Report as of FY2010 for 2008FL215B: "Addition of Ecological Algorithms into the RSM Model"

Publications

- Dissertations:
  - Lagerwall, G.L., Kiker, G.A., Muñoz-Carpena, R., James, A., Hatfield, K., Wang, N., 2011, Modeling Typha domingensis in an Everglades Wetland. University of Florida. Dissertation.
- Articles in Refereed Scientific Journals:
  - Lagerwall, G.L., Kiker, G.A., Muñoz-Carpena, R., 2011, Accounting for the Impact of Management Scenarios on an Everglades Wetland. Ecological Informatics. In Submission.

Report Follows

Status Report
104B Student Assistantship Program
Project: Addition of Ecological Algorithms to the Regional Simulation Model (RSM)

CoPIs: Gregory Kiker, Rafael Muñoz-Carpena, Wendy D. Graham,
SWFMD Coordinator: Naiming Wang
Ph.D. Student: Gareth Lagerwall
Collaborator: Andrew James
External Committee Member: Kirk Hatfield

Recent publications, proceedings, or presentations:

Lagerwall, G.L., Kiker, G.A., Muñoz-Carpena, R., 2011, Accounting for the Impact of Management Scenarios on an Everglades Wetland. Ecological Informatics. In Submission.

Lagerwall, G.L., Kiker, G.A., Muñoz-Carpena, R., James, A., Hatfield, K., Wang, N., 2011, Modeling Typha domingensis in an Everglades Wetland. University of Florida. Dissertation.

Objectives:

This research project aims to systematically review, design and develop selected ecological algorithms for the RSM model (RSM-ECO) using a similar methodology to the development of water quality algorithms (RSM-WQ) (Jawitz et al., 2008). To this end, the objectives of this research are:

- Review of relevant ecological models, design concepts and code implementation tools for development of RSM-ECO ecological algorithms.
- Selection of ecological species (habitat, plant and/or animal) to be included in the initial development and testing of RSM-ECO.
- Development of the conceptual model of RSM-ECO organisms
- Prototype model development and testing on the “10x4” mesh (Jawitz et al., 2008)
- Selection of a test site for model calibration and testing
- Systematic global sensitivity analysis

Status Report:

All work required for the completion of the PhD has been completed. The abstract of the dissertation can be read below:

The regional simulation model (RSM), developed by the south Florida water management district (SFWMD), was originally coupled with the transport and reaction simulation engine (TARSE) in order to model phosphorus dynamics in an Everglades wetland in Southern Florida, USA. The dynamic nature and user-defined inputs and interactions of this coupled model allowed for adapting it towards modeling ecology. Specifically, it was applied towards modeling Typha domingensis (Southern Cattail, or more generally, cattail) densities across Water Conservation Area 2A (WCA2A). In order to address the issues of complexity, uncertainty, and sensitivity, (i.e. how complex can a model be made in order to reduce uncertainty, while maintaining a relatively low level of sensitivity/instability) five levels of increasing algorithmic complexity were used. The two main factors determining cattail density are water depth and phosphorus concentration, and were thus used to inform the levels of complexity. A simple logistic function was used as the Level 1 complexity to model cattail density. Water depth was used to influence the logistic function in the Level 2 complexity. Water depth along with phosphorus concentration, were used to influence the logistic function in the Level 3 complexity. An inter-species competition factor in the form of a Level 1 Cladium jamaicense (sawgrass) modeled density was used along with water depth and phosphorus concentration to influence the logistic function in the Level 4 complexity. And lastly, an inter-species feed-back mechanism was implemented in the Level 5 complexity, which is essentially a Level 4 complexity but with the cattail density negatively influencing the sawgrass density. Vegetation maps for the years 1991, 1995, and 2003 were used for initialization and comparison of model output during training (1991-1995), testing 1 (1991-2003) and testing 2 (1995-2003) simulations. The growth rate value which influences the logistic function throughout all the levels of complexity was calibrated to 6.7*10-9 g/gs during the training simulation. The difference between model output and historical data was calculated, along with the Moran's I statistic for spatial correlation, and an abundance-area curve for comparing regional density distribution, and it was determined that Level 4 and Level 5 complexities were best suited for matching the historical data. Spatial uncertainty, through the use of sequential indicator simulation, was used to influence a global uncertainty and sensitivity analysis (GUSA). The variance based Sobol method was used to conduct the GUSA, and it was determined here too that a Level 4 complexity was best suited to model cattail densities in the region – providing the best balance between complexity, uncertainty and sensitivity. Finally, based on the previous two findings, a Level 4 and Level 5 complexity was used to determine the impact of alternate management scenarios on the area. Scenarios included high, medium, and low, as well as annually alternating (high and low) water depths and phosphorus concentrations. A GUSA was conducted on these management scenarios to determine their influence relative to the other uncontrollable factors such as the growth and death rates. As with the previous GUSA, the depth was a highly influential parameter, with initial cattail and sawgrass densities coming into play largely through their interaction effects. Time series of select management scenarios were plotted, and it was determined that expansive cattail growth required a high soil phosphorus

concentration. Also, in order to prevent cattail densities increasing significantly, it was determined that a high water depth be used in combination with a low soil phosphorus concentration. In summary, this is a unique, spatially distributed, deterministic, ecological model, providing cattail density values across WCA2A. Provided adequate data, this coupled RSM/TARSE model, along with the groups of analyses conducted, could be applied towards simulating other vegetation species in other habitats.

References

Jawitz, J W; Muñoz-Carpena, Rafael; Muller, Stuart; Grace, Kevin; James, Andrew I; 2008; Development, Testing, and Sensitivity and Uncertainty Analyses of a Transport and Reaction Simulation Engine (TaRSE) for Spatially Distributed Modeling of Phosphorus in South Florida Peat Marsh Wetlands; U.S. Geological Survey Scientific Investigations Report 2008-5029