

DENDROCHRONOLOGICAL DATING OF FLOOD SCARS AND FLOOD FREQUENCY  
ALONG THE BIG THOMPSON AND FRASER RIVERS  
IN THE COLORADO FRONT RANGE

By The Riparian Raiders<sup>1</sup>

ABSTRACT

Tree-ring analysis techniques were used to date the intensity and occurrence of recent flood events along two significant controlled streams that drain portions of the Colorado Rockies. The 1976 flood (799 m<sup>3</sup>/s peak discharge) on the Big Thompson River is the flood of record and has been estimated to have a return period of about 1000 years. Dating of old flood scars indicates that previous catastrophic floods of similar magnitude may have occurred also in 1737, 1756, and 1816. Three additional large floods over a 250-year period could reduce the 1976 flood's return period by an order of magnitude, which has significant flood-hazard implications.

The Fraser River channel cut off a meander bend during the 1918 flood, and this channel shift was recorded by reaction-wood formation in trees that were tilted by bank undercutting in the new cutoff channel. Flood events also occurred in 1926, 1931, 1952, and 1959, but only the 1952 flood was recorded by flood scarring and significant additional tree tilting.

INTRODUCTION

Since settlement of the western United States and particularly since the establishment of large metropolitan centers along the Colorado Front Range, the demand for and use of water has been a crucial element in directing future development. Significant measures have been taken to control and regulate streamflow to minimize flood hazards and to divert water for metropolitan and agricultural use. Water resource management activities directed at regulating stream runoff must address a wide variety of considerations, including the magnitude and frequency of floods as well as stream channel integrity. In this study we have attempted to demonstrate how tree-ring analysis techniques, in combination with observations of changes in geological features, can be used to date and reconstruct past flood events and to document stream channel changes.

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callous tissue. Positions of slackwater flood deposits and lichen trimlines were also noted locally.

In the Big Thompson canyon, trees were sampled at 4 sites between Estes Park and the canyon mouth. Site BTR1, located about 10 km downstream from Estes Park at Sleepy Hollow Park, had a small number of mature ponderosa pines situated on a terrace 1.2 m above present stream level. Three of these pines exhibited relatively fresh scars (generally facing upstream), and in addition, one had an old, well-healed scar. Multiple cores were collected from all 3 trees. Two trees were sampled at site BTR2, about 3 km upstream of BTR1. One tree was dead and situated in the river due to lateral bank erosion. The other tree, a ponderosa pine, was on the flood plain and several meters from the active channel. Site BTR3, about 29 km downstream from Estes Park at Narrows Park, provided scarred white poplars for sampling. Site BTR4 was situated just outside of Drake at Forks Park, about 18 km downstream from Estes Park. This site had scarred ponderosa pines on a terrace 2.5 m above present stream level.

In the Fraser River, trees were sampled beginning at a point just above the original channel and downstream along both previous and present channels. Basal cores were taken from each tree and additional cores were taken at several points near scars if any were present. Dbh, diameter at the point of coring, distance to and size of nearest neighbor were recorded as well as position and angle of the tree in relation to the stream. Peak and annual discharge records were compared to dates obtained for flood scars and reaction-wood initiation.

Once cross-dated, a subsample of cores taken through trees leaning over the stream channel were measured. Two new time series were calculated to determine if the onset of reaction wood formation could be detected quantitatively. The first was a simple difference between increments of the same year and the second a ratio between the stream side growth increment and that of the bank side (equation 1 and 2)

$$\text{diff}(i) = \text{rrw}(i, \text{bank}) - \text{rrw}(i, \text{stream}) \quad (1)$$

$$\text{ratio}(i) = \text{rrw}(i, \text{bank}) / \text{rrw}(i, \text{stream}) \quad (2)$$

facing scar 88 cm above the ground surface revealed possible evidence of 3 older, prehistoric floods.

