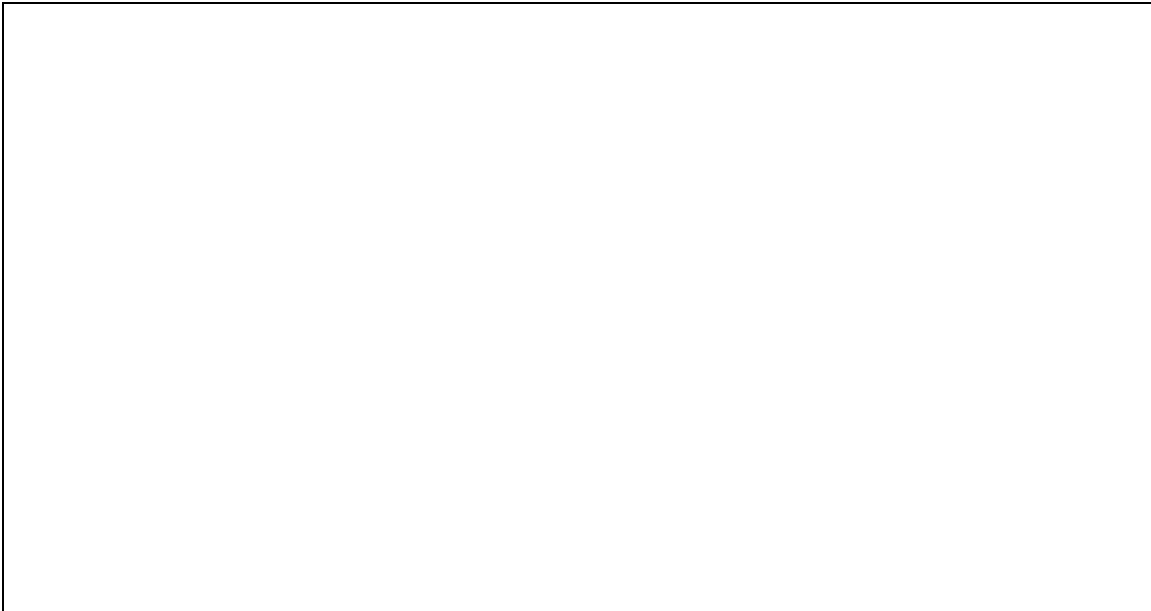
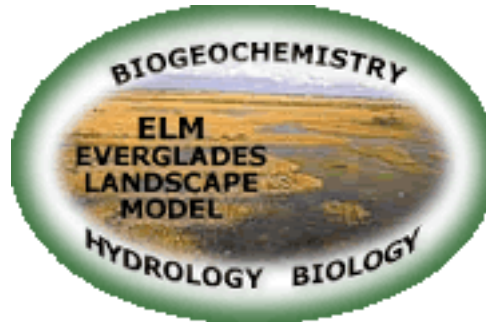


**Documentation of the
Everglades Landscape Model:
ELM v2.8**

Overview version of full report



<http://ecolandmod.ifas.ufl.edu>

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Preface

Documentation purpose

This documentation report provides the information necessary to fully understand the *goals & objectives, supporting data, algorithms, performance, and application* of the Everglades Landscape Model (ELM). This document, the model source code & data, and further supporting information are maintained on the ELM-development web site:

<http://ecolandmod.ifas.ufl.edu>

The primary objective of the documentation is to describe the fine-resolution application of the regional ELM, for use in evaluating ecological responses to alternative management scenarios in the greater Everglades landscape. This is a documentation update, limited to describing changes that were made in model design and data during the transition from ELM v2.5 to ELM v2.8. A number of original ELM v2.5 Documentation Chapters are not included here, as their content remains unchanged; the documentation is available in the above ELM-development web site, and at the ELM-application web site:

<http://my.sfwmd.gov/elm>

The only Chapters included in this ELM v2.8 Documentation Report are those that contain significant new information that is relevant to current application objectives.

Document organization

Each Chapter of this document has its own Table of Contents.

- (see ELM v2.5) Chapter 1: **Introduction** to the Everglades and the model **Goals & Objectives**.*
- (see ELM v2.5) Chapter 2: General overview of **Wetland Ecological Models**.*
- (see ELM v2.5) Chapter 3: Graphical and verbal descriptions of the South Florida and General Ecosystem **Conceptual Models** on which the ELM is based.*
- Chapter 4: Graphical, verbal, and statistical-summary descriptions all of the updates to **Data** that are used in the new model application.
- Chapter 5: Graphical, verbal, and mathematical descriptions of the updates to **Model Structure** and algorithms (including links to source code).
- Chapter 6: Analysis of **Model Performance** relative to the historical period of record in the regional system (1981 - 2000).
- (see ELM v2.5) Chapter 7: Aspects of **Uncertainty** in the model and associated data, including sensitivity analysis, appropriate model expectations, and model complexity.*
- (see ELM v2.5) Chapter 8: Descriptions of **Model Application** in the regional Everglades system.*
- (see ELM v2.5) Chapter 9: Descriptions of past and planned **Model Refinements**, including an overview of its current limitations.*
- Chapter 10: A **User's Guide** that provides the simple steps to installing and running this Open Source model.

