult, if not impossible, to predict mathematically. Changes in climate and human impacts upon the land create conditions conducive to channel changes (Bull, 1979). With changes in the variables affecting the hydrologic cycle, there can be changes in peak flows, total runoff, water quality, and appearance of the water (Leopold, 1968).

There are, however, some principles and processes that are important to mention:

-- Rate of Flow

Kenetic energy increases as the square velocity of the flow (Harr, 1976). Bull (1979) found suspended sediment transport rates to increase by the exponential factor of 2.5 of the flow change. For example, a 10 percent increase in flow will cause a 25 percent increase in suspended sediment transport ability.

-- Stream Power

Bull (1979) also identifies the concept of stream power. Stream power is related to the amount of energy necessary to move stream materials and is a function of the amount of flow and channel slope. Critical power, however, is related to the amount of material available to be moved, and the volume, shape, weight, and sizes. If the stream power is sufficient to move exactly what is available in the stream, the ratio of stream power to critical power is 1. If there is not enough power to remove the materials, the ratio is less than 1, and there would be deposition. With a ratio greater than 1, there is extra power and down-cutting or other erosion.

-- System Response

The change in one portion of a drainage network is eventually felt elsewhere in the system. Normally there is an adjustment in the flow character, channel character, or both. There can be a change in water velocity and channel dimensions (Morisawa and LaFlure, 1979). Based on work in Western Oregon, Harr (1979) indicated that the larger flows (approximately 40 cubic feet/second per square mile on up) are the ones shaping headwater channels. Transport of sediment through a stream reach can occur at smaller flows.

The shape and character of a stream channel is due to bedload moving flow rates, sediment inputs, debris, and manmade structures or channel alterations. Bank-full flow is sufficient to move bedload (Megahan, 1979). Megahan referenced two studies indicating that bank-full flow is reached about every two years. In addition to flow changes influencing channel form, he also mentions that the addition or removal of debris, channel encroachment, and total sediment storage and transport can interact with the flow to produce changes.

Soil Moisture/Slope Hydrology

As mentioned previously, the amount of precipitation delivered is generally not altered in the Pacific Northwest. However, the timing and the amount reaching the soil surface can be changed. The storage and transport of moisture out of or through the soil profile can be modified.

Soils in Western Oregon have high water infiltration and transport rates. After prolonged periods of rain, the stream flow rate approaches the average precipitation rate (Harr, 1976).

Increases in water yield have been observed in most cases after harvest. Peakflow increases are generally most pronounced during the first large storm after the dry season. Low flow increases are small in absolute terms but large relatively. A reduction in low flow increases has been observed over time after logging and is believed due to growth of riparian hardwood vegetation (Rothacher, Dyrness and Fredriksen, 1967).

The only way I found in the Northwest literature to consider regrowth as it affects transpiration was through leaf area. Normally leaf area increases rapidly from the time of tree establishment until crown closure (Gholz, Fitz and Waring, 1976). At canopy closure (Douglas-fir and other conifers) maximum leaf area has been essentially reached. On a given site, shrubs do not achieve the same leaf area as conifers. The hardwoods may only reach about one-fourth of the potential leaf area. Alder does not have as much leaf area as conifers either. Canopy closure by Douglas-fir and other conifers may take from 25-60 years depending on site quality and stocking (Gholz, 1979).

The amount of transpiration from the foliage depends upon the surface area and physiology. Evapotranspiration from Douglas-fir during winter has been found to be about the same as during the summer. The reasons are wetted surfaces transpire more freely, and in the summer only the young needles are the ones transpiring rapidly (Fritschen and Doraiswamy, 1977). Winter temperatures even at higher elevations in the Western Cascades are often above freezing. The warmer canopy temperatures (compared to ground level) plus Douglas-fir stomata remaining open down to -2 degree centigrade (Waring, Emmingham, Gholz, Grier, 1978) allow transpiration throughout much of the winter.

The water delivered to the soil minus any losses due to evaporation and transpiration is available for routing downslope as ground water or eventually as streamflow. Westside Cascade soils respond rapidly to soil moisture input, however, the slope position of an area affects how dynamic the response is. Concave areas and headwalls are generally the most dynamic in the response to the storm precipitation.

Roads have the most potential affect on slope hydrology. Roads can increase the volume and rate of flow, alter the drainage net, and change the downslope soil moisture regime (Megahan, 1972). Megahan's work showed that subsurface flow interception because of a slope incision by road yielded over seven times the estimated flow due to road surface interception alone. Not only did ground water become surface flow, but it also was delivered to streams sooner.

IV. LOCAL DATA AND INFORMATION

During this investigation I evaluated existing information that could be related to a change in watershed response. The longest term records were used. Information will be presented on the basins, management history, streamflow and precipitation. Much of the information is from areas shown in Figure 1.

SELECTED WATERSHEDS

Willamette National Forest

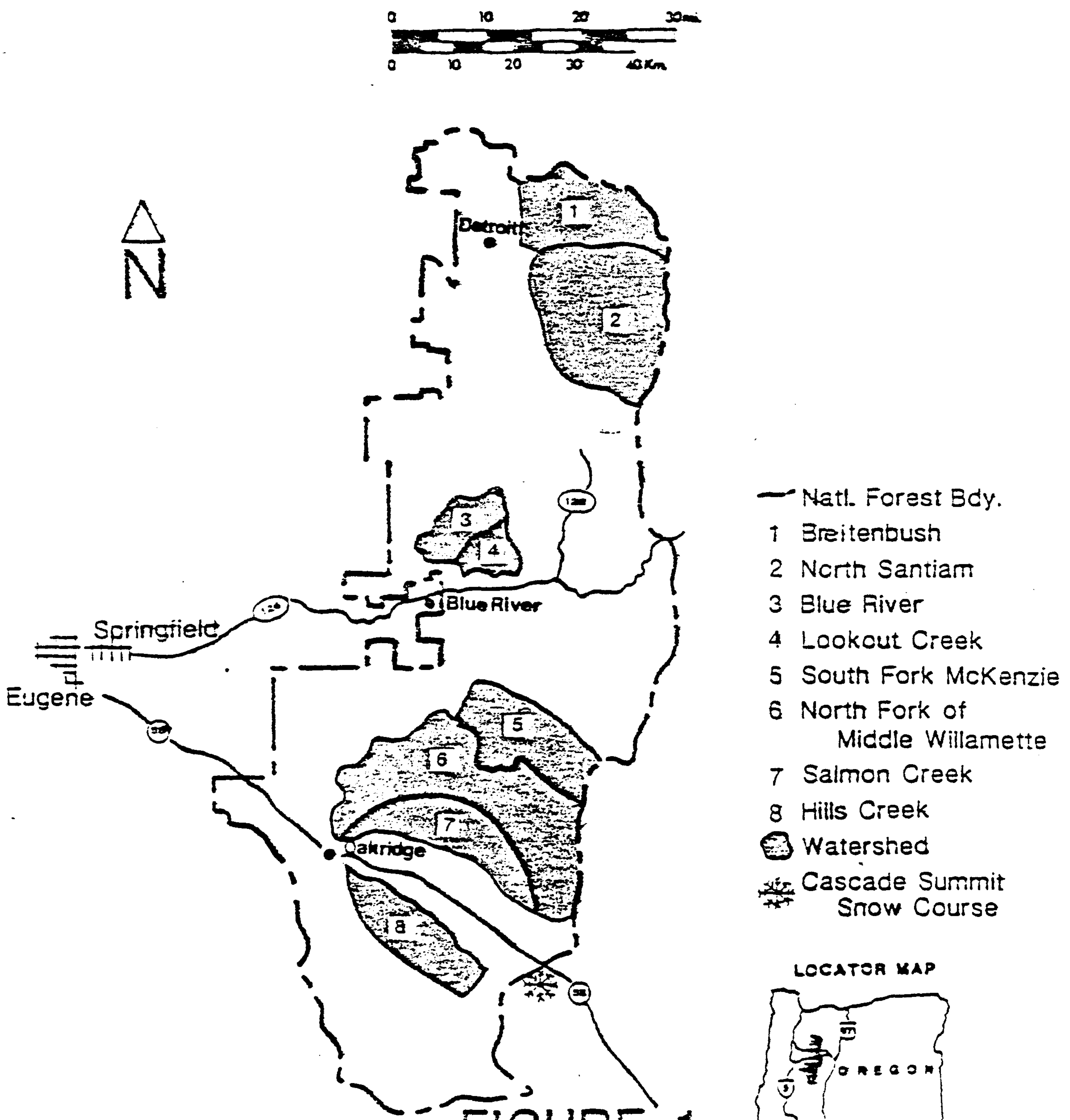


FIGURE 1

Basin Characteristics

Consistent with other data in this report, the information is presented at the basin level. Basin delineation is determined by the stream gage location. Table 1 below lists primary basin characteristics.

TABLE 1
Basin Characteristics

Basin/ Stream Gage #	Area (Mi^2)	Mean Channel Length (Mi)	Aver. Elev. (Ft)	Approx. Mean Channel Grade (%)	Miles/Number of Streams by Order 1	2	3	4	5	6	Drainage Density Mi/Mi^2	Years of Flow Record
Salmon Ck. near Oakridge 141465000	117	24.7	4140	1.7	176/588	90/144	32/28	24/7	12/1		2.9	53
North Fork Middle Willamette 14147500	246	51	3760	2.1	414/1496	178/338	79/63	36/13	18/2	13/1	3.0	50
South Fork McKenzie above Cougar 14159500	208	32.5	4080	2.3	315/1227	128/237	56/48	27/8	8/2	6/1	2.6	21
Blue River below Tidbits 14161100	45.8	12	3000	6.2	127/561	62/129	22/23	11/7	7/3	4/1	5.1	14
Lookout Cr. Near BR 14161500	24.1	9.5	3190	4.9	62/173	21/47	9/7	4/3	5/1		4.2	24
Breitenbush above Canyon Cr. 14179000	106	21.8	3720	3.4	213/719	73/132	31/30	24/7	11/2	7/1	3.4	46
North Santiam below Boulder Cr. 14178000	216	35.7	3720	1.8	324/1050	131/195	67/40	22/8	11/2	7/1	2.5	53

Table 2 gives the percent of first and second order streams and the percent of the basin below 4,000 feet elevation. The rationale for selecting 4,000 feet will be explained in the peak flow section.

