A Closer Look at the Everglades and the Kissimmee River Restoration Project...

Florida Bay
Everglades: Oxbows
Everglades: Fire Season

Human Change: Canalization
Human Change: Agriculture

Everglades: SFWMD
The Journey to Restore America’s EVERGLADES

Wetlands Restoration and Creation
Wetlands Restoration and Creation
Mangroves

Plant Symbiosis
Everglades Native Flora

Sawgrass

Water Lily

Cattail

Arrowhead and Spiked Rush

Everglades Flora

Seagrass

Turtle Grass

Widgeon Grass

There are seven species of seagrasses in the Florida waters.
Everglades Wildlife

Osprey

Manatee

Gator

Florida Panther: Endangered Species
What Type of Birds?

Biodiversity in the Everglades

The Everglades National Park, the third largest park in the nation covers more than 2,000 square miles and holds a beauty incomparable to any other place in the world. Serving as home to nearly 300 varieties of birds, 600 kinds of fish and more than 40 indigenous species of plants, the Everglades is a nature lover's paradise.
Variety of habitats exist within the Everglades, defined in part by elevation, salinity, and soil types:

- Marine/Estuarine: Mangroves
- Coastal Prairie: Mangroves Slough
- Freshwater Marl Prairie
- Cypress
- Freshwater Slough
- Cypress
- Hardwood Hammock
- Pineland
I. Flood Control: Kissimmee River was canalized as part of a flood control effort (1962-1971)

II. Result: Loss of 43,000 acres of river floodplain wetlands, habitat for 90% of the waterfowl in the valley

III. Natural Hydrology: Floodplain area subject to extended inundation (~ year round) following major storms, such as floods of ’45,’46,’47, and ’53
Kissimmee River Prior to Canalizing 1961

Remnant riverbed

C-38, or “the ditch”
Hydrologic Characteristics of the Basin

- Wet season: June to October
- Precipitation averages 6.5 in. in wet months to 2.6 in. in dry months
- Mean flow during wet months is between 22-47 m^3/s or about three times the flow in the dry months
- Lake Okeechobee overflowed into the Everglades
- Water table about one foot beneath the ground surface in the Everglades
Impacts of Drainage, Canalization, and Levee Construction

• The average water table dropped from one to five feet beneath the surface in the Everglades (1915-’39)

• Hydrologic isolation of Lake Okeechobee from the Everglades, separation of north and south Everglades

• Once drained, the soils were exposed to aerobic decomposition, resulting in subsidence and reduced soil elevation levels (also fires and compaction result)

• Obviously shorter hydroperiods, reduced flooding

Hydrologic Restoration Criteria

• Restoration of “natural conditions after the occurrence of manmade changes”

• Establishing continuous flow with “duration and variability characteristics comparable to pre-canalization flows”

• Examining historical daily discharge records:
  (1) Continuous flow from July-October
  (2) Peak annual discharges in September-November and lowest flows in March-May
  (3) Range of stochastic discharge variability
Additional Considerations

- Favorable dissolved oxygen regimes, a key component of which is flow velocity: 0.24 to 0.55 m/s within channel banks

- Specific criterion: “flow velocities within 60% of river-channel cross sections must not fall below 0.24 m/s for greater than three consecutive days during July-Sept. and 10 consecutive days Oct.-June”

- Nondisruptive flows for fish species during reproductive period

- Stage-discharge relationships: over-bank flow for discharges above 39.6-56.6 m^3/s

Hydraulics

- Hydraulic resistances: determine basin flooding levels and flow distributions

- Difficulty: estimating future vegetation growth

- Determination of vegetation friction resistances: use of test sites or the historical record to calculate Manning’s n

- Water-surface profiles: backfilling can cause a large elevation in water levels at downstream pools

- Hydraulic elements: use of weirs to direct flow to oxbows for ecological benefits
Economics of the Kissimmee Project

• The project is completed in 1971 and in 1983 begin Governor Bob Graham’s “Save Our Everglades Initiative”
• None of the restoration alternatives yielded positive net benefits, as determined by ACE
• Final Federal/Local cost sharing agreement: 25/75
• 15-year restoration project aimed at restoring approximately 11,000 ha of wetlands: in the first stage of funding

Modeling as a Restoration Tool

“The design of ecological landscape models for Everglades restoration”
F.H. Sklar, et al.
Historical Background

- First wave of drainage activity in 1880… relatively little impact
- Second wave from 1906 to 1930
- 1940’s and 50’s: Central and Southern Florida Project for Flood Control and Other Purposes, SFWMD was given authority for management
- 1960’s and 70’s: additional levees were added that further fragmented the Everglades
Comprehensive Everglades Restoration Plan

