Elevation Control on Vegetation Organization in a Semiarid Ecosystem in Central New Mexico

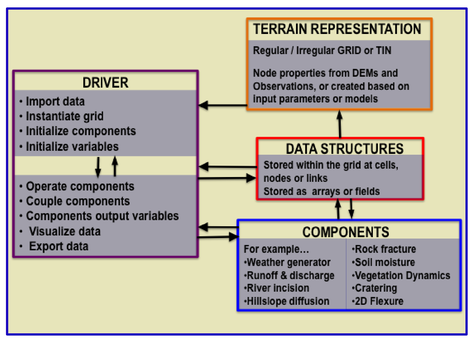
Sai Siddhartha Nudurupati[1], Erkan Istanbulluoglu[1], Jordan M. Adams[2], Daniel Hobley[3], Nicole M. Gasparini[2], Gregory E. Tucker[3] and Eric W. H. Hutton[4]

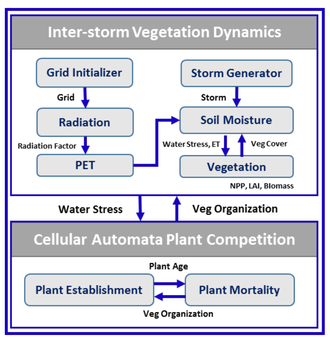
1 Department of Civil and Environmental Engineering, University of Washington, Seattle, WA, USA
2 Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, USA
3 CIRES and Department of Geological Sciences, University of Colorado, Boulder, CO, USA
4 Community Surface Dynamics Modeling System (CSDMS), University of Colorado, CO, USA

INTRODUCTION

- Semiarid and desert ecosystems are characterized by patchy and dynamic vegetation
- Topography has been observed to play a commanding role on vegetation patterns
- In this study, we investigate the role of elevation dependent climatology on vegetation organization in a semiarid catchment in New Mexico, USA
- We develop a ecohydrologic cellular automaton model within Landlab, a component based modeling framework for earth surface (http://landlab.readthedocs.org).
- The model couples local vegetation dynamics model with cellular automata plant establishment and mortality model based on Zhou et al. (2013).
- The model is driven by elevation dependent rainfall, temperature and radiation
- Model results reproduce elevation and aspect controls on observed vegetation patterns

LANDLAB: ECOHYDROLOGY





Landlab Ecohydrology Components:

Storm Generator: generates rectangular Poisson distributed storms

Radiation: calculates daily spatially distributed solar radiation (Radiation Factor)

Potential Evapotranspiration (PET): uses solar radiation fields and weather variables to calculate PET at each model element

Soil Moisture: solves root zone water balance between two storms given PET and rainfall fields ; returns actual evapotranspiration and soil moisture at inter storm durations

Vegetation: *computes net primary productivity based on actual evapotranspiration and calculates leaf area index and biomass*

Cellular Automata Competition: models competition by keeping track of probabilistically calculated mortality and establishment of plants driven by water stress and plant age

