CHANGES IN TIMING AND MAGNITUDE OF HIGH AND LOW FLOWS, 1958-1988, EAGLE CREEK, OREGON

By
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INTRODUCTION/STUDY AREA

The residents of the Eagle Creek valley are very dependent on the quantity and timing of the streamflow for irrigation as there are no major water storage facilities within the watershed. This study was undertaken in response to public concern over the potential effects of forest management activities on streamflow.

Most studies that have examined changes in streamflow characteristics in relation to various timber harvest treatments have occurred on relatively small, experimental watersheds (eg. Baker, 1982; Troendle, 1983). This study was designed to detect changes in various measures of streamflow on a relatively large watershed where no control watershed was available.

Eagle Creek (above the gaging station) is 43 km long draining a 404 km^2 watershed on the south face of the Wallowa Mountains in northeastern Oregon, 51 km east of Baker City, OR. The runoff regime is dominated by snowmelt, however summer rainfall events often cause high flows and localized debris torrents. Through the 2300 m elevation change from the top of Eagle Cap Peak to the Powder River arm of the Brownlee Reservoir on the Snake River, the creek travels through alpine and forest ecosystems where precipitation ranges from 165 to 38 cm annually.

Over 90 percent of the watershed is managed by the USDA Forest Service and 50% of the area is classified as productive forest land (growth rates exceeding 1.4 m^3/ha/yr) while the remainder of the area is classified as non-forest (rock, grass, water) or unproductive forest land. Timber harvest, livestock grazing and road building have taken place throughout the watershed. Regeneration harvests, which create openings in the forest canopy, have become more common in recent years as opposed to partial removals and thinnings which were more common in the past. The creek was designated as National Wild and Scenic River in 1988.

METHODS

The approach used in this study was to relate streamflow variables (magnitude of annual peak flows, timing of peak flows, volume of flow through the irrigation season and timing of low flows) with meteorological variables (various measures of precipitation and temperature) using multiple regression analysis. When the best prediction models were developed, time (in years) was used as a variable to see if any trends were present. Various measures of management activity on each of the watersheds were considered for inclusion in the regression models including the miles of roads, average basal area, acres influenced by harvest, equivalent clear-cut acres, equivalent roaded area and the number of animal unit months of grazing that have occurred. These variables were not used because of limitations in data availability and quality, and the inadequacy of the parameters to accurately account for watershed conditions or all management effects through time. Instead, time was used as an integrator of the cumulative effects of land management activities.

The timing of peak flows was defined as the number of days after March 31 to the date of the peak. The timing of low flows was defined as the number of days after July 1 that the streamflow reached 28.3 m^3/s. This flow level corresponded with the level that the watermaster typically shut off the flow to the ditch with the youngest

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water rights. Prediction models were evaluated based on the coefficient of determination (r^2), the standard error of the estimate (SE), and the probability of significance of regression (p-value) using the F-test for lack of fit.

Streamflow data available was a 31 year period of record (1958-1988) from the Eagle Creek gaging station near New Bridge, Oregon, maintained by the USDI Geological Survey (USDI Geological Survey, 1958-1988). Snow-pack data was available thorough the period of record from the Schneider Meadows snow course (USDA Soil Conservation Service, 1958-1988) which is located 13 km east of the watershed centroid in an adjacent watershed. Temperature and precipitation data were available from Halfway, Oregon (USDC National Oceanic and Atmospheric Administration, 1958-1988), approximately 22 km southeast of the watershed centroid and 11 km east of the gaging station.

RESULTS AND DISCUSSION

A regression model based on the snow-water equivalent and mean spring temperature data best described the variation in the volume of streamflow through the irrigation season ($r^2=0.77$, SE=3.01 cm, $p<0.001$):

$$Q = e^{[2.79 + 1.66(S) - 0.136(T)]} \tag{1}$$

where Q = cumulative July-September streamflow (cm)
S = April 1 snow-water equivalent (m)
T = mean April-June temperature (degrees C).

A logarithmic transformation of the flow data was necessary in order to satisfy the assumptions of simple linear regression, therefore the standard error of the estimate is biased. Observed and predicted streamflow volumes are presented in Figure 1.