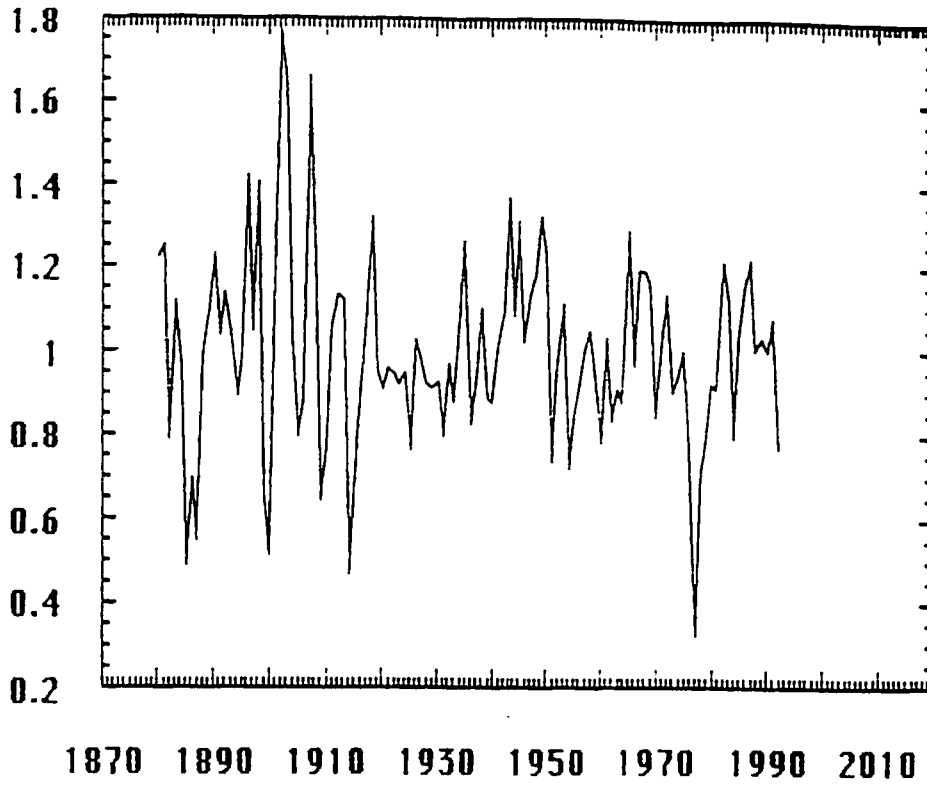
The 1756 ring is terminated by a scar covered by wound-response tissue and followed by a severe ring-growth suppression that lasts about a decade. This same wound was also crossed by the increment borer on the back (downstream) side of the tree, indicating that cambial damage was radially extensive. An almost identical decade-long suppression, preceded by a gap in the wood, begins in 1738, suggesting a severe injury possibly caused by flooding in 1737. A third such suppression begins after 1816 in the rings on the downstream side of the tree; the equivalent wood on the upstream side was destroyed in an internal rot pocket that was possibly induced by flood scarring (Fig. 2).

The old scar producing this evidence of possible earlier large floods extends about 1.5 m above the ground surface, which is about 1.8 m lower than the highest 1976 scars at this site. These older scars may have been caused by floods somewhat smaller than the 1976 event, but, on the other hand, the 1976 flood produced scars at that level and lower. If these older injury-causing events were floods of a magnitude roughly equivalent to the 1976 flood, the recurrence interval for such floods would be decreased from 1000 years to the order of 100 years. This tentative conclusion needs to be corroborated by cores from more old trees in the canyon bottom. The 1919 flood, the second largest of record (~200 m<sup>3</sup>/s), scarred none of the examined trees, but trauma cells were produced in the 1919 ring in tree BTR2-2 and a suppression starting 1921 was induced in tree BTR1-3. If additional episodes of flooding at 1976-equivalent magnitudes is verified by additional research, current flood-frequency estimates for the Big Thompson River are seriously in error.

#### Fraser River

In the Fraser River both reaction wood formation and scarring can be correlated with times of peak streamflow (Fig. 3). The record of multiple flood events can be seen in instances where a single tree records several individual stream flood events. Using three independent techniques, years of significant flood events along the Fraser River were confirmed against the historical record. Initial years of reaction wood formation are 1918, 1926, 1931, 1952, and 1959. These years also coincided with record high peaks in river flow. However, in some instances there appears to be a lag time between recorded peak flows and the onset of reaction wood formation. There are two possible causes for this delay. The first may be that the undermining of the bank occurred at the end of the growing season therefore tree response does not begin until the commencement of growth in the following year. A second explanation for the lag may be that undermining of the bank is not complete until the following year or two. Three trees, MC15, MC12 and MC11 show reaction-wood formation beginning around 1918. These trees, found along the oxbow cutoff and

