Geochemical transformation of forested catchments following bark beetle infestation: Evidence from EC hysteresis during rainfall-runoff events

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Forest disturbance resulting from bark beetle infestation is becoming a widespread phenomenon due to climate warming and changing precipitation patterns. Such disturbance could result in alterations of streamflow and stream geochemistry. Our previous study found that these changes developed relatively rapidly after infestation and have long-lasting (decadal-scale) effects. Furthermore, infestation-induced changes in event-scale dynamics of in-stream electric conductivity (EC) - discharge (Q) relations were found to be considerable, impacting even the annual average EC-values. In this study, therefore, all rainfall-induced runoff events occurring during an 11-year period were identified and their distinct EC-Q relations were evaluated. The evaluation was done based on 10-min high-frequency monitoring of Q and EC and in four experimental catchments (~4 km² each; located in the Sumava Mountains, Central Europe), having different forest cover (disturbance) stages. Furthermore, snapshot sampling was carried out to map EC and chemical parameters (N, DOC, etc.) in different hydrological landscape units (riparian area, hillslope, and terrace) and in multiple vertical layers of soil (surface, soil, and groundwater). Results showed that after infestation the EC-Q hysteresis loops at the event-scale shifted from positive to negative relationships, implying changes in the subsurface chemical composition and runoff patterns. Specifically, healthy forest systems required event flows to mobilize substances in the soil and groundwater systems as the groundwater level rose into the relatively conductive, shallow part of the soil profile during an event. Such flush-driven systems were known for their release of large fractions of total annual in-stream substance loads showing a positive EC-Q relationship. By contrast, after infestation-induced tree mortality, the mobilization and downward percolation of nutrients and carbon from litter and decomposing needles may be considerable even during moderate rain and infiltration events. When the system is flooded under event conditions, substance-enriched soil water and groundwater may be mixed with and diluted by low-salinity event water, leading to a negative EC-Q relationship. This study exemplifies how EC monitoring techniques can be used as an alternative to high-cost geochemical monitoring in quantifying complex rainfall-runoff processes as well as runoff generation processes, allowing for long monitoring periods at high temporal resolution and reasonable costs.