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Can spatial patterns along climatic gradients predict ecosystem responses to climate change? Experimenting with reaction-diffusion simulations

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Distinctive number of studies has recognized the Mediterranean Basin as a hot-spot of climate change and a predicted decline in water resources. In the light of these forecasts, expected changes in properties of vegetation patterns that evolve along the rainfall transition between semi-arid and arid rainfall regions were assessed by using reaction-diffusion equations. Two types of scenarios were investigated: the first, a discrete scenario, where the potential consequences of climate change are represented by patterns evolving at discrete rainfall levels along a rainfall gradient. This scenario concerns space-for-time substitutions characteristic of the rainfall gradient hypothesis. The second, a continuous scenario, represents explicitly the effect of rainfall decline on patterns which evolved at different rainfall levels along the rainfall gradient prior to the climate change. The pattern response to rainfall decline was indicated by the ratio of eccentricity and solidity (where the eccentricity = elongation / directionality and solidity = compact/convex of the patches). Since the eccentricity and solidity of patterns that emerge through these two scenarios behave inversely (it was found that the eccentricity decreases with decreasing rainfall, while the solidity increases); their ratio was found to be highly sensitive to reduction in precipitation rates'. An eccentricity ratio versus rainfall (ER:R) line was generalized from the results of the discrete experiment, where ERs above this line represent developed (recovered) patterns and ERs below this line represent degraded patterns. For the rainfall range of 1.2 to 0.8 mm/day, the continuous rainfall decline experiment with ERs that lie above the ER:R line, yielded patterns less affected by rainfall decline than would be expected according to the discrete representation of ecosystems' response. Thus, for this range, space-for-time substitution represents an overestimation of the consequences of the expected rainfall decline. For low rainfall levels (below 0.8 mm/day), eccentricity ratios from the discrete and continuous experiments almost converge to the same trend of pattern change along the ER:R line. Thus, the rainfall gradient hypothesis may be valid for regions of desert fringe ecosystems which characterized by this rainfall range.