# BIG THOMPSON RIVER SCARRED TREES



# CHANGES IN VARIANCE OVER TIME

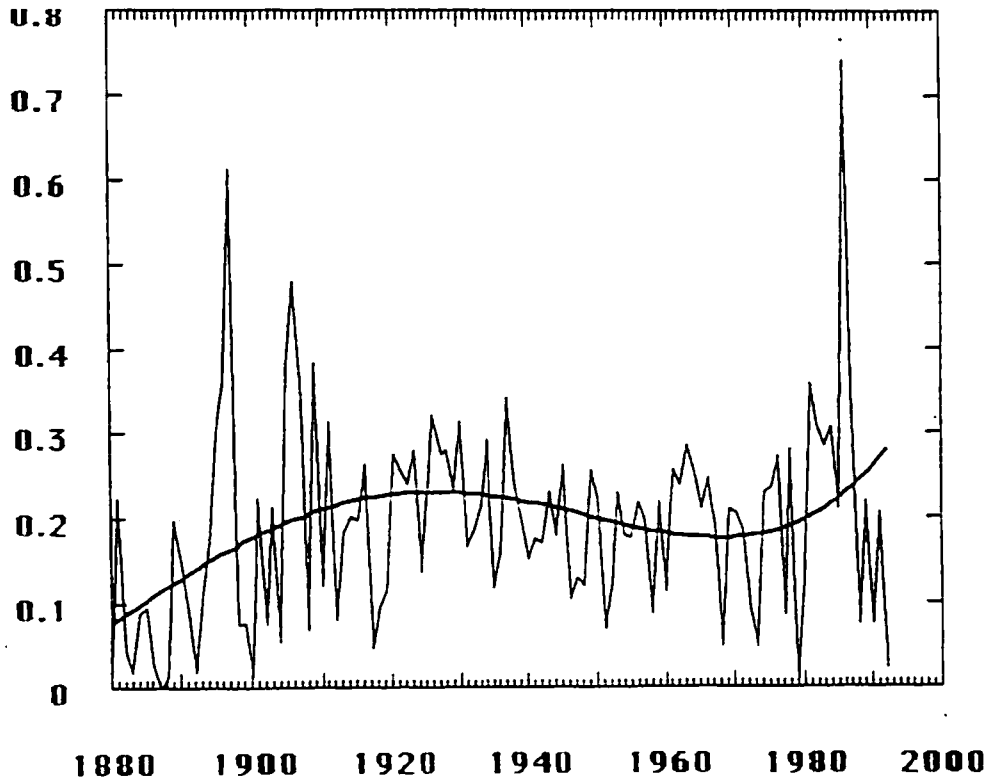


Fig. 1

