Coupled ABM-GIS Modeling of Agro-Pastoral Systems in Eastern Spain

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The MedLanD Project

•The project aims to understand the long-term effects of human-environment interaction in the Mediterranean Basin.

•To accomplish this goal we have developed a modeling laboratory for studying the long-term consequences of human landuse decisions on regional landscapes

•Our model couples agent-based human-action simulations, constructed in the DEVS Java environment (Mayer and Sarjoughian 2007), with landscape dynamics simulations, constructed in the GRASS GIS environment (GRASS Development Team 2010).

•Here, we simulate landscape dynamics in the Penaguila Valley in Eastern Spain resulting from agricultural and agropastoral landuse and contrast them to a simulation of an unoccupied landscape.

Figure 1. The Penaguila Valley Study Area, Spain

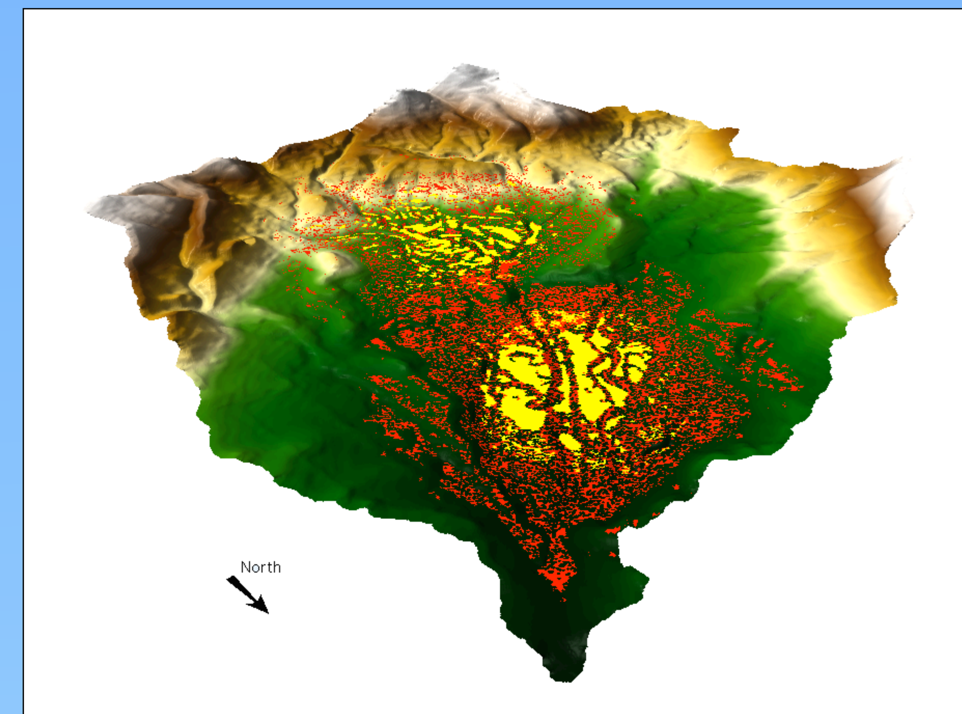

Figure 3. The Penaguila Valley after 5 years of simulation with Agricultural land use (yellow) and pastoral land use (red) highlighted.

