Ecohydrological significance of fire-wind erosion interactions in arid landscapes

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Abstract

Land degradation at the desert margins is often associated with changes in vegetation cover and plant community composition. Hydrological and aeolian processes are major abiotic drivers in the dynamics of these landscapes in that they contribute to the loss and redistribution of soil resources with important implications for the conversion of disturbed desert grasslands into shrublands. Even though fires are known to interact both with wind and water erosion, a process-based understanding of these interactions and of their effect on aridland degradation is still missing. Through field manipulation experiments in a grass-shrub transition zone it is shown how the interaction of fires with wind erosion may affect the distribution of soil resources with consequent effects on changes in vegetation structure and composition. Sediment sampling, wind tunnel experiments, microtopography measurements, and isotopic tracers provide experimental evidence for the occurrence of post-fire enhancement of soil erosion. This effect is explained as the result of the weakening of interparticle bonding forces associated with the emergence of fire-induced soil hydrophobicity. It is shown how the increase in post-fire soil erodibility in shrub-dominated areas favors the redistribution of soil resources from relatively fertile vegetated areas (or "fertility islands") to bare soil interspaces. This effect enhances the reversibility shrub-to-grass transitions, thereby contributing to the resilience of fire-prone arid grasslands and savannas. This resilience is further enhanced by random environmental fluctuations.