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The influence of debris flows and sheetfloods on tree-ring growth in upper Valtellina (Sondrio, Italy)

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INTRODUCTION

Debris flow activity in some Alpine regions is particularly frequent in relation with the pattern of local summer precipitation and also with the available amounts of debris material. These flows cut into the apices of the debris flow fans, depositing coarse material at the top of the fans and gradually sand and silt towards the more distal areas. In upper Valtellina (Central Italian Alps), the phenomenon has been under investigation for years in relation to geomorphological hazards and risk (PELFINI & SANTILLI, 2003; PELFINI et al., 2004), and also as concerns the dating of past events by means of dendrogeomorphological studies (SANTILLI & PELFINI, 2002; SANTILLI et al., 2002). The present study focuses on the influence of these flows on the development of a tree population (Pinus montana Miller). This population grows at 1930 m a.s.l., at the toe of one of the Valle del Gallo fans in upper Valtellina. The trees are affected mainly by the most liquid phases of the debris flows that can be considered to be sheetfloods as they are characterized by thin layers of water bearing fine debris (silt, fine sand); these sheetfloods are no longer capable of opening wounds in the tree stems, but can, in any case, modify their radial growth.

METHODS AND RESULTS

The first phase to investigate the effect of the debris flows and sheetfloods on the tree growth, consisted of building a first chronology for this disturbed population. Thereafter two reference chronologies were built using samples from undisturbed trees of the same species growing on the two stabilized slopes (E and W aspect) close to the zone affected by flow deposits. For each of the three chronologies, samples were taken from about 30 dominant trees that were undisturbed as regards growth and canopy.

Chronologies has been analysed since 1939, because this is the first year in which they show a good stability of the signal. (A) The reference chronologies of the slopes are very similar in the patterns and show high values of the similarity indices. These trees had grown under similar environmental conditions, although they were from two opposite slopes in the valley. The chronology for the trees at the fan toe, however, showed several differences in the patterns (in 1944, 1946, 1948, 1953, 1962, 1976 and 1984) and greater variability in the ring width indices, indicating the presence of a disturbance in the chronology that distinguishes it from the two reference ones. (B) In addition, the patterns of all the growth series in the three different chronologies were analyzed, considering thresholds of 40%, 55% and 70% in positive or negative growth variations (SCHWEINGRUBER, 1986), with respect to the mean value of the 4 previous years. For the two groups of trees growing on the slopes, this analysis showed simultaneous growth variations involving a percentage of sampled trees that was always under 35% (with the exception of 1941). The series for the trees growing at the fan toe, however, showed 5 years with over 55% of the sampled trees displaying simultaneous abrupt growth variations; of these trees, there were always at least 3 with an evident growth alteration of over 70%. An anomalous increase in growth was observed for the years 1944, 1952 and 1962, as well as an anomalous decrease for 1948 and 1949.

DISCUSSION AND CONCLUSIONS

The analyses of the patterns in the three chronologies led to the conclusion that the chronology for the trees at the fan toe reveals a signal that is missing from the two slope reference chronologies. This signal can be traced back to a disturbance that is not of climatic origin, as all of the trees in the three chronologies grew under the same climatic conditions. The two groups of dates obtained from pattern analysis (A), and from the analysis of the growth variations (B), were then compared, obtaining 4 different cases. 1) Strong growth variations and opposite patterns respect to the reference chronologies: years 1944, 1953 and 1962. 2) Strong growth variations and amplification of the signal of the reference chronologies: years 1946 and 1948. With reasonable certainty, the anomalies of these two cases can be attributed to debris flow disturbance, as a variation in growth recorded by over 55% of the trees (with exception of 1953, with about 30%) corresponded with a different pattern emerging in the reference chronologies. 3) Strong growth variations but same pattern of the reference chronologies: years 1949 and 1952. The debris flows cannot be considered as the only possible cause affecting the growth. In fact, the climatic component cannot possibly be excluded, because at these altitudes, it can have a synergistic effect on slope dynamics and an influence, in any case, even on a strictly local scale. 4) No growth anomalies but differences with the reference chronologies: years 1976 and 1984. For these years it is possible to hypothesize an effect induced by very light debris flows that didn't produce any abrupt variations in growth, but that affected slightly the growth of these trees.

Although they cannot have the same certainty that is given by scars or compression wood in a stem, these dates can be considered to be reliable, in spite of interpretation difficulties regarding the chronologies. Therefore, the years in which the trees of the population affected by debris flows show strong anomalies in growth and their population chronology show different patterns, compared to the reference chronologies, can be considered years in which the debris flows have modified the normal growth pattern of these trees. Thus, from 1939 to 2001 there are at least 5 years in which it is possible to ascribe the anomalies in growth to debris flows events: 1944, 1946, 1948, 1953, 1962.

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