Hydrol. Earth Syst. Sci. Discuss., 3, S2014–S2018, 2007
www.hydrol-earth-syst-sci-discuss.net/3/S2014/2007/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Eco-geomorphology and vegetation patterns in arid and semi-arid regions" *by* P. M. Saco et al.

M. Boer (Referee)

mboer@cyllene.uwa.edu.au

Received and published: 15 August 2007

The modelling experiment described by Saco et al. is one of many in which regular or irregular vegetation patterns are shown to be reproduced by a relatively simple set of feedback mechanisms. Many of these modelling studies have focused on the formation of vegetation patterns that are characteristic of arid and semiarid environments. As stated by Saco et al.'s their experiment differs from much of the previous work by coupling a vegetation growth model with a landform evolution model and running the two at relatively small time steps over geologic timescales. This is an interesting modelling exercise from which new insight may be expected. The paper is generally well-written but lacks a clear set of research questions to be tackled with the coupled models. This then causes a lack of focus in the results and discussion section and leaves the reader somewhat unconvinced about what has actually been achieved. I concur with other reviewers comment that

Simulation modelling usually involves making assumptions about what processes to include, parameter values, length of time steps, initial conditions, etc. When reporting the on the approach and results of simulation studies it is crucial to discuss the choices that have been made while building and running the model as detailed as possible. Such detail is not always available in the present paper by Saco et al. For example, what were the reasons for initialising the model (page 2574) with this particular vegetation pattern consisting of randomly placing “biomass peaks” in 1% of the grid cells? What processes could be responsible for generating such a pattern? What effects could this particular initial pattern have on the modelling results? Why combine this random vegetation pattern with a purely planar slope and not with one that has some noise added to the general gradient? What would be the impact of such surface irregularities on the vegetation patterns that evolve? Another modelling choice that has not been discussed in detail concerns the climate or weather data that drive the coupled models. Was the rainfall rate assumed to be constant or to vary in any particular way? To what extent has this choice of weather input affected the resulting patterns of vegetation and micro-topography? This is important, especially if the pattern being stationary or migrating is to be highlighted as a key result.

Another point of concern is the way that some of the key feedbacks have been implemented in the model. As stated by the authors the feedback between vegetation density and soil hydrological properties (in particular infiltration, storage and retention capacity) is crucial for the development of landscape scale vegetation patterns. As shown in equation 4, the infiltration is modelled as a function of, amongst others, vegetation density. In the model the positive effect of plant biomass on infiltration is immediate and relatively strongest for very low amounts of plant biomass. In the field, infiltration capacity and other soil attributes are likely to initially respond very little to

HESSD

3, S2014–S2018, 2007

Interactive Comment

EGU

small quantities of plant biomass as it will take a long time ($>>$ years) to change soil organic matter content, porosity, aggregate stability, etc. On the other hand, the positive effect of vegetation on infiltration and other soil hydrological properties may remain for considerable time after the vegetation cover has declined. I suspect that omitting this hysteresis effect could have potentially important implications for the resulting pattern of vegetation and surface topography. For example, if erosion rates on nearly bare soil surfaces are relatively high compared with the rate at which local soil hydrological properties improve with increasing vegetation density, the vegetation cover might never develop from the nearly bare initial condition to a banded form that retains all water on the slope (see e.g. Thornes JB (1985) The ecology of erosion. *Geography* **70**, 222. or Thornes JB, Brandt J, Millington AC, Pye K (1994) Erosion-vegetation competition in a stochastic environment undergoing climatic change. In 'Environmental change in drylands: biogeographical and geomorphological perspectives' p. 305. (John Wiley & Sons Ltd.: Chichester). Another feedback that has been modelled rather roughly in Saco et al.'s paper concerns the vegetation-surface roughness relationship. The authors assumed a constant and spatially uniform value for Manning's n. This does not seem consistent with the common field experience that stems and vegetation debris reduce overland flow rates. If vegetation density is assumed to affect infiltration and erodibility why would you ignore the effect on surface roughness?

In summary, there are several important steps in the modelling exercise that require a stronger underpinning with (published) field knowledge or a more thorough argumentation for the taken approach. I therefore concur with David Dunkerley's review that the author's claim of their model correctly capturing the essential processes driving these ecosystems is premature. To improve our understanding of complex dryland systems we could, perhaps, worry less about simulated patterns being similar to the observed and focus more on systematically exploring the (multi-scale) consequences of representing key processes in one way or another.

Other more specific comments are listed below.

Page 2560, line 15-20: “The redistribution of water . . . .is a fundamental process within drylands that may be disrupted if the vegetation structure is disturbed”. Rather than disrupted, I would say the redistribution process may be altered since they will probably continue to operate but at different spatiotemporal scales.

Page 2561, line 0-5: Effects of vegetation in controlling runoff flow paths is likely affected by overall slope gradient, being relatively important on gentle slopes (such as common in interior Australia) and relatively less important on steep slopes (common in drylands of the Mediterranean Region).

Page 2561, line 5-10: Although, I agree that in principle vegetation patterns may provide information on hillslope redistribution processes, and therefore on resource retention capacity and land condition, I don’t believe this is straightforward at all.

Page 2561, line 20-25: The statement that the most common vegetation pattern in arid and semi-arid ecosystems is spotted or stippled is unsupported. It may be common, but I don’t think it is the most common. Also, whether the vegetation pattern is stippled, spotted or whatever depends on the spatial resolution and extent of observations.

Page 2562, line 15-20: Rather than overland flow being “lost” redistribution distances increase. Even if this involves concentration in channels the water may still contribute to increased water availability (and biomass production) downstream.

Page 2565, line 0-5: The model appears to be sensitive to the relative importance of isotropic versus anisotropic (runoff-driven) seed dispersal. What is the basis for the parameter values that have been used to control these processes and how common are these in nature?

Page 2567, line 5-10: I doubt that for the prevailing conditions under which runoff-runon processes operate there would be a hillslope-scale gradient of flow depths. Please, provide support.

Page 2567, line 15-20: The trend of decreasing infiltration rates with distance from

HESSD

3, S2014–S2018, 2007

Interactive Comment

trees is usually explained by the greater porosity associated with high root densities, organic matter content, soil faunal activity, etc. near trees or large shrubs. I doubt that these trends in infiltration are due to micro-topography alone.

Page 2575, line 5-10: The choice to not allow any lateral competition for water by vegetation in adjacent grid cells requires better support. To what extent does this choice affect resulting vegetation patterns?

Page 2578, line 20-25: Earlier modelling work by Sánchez & Puigdefábregas reproduced similar terraced slope profiles for dry Mediterranean hillslopes dominated by the tussock grass *Stipa tenacissima.* See: Sánchez G, Puigdefábregas J (1994) Interactions of plant growth and sediment movement on slopes in a semi-arid environment. *Geomorphology* **9**, 243-260. Puigdefábregas J, Sánchez G (1996) Geomorphological implications of vegetation patchiness on semi-arid slopes. In 'Advances in hillslope processes'. (Eds MG Anderson, SM Brooks) p. 1027. (John Wiley & Sons Ltd.: Chichester).

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 2559, 2006.

HESSD

3, S2014–S2018, 2007

Interactive Comment