BIO_SOS Modelling Activities: Modelling Runoff-Sediment Connectivity

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Extended Abstract

Pressures and threats to an ecosystem and its function need to be predicted and quantified: only knowing them, actions can be taken to avoid them. This is particularly true when the pressures are created by human actions and decisions. Part of these pressures causes changes in a) the water (and sediment) regime, b) the input of water and sediment into given parts of an ecosystem and c) water availability. These impacts can be estimated by means of a simple runoff-erosion model, easy to use and to understand and linked to a spatially distributed description of the landscape where the ecosystem to protect and conserve is located.

The model that has been developed (LANDPLANER from "Landscape, plants, landslides and erosion") has been developed within the framework of EC project SPACE-2010-1 – 263435 – BIO_SOS "BIOdiversity Multi-Source Monitoring System: from Space to Species". It is a spatially distributed model which simulates runoff, infiltration and sediment fluxes in the landscape. Written in R, LANDPLANER is based on a series of pre-existing models/modules so that it can take advantage of existing knowledge (tables, algorithms) characterizing soil/vegetation/landuse response to daily rainfall. The main models/modules on which LANDPLANER is based are: 1) a particular application of the NRCS Runoff Curve Number (RCN) method (HAWKINS et al. 2009); 2) an EUROSEM-based sediment generation routine (MORGAN et al. 1998, DEBAETS et al. 2008, SMETS et al. 2010), and 3) an overland flow direction and accumulation routine as developed in GRASS (© GRASS Development Team, 1998-2013).

LANDPLANER builds on these models and adds: 1) a simplified multi-layers routine for infiltrating water into the soil; 2) a modification of flow direction and accumulation imposing roads and other structures as modification of the real DTM; and 3) and identification of the areas subject to gully erosion (from ephemeral gullies to retreating-eroding gullies) based on a deep modification of the topographical thresholds equation for gully-head (MONTGOMERY & DIETRICH 1994, POESEN et al. 2011) and the introduction of the effect of vegetation, land use, and soil in the definition of the threshold conditions.

LANDPLANER allows analyses such as: which is the water amount that actually can reach a given spot (e.g., a pond with amphibians) and from which area is the water coming under the prevailing meteo conditions, land use, morphology etc.; hence, if we add a road cutting through the overland flow source area, how will runoff harvesting change at the pond? Can we build the road without impacting negatively?

Jekel, T., Car, A., Strobl, J. & Griesebner, G. (Eds.) (2013): GI_Forum 2013. Creating the GISociety.

Sediments too can have positive/negative effects, e.g. silt the pond. Where do they come from? Can we decrease the sediment input (to the pond) to an acceptable quantity? How can we do it without changing runoff harvesting? And if there is a wildfire, how will the situation change? This particular type of destructive events was tested by chance when a closed oak plantation was burned in Umbria, in July 2012, with the generation/re-activation of a system of old gullies (Fig. 1).

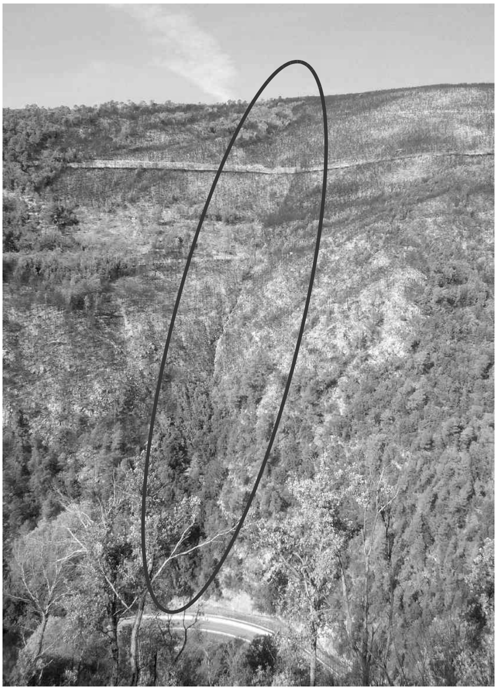

Fig. 1:
Gully systems that developed after intense fire (July, 2012) between Terni and Spoleto (Umbria, Italy)

Further the model integrates a 2.5D simplified multi-layers routine for infiltrating water, allowing the estimation of degree of soil saturation and of excess water in each soil layer. This datum permits a rough estimate of the instability condition along a slope, and can be the basis for a more complex slope instability model. In an integrated modelling framework, this makes the evaluation of erosion and instability processes in a slope under different changing scenarios (i.e. climatic, natural, or anthropic changes) possible.

It can be argued that all this is not particularly new: it is what runoff-erosion-infiltration models should do, but usually models lack either the road- or the gully-routine (or both) and generally they are dedicated either to landslide or to soil erosion description.

LANDPLANER gives a paramount importance to vegetation and land use, included artefacts. As LANDPLANER hydrological part is actually based on the RCN method, then vegetation, land use and management have an important role in the evaluation of the amount of water that is infiltrated into the soil (which is expressed through a water storage index, usually represented with the letter S). When we further refined the gully head-cut threshold equation, S was used as a way to quantify land use effect on the threshold. S is quite good in transforming the land use classes into numbers which can be used in a numerical model.

This contributes to give strength to LANDPLANER because input data are kept to a minimum while descriptions of the processes are improved.

As an example of the new insight, Fig. 2 shows trends between catchment area upslope the gully head and the slope (sinus, s in Fig.2) around the gully head. The threshold for gully head to develop is the one reported in Fig. 2. It can be noted that trends are scattered but almost parallel. Hence the exponent b is a constant (b=0.38). Under these circumstances it is possible to estimate k (i.e. the value of slope when the area of the catchment above the gully-head is 1 ha): TORRI & POESEN (2013, submitted) showed that k depends linearly on the storage parameter of the RCN method.

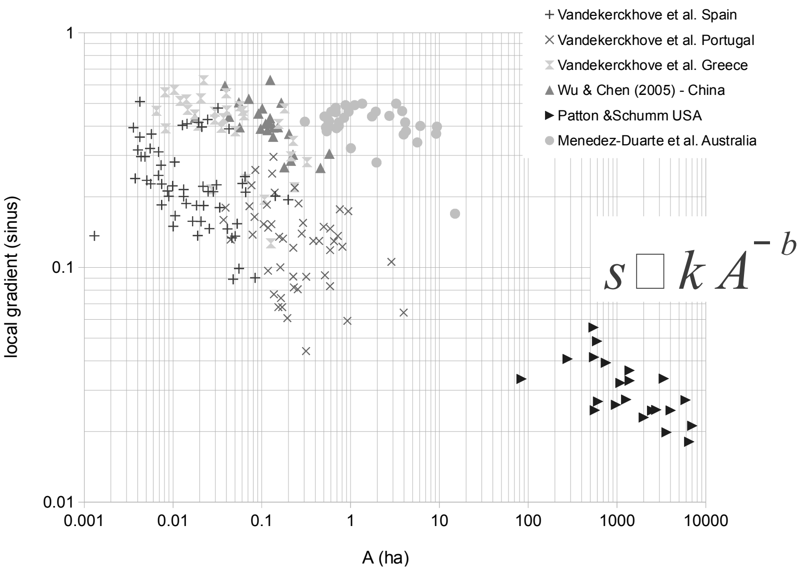

Fig. 2: Relationship between local gradient nearby the gully head and the catchment area draining into the gully head

LANDPLANER is simple to run, relatively easy to use and cheap (being based on open software). It needs a user manual, which has not been written yet. Obviously LAND-PLANER can be expanded to build more around the novelties it contains.

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