An attempt to estimate tolerable soil erosion rates by matching soil formation with denudation in Alpine grasslands

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Purpose Natural rates of soil production or a target soil thickness that allows unrestricted land use can serve as a basis for defining tolerable soil erosion rates. Guidelines for tolerable soil erosion rates in alpine grasslands do not yet exist, partly due to the lack of information of soil formation and production rates. We (i) defined soil formation/production rates for alpine grasslands on siliceous lithology and compared them to measured and modelled soil erosion rates and resulting soil thickness with a special focus on the Urseren Valley (Central Swiss Alps) and (ii) discussed possible trends for alpine soils under global change. Materials and methods Ranges of soil formation, production and erosion rates were determined using published and our own data for Alpine grasslands soils. Two definitions of tolerable erosion rate were used: when (i) current soil depth remains constant over time; and (ii) at least a minimum soil depth is maintained (minimum thicknesses for individual land uses still need to be defined). Results and discussion Soil production and related tolerable erosion rates (i.e. 50–90 % of the soil production rate) are a strong function of time. Average soil production rate in alpine areas for relatively old soils (>10–18 kyr) is between 54 (ś14) and 113 (ś30)km−2 year−1, for young soils (>1–10 kyr) between 119 (ś44) and 248 (ś91)km−2 year−1 and for very young soils (≤1 kyr) between 415 (ś242) and 881 (ś520)km−2 year−1. Measured recent soil erosion rates in alpine areas at intensively used slopes range from 600 to 3000 t km−2 year−1. Average catchment values for the Urseren Valley using the model USLE plus soil loss due to landslides resulted in an overall loss of 180 t km−2 year−1, which considerably exceeds production rates of the soils. Conclusions The comparison of soil production and erosion rates indicated unsustainable management of grassland soils in the Urseren Valley. Other Alpine regions report similar or even higher erosion rates. Consequently, attention has to be paid to Alpine grasslands used for agricultural purposes because today's soil erosion rates often considerably exceed soil formation, thus resulting in very shallow soils. Future global change is likely to increase soil erosion rates even further.
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