Addressing the Challenge of Climate Change in the Greater Everglades Ecosystem:
A Stakeholder-Based Approach

A MIT-USGS Science Impact Collaborative Project Cosponsored by the US Fish and Wildlife Service

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MIT Research Team

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- Aaron Thom *Physics*
Overview

- Goals & Motivation
- Methods
- Examples
  - Scenario Development
  - Climate Change Futures Simulation
- First Year Conclusions
Project Purpose

- To assist US Fish and Wildlife Service in climate change planning for Southern Florida
  
  - Assessing risks to ‘trust resources’
    - species, habitats, migratory routes
  
  - Bringing to bear USGS and other best-available science, including ‘decision science’
Project Scope and Resources

- A four-year project, with small, remotely-located, research team
- MIT focused on stakeholder scenario creation and simulation, with USGS to conduct impact evaluations
- Interest is in helping FWS planning, not in replicating existing work
Why a Stakeholder-based “Alternative Futures” Approach?

- Proven method for dealing with high-consequence decisions in face of irreducible uncertainty
- Provides a roadmap for organizing existing and future scientific efforts

Bottom line: Climate change is “too big” an issue for unilateral agency planning approaches
“Alternative Futures” Process Phases

- Phase 1: Alternative Futures Generation
- Phase 2: Comparative Impact Evaluation
- Phase 3: Strategic Planning & Communication
Stakeholder-based Scenario Planning
Phase 1: “Alternative Futures” Generation

• Start with managers & their decisions

• Develop scenarios which encapsulate key uncertainties (in policy as well as science)

• Use simulation models to generate long term spatially-explicit “alternative futures”
Stakeholder-based Scenario Planning Phase 2

- Evaluation & Strategic Synthesis
  - Use scientific impact modeling to quantify meaningful differences, wherever possible
  - Use Delphi processes to organize expert opinion, where necessary (i.e. multiround blind review producing qualitative assessments)
Stakeholder-based Scenario Planning
Phase 3: Strategic Synthesis & Communication

- Organize management discussions to develop strategies robust across multiple scenarios
- Document and visualize key findings and strategies for agency and partner action planning
Study Areas and Scales

- Regionally, looking at all of Southern Florida
- More locally, looking at context areas around FWS refuges
Landscape Change Dynamics - under climate change -

- Dynamic Gap Analysis (Schematic only)
  - Sea Level Dynamics
  - Habitat Displacement
  - Strategic Habitat for the future (???)

Areas for strategic Habita
DOI-Conservation Areas
New Conservation Efforts
Starting with Managers & Decisions

- Which people making which choices?
- What information in what formats would best support management needs?
- Don’t assume – ask (informally & through survey)
Stakeholder Identification
Towards Alternative Futures

- Try to capture major generating assumptions and ranges
Which dimensions were given the highest priority?

### Suggested Additional Dimension

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DEFINITION OF SCENARIO COMPONENTS & ASSUMPTIONS

Based on literature

Scenario 3

How can scenarios be evaluated? What are their impacts?

Scenario 3

IMPACTS

HYDROLOGY

STRATEGIC HABITAT & REST.

MODEL

MANAGEMENT DECISION NEEDED

Model

POPULATION GROWTH & URB.

CLIMATE CHANGE SCIENCE

LAND USE

ECOLOGICAL MODELING

Employ Existing Evaluation Models
**IMPACTS**

**DEFINITION OF SCENARIO COMPONENTS & ASSUMPTIONS**

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**MANAGEMENT DECISION NEEDED**

**Spatially-Explicit Alternative Futures**

How can scenarios be evaluated?
What are their Impacts?

**STRATEGIC HABITAT & REST.**

**HYDROLOGY**

**POPULATION GROWTH & URB.**

**CLIMATE CHANGE SCIENCE**

**LAND USE**

**ECOLOGICAL MODELING**

**Employ Existing Evaluation Models**

**How can scenarios be evaluated?**
**What are their Impacts?**

**Based on Consultative Process**

**Possible**
**Plausible**
**Feasible**
Simulating Future Development & Conservation Patterns Under Sea Level Rise

MCP Thesis 2009
Alison Lassiter
Conservation Policy Questions

- How much conservation land are we getting?
- How much might we lose to Sea Level Rise?
- Are there important differences between two major available land protection strategies?
  - Fee simple purchase
  - Conservation easements
Simulation Methodology