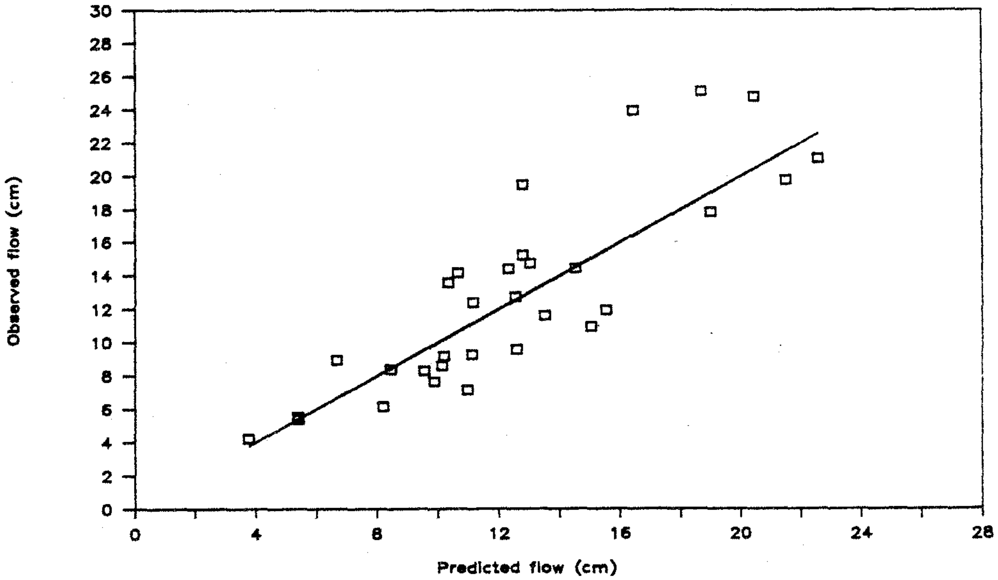

Figure 1. Observed and predicted July-September streamflow volume.

After accounting for the variation in flow volume caused by the snow and temperature variables, a trend through time was detected which indicated that streamflow had been increasing by an average of 0.095 cm per year (Figure 2).

It was not possible to determine the cause(s) of the increase in summer streamflow volume. One possible explanation is that the reduction of transpiration and

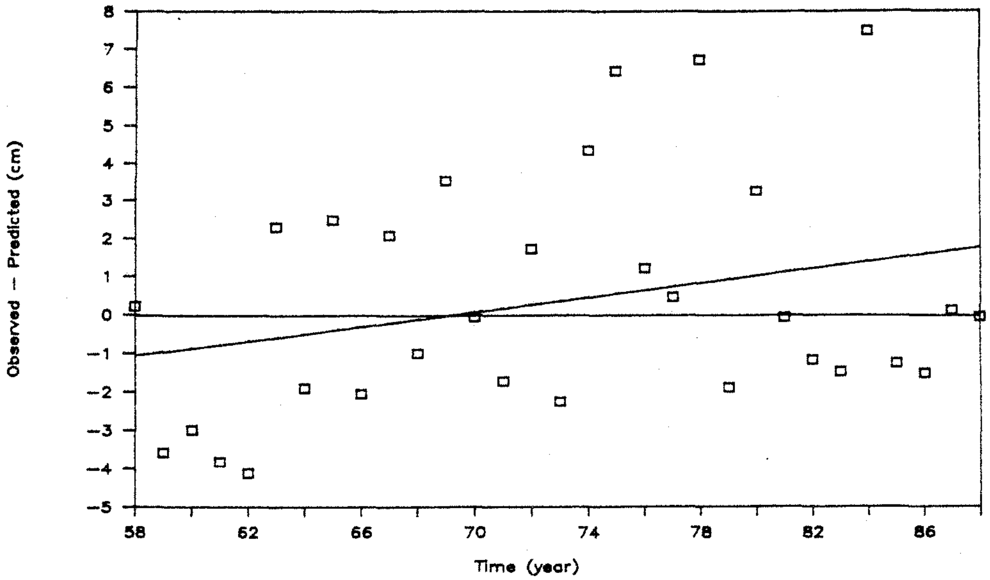

Figure 2. Residual errors (eq. 1) versus time; the line through the data shows a significant increase in streamflow through time ($p<0.10$).

interception losses resulting from the harvest of trees has resulted in more water available for summer streamflow. Changes in climate that were not accounted for in the snow and temperature variables may also have contributed to the trend observed, although no significant trends through time were observed in the meteorological variables used in this study.

The same snow and temperature variables also explained most of the year-to-year variation in the timing of low flows ($r^2=0.71$, SE=13.6 days, $p<0.001$). Therefore, the amount of snow on the watershed and the rate of melt during April, May and June largely determined the volume and timing of streamflow through July, August and September. While several studies have demonstrated that timber harvest influences the timing of melt (eg. Baker, 1982; Haupt, 1979; Troendle, 1983; Troendle and Leaf, 1981), no change in the timing of late summer streamflow was detected in this study.

Variation in the magnitude of the peak flows was best explained by the snow-water equivalent alone ($r^2=0.60$, SE=9.8 m^3/s, $p<0.001$), while the timing of peak flows was best predicted by the snow-water and mean May temperature variables ($r^2=0.39$, SE=10.1 days, $p<0.01$). No trend through time was detected in the magnitude of the peak flows, however a trend in the timing of the peak flows ($p<0.05$) indicated an advance in the date of the peak flows (earlier than would be expected) of 0.39 days per year or almost 12 days over the 31 year period.

It appeared as though the shape of the annual hydrograph may have changed over the study period with the peak flows occuring earlier and the late summer streamflow volume increasing. The earlier peak flows did not appear to cause a corresponding shift in the entire hydrograph as the timing of low flows did not change.

Regression analysis provided a simple way to determine the major contributors to various measures of streamflow and a way to determine if trends through time existed where a control watershed was not available. The results of this study went a long way toward establishing credibility and a rapport with the local community. Analysis of data from a major stream that everyone in the community was familiar with provided a timely response to a concern that would not be satisfied by literature from experimental forests elsewhere in the west. The study points out the extreme importance of establishing and maintaining long term meteorological and streamflow stations.

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