Projecting the Relative Ecological Effects of Climate Change over an Ecoregion

Our Research

We used model results simulating projected climate change impacts as inputs to a fuzzy logic model to produce data layers reflecting the relative effects of climate change on Sonoran Desert & Colorado Plateau ecoregions during the period 2045-2060.

Fuzzy Logic - Background

Fuzzy logic is based on the concept that true & false are not binary but can be represented by a continuum ranging from -1 for fully false to +1 for fully true. Fuzzy logic modeling applies logic operations to model variables using a tree structure, with the root of the tree representing the final model value & the leaves of the tree representing the input variables. As leaves, variables must be mapped from their original data space into fuzzy space. To do this, we set two threshold values for each input variable, one threshold corresponded to -1 (fully false) & the other to +1 (fully false). If an input variable's value falls between that variable's thresholds, its fuzzy value is assigned using linear interpolation. If it falls outside the thresholds, it is assigned either -1 or +1 depending on which threshold it is closer to. We implemented fuzzy logic modeling using python scripts for fuzzy conversion & fuzzy logic functions integrated with Arc ModelBuilder.

Methods & Results

Variables used in the fuzzy logic model (Figure 1) were summer & winter temperature anomalies (Echam5), absolute values of precipitation anomalies normalized to ecoregion variability (Echam 5), vegetation type change as a binary (simulated using the biogeography model MAPSS), & runoff change (also simulated by MAPSS). Inputs for MAPSS were elevation, mean monthly temperature (PRISM baseline with Echam5-driven RegCM3 anomalies), mean monthly precipitation (PRISM baseline with Echam5-driven RegCM3 anomalies as ratio), mean monthly vapor pressure (RegCM3), historical mean monthly wind speed (VEMAP), & soils characteristics (Jeff Kern, xxxx). All data were projected to the 4km Albers Equal-Area projection. In addition to the 4km grid, the fuzzy logic model was run on each ecoregion using HUC-5 watersheds as the base unit. For this, HUC-5 watersheds were overlaid on top of the 4km grid, & input variables averaged using weighted averages of overlapped 4km cells. **Results from the model show discernible patterns consistent with geographic features** (Figure 2).

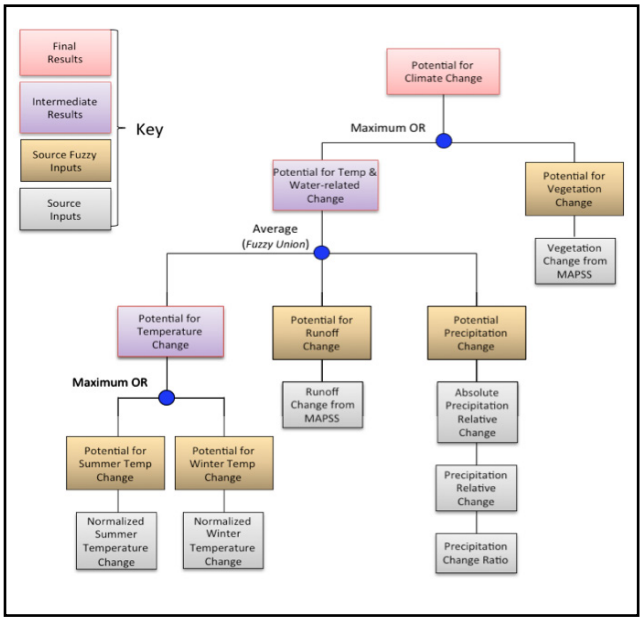

Figure 1: Logic model for relative potential future climate related ecological change

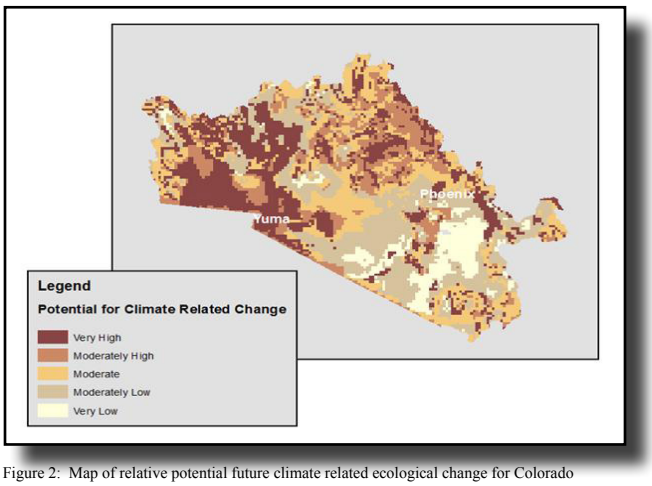

Figure 2: Map of relative potential future climate related ecological change for Colorado Plateau ecoregion.

Data Basin & EEMS

The python scripts utilized for the modeling were further refined into a cohesive package called the Environmental Evaluation Modeling System (EEMS) which can be used for a range of ecological evaluations in other geographic areas. An EEMS-based model exploration tool for DataBasin (www.databasin.org) has been developed and deployed. Expansion of EEMS to work with other file types (including NetCDF) is planned pending funding. The combination of EEMS & the evaluation tool provides a powerful system for evaluative model development & analysis as well as land management planning.

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