TABLE 2
Basin Characteristics

	Salmon Creek	North Fork	South Fork	Blue River	Lookout Creek	Breitenbush	North Santiam
Percent of first and second order streams	80	80	82	81	82	80	81
Percent of basins less than 4,000 feet elevation	52	53	28	85	80	62	49

Using the characteristics of Tables 1 and 2, and geographic locations, the basins were grouped as follows:

1. Salmon Creek/North Fork

2. South Fork

3. Blue River/Lookout Creek

4. Breitenbush/North Santiam

Management History

Since primary activity in each of the basins has been timber harvest and road construction, it is logical to look at development over the years. The best available information on harvest was obtained from the Total Resources Inventory (TRI) which is maintained at each Ranger District. Information prior to data entries in TRI was obtained from the 1965 Willamette National Forest Timber Management Plan and the 1963 Timber Type Map which gave date of stand origin/date planted to nearest ten years.

The first recorded Willamette National Forest timber sale was in 1905. The sale was for 14 million board feet from the Oakridge area. Prior to 1941 there was very litte harvest of National Forest timber. At the start of World War II the amount of harvest from National Forest began its increase. Table 3 and Figure 2 show a summary of harvesting for the seven selected basins. Note that the data are for the portion of the basin less than 4,000 feet elevation.

TABLE 3

Cumulative Percent of Basin Harvested 1/ (Less Than 4,000 Feet Elevation)

Year	Salmon Creek	North Fork	So. Fork McKenzie	Blue River	Lookout Creek	Breiten-bush	North Santiam
1925	--	2.9	--	.3	--	4.0	1.1
1935	1.2	9.9	--	.5	--	4.3	3.0
1945	4.1	17.5	--	.8	--	4.3	14.4
1950	4.7*	18.1*	.6	1.1*	.6	5.3*	16.4
1955	5.3	18.7	3.2	1.4*	6.9	6.3	18.3
1960	6.2	20.3	3.8	2.5	11.4	8.1	20.0
1965	13.0	22.9	6.9	5.0	16.1	13.0	23.6
1970	19.2	25.7	8.2	5.3	19.4	15.8	25.8
1975	25.3	30.0	13.0	11.3	19.9*	17.9	28.9
1977	27.5	30.8	13.3	12.7	19.9*	18.8	30.4
1978	27.8	31.0	13.4	13.3	20.0*	19.3	31.0
1979		31.3		13.6	20.0* 2/		

1/ Includes private inholdings.
2/ Salvage of small areas during 74-79 period.
* Estimated value for interval.

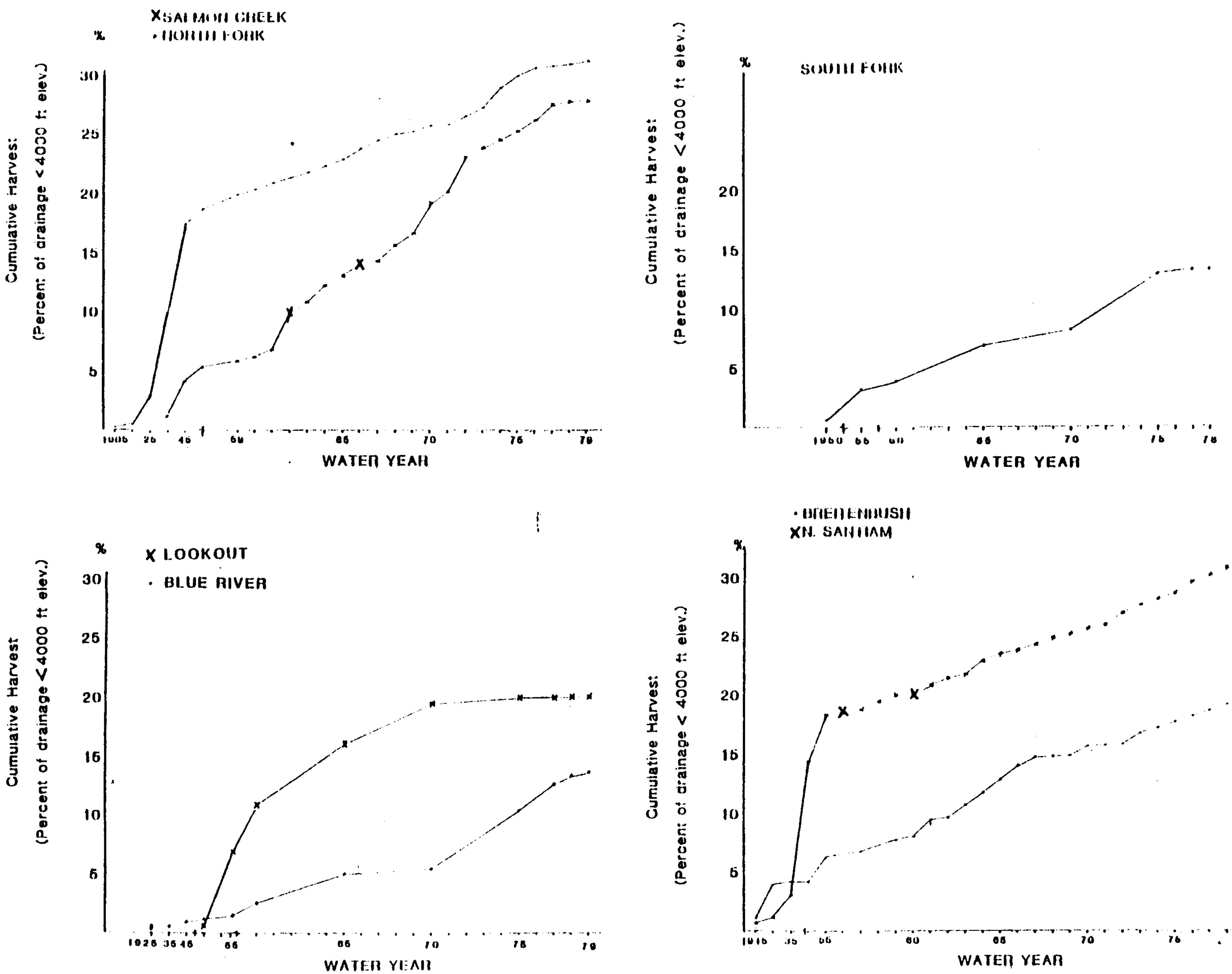

XSALMON CREEK
• NORTH FORK
Cumulative Harvest
(Percent of drainage < 4000 ft elev.)
WATER YEAR
SOUTH FORK
Cumulative Harvest
(Percent of drainage < 4000 ft elev.)
WATER YEAR
X LOOKOUT
• BLUE RIVER
Cumulative Harvest
(Percent of drainage <4000 ft elev.)
WATER YEAR
• BREITENBUSH
XN. SANTIAM
Cumulative Harvest
(Percent of drainage < 4000 ft elev.)
WATER YEAR

FIGURE 2

Table 4 gives the cumulative miles of road as measured off on various Forest Service maps. Generally the maps did not show temporary roads such as spurs or skid trails.

TABLE 4
Cumulative Road Miles 1/

Year of Map	Salmon Creek	North Fork	So. Fork McKenzie	Blue River	Lookout Creek	Breiten-bush	North Santiam
1913		5					
1925	2	20					
1930	5	22	2			8	17
1935	14	52	14	3		26	37
1940	14	69	14	3		29	55
1950	20	100	14	3	(5) 1	30	94
1959	45	161	34	7	(43) 23	35	118
1965	95	188	49	20	(66)	55	146
1967	135	250	92	37	(70) 51	119	171
1974	176	304	115	57	(72) 51	138	209
1978	180	328					
1979			111	73	(72) 61	163	271

1/ From Forest Service Maps. Miles from detailed Pacific Northwest Forest's Range Ept Sta. records shown in ( ).

Streamflow

In December 1978, I observed a major rain-on-snow runoff event. At an elevation of approximately 4,000 feet, the runoff was heavy and exceeding the capacity of many of the road drainage structures. There was localized damage to the road surface and drainage. Checking the flow records for Salmon Creek, I found that the December 1978 flood peak exceeded that of the November 1977 flood which had caused widespread road and resource damage and some flooding in the Willamette Valley. Yet no flooding was experienced in the Willamette Valley in December 1978.

The Salmon Creek drainage seemed to experience a higher flow (December 1978) than nearby streams. Checking USGS records and figuring recurrence intervals, I found that the December 1978 flood in Salmon Creek had about a five year recurrence interval. The same flood in two nearby drainages, the North Fork of the Middle Fork Willamette and Hills Creek, (see Figure 1 for location) had about 2.6 and one-year return periods, respectively. Next I compared the return periods for the same three drainages for the five most recent peak flows. The bar graph (Figure 3a) shows computed return periods for the runoff events. Figure 3b shows the magnitude of each event. During the past three water years (1978, 1979, 1980) it is interesting to note that Salmon Creek had three peak flows with return periods greater than three years, whereas Hills Creek and the North Fork had only one each. Also, the highest peaks were December 1978 for Salmon Creek, January 1980 for Hills Creek, and November 1977 for the North Fork.

