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PII: S0022-5193(17)30028-0
DOI: http://dx.doi.org/10.1016/j.jtbi.2017.01.029
Reference: YJTBI8939

To appear in: *Journal of Theoretical Biology*

Received date: 19 July 2016
Revised date: 26 November 2016
Accepted date: 19 January 2017

Cite this article as: Yuval R. Zelnik, Hannes Uecker, Ulrike Feudel and Ehud Meron, Desertification by Front Propagation?, *Journal of Theoretical Biology* http://dx.doi.org/10.1016/j.jtbi.2017.01.029

Desertification by Front Propagation?

Yuval R. Zelnik[a], Hannes Uecker[b], Ulrike Feudel[c], Ehud Meron[a,d]

[a]*Department of Solar Energy and Environmental Physics, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer Campus, 84990, Israel*
[b]*Institute for Mathematics, Carl von Ossietzky University Oldenburg, P.F 2503, 26111 Oldenburg, Germany*
[c]*Institute for Chemistry and Biology of the Marine Environment, Carl von Ossietzky University Oldenburg, PF 2503, 26111 Oldenburg, Germany*
[d]*Department of Physics, Ben-Gurion University of the Negev, Beer Sheva, 84105, Israel*

Abstract

Understanding how desertification takes place in different ecosystems is an important step in attempting to forecast and prevent such transitions. Dryland ecosystems often exhibit patchy vegetation, which has been shown to be an important factor on the possible regime shifts that occur in arid regions in several model studies. In particular, both gradual shifts that occur by front propagation, and abrupt shifts where patches of vegetation vanish at once, are a possibility in dryland ecosystems due to their emergent spatial heterogeneity. However, recent theoretical work has suggested that the final step of desertification - the transition from spotted vegetation to bare soil - occurs only as an abrupt shift, but the generality of this result, and its underlying origin, remain unclear. We investigate two models that detail the dynamics of dryland vegetation using a markedly different functional structure, and find that in both models the final step of desertification can only be abrupt. Using a careful numerical analysis, we show that this behavior is associated with the disappearance of confined spot-pattern domains as stationary states, and identify the mathematical origin of this behavior. Our findings show that a gradual desertification to bare soil due to a front propagation process can not occur in these and similar models, and opens the question of whether these dynamics can take place in nature.

Keywords: Desertification, Spatial transitions, Regime shifts, Vegetation patterns, Homoclinic snaking