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Pedo-geomorphic processes along climatic transects - significance for spatial patterns and climate change

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The spatial variability of a number of "quick response" pedo-geomorphological variables was studied along two climatic transects in Israel, the first one runs from west to east (W-E), covering an annual rainfall range of 700 – 100 mm, and the second runs from north to south (N-S), covering a rainfall range of 800 – 90 mm. Soil properties, runoff and sediment yield were investigated at the regional, plot and patch scales.

At the W-E gradient the study concentrated on the regional and plot scales. Soil samples were taken only from open areas between shrubs and overland flow was monitored in plots of 7, 14 and 21 m in length. At the regional scale it was found that: 1) high correlation exists between climatic conditions and pedo-geomorphic variables (such as organic matter content, aggregate stability and soil moisture) and processes (such as infiltration and overland flow), and 2) the rate of change of these variables along the climatic transect is non-linear. A steplike threshold exists at the semi-arid area, which sharply separates the arid pedo-geomorphic system, controlled by a-biotic factors such as soluble salts content and mechanical crust formation, from the Mediterranean sub-humid system controlled by biotic processes such as plant growth, microbial activity and organic matter production and decomposition. This means that even a relatively small climatic change is enough to shift the border between these two systems. As many regions of Mediterranean climate lie adjacent to semi-arid areas, they are threatened by desertification in the event of climate change.

At the plot scale it was found that: 1) a significant spatial variability of soil properties exists, in spite of measuring them only in the open areas. While the Mediterranean and the arid areas are characterized by a relatively uniform distribution (narrow range of values) of soil properties, a large range of values is typical of the transitional semi-arid area. 2) runoff coefficient decreases with increasing hillslope length, which means that there were water losses along the hillslope.

At the N-S gradient the spatial distribution of soil properties and overland flow at the patch scale was studied. Soil samples were taken from four micro-environments (under shrub (US), open area between shrubs (BS), under rock fragment and under tree) and overland flow was monitored in micro-plots representing US and BS patches. Organic matter content and aggregate size at the US were higher than in the BS, leading to higher infiltration rates. Runoff coefficients at the BS were always higher than at the US. The main conclusion is that the US areas function as sinks, so that at least part of the overland flow from the BS areas (that function as sources) infiltrate under the shrubs.

While in the sub-humid area, due to the high vegetation cover, most of the hillslope functions as a sink so that only saturated overland flow might develop from time to time and in the arid area most of the hillslope functions as a source, a mosaic-like pattern of sources and sinks is typical to the semi-arid zone, in accordance with the spatial distribution of shrubs. The development of such mosaic pattern enables most rainfall to be retained in the hillslope.