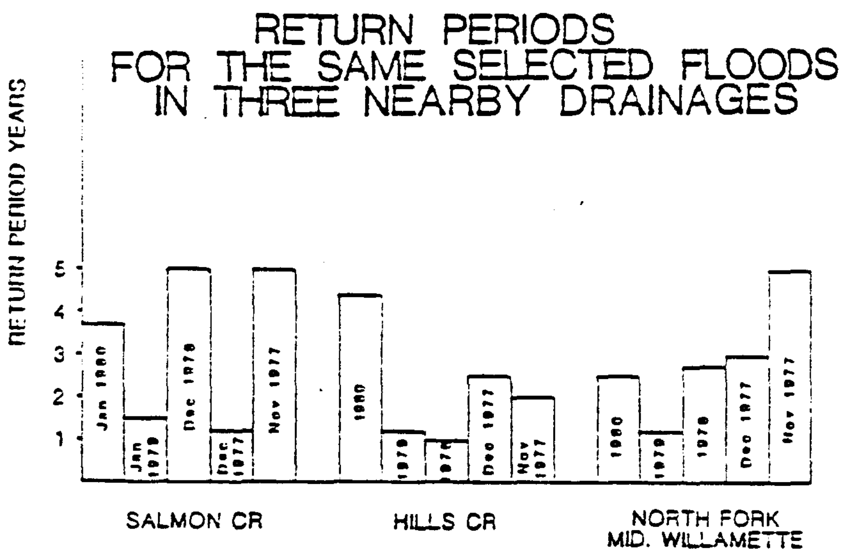


FIGURE 3A

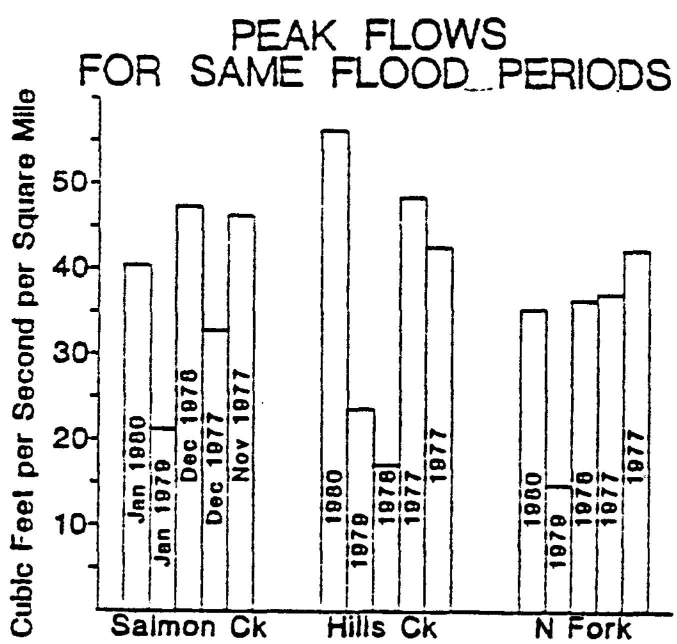


FIGURE 3B

Clearly the responses of the three drainages are at times similar, and at other times different. Climatic data are not specific enough to determine any difference in storm patterns among the three drainages. However, there may be differences in the proportion of each area affected by fluctuations in freezing levels.

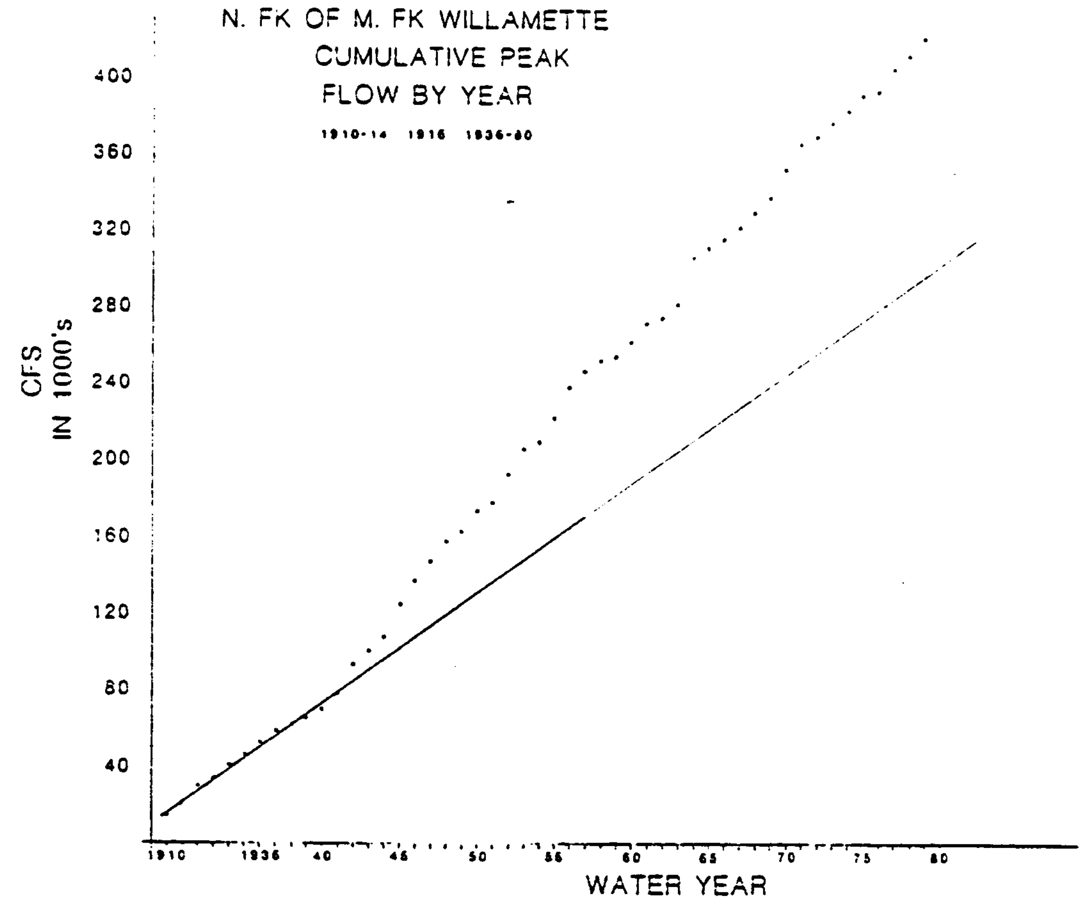
The comparison above prompted me to look further into existing streamflow records. First, annual peaks from seven basins were checked to see if there have been changes over time. The seven basins selected are located throughout the Willamette National Forest. They do not have any diversions or regulations and have long periods of record. They range in size from 24 to 246 square miles.

My initial intent was to plot double mass curves using the drainages of interest and an untreated control drainage. However, it was not possible since there are no untreated drainages in the size range of the seven basins. Instead, I plotted the cumulative annual peak flows by year, to visually check the trend.

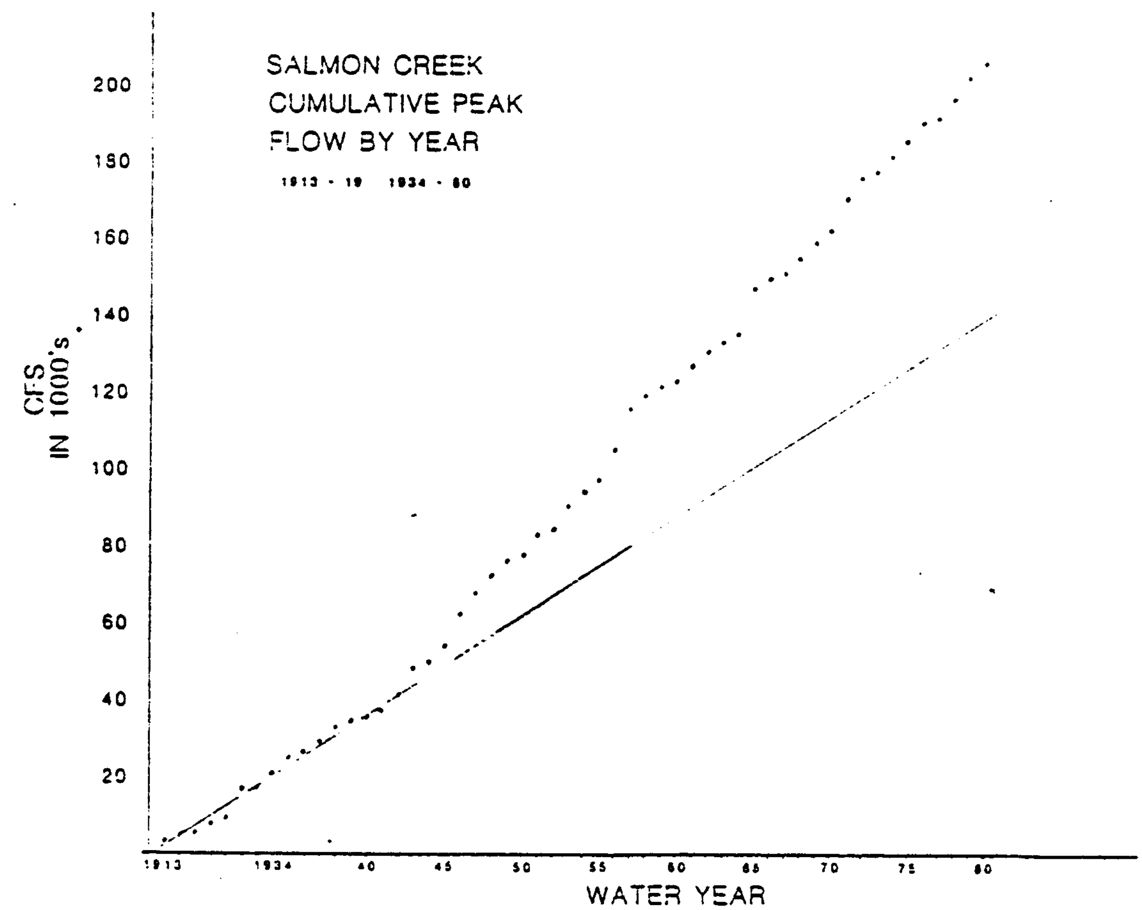
Figures 4a-d show if annual peak flows have changed throughout the period of record. For comparison, an extension of the first few years was made. A straight line would indicate that annual peaks had not changed. Constant conditions with an occasional large flood would show up as straight line segments of uniform slope and jumps upward the years of floods.