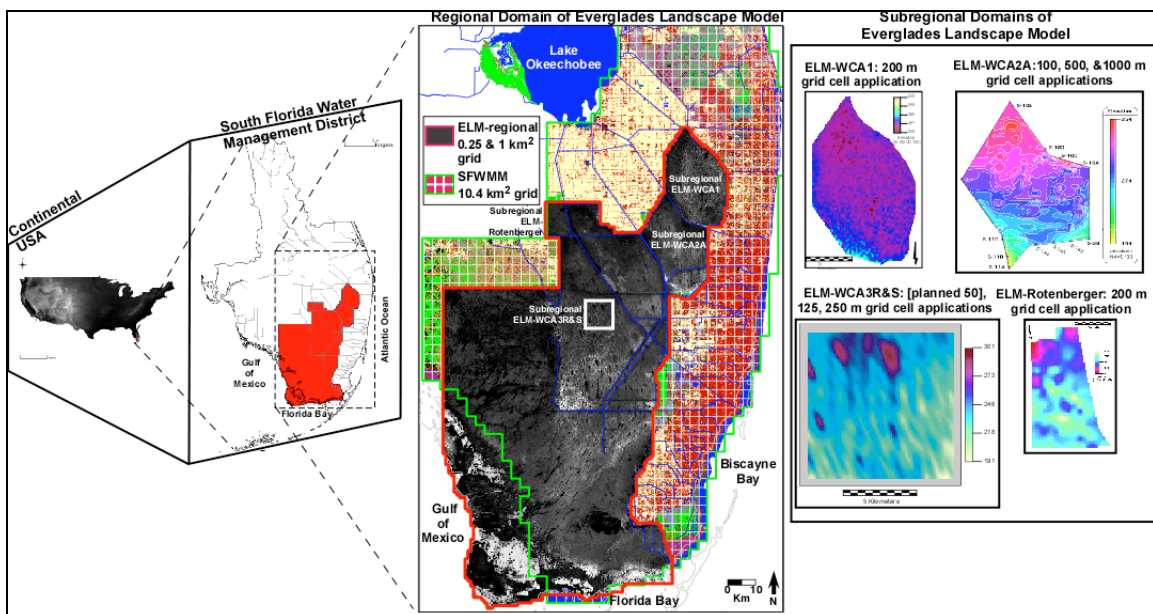
Acknowledgments

Funding for this ELM application came primarily from the U.S. Geological Survey, Priority Ecosystem Science Program, within the auspices of the Joint Ecosystem Modeling partnership. L. Brandt and R. Best provided management and direction for the model refinements described in this documentation update. See the ELM v2.5 Documentation Report for descriptions of other collaborations that were part of the overall ELM development.

Executive Summary

Today's Everglades are significantly different from the landscape that existed a century ago. Humans compartmentalized a once-continuous watershed, altering the distribution and timing of water flows, and increasing the quantity of nutrients that move into the Everglades. The result is a degraded mosaic of ecosystems in a region that is highly controlled by water management infrastructure. However, plans are being developed and implemented to restore parts of this system towards their earlier state.

To support scientific evaluations of restoration plans, computer simulation models can be used to predict the relative benefits of one alternative plan over another. One such tool is the Everglades Landscape Model (ELM). The ELM is designed to improve understanding of the ecology of the Everglades landscape, and can be applied at a range of spatial and temporal scales depending on the project requirements. This model integrates, or dynamically combines, the hydrology, water quality, and biology of the mosaic of habitats in the Everglades landscape. It is a state-of-the-art *model that is capable of evaluating long-term benefits of alternative project plans with respect to hydrology, water quality and other ecological Performance Measures.*



Existing regional and subregional applications of the ELM, including the 500 m grid resolution application developed for the regional Everglades system.

Because the ELM was designed to be explicitly scalable, it is relatively simple to adapt (spatial input map) data to accommodate the scientific objectives that may call for a particular scale of grid resolution or extent. There are a variety of ecological models (i.e., ATLSS (<http://atlss.org>)) that operate at a 500 m grid resolution, which is 4x finer resolution than that of the regional ELM v2.5. The finer scale was chosen by the model developers to capture more of the variability of animal community responses than possible with 1 km or larger grids. The hydrologic data used to drive these models is output from the South Florida Water Management Model (SFWMM), with 2x2 mile (~10 km²) grid resolution. While there exist several innovative methods to obtain 500 m

resolution hydrologic data from the SFWMM output and fine scale land elevation data, there was interest in obtaining finer scale hydrology from the regional ELM.

