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An Integrated Socio-Ecological Simulation Model of Succession-Disturbance Dynamics in a Mediterranean Landscape

James D.A. Millington (1), John Wainwright (2), George L.W. Perry (3), Raul Romero-Calcerrada (4) and Bruce D. Malamud (5)

(1) Center for Systems Integration and Sustainability, Michigan State University, USA, (jmil@msu.edu, Phone: +1-517-432-5068)(2) Sheffield Centre for International Drylands Research, Department of Geography, The University of Sheffield, Sheffield, UK, (3) School of Geography, Geology and Environmental Science, University of Auckland, New Zealand, (4) School of Experimental Science and Technology, Rey Juan Carlos University, Madrid, Spain, (5) Environmental Monitoring and Modelling Research Group, Department of Geography, King's College London, London, UK

Here we present the construction, testing and initial use of an integrated socio-ecological model to examine the spatial succession-disturbance dynamics of a region of Madrid, central Spain. The model combines a landscape fire succession model (LFSM) with an agent-based model of agricultural land use/cover change. Vegetation-dynamics are represented in the model using functional types to represent spatial and temporal competition for resources (predominantly water and light) in a rule-based modelling framework. Wildfire behaviour is represented using a grid-based cellular-automata (CA) model of fire spread. Land-cover flammability, slope, vegetation moisture and wind are considered as factors influencing individual fire behaviour. As similar wildfire CA-type models have found, we observe a critical threshold in vegetation flammability values at which system behaviour shifts from wildfire events that consistently burn very few grid cells to events that consistently span the entire grid. This shift results in a change from landscapes dominated by forest land covers, to more spatially-homogenous landscapes dominated by shrubland. We use a 'pattern-oriented modelling' approach in conjunction with wildfire power-law frequency-area scaling

exponent, β to calibrate the model. The novel integration of an agent-based model of agricultural decision-making with the LFSM also allows us to examine the impacts of scenarios of economic, demographic and climatic change on the wildfire regime, and associated land-cover change. Results indicate that mean largest wildfire and mean total burned area will increase if agricultural activity declines. Modelled fires ignited by human causes burned greater areas of shrubland than would be expected at random, and modelled lightning fires burned greater areas of forest land-cover types than would be expected at random.