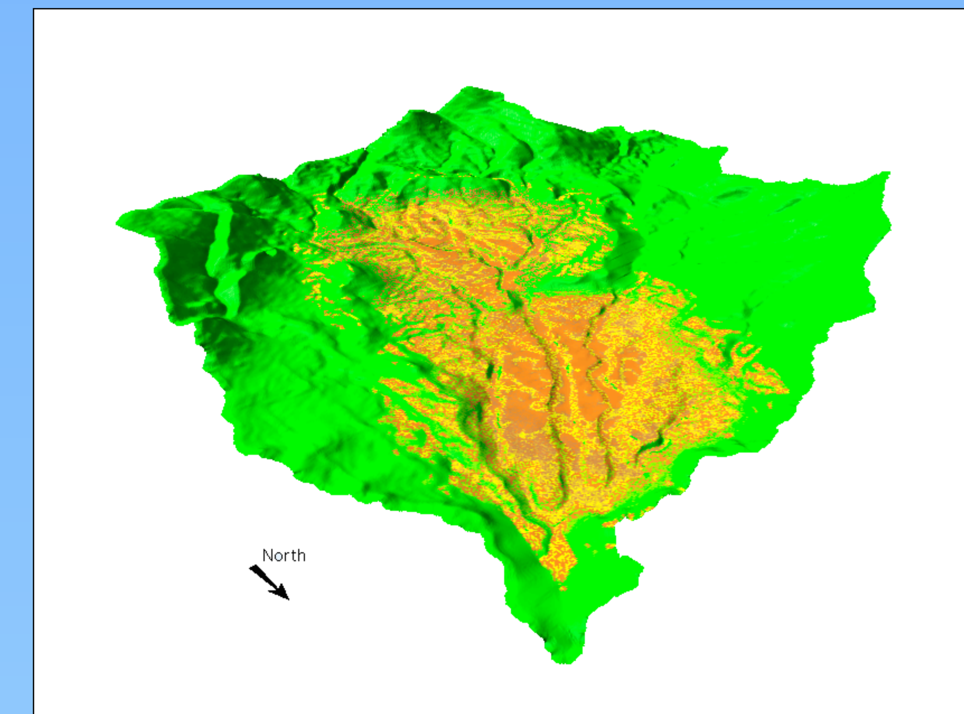

Figure 4. The Penaguila Valley after 5 years of simulation displaying simulated landcover ranging from woodland to shrubs.

AP-Sim

•The DEVSJava agent-based Agropastoral Simulation (AP-Sim) model emulates non-irrigated subsistence cereal farming and central place pastoralism.

•The agent-based component of the hybrid model is made up of two agent types, villages and households. In this simulation, two villages consisting of three households each were modeled at the location of two Early Neolithic villages.

•Household agents must decide upon a farm plan consisting of the plots that will be farmed, and the plots that will be released to the rest of the village. They may also decide upon a grazing plan which consists of nearby non-agricultural land.

•Each cycle of the simulation (1 year), households receive new information about the land around them and must reassess their landuse. Households make future land-use decisions based upon the landcover, slope, distance, and soil depth.

•Villages are responsible for managing household landuse plans, ensuring that households do not utilize identical plots of land, and enqueuing plots of land that have been released to the agents within the village.

•Agricultural and pastoral landuse have impacts upon the landscape and subsequently affects landuse decisions in the next year.

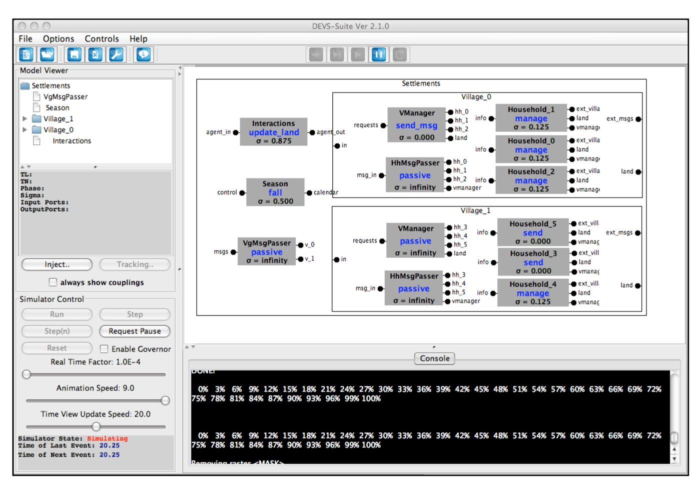

Figure 2. The DEVS Java Simulation Window which is used to control the simulation