Looking at the first two (Figure 4a), Salmon Creek and the North Fork, there have been changes in the slopes with the trend being that the annual peak is larger now. It appears that in recent years, the peaks of Salmon Creek have still been increasing in size but those of the North Fork have been about the same. Figure 4b shows the South Fork in the McKenzie which has headwaters just over the ridge from the headwaters of the North Fork. Although there have been some large peaks from flooding, it appears that the average annual peaks (based on a visual check of the slope of the curve) are about the same throughout the period of record. Blue River and Lookout Creek (Figure 4c) are adjacent drainages on the north side of the McKenzie River. Blue River appears to have higher annual peak flows, whereas the annual peaks of Lookout Creek are dropping off. Two adjacent drainages at the north end of the Forest are the Breitenbush River and the North Santiam River (Figure 4d). They both have annual peak flows that are higher now, than in earlier years.

Because snowmelt could be a major factor influencing peak runoff I plotted flood magnitude versus elevation. Flood recurrence data for stream gages from a USCS publication (Harris, Hubbard and Hubbard, 1979) were plotted using average basin elevation (Figures 5a and b). For comparison, 5-year and 25-year recurrence intervals were used. Both figures show that the unit area runoff is higher below about 4,000 feet elevation than it is above that level. Also, the range is wider between 2,000 and 4,000 feet than it is above 4,000 feet. The plots confirm field observation and other reports of an active elevation zone with periodic snow and rapid melt.



N. FK OF M. FK WILLAMETTE
CUMULATIVE PEAK
FLOW BY YEAR
1910-14 1916 1936-80
CFS
IN 1000's
400
360
320
280
240
200
160
120
80
40
1910
1936
40
45
50
55
60
65
70
75
80
WATER YEAR



SALMON CREEK
CUMULATIVE PEAK
FLOW BY YEAR
1913 - 19 1934 - 80
CFS
IN 1000's
200
180
160
140
120
100
80
60
40
20
1913
1934
40
45
50
55
60
65
70
75
80
WATER YEAR

FIGURE 4a

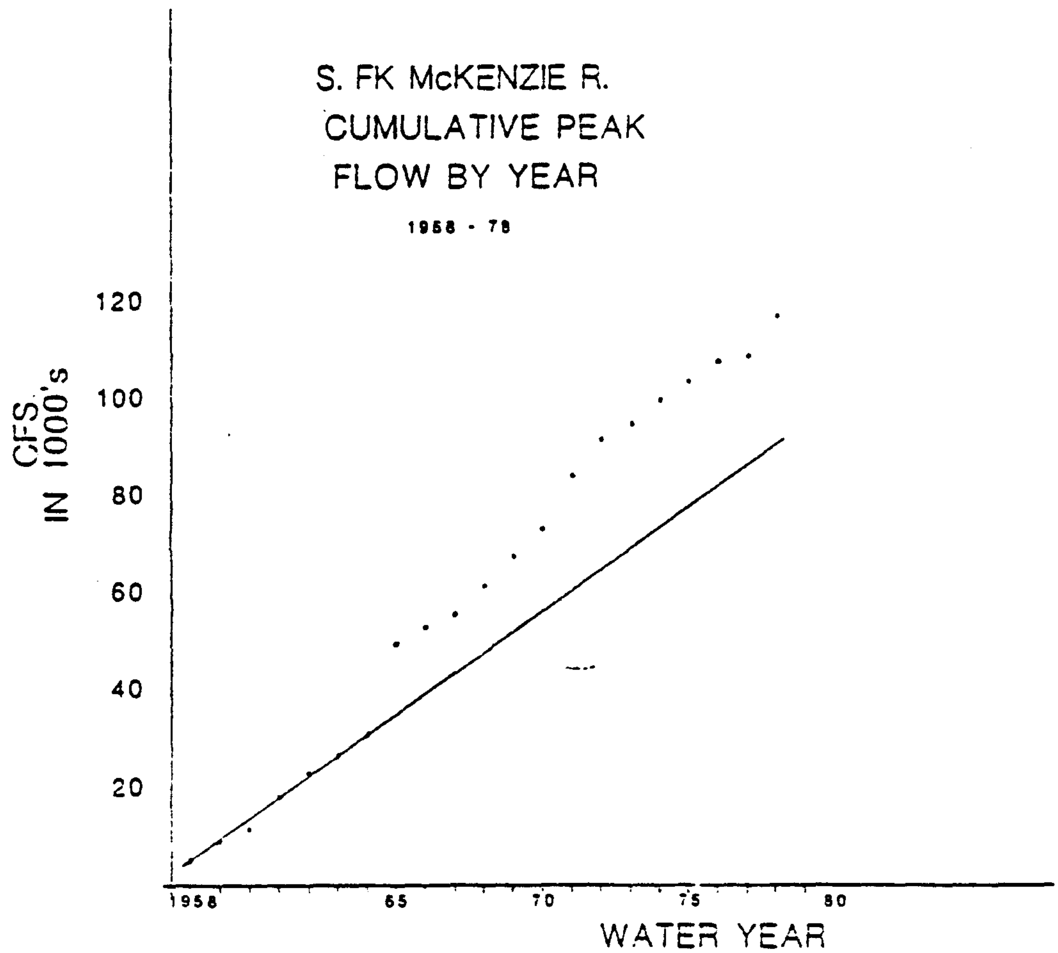
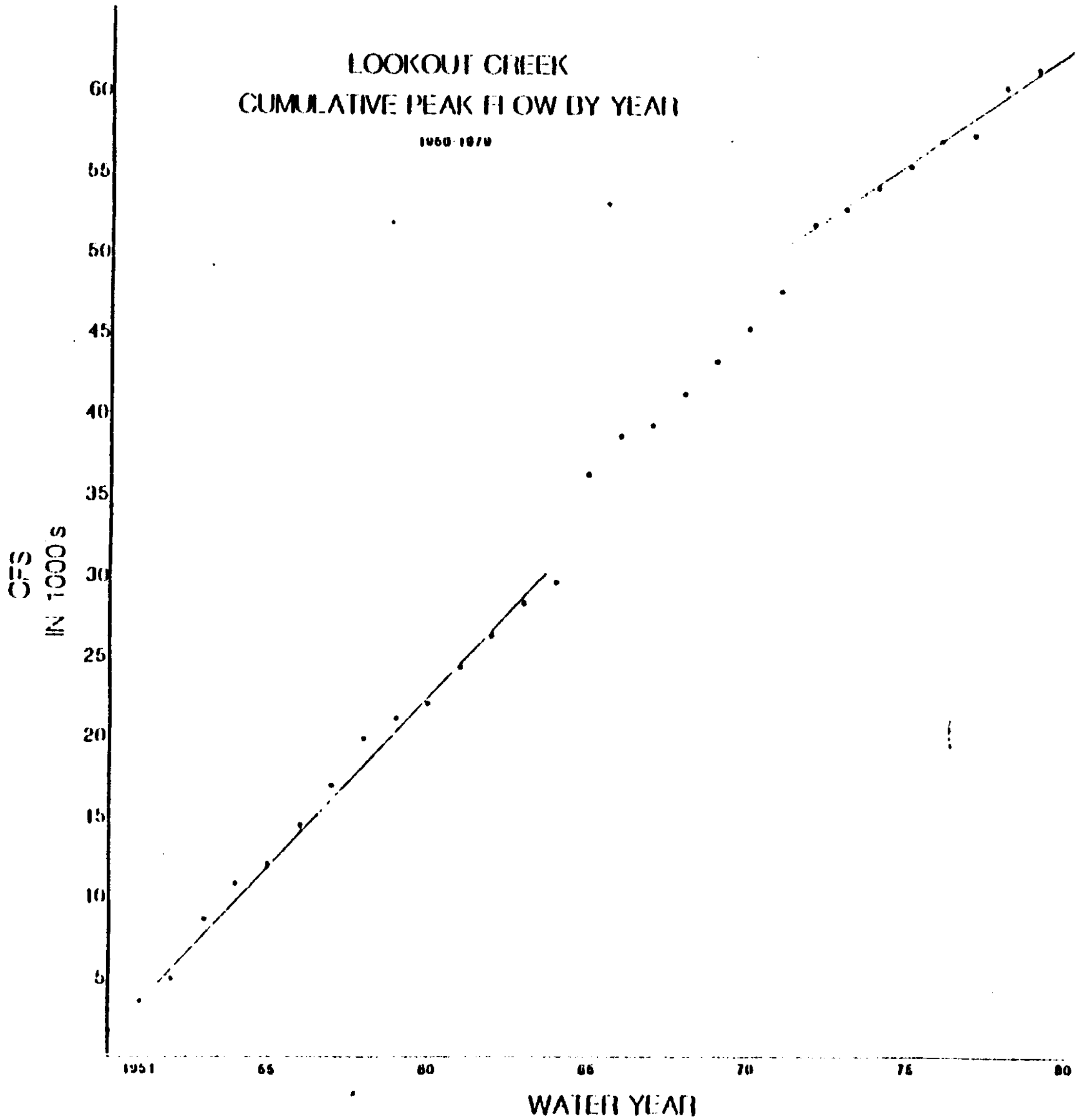

