Dendrogeomorphic Applications to Debris Flows in Glacier National Park, Montana USA

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Dendrogeomorphology, the use of tree rings to determine the age of a geomorphic event such as debris flows, is a useful tool in determining the recurrence interval and to some extent, the magnitude, of potentially hazardous geomorphic events. Debris flows will damage trees as the debris moves downhill. The impact scars can be dated by counting the tree rings that have grown since the impact, or by determining the year of the onset of suppression rings or reaction wood. The following example refers to the use of dendrogeomorphology in the examination of debris flow hazards within Glacier National Park, Montana USA.

Our 10-year study of debris flows in Glacier National Park focused on forty-one separate debris flows in seven drainage basins within Glacier National Park, Montana USA (Wilkerson and Schmid 2003). We applied a combination of geomorphic techniques including dendrochronology, lichenometry, vegetation succession, event stratigraphy, and repeat photography to investigate the geomorphologic variables responsible for these debris flows (Fig. 1). The dendrogeomorphic analysis of tree cores and cross sections was critical in establishing a chronology for undocumented debris-flow events (Fig. 2).

Tree-ring records were used to delineate the age of a specific debris-flow event that had impacted or damaged a specific tree, or were used as proxy data for determining the minimum age of debris flow deposits or channel incision (McCarthy and Luckman 1993; Pierson 2007). If a tree had obvious impact damage from moving debris-flow rocks, then an absolute date for that event could be determined. If a tree was growing on either the deposits or within the debris-flow channel, then a minimum age could be determined for the event associated with that portion of the debris-flow landform. Minimum ages are less accurate than absolute ages due to the unknown time period between the debris flow event and when the debris stabilized enough to allow tree growth to begin.

Snow avalanches are common in Glacier National Park, and avalanche impact on trees can be difficult to discern from debris-flow impacts. Although a total of 39

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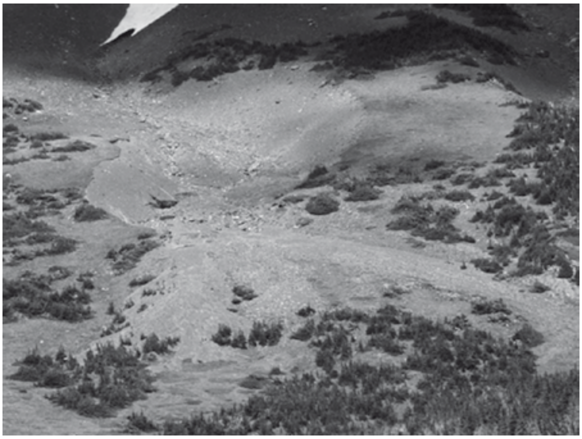

Fig. 1 The Apikuni Creek Big Red debris flow (Apikuni number 1) is evolving into a first order channel that drains the summit of Apikuni Peak. This landform has witnessed repeated debris-flow activity, with four known events since 1994. Note the impact of the channel incision on trees along the upper edges, and within the lower toe deposits

Fig. 2 An image of a cross section removed from the Windy Creek debris flow. The tree was severely damaged and partially buried by a debris flow that occurred in 1955. The damaged portion of the tree visible near the bottom of the photograph was facing upslope

tree cores and 13 cross sections were sampled for dendrochronologic analysis, only 24 cores and six cross-sections produced results that could confidently be identified as debris flow impact and not snow avalanche damage.

The results of the dendrogeomorphic event chronology are summarized in Table 1.

Table 1 Summary of dendrochronology analysis of debris flows in Glacier National Park, Montana

Drainage basin	Debris flows sampled (Year sampled)	Event chronology (c = core; xs = cross section)
Apikuni	1 (1997)	1906c, 1934c, 1956c
	2 (1997)	1930c
	3 (1997)	1898c, 1906c, 1932c
Appistoki	1 (1997)	1959c
	2 (1997)	1959c
Kennedy	1 (1997)	1984c
	2 (1997)	1955c, 1977c
	3 (1997)	1935c, 1952c, 1974c
	4 (1997, 2000)	1842c, 1857xs, 1947xs, 1964xs, 1968xs, 1979xs
Rose	1 (1994)	1904c, 1921c, 1961c
	2 (1997, 1999)	1954c, 1964c
Windy	1 (1997)	1955xs

Although the initial hypothesis behind our research was that basin-wide storm events would be identified as the trigger responsible for initiating debris flows, it can be seen from the data that storm events are not necessarily consistent within basins. Only three years have a dendrogeomorphic signal that records more than one debris flow in the same year: 1906 in the Apikuni basin, 1959 in the Appistoki basin, and 1955 in two basins sharing a common drainage divide, Kennedy and Windy.

These results are complicated by the fact that not all debris flows had trees that could be sampled and not all debris-flow events will impact the trees that are present. Despite these complications, the combination of using the tree cores along with other geomorphic techniques, led to the conclusion that the interaction of several geomorphic variables unique to each landform are responsible for the initiation of debris flows in Glacier National Park. Antecedent storm conditions (water content in the slope debris) and storm characteristics are the most important variables on the scale of each individual debris flow landform. Isolated summer thunderstorms provide enough water to initiate flows, but are highly variable in scale. Larger, basin-scale rain on snow events are also important, but are again going to be controlled by the antecedent snowpack conditions on each slope.

References

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