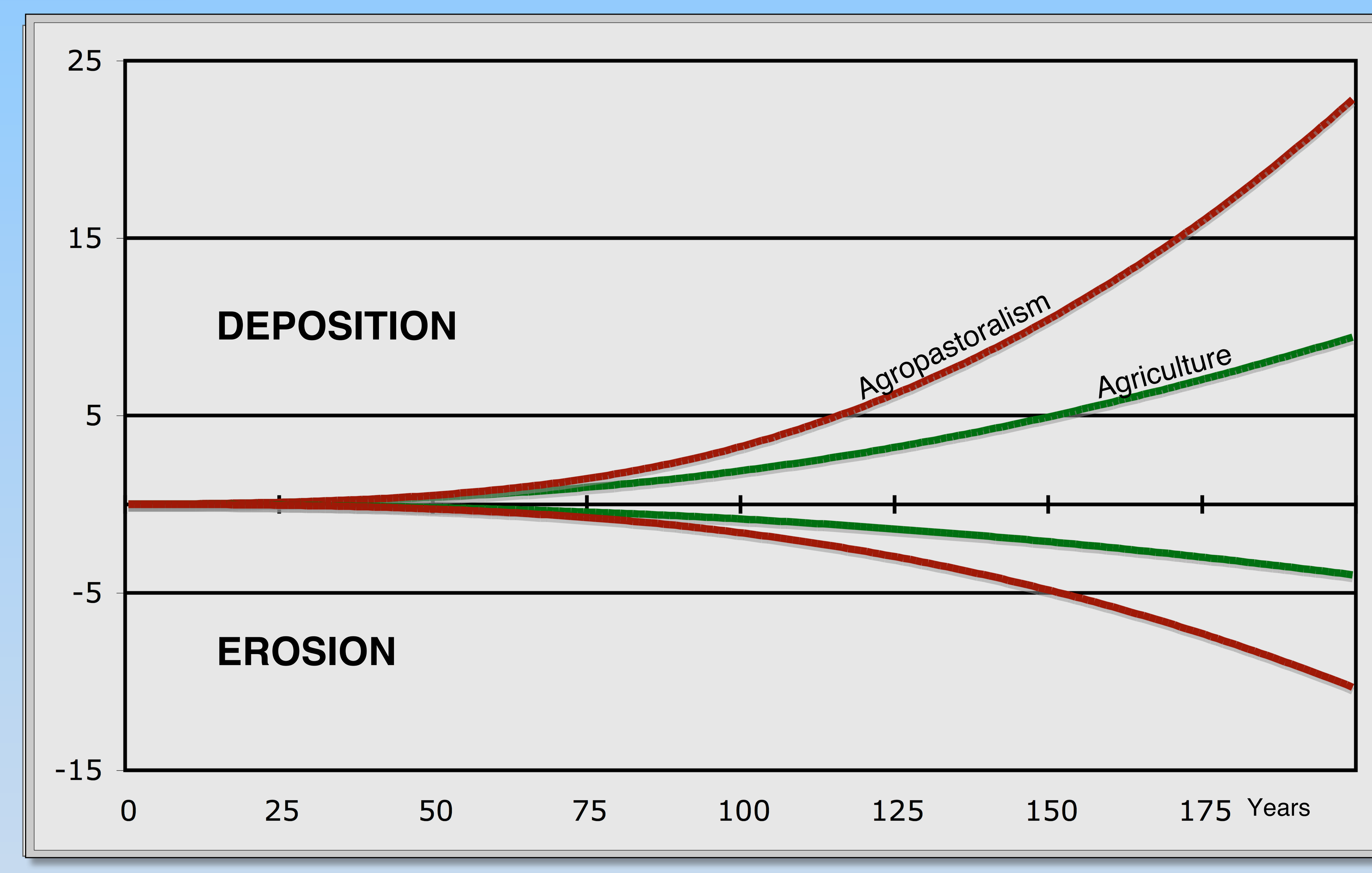

Figure 5. Two hundred years of cumulative erosion and deposition resulting from the agropastoral and the agricultural landuse simulations.