S. FK McKENZIE R.
CUMULATIVE PEAK
FLOW BY YEAR
1958 - 78
CFS
IN 1000's
120
100
80
60
40
20
1958
65
70
75
80
WATER YEAR

FIGURE 4b


LOOKOUT CREEK
CUMULATIVE PEAK FLOW BY YEAR
1950-1979
CFS
IN 1000's
60
55
50
45
40
35
30
25
20
15
10
5
1951
55
60
65
70
75
80
WATER YEAR

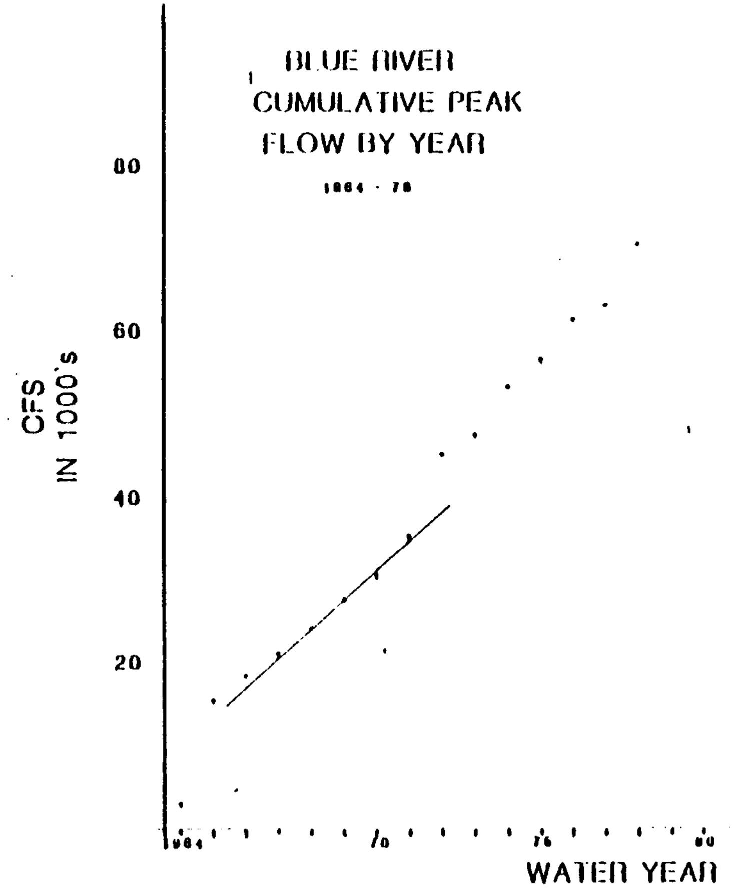
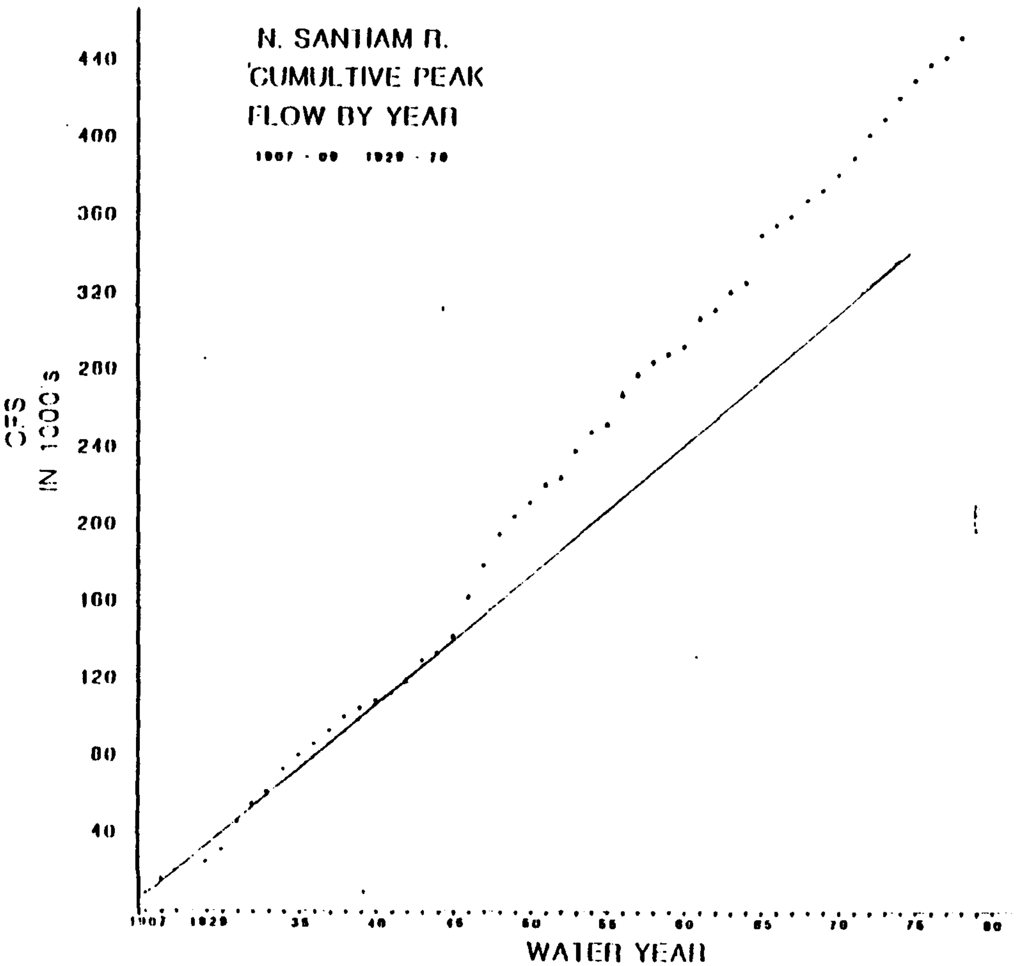

BLUE RIVER
CUMULATIVE PEAK
FLOW BY YEAR
1964 - 78
CFS
IN 1000's
80
60
40
20
70
75
80
WATER YEAR

FIGURE 4c


N. SANTIAM R.
CUMULTIVE PEAK
FLOW BY YEAR
CFS IN 1000's
440
400
360
320
280
240
200
160
120
80
40
WATER YEAR

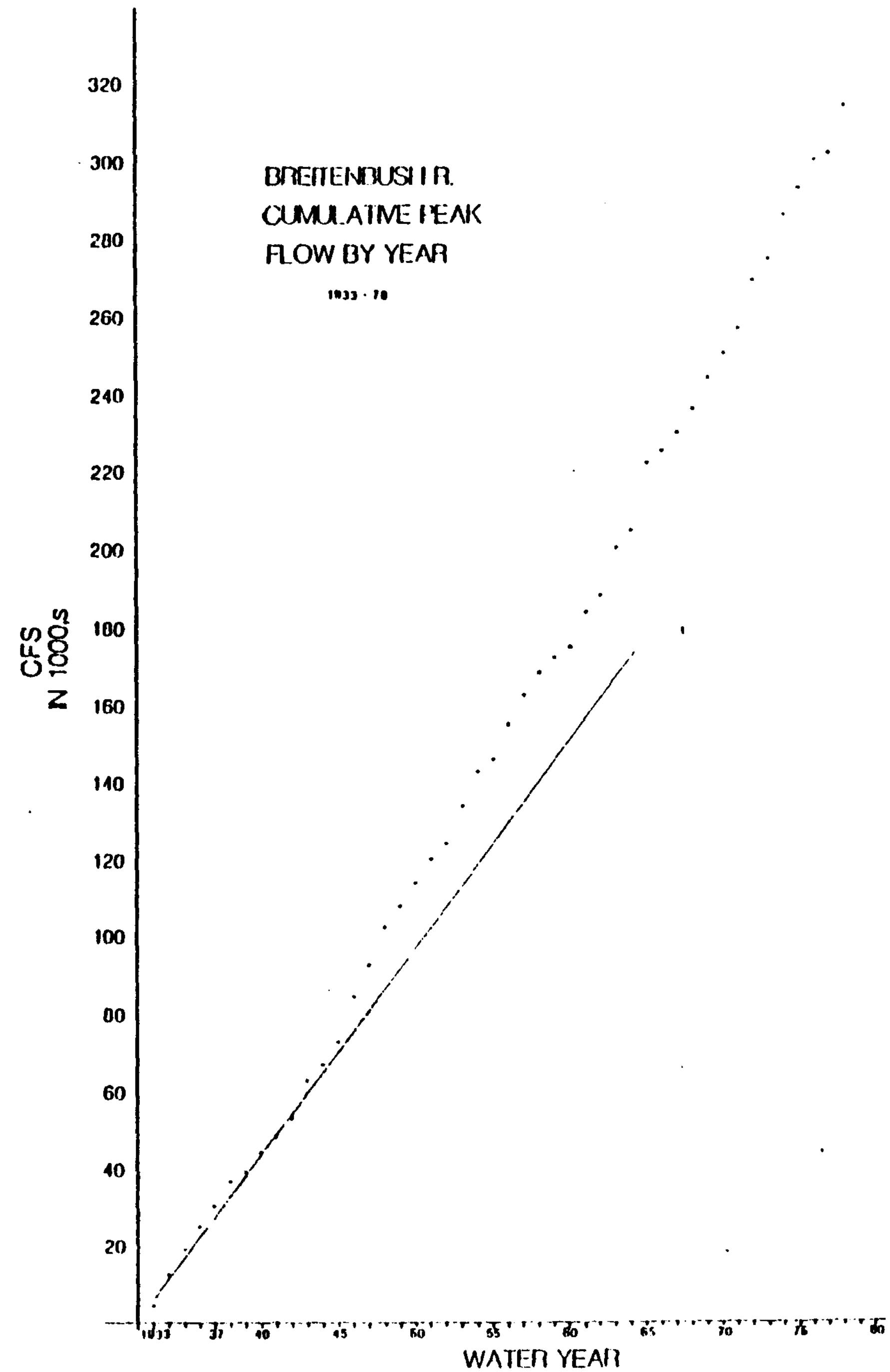

BREITENBUSH R.
CUMULATIVE PEAK
FLOW BY YEAR
CFS IN 1000,s
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
WATER YEAR