At the request of the Joint Ecosystem Modeling¹ group, and with funding from the USGS Priority Ecosystem Science program, we developed the 500 m resolution regional ELM v2.8² in order to provide another alternative for “driving” the other ecological models with fine scale hydrologic data. Moreover, this finer scale regional ELM application is available for evaluating other hydro-ecological responses of the Everglades landscape to alternative scenarios of water and nutrient management. This ELM v2.8 Documentation Report includes the information necessary for scientists and planners to understand this application of ELM, including *a) the ELM objectives, b) how it works, c) how well it works, and d) how to interpret its results.*

The fine spatial scale and very good performance of the resulting model may be useful in a variety of projects involving Everglades synthesis and management. The model “skill” in predicting stage and flow was improved over earlier ELM versions, and continued to be consistent with the SFWMM output. Of particular interest with respect to “driving” fine scale ecological models, this scale of ELM hydrologic output exhibited detailed spatial patterns of flow, with improved connectivity among and within habitats (such as sloughs) relative to the 4x (ELM v2.5) or ~40x (SFWMM v5.4) coarser-scale resolution hydrologic models previously available for the greater Everglades region. In particular for the JEM partnership, making use of a model with a “native” (original) resolution of 0.25 km² may likely lead to improved realism in modeling animal communities which respond to hydrologic patterns at these relatively fine scales.

¹ JEM, a partnership among several US Dept. of Interior agencies, several universities, and government and non-government organizations

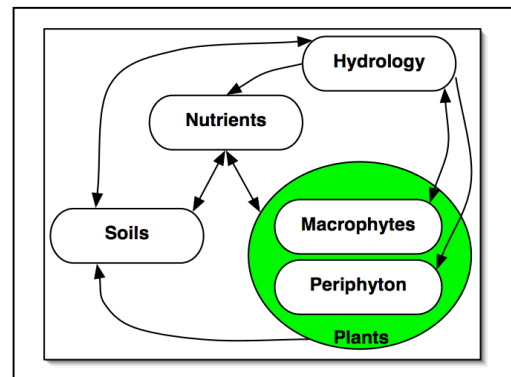
² The tertiary subversion designation of this v2.8 application release is v2.8.3.

Goals

- Develop a simulation modeling tool for integrated ecological assessment of water management scenarios for Everglades restoration
 - Integrate hydrology, biology, and nutrient cycling in spatially explicit, dynamic simulations
 - Synthesize these interacting hydro-ecological processes at scales appropriate for regional assessments,
 - **Understand and predict the relative responses of the landscape to different water and nutrient management scenarios**
 - Provide a conceptual and quantitative framework for collaborative field research and other modeling efforts

Design

- Can be applied at multiple spatial or temporal scales, for regional or subregional evaluations
 - Regional application at fine resolution (40x finer than SFWMM³)
 - Multi-decadal (36-yr) simulation period
- Combine physics, chemistry, biology – *interactions*
 - *Hydrology*: overland, groundwater, canal flows
 - *Nutrients*: phosphorus cycling and transport
 - *Periphyton*: response to nutrients and water
 - *Macrophytes*: response to nutrients and water
 - *Soils*: response to nutrients and water
- Combine ecological research with modeling
 - research advances led to model refinements
 - model output aided research designs



Reliability

- Excellent performance (1981 - 2000 history-matching)
 - *Hydrology*: the offset (median bias) of predicted and observed values of water stage elevations in the marsh was 0 cm
 - *Water quality*: the offset (median bias) of predicted and observed values of phosphorus in the marsh was 0 ug L⁻¹; chloride was 6 mg L⁻¹.
- Tested computer code
 - evaluated model response to wide range of conditions (sensitivity analyses)
 - years of experience in testing and refining code
 - applied at different scales for regional and sub-regional evaluations
- Uses best available data
 - comprehensive, unique summary of Everglades ecology
 - thorough QA/QC of input data
 - continuous interactions with other Everglades scientists and engineers

³ South Florida Water Management Model, the widely-accepted simulation tool used for regional evaluations of water management alternatives

Model Reviews

- Open Source
 - All ELM data and computer source code freely available on web site
 - Requires only Open Source (free) supporting software
- Publications
 - 1996-2008: Peer-reviewed scientific journals and book chapters
 - 1993-2006: Technical reports published by SFWMD
- CERP⁴ Model Refinement Team
 - 2003: Recommended independent peer review
- Independent Panel of Experts
 - 2006: Peer review of ELM by an independent panel of experts
- CERP Interagency Modeling Center
 - 2007: Review of ELM for CERP applications

Application

- Specific **model objectives** (Performance Measures)
 - For Joint Ecosystem Modeling partnership, provide fine-scale hydrologic output for use in “driving” other ecological models
 - ELM v2.5 – 2.8: Relative predictions of phosphorus 1) concentrations and 2) net load along spatial gradients in the greater Everglades, over decadal time scales
 - Other ecological Performance Measures proposed, pending model/data updates
- Appropriate applications
 - Relative comparisons of the above Performance Measures under scenarios of alternative water management plans
- Recent applications
 - ELM v2.8.2 application to subregional domain of Water Conservation Area 1, 200 m grid resolution; evaluated hydrologic and water quality responses to simple management scenarios

⁴ Comprehensive Everglades Restoration Plan