LandDyn

•Our GRASS GIS Landscape Dynamics (LandDyn) model simulates surface process dynamics (e.g., erosion and deposition) using simple geomorphologic transport laws (Barton, Ullah et al. n.d.), and simulates simple vegetation succession dynamics based on field data from Southern Spain (Bonet and Pausas 2004).

•The core script of our landscape evolution model is *r.landscape.evol*, which is a process-based cellular-automata simulation of surface runoff flow, sediment detachment (erosion), sediment transport, and sediment deposition.

•The simulation is set upon a 5m resolution DEM of a “reconstructed” paleosurface with the aid of geomorphologic field work in the region.

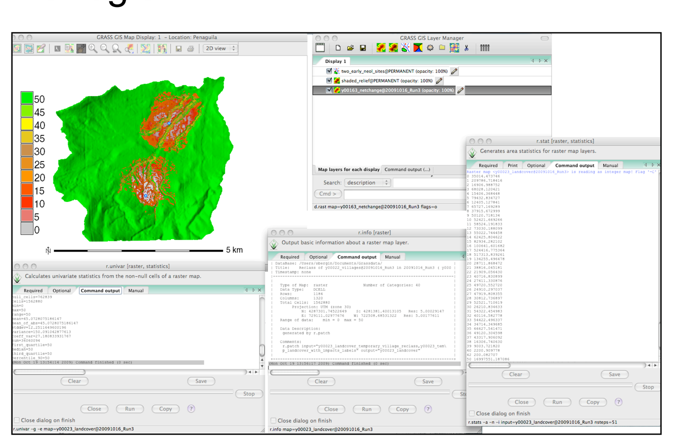

Figure 3. The GRASS GIS Interface which contains the core lands dynamic scripts

•LandDyn also includes a simple vegetation succession model, *r.landcover.update,* which maintains a landcover map where vegetation types are coded as numerical values in a 50 year succession scheme (Pardo and Gil 2005).

•Human impacts are accepted using *r.landcover.update,* which modifies the landcover map according to the activity conducted in each location. Cells that are unmodified by agents are regenerated as a function of soil-depth, soil-fertility, and time.

•Finally, a simple soil fertility routine, *r.soil.fertility,* is used to keep track of the fertility of farmed plots. Farming a plot will reduce the fertility and landcover in that plot, while grazing a plot will only decrease the landcover of a plot.