FIGURE 4d

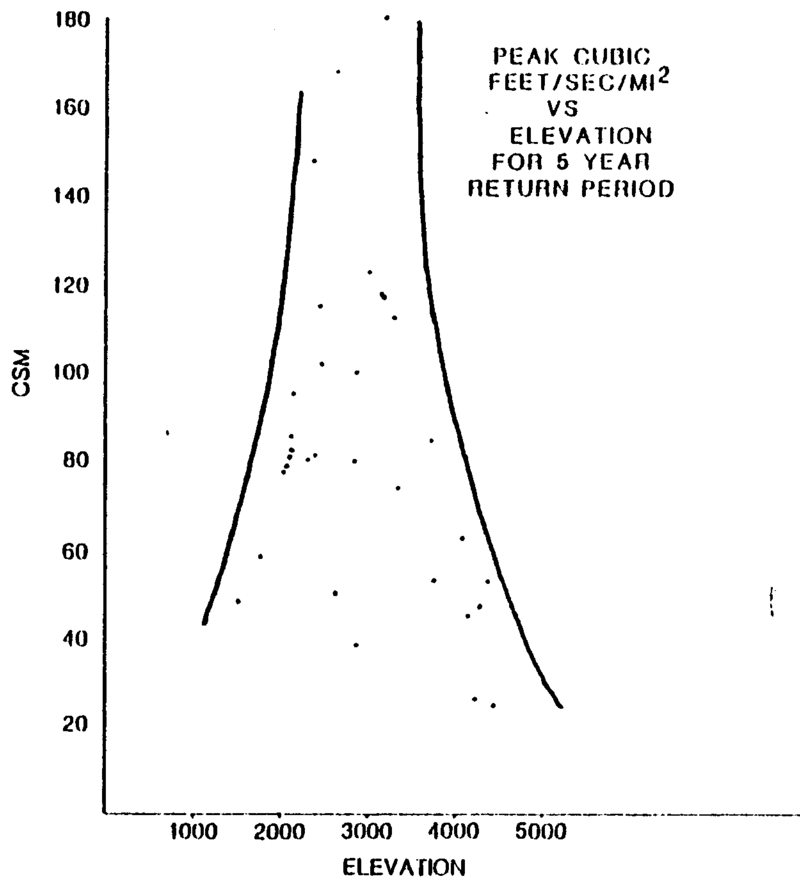


FIGURE 5a

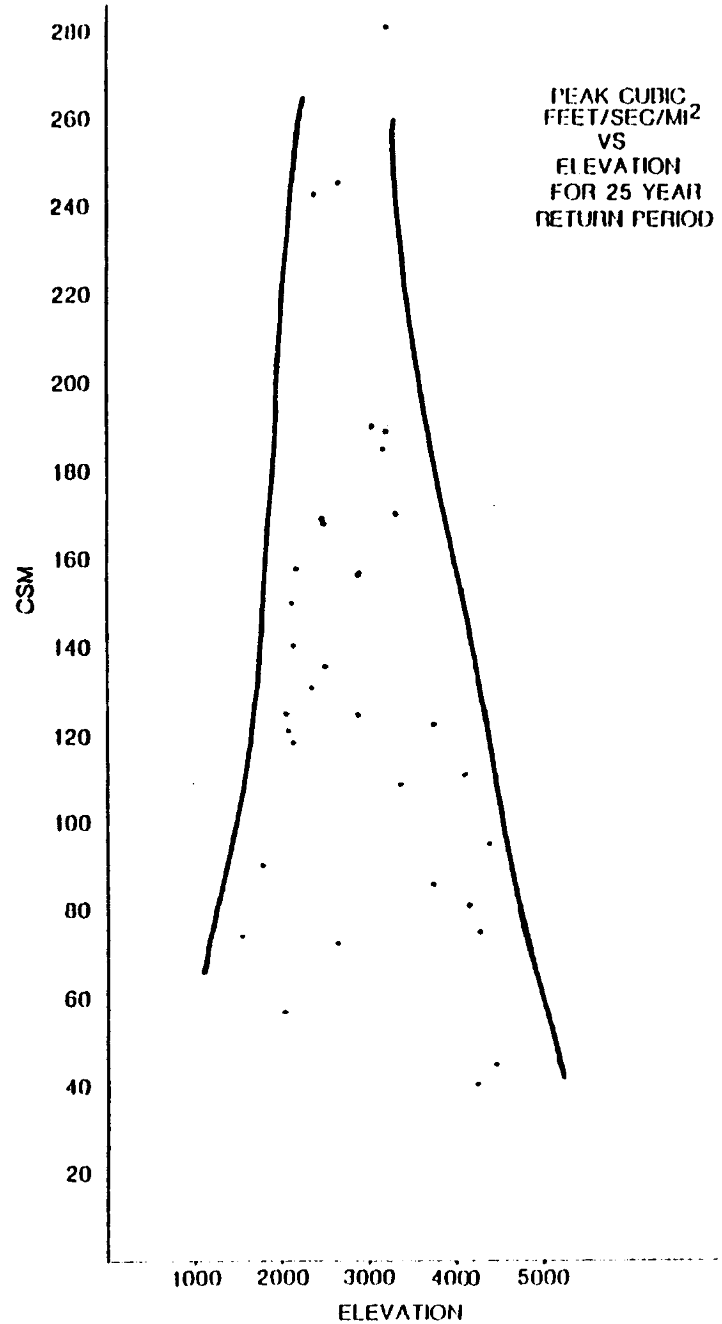


FIGURE 5b

Precipitation

Since the flow data presented are long term, precipitation data were evaluated to see if any obvious trends or fluctuations occurred. The precipitation data (Figure 6a, b, c and d) are from Eugene, Oakridge, Salem and Detroit -- the longest term stations. Snow course data (Figure 7) are from Cascade Summit, the snow measurement course with the longest record.

Winter and summer precipitation for all stations appeared to have a fairly level trend except for the past 25 years. The winter period (October-March) was broken into two periods of 12 years and 13 years (1954-65 and 1966-78). The trends are summarized in Table 5 below:

TABLE 5
Average Precipitation

Station		Period 1954-1965	Period 1966-1978	Recent Trend
Oakridge-Elev. 1,275 Feet	Winter	36.28 in.	35.25 in	Down
	Summer	10.88 in	10.82 in	No Change
Eugene-Elev. 364 Feet	Winter	35.95 in	39.80 in	Up
	Summer	7.49 in	9.70 in	Up
Detroit-Elev. 1,220 Feet	Winter	62.22 in	66.92 in	Up
	Summer	18.71 in	18.01 in	No Change
Salem-Elev. 195 Feet	Winter	32.03 in	32.22 in	No Change
	Summer	7.96 in	8.78 in	Up

The snow water equivalent from the February 1 snow course measurements was selected because it is near the date of maximum accumulation, and has been measured each year since 1930. As can be seen from the plotted data (cumulative snow water equivalent by years) of Figure 7, the line is generally straight with only a few plateaus of less slope. The average snow water equivalent for two periods during the last 25 years is in Table 6 below:

TABLE 6
Snow Water Equivalent

Station	Period 1954-1965	Period 1966-1978	Recent Trend
Cascade Summit-Elev. 4,880 Feet	18.32 in	19.41 in	Up