- Used Att-Con Land Use Change Model (Flaxman & Li 2009)
  - Deterministic GIS allocation of projected land use demand
  - Spatial attractiveness functions govern allocation sequences
  - Development constraints include biophysical and policy exclusions
  - Sequential allocation based on “willingness to pay” or “government first” policies

- Projected (50 years) spatial allocation of:
  - Urban land
  - Conservation land
  - Inundated land
Model Assumption #1

Population grows at 30% higher than state demographer’s trend projection (~ “high growth”)
Model Assumption #2

Build-out densities consistent with adjacent urban land
Model Assumption #3

Sea level rises 2 meters by 2100
Model Assumptions #4 and #5

4. There is a conservation budget of $30 million/year (decadal trend)

5. Florida FWC High-priority Strategic Habitat Conservation Areas are appropriate conservation targets
1. Compute “urban attractiveness surface”
   Based on UF Geoplan model & State Transportation Model

2. Compute “conservation attractiveness surface”
   Based on FWC prioritization

3. Compute “land cost surface”
   Regional spatial model calibrated to USGS Ecosystem Portfolio
   Modeling hedonic pricing analysis in Miami-Dade
Urban & Conservation Suitability Surfaces

Conservation suitability

Urban suitability
Allocate iteratively over 5 decadal time steps

Urban occupies most preferred urbanizable land, stopping when population demand met

Conservation allocated in most preferred available conservation lands, stopping when budget runs out
Urbanization Results 2060: Fee Simple vs. Easements

10,160,524 acres urban land  
221% increase from 2000

9,957,832 acres urban land  
214% increase from 2000
Results 2060: Fee Simple Conservation

- 5 million acres in conservation
- 5% increase in new land holdings
- 16% total loss of conservation land after sea level rise, despite new holdings
5.3 Million acres under conservation
9% increase in conservation holdings
12% loss of conservation land after sea level rise, despite new holdings
Rural Florida 2060: Fee Simple vs. Easement Scenarios

76% of rural lands converted
24% remains rural

61% of rural lands converted
33% remains rural
Are Simulated Conservation Strategies Likely to Work?

Fee Simple

Conservation Easements

Existing urban land
Projected urban land in 2060
Method Can Simulate Future Conservation & Development
  - Yields similar results to existing methods with very fast processing
  - Adds support for SLR, more realistic density and regional migration
  - Current average rate of conservation slower than 2m 2100 SLR

Limitations & Future Work
  - Sensitivity testing & formal comparisons
    - Vary urban population amounts and densities
    - Vary conservation budgets, land cost surface
    - Quantitative comparison to UF GeoPlan and State models
  - Re-examine SHCA under climate change
  - Run FWS Scenarios once developed
  - Put model online (SLR component in progress)
Decision maker-Guided Scenario Planning

STAKEHOLDER INPUT ON THE SCALE OF THE REGION

PUBLIC REVIEW OF STUDY PROGRESS & FINDINGS AS A COMPONENT OF LOCAL DEBATE AND DECISION MAKING PROCESSES

RESEARCH TEAM

DATA COLLECTION, REGISTRATION, DOCUMENTATION

COMMON LEXICON

SCENARIO SIMULATION, ALTERNATIVE FUTURES

RESULTS

DOCUMENTATION, DISTRIBUTION

SCENARIOS → DATA → PROCESS MODELS → IMPACTS

AN INTEGRATED SIMULATION SYSTEM

MIT - USGS
SCIENCE IMPACT COLLABORATIVE (MUSIC)
Testing Collaborative Approaches to Environmental Decisionmaking and Training Science Impacted Coordinators
Conclusions: Major Challenges

1. Spatial & Management Scale
   This is a *very big, very wicked* problem
   Scenario planning methods created for “small decision group, joint meeting” contexts need expansion to work in distributed context with larger groups

2. Legal & Agency Cultural Issues
   Effective scenario planning requires a multidisciplinary stakeholder group, typically with a commitment to action by date certain and appropriate resources. FWS is under-resourced and there are significant legal impediments (i.e. FACA interpretation)
3. Valuing & Evaluating Trans-disciplinary Work

Climate change action research requires not only non-trivial synthesis of existing science, but also development of trans-disciplinary modeling and policy evaluation approaches.