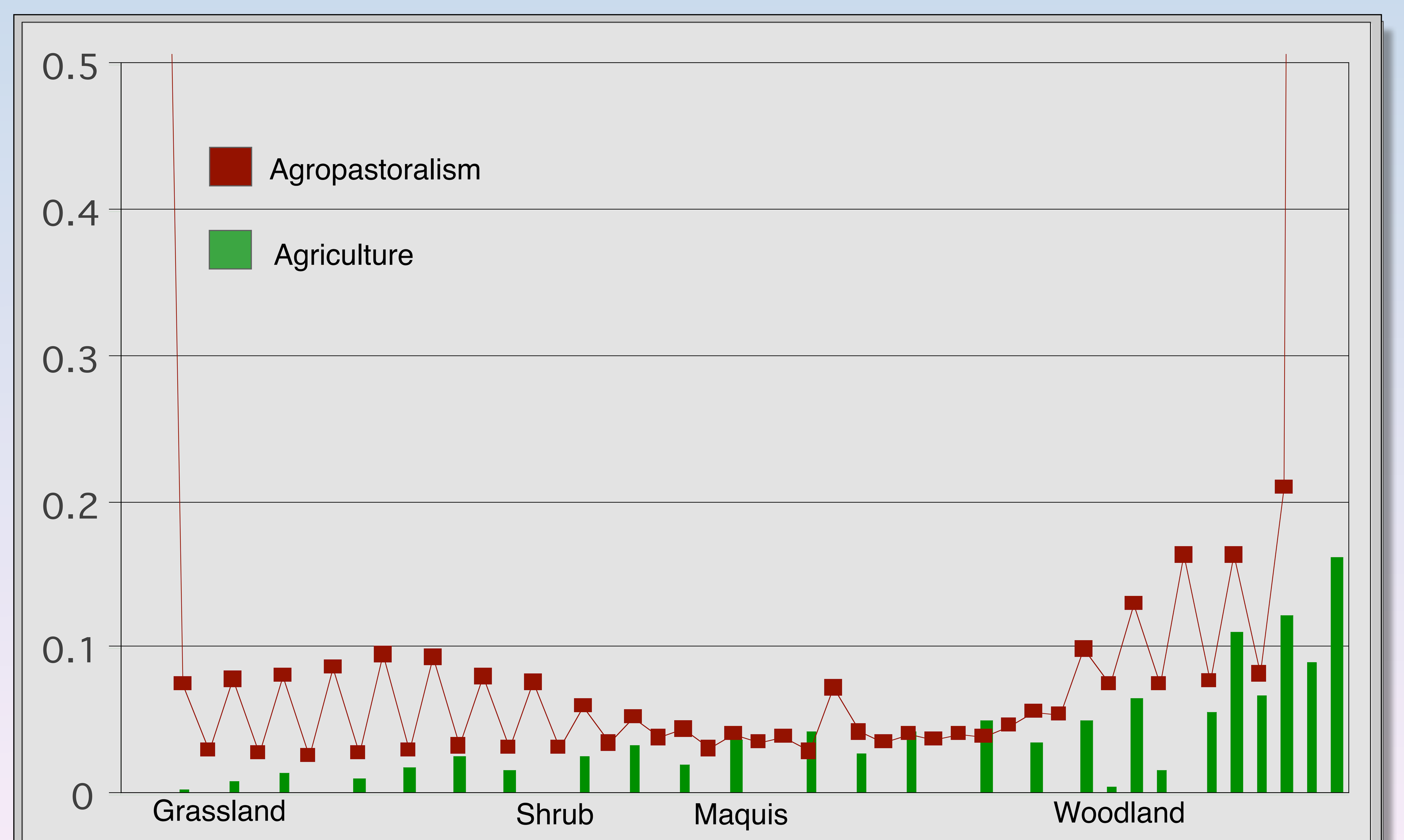

Figure 6. Area (km^2) of landcover distribution for year 200 of the agropastoral and agricultural landuse simulations

Penaguila Landscape Evolution

•Agropastoral landuse results in greater erosion and deposition rates through time than agriculture alone.

-Agropastoral landuse results in a large mosaic impact footprint that is larger than the smaller, but more acute, impact footprint of agriculture alone. Ovicaprids also graze on vegetation that lies on steep slopes, exposing these already unstable areas to increased erosive impacts The wider footprint has a more widespread and thus greater impact on the hydrology of the Penaguila watershed.

•Agropastoral landuse also results in wider diversity of landcover types over time when compared to agricultural landuse.

-Agriculture is a bottom-up impact resulting from initial deforestation from clearing and a long period of regrowth. Grazing is a top-down impact resulting from long periods of minor landcover degradation due to repeated ovicaprid browsing. Agropastoral landuse combines these effects creating a bimodal impact upon landcover and thus greater diversity than agricultural landuse.

•This type of coupled ABM and GIS model is very capable of reproducing highly complex agent and landscape dynamics. Our model allows agents to actively modify their environment, and then recursively react to the repercussions of these modifications. We believe that this kind of modeling will eventually provide an accurate and interesting way to interpret and better understand the way humans interacted with, affected, and were affected by their environment.

•Forthcoming experiments will include the addition of greater social complexity and the addition of reciprocity. Further research will also include other Mediterranean locations, and has already begun in Jordan.

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For Further Information

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