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How do both valley head initiation and headwater catchment extent change with relief?

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Headwater catchments, each of which consists of hillslopes, valley heads, and colluvial channels, make up a major portion of a drainage basin, supplying sediment, water, and nutrients downstream. In a headwater catchment, valley heads where hillslope diffusive transport transits to fluvial transport play an important role in channel initiation. Headwater catchments where mass movements are dominated are sensitive to human activities. Human activities in headwater catchments, such as logging and crop cultivation, change the rate of hillslope erosion, thereby increasing sediment inputs and leading to channel form change and stream habitat destruction. In recent years, such human activities have increased significantly in headwater catchments. As such, delineations of the extent of headwater catchment and valley head initiation become increasingly important for watershed protection and management. Previous studies have shown that the area of the headwater catchment ranges from 10^4 to 10^6 m^2, but little is known about what factors affect its range. The evolution of headwater catchment topography is mainly determined by surface processes such as landslides and runoff. The rates of these processes vary depending on the hillslope gradient closely related to topographic relief. To understand the impacts of relief on the valley head initiation and the extent of headwater catchment, we analyzed the slope-area relations of the Seo River drainage in South Korea. Firstly, we found that the upslope area at the valley head shows a weak positive correlation with relief. This finding seems to be associated with hillslope material input to fill valley heads. Steep hillslopes in a high relief region could induce more hillslope material supply, consequently filling valley heads. Such abundant flux into valley heads probably enhances the hillslope length and makes valley head initiation downstream. Secondly, the upslope area of the headwater catchment, which is set by the downstream limit of the colluvial channel increased exponentially with relief. This exponential correlation would be related to the length of debris flow-dominated channel. In high relief regions where the channel slope is steeper, debris flows scour for a further distance, resulting longer colluvial channels. These results reveal the importance of relief as controls on valley head initiation and headwater catchment extent.