Predicting Vegetation Change in the Everglades

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Plant communities are key components of the Greater Everglades. In addition to providing food and shelter to higher trophic-level species, plants influence abiotic ecosystem processes such as fires and soil formation. The hydrologic modifications proposed as part of Greater Everglades restoration will affect both the spatial distribution of plants through time and the fire regime. Understanding the complex interrelationships among these components and processes is an important part of evaluating hydrologic restoration. Across Trophic Level System Simulation (ATLSS) has developed models for vegetation succession and fire that incorporate the effects of hydrology. These models examine relative differences under proposed hydrologic changes in (1) the number, diversity and spatial configuration of Everglades plant communities and (2) the number, size, frequency and distribution of fires in the Everglades. Hydrologic input for the models is based on the output of the South Florida Water Management Model (SFWMM), the standard tool for projecting hydrologic patterns resulting from changes in water management in South Florida. ATLSS High Resolution Hydrology (HRH) interpolates SFWMM output, provided at a 2-mile scale of resolution, over a high-resolution topographic map to create water depths at a 500-meter scale over the model area.

The ATLSS Vegetation-Succession Model (VSMod), developed at the University of Tennessee by S. Duke-Sylvester, simulates the pattern of spatial and temporal changes in the distribution of vegetation in the Greater Everglades landscape as a function of the hydrologic regime, patterns of fire disturbance, and nutrients. A primary goal is to quantify the relative differences among various hydrologic scenarios as reflected in their effects on vegetation succession. VSMod incorporates a spatially explicit, stochastic cellular automata model to simulate vegetation succession. At any given time, each 500x500 meter plot is in one of a finite number of states. The transition between states occurs with a probability that varies in both space and time, dependent on local hydrologic and fire history as well as on the current vegetation. The model runs on a yearly time-step, synchronized with the fire model, and produces annual maps of projected vegetation over the model area. Three modeled factors influence the succession of one plant association to another: fire, nutrient change, and prolonged hydrologic change.

The purpose of the ATLSS fire model is to provide annual estimates of the spatial distribution of the areas burned by naturally occurring fires in the Florida Everglades. The fire model provides input for the ATLSS vegetation succession model, VSMod, while VSMod provides local vegetation information for the fire model, simulating the effects of feedback between fire history and vegetation. The fire model's yearly time step ends on May 31 - the end of the natural fire season. The fire model provides estimates of the spatial distribution of both hot and cool fires. Hot fires are those that result in the death of trees and/or the burning of soils and peat material. These fires reset the successional process to "early" vegetation types. Cool fires are those that do not kill trees or burn soils. These fires burn only above-ground portions of plants, and arrest succession at different stages of development depending on fire frequency.

The fire model simulates landscape-scale fire patterns by modeling fire spread as a collection of local stochastic processes. Each plot is represented by a stochastic cellular automata model. Each plot is in one of three states: unburned; burned by cool fire; or burned by hot fire. Transitions between these states are stochastic and depend on local environmental conditions and the presence or absence of fire in the neighborhood of each plot. The model assumes that all natural fires are caused by lightning strikes. The spatial distribution of area burned for each year is estimated by computing for each plot in the landscape the number of lightning strikes, the probability of burning, and the number of resulting fires. Finally, fire spread is simulated by incorporating a locally determined conditional probability of burning given that a neighboring plot is burning.