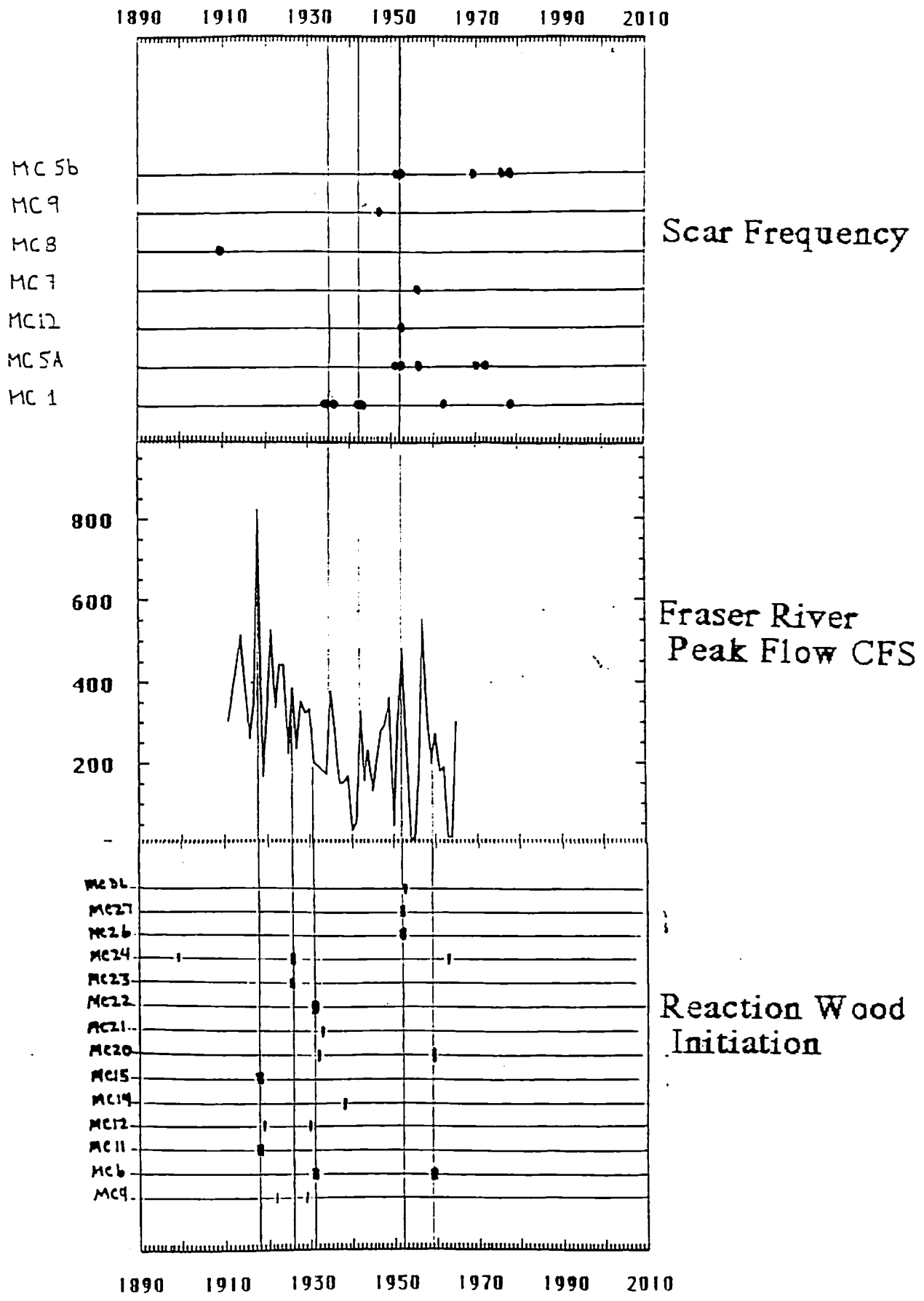


Fig. 3

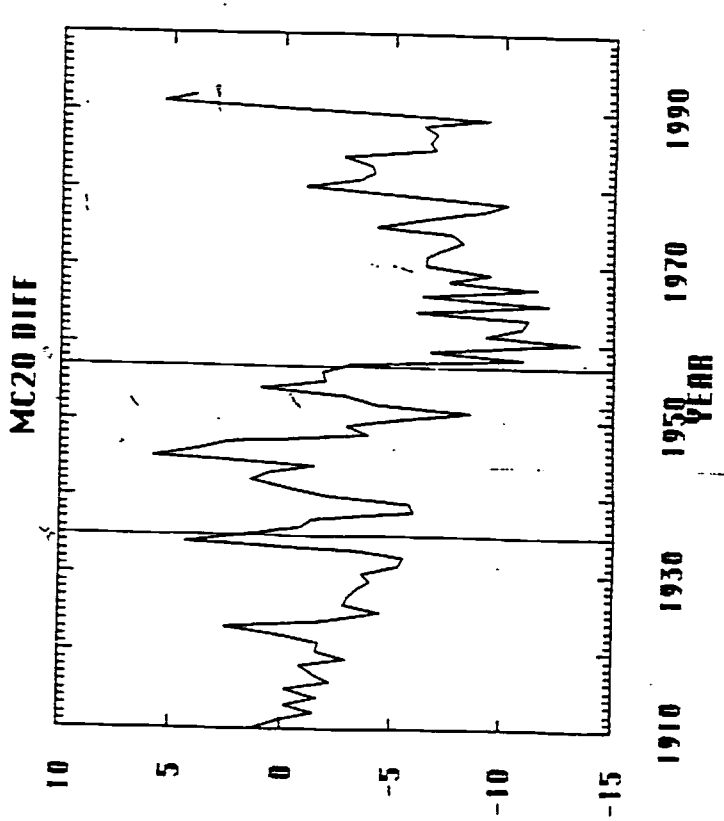
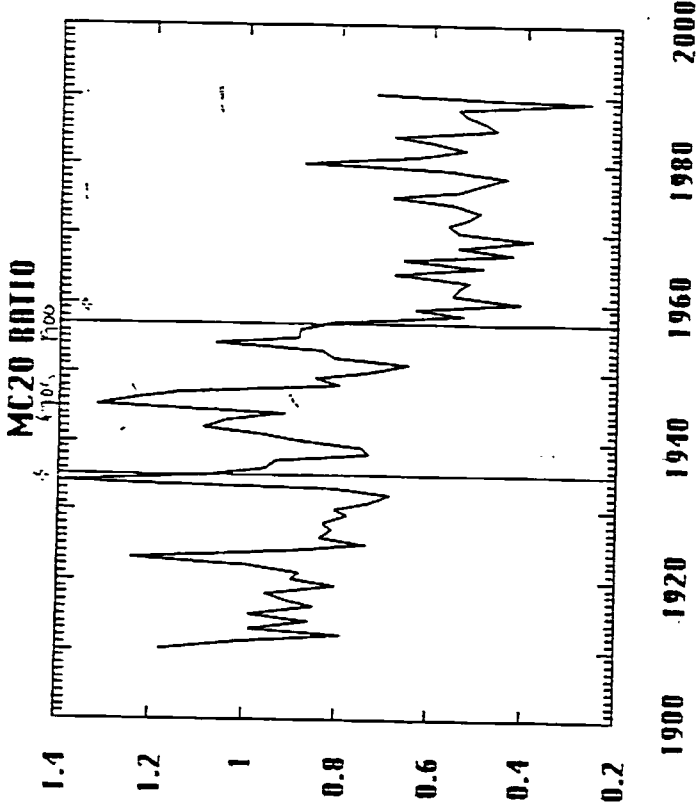


Fig. 4 (cont.)