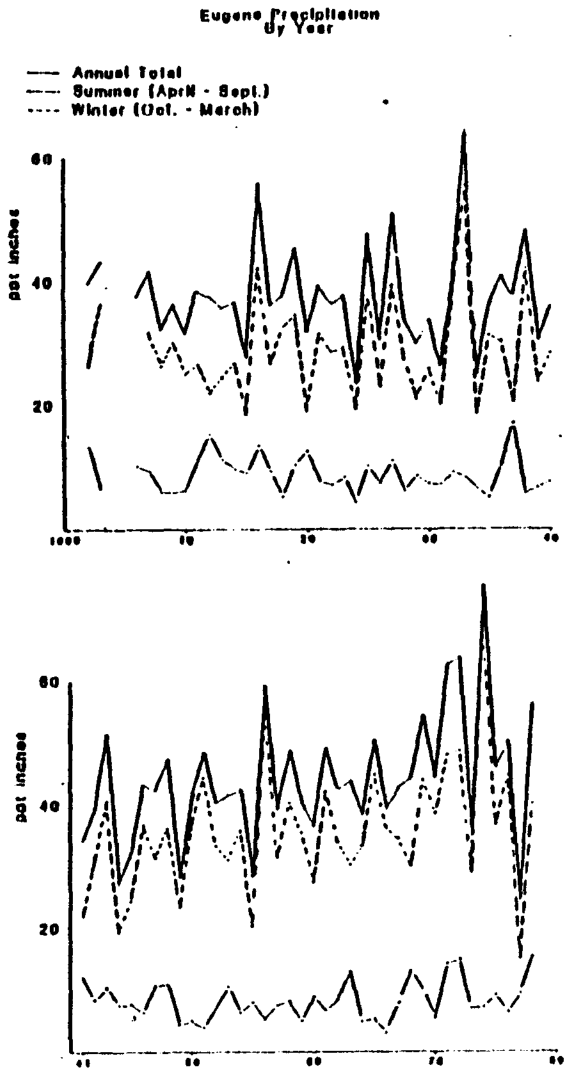


FIGURE 6A

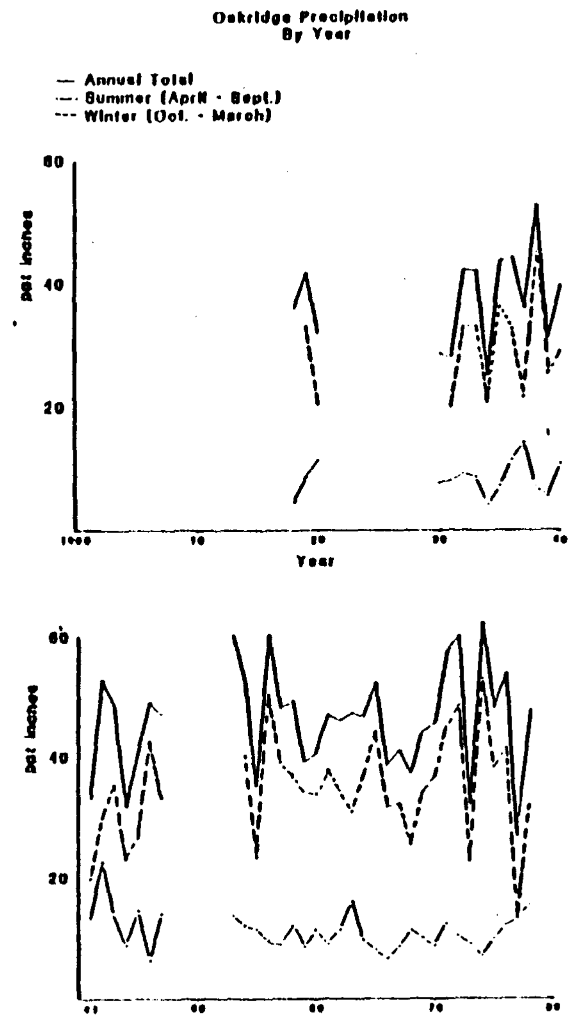


FIGURE 6B

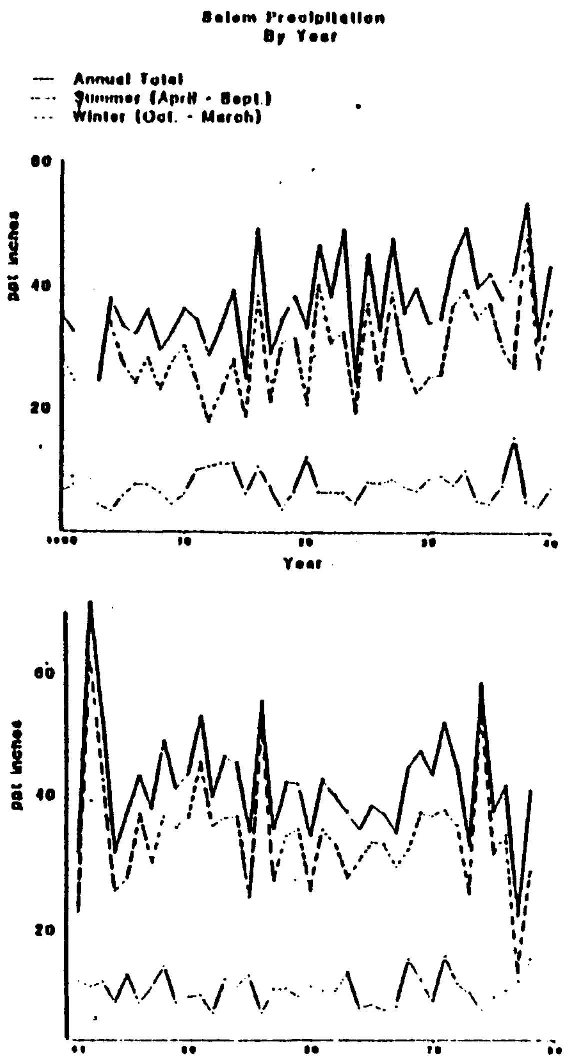


FIGURE 6C

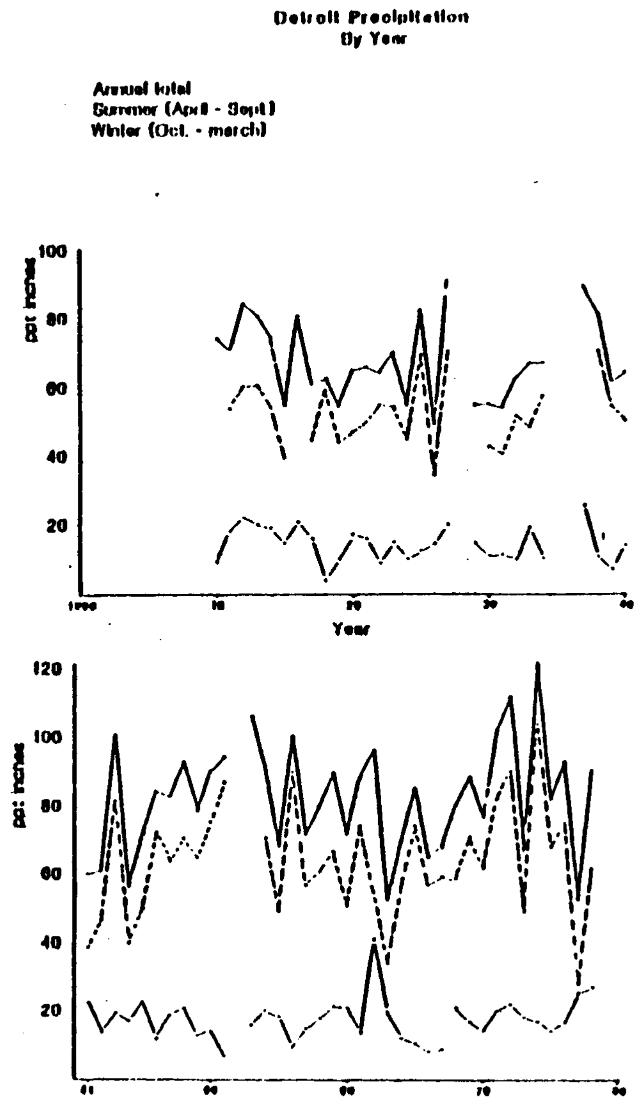


FIGURE 6D

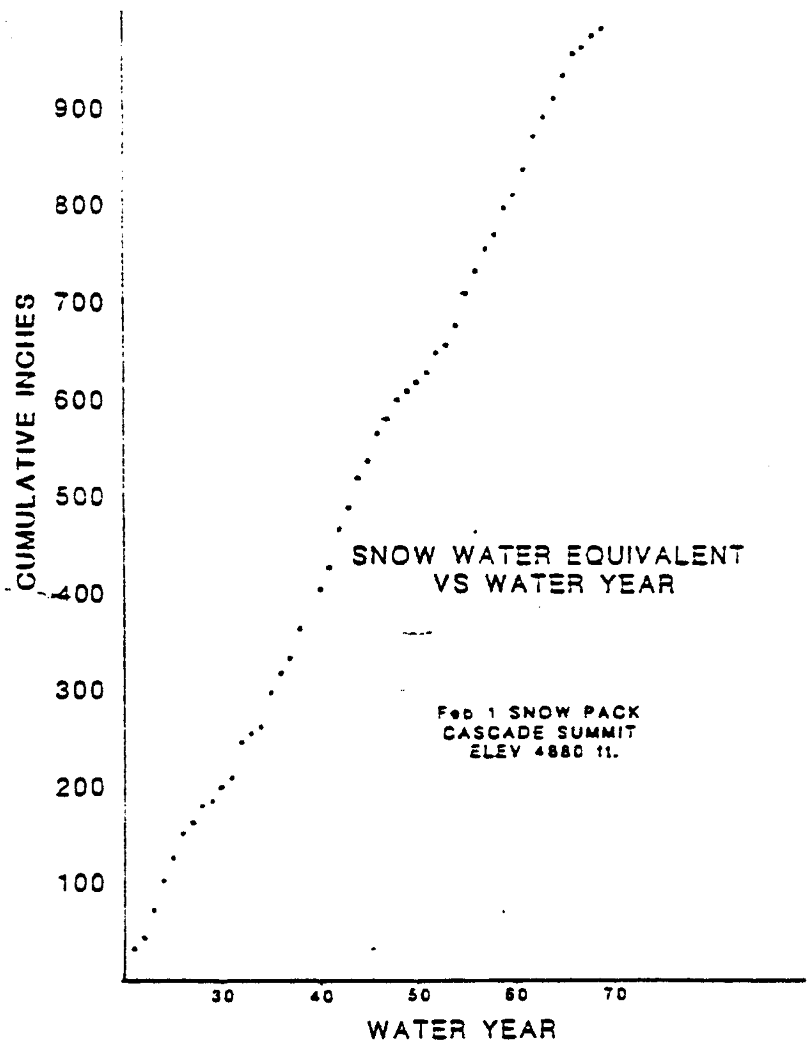

SNOW WATER EQUIVALENT
VS WATER YEAR
Feb 1 SNOW PACK
CASCADE SUMMIT
ELEV 4880 ft.
CUMULATIVE INCHES
100
200
300
400
500
600
700
800
900
30
40
50
60
70
WATER YEAR