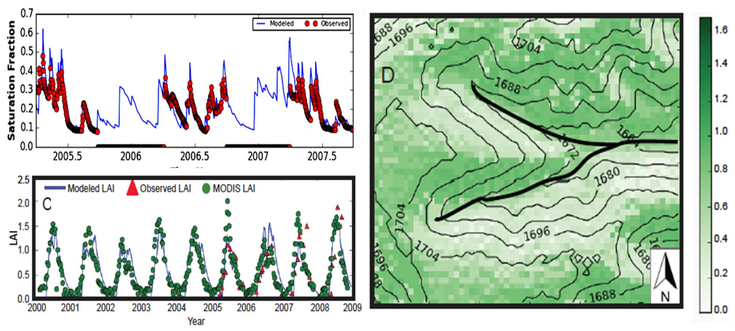


Fig. *1:* *Point Model Validation of Leaf Area Index at Nebraska Sand Hills*

VEGETATION ORGANIZATION: ASPECT

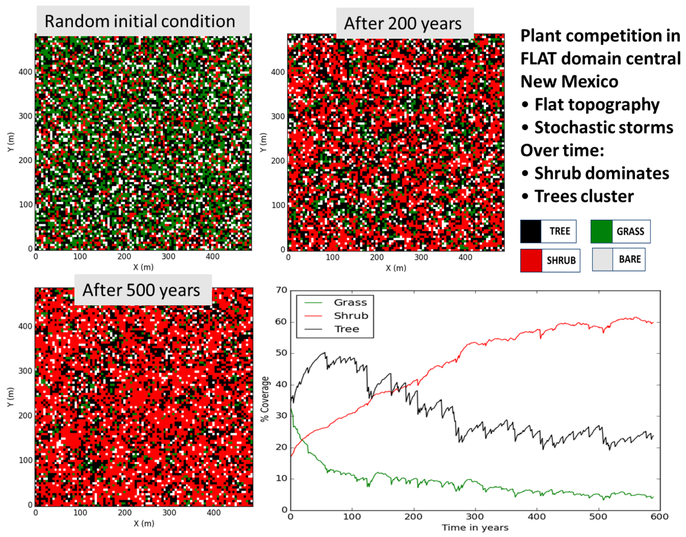


Fig. *2:* *Simulation on flat topography*

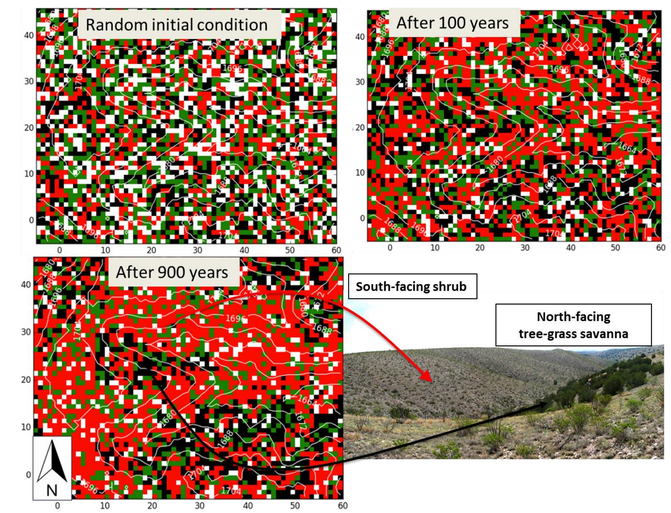


Fig. *3:* *Simulation on actual topography in Sevilleta, Central New Mexico*

Stochastic climate with elevation-dependent precipitation and potential evapotranspiration (PET) drives the model

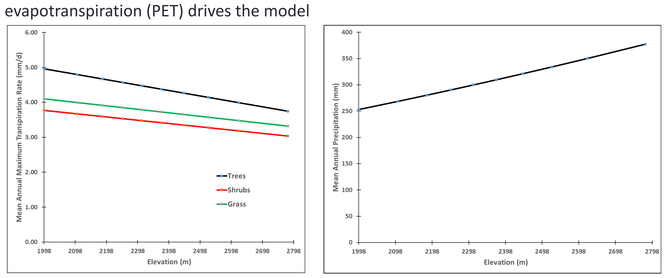


Fig. *4:* *Elevation dependence on Potential Evapotranspiration and Precipitation [1]*

VEGETATION ORGANIZATION: ELEVATION

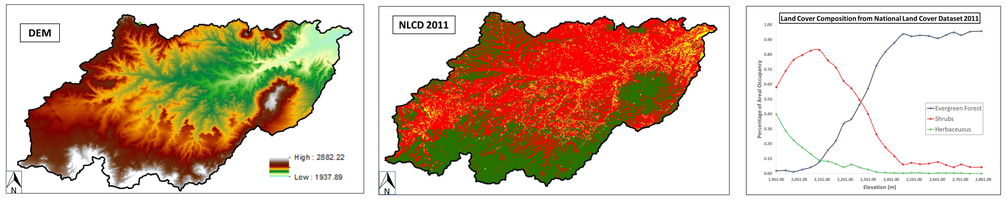
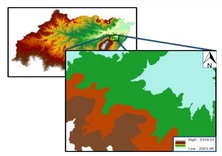
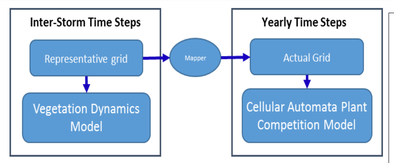