- 1991: Federal Settlement Agreement established the need to reduce P and restore natural hydroperiods
- 1994: the Everglades Forever Act mandated an increase of flows of freshwater and the establishment of a P runoff threshold (10 ppb) that would not cause an ‘imbalance’ to the system
- 2000: CERP approved by the US Congress.
- $8 Billion over 30 years

Landscape Models for the adaptive management of the Everglades

- Objective: predict the hydrology, water quality, ecology, and animal distributions
- Goal: develop hundreds of control structures to prevent further environmental damage and restore plants and animals to a more ‘natural’ status
SAWCAT Model

Framework:

I. Transitional Probability Model: the spatial distribution of cattails and sawgrass is simulated using a discrete state space

II. Structure: cells or “mosaics of cells” using information on neighboring cells, environmental conditions, and spatial dependencies

III. Representation: Landscape transition matrix with four transition probabilities:

1. Cell changing from sawgrass to cattail
2. Sawgrass cell not changing
3. Cell changing from cattail to sawgrass
4. Cattail cell not changing
SAWCAT Model

Q1. Where do the probabilities come from?

The transition probability is estimated using four input probabilities, and then weighted by \( e \), a soil phosphorous parameter.

\[
\text{Psawcat} = e(P_{\text{adj}} + P_{\text{nat}} + P_{\text{level}} + P_{W\text{and TP}})
\]

SAWCAT Model

Model Results:
I. Provided a way to estimate a phosphorous level that would induce habitat change, based on “simple landscape model”
II. Predicted a 50% conversion to cattail by 2000
III. Complete conversion to cattail after 2030
## SAWCAT Model

Q2. How and why do the physical reality and the model results differ?

The nutrient levels were lower than the levels assumed by the model for the time period. However, the phosphorous levels were reported increasing in 2001.

## NSM Model

**Framework:**

I. **Finite Difference Model:** numeric representation of the hydrologic response of a pre-drainage Everglades system to 1965-1995 rainfall patterns

II. **Structure:** 2328 computational cells, 2x2 mile each

III. **Structures and canals replaced with the assumed rivers and creeks**
NSM Model

Q1. How was it calibrated?

Indirectly. The parameters were obtained from the SFWMM
NSM Model

Q2. What does it tell you? How was it used?
Provides the ‘natural’ hydropattern that the CERP wants to achieve.
The CERP design was based upon a simulated SFWMM hydropattern that matched this ‘natural condition’

SFWMM Model

Framework:
I. Finite Difference Model: numeric representation of the hydrologic response of the post-drainage Everglades system to 1965-1995 rainfall patterns
II. Structure: similar to the NSM
III. Takes into consideration the network of canals, levees and water control structures
Q1. How were Florida’s karst geologic features modeled?

As a porous media
SFWMM Model

Q2. Why and how were these very simplistic models accepted?
   Overriding scarcity of environmental data.
   Time constraints (legal and political deadlines).

EWQM Model

Framework:
I. Gradient Model: adds a TP removal rate to the SFWMM
II. Structure: similar to the SFWMM
III. Phosphorus has been found to be linked to environmental degradation and the expansion of cattails in the Everglades
EWQM Model

Removal coefficient $K_e$ represents the net consequence of many ecological processes with no attempt to represent specific mechanisms.

The removal rate is affected by vegetation type, droughts, soil chemistry, decomposition, and peat accretion.

Q1. How was the EWQM model used?

To quantify land requirements for artificial wetlands, Stormwater Treatment Areas (STAs) dominated by cattail, to reduce TP inflows to the everglades.
EWQM Model

Q2. What is the biggest uncertainty in this model?

$K_e$

Although in the case of STAs, the size can be adjusted, if applied to a pristine area, the recommendations drawn from this model could lead to further damage.

ELM Model

Framework:
I. Process-based mosaic Model
II. Requires a large database for initialization, complex numerical analysis, lots of experimental observations for calibration, and validation
III. Structure: 1x1 km cells. Each cell is a ‘unit model’
ELM Model

Framework:
IV. Flows of surface water among cells calculated using a finite difference algorithm solving two-dimensional diffusion equations
V. Feedback from vegetation growth included in Manning’s n

Q1. Why was it not used in the design of the CERP
   Not completed in time to evaluate the design
Q2. What limitations does it have?

Framework:
I. Individual-based model
II. Intrinsic growth ($r$) and carrying capacity ($K$) parameters
III. Not a single model. Three types of models for different animal communities
Wood stork model:

- Adult behavior based upon energetic requirements of movement and rules for foraging efficiency
- It was found that decreasing the extent of shallow, short-hydroperiod wetlands by a small amount delayed nesting for large colonies
- Later in the season, long hydroperiod wetlands supply most of the energy

Q1. What approaches can be incorporated into individual-based models?

Probability, Process, and rulebased modeling approaches
ATLSS Program

Q2. What would you do with this information?