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Geodiversity, self-organization, and health of three-phase semi-arid rangelands, in the Israeli Negev

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Source-sink, two-phase mosaic-like ecosystems are widespread throughout the world's drylands. Such ecosystems are composed of woody vegetation patches and intershrub spaces, and have been characterized as having high flexibility and survivability under a wide range of precipitation regimes. Recent studies from the semi-arid Negev drylands of Israel reported that livestock grazing has resulted in the modification of two-phase mosaic-like shrublands into three-phase mosaic rangelands, with livestock trampling routes encompassing a separate- and the most degraded- phase, while the shrubs encompass the most improved phase. The objective of this study was, therefore, to reassess this theory through the investigation of patch-scale (spatial scale of one decimeter to several decimeters) geodiversity and self-organization of these ecosystems. In terms of the effect of type of surface cover (microhabitat), the soil hygroscopic moisture content and stable aggregates content of the uppermost layer (0-5 cm depth) were significantly affected by this factor, and revealed the highest, intermediate, and smallest values for the shrubby patches, intershrub spaces, and the trampling routes, respectively. An opposite effect was recorded for the sand content. The clay dispersion index was also significantly affected by microhabitat, and revealed a higher value for the trampling routes than for the intershrub spaces and shrub patches. At the same time, other soil characteristics were not significantly affected by microhabitat. Overall, some differences were recorded between north- and south-facing hillslopes, proposing somewhat better soil quality in the more mesic northern aspects that that under the more xeric southern aspects. A conceptual model is proposed, in which moderate livestock pressure increases ecosystem geodiversity at the patch scale, modifying the ecosystem's self-organization to encompass a new (dynamic) equilibrium of a tri-modal pattern, and increasing ecosystem health. Also, a simple numerical simulation is proposed, modeling the effect of livestock trampling routes on the redistribution of water at the patch scale, with the resultant modifications in distribution of vegetation cover. Yet, it is proposed that functioning of three-phase mosaic rangelands is more complex than previously suggested, encompassing several simultaneous effects, of which some may have offsetting impacts.