Fig. *5:* *Observed elevation dependent land cover in a catchment in central New Mexico*

MODELING ELEVATION DEPENDENCE



Sample Area for Analysis



Landlab Driver for this Analysis

- To increase computational efficiency ecohydrologically similar grids are developed into bins for soil moisture and water stress simulations.
- 10 slope bins X 12 aspect bins X 5 elevation bins X 4 vegetation type bins are used.
- Water stress is mapped from representative grid to actual (topography) grid annually.
- CA plant competition is driven by water stress

Simulations: Random initial plant type is used. Role of elevation-dependent precipitation and PET is examined in a sample site.

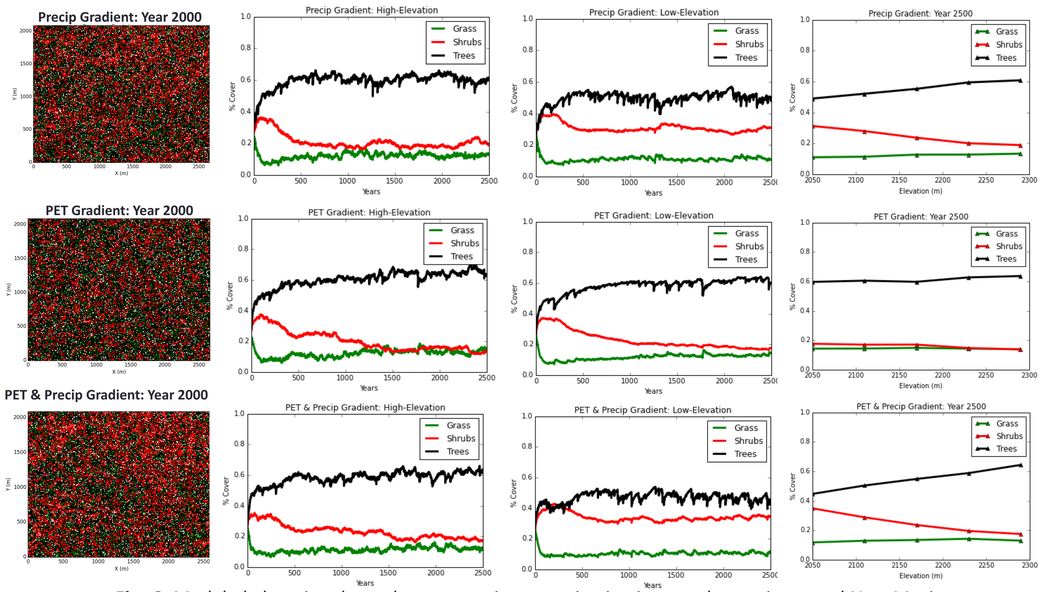


Fig. *6:* *Modeled elevation dependent vegetation organization in a catchment in central New Mexico*

CONCLUSIONS

This study demonstrates a preliminary evaluation of Landlab: Ecohydrology in Central New Mexico.

- The model shows general agreement with observed aspect-dependent and elevation-dependent plant organization.
- These patterns emerge as a result of differences in plant water stress tolerance and longevity.
- Precipitation change with elevation impose a stronger control on plant organization than PET change only.
- At higher elevations, using both PET and P variation led to a greater change in tree cover.
- Future work includes the extension of the analysis to the entire catchment shown in Fig. 5

Contact: saisiddu@uw.edu & erkani@u.washington.edu

Know More About The Landlab here: http://Landlab.github.io

AGU 2015 Poster# H11C-1359

References: 1. Caylor, Kelly K., Salvatore Manfreda, and Ignacio Rodriguez-Iturbe. "On the coupled geomorphological and ecohydrological organization of river basins." Advances in Water Resources 28.1 (2005): 69-86.

2. Zhou, Xiaochi, Erkan Istanbulluoglu, and Enrique R. Vivoni. "Modeling the ecohydrological role of aspect-controlled radiation on tree-grass-shrub coexistence in a semiarid climate." Water Resources Research 49, no. 5 (2013): 2872-2895.