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Landscape Degradation in Australian Semiarid Shrublands: Variations in Hydrological Connectivity Indicate Abrupt Changes in Ecosystem Functionality

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Dryland vegetation frequently shows self-organized spatial patterns as mosaic-like structures of sources (bare areas) and sinks (vegetation patches) of water runoff and sediments with variable interconnection. Good examples are banded shrublands displayed by Mulga (Acacia aneura F. Muell) in semiarid Australia, where the spatial organization of vegetation optimizes the redistribution and use of water (and other scarce resources) at the landscape scale. The spatial structure of vegetation has therefore important implications for the resilience of these ecosystems, and is particularly relevant for the detection of landscape degradation processes in the present context of both climate and anthropogenic pressures. In fact, disturbances can disrupt the spatial distribution of vegetation causing a substantial loss of water by increasing landscape hydrological connectivity and consequently, affecting ecosystem function (e.g. decreasing the rainfall-use efficiency of the landscape).

We analyze (i) hydrological connectivity trends obtained from coupled analysis of remotely sensed vegetation patterns and terrain elevations in several Mulga landscapes near Alice Springs (Northern Territory, Australia) subjected to different levels of disturbance, and (ii) the rainfall-use efficiency of these landscapes, exploring the relationship between rainfall and remotely sensed Normalized Difference Vegetation Index (NDVI).

The analysis of the NDVI data series indicates that small reductions in the fractional cover of vegetation near a particular threshold can cause abrupt changes in ecosystem function, driven by large non-linear increases in the length of the connected flowpaths within the landscapes. In addition, simulations with simple vegetation patch thinning algorithms show that these non-linear responses are especially sensitive to the type of disturbance, suggesting that the amount of alterations that an ecosystem can absorb and still remain functional largely depends on disturbance type. In fact, selective thinning of the vegetation patches from their edges can cause a higher impact on the landscape hydrological connectivity than spatially random disturbances. Overall these results highlight surface connectivity patterns as practical indicators for monitoring landscape health.