FIGURE 7

Precipitation During Pre-flood Period (of NORTH FORK)
vs Cumulative Winter Precipitation (Oakridge or nearerst location)

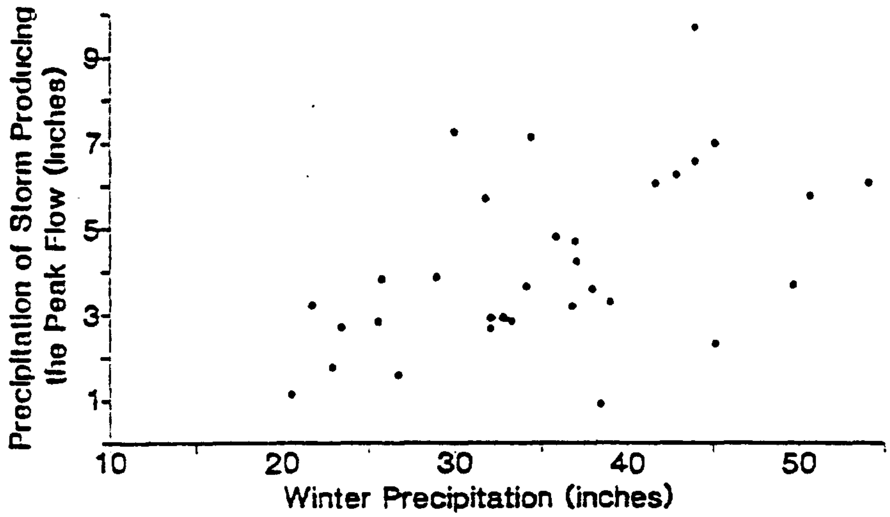


FIGURE 8

NORTH FORK Two Day Precipitation
vs Annual Peak Flow

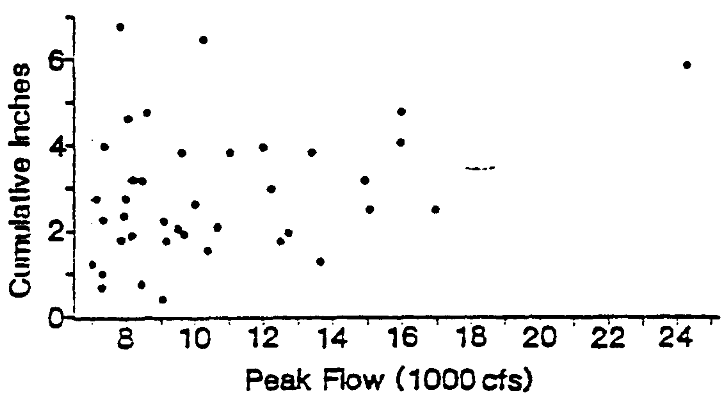


FIGURE 9

NORTH FORK Storm Precipitation vs Peak Flow

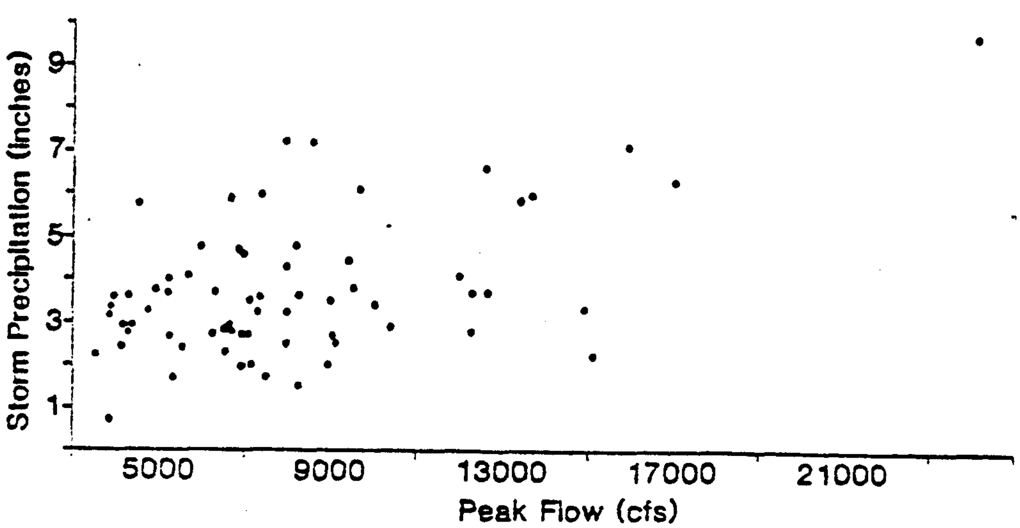


FIGURE 10

The relationship between snow water equivalent at Cascade Summit and precipitation at Oakridge is not necessarily the same. For example, in 1959 Oakridge had 30.45 inches during the winter and there were 6.9 inches of snow water equivalent at Cascade Summit. In 1960 there were 29.01 inches at Oakridge and 10 inches at Cascade Summit. In other cases the amount of snow water is directly related to the amount of precipitation measured at Oakridge.

Because a change in streamflow might be attributed to a long-term climatic change, I examined precipitation at Oakridge and streamflow on the nearby North Fork.

-- Data were plotted to check if the amount of winter precipitation is an indicator of precipitation producing peak flows (Figure 8). Precipitation contributing to a peak flow event was accumulated back in time until a day was encountered with 0.1 inch or less of precipitation. Even with the scattered points, the winters with more precipitation tend to have more storm precipitation antecedent to the time of the annual peak flow.

-- The relationships of 2-day precipitation and resulting annual peak flow was checked (Figure 9). As expected, due to the snowmelt contribution, more two-day precipitation does not necessarily mean higher annual peak flows.

-- Figure 10 shows the relationship of storm precipitation to all peak flows of significance. The precipitation was accumulated over the duration of the storm. Again, due to snowmelt, more storm precipitation does not mean higher peak flows.

V. EVALUATION

Peak Flows

Both research and locally available information have shown there are changes in the high or peak flows.

In the six of the seven basins with long-term flow records, peak flows generally are tending to be higher now than in previous periods. The increase in the magnitude of peak flows occurred about the same time as accelerated timber harvest activity. In one drainage with minimal activity in the past ten years (Lookout Creek), the peak flows seem to be smaller than before.

Since the flows examined were measured on fifth and sixth order basins ranging from 24 to 250 square miles, increases could be even more marked in lower order basins. With the usual progression of harvest activity, not all lower order basins are affected in the same way each year - some streams would respond normally while others could have higher peak flows.

If the peak flows are increasing, then the recurrence interval for flood of a given magnitude is getting shorter; or looking at it another way, the size of the 5, 10, 25, etc., year floods is increasing.

An increase in flows means there is more energy to move sediment and bedload. The more frequently the channel-forming or modifying flow occurs, the more channel shape, character and aquatic habitat are modified.

Roads

Roads no doubt play a role in routing water to streams. Because there appears to be peak flow recovery in Lookout Creek, I feel that roads may contribute only a part of the total effect. Recovery might go farther in a managed forest situation if there are no or few roads. In the large basins studied road density did not appear to be an indication of peak flow response. There could be local effects caused by aspect, slope position, elevation and water handling, characteristics of the soil where the road is located. That detail of data collection and evaluation was beyond the scope of this report.

Management Activity

Harvest of timber is next to roads in degree of site modification and duration. The rate of harvest has been high during the past twenty years in every drainage. Lookout Creek has experienced marked reduction in harvest during the past ten years, however.

Even with the variation between drainages and the probabilistic nature of peak flows, a graphic correlation is apparent between peak flows and the amount of harvested area. The departure of the peak flow from the trend of the pre-harvest record follows the acceleration in harvest. For the Lookout Cr drainage, a reduction in harvest in the past 10 years has been followd by a slight recovery of the peak flows.

Conclusions

From the information presented, I have inferred the following:

1. There is an elevation zone of importance from the snowmelt standpoint.

2. Over the years, peak flow increases have been associated with timber harvest.

3. Some degree of return to lower peak flows can occur with less harvest.

4. Snowmelt is a phenomena involved in the changes to peak flows.

5. Manipulation of vegetation can influence snow accumulation and melt. It is due to the change in vertical and horizontal structure which can influence snow storage and microclimate.

VI. MANAGEMENT IMPLICATIONS

A. Increases in the size of peak flows can have the following effects:

-- More frequent problems from high runoff events due to "underdesign" of structures.

-- Accelerated channel changes.

-- Damage to and delayed recovery of riparian areas which provide habitat and shade.

-- Increased mass failure and streambank erosion in susceptible areas. As a result, productive land is lost.

-- More sediment and debris is available for streams to move.

-- Greater sediment transport capability.

-- Reduced water quality.

-- Degraded aquatic habitat.

B. Measures that can help minimize the increase in peak flows and reduce impacts.

-- Avoid overimpacting small (third and fourth order) basins. Analyze the entire area to aid in locating, scheduling and designing harvest. Particular attention should be given to areas in the transitory snow zone (1,500-4,000 feet elevation) and areas with sensitive stream channels and fragile or unstable soils.

-- After harvest, promptly replant to quickly as possible achieve crown closure and thermal cover.

-- Avoid interruption of surface and subsurface drainage. Keep roading to a minimum. Design roads and drainage to minimize the concentration of water.

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