Wisconsin Environmental Modeling and Policy: Cows, Fish and Optimization

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How to enhance the impact of optimization in applications?

- Engage people with breadth of, and complementary expertise - theory, algorithms, computation, applications
- Key impact area: decision making in (environmentally) resource constrained problems
- Feature: shared resource that interacts with complex multi-user systems
- Enhance understanding of decision space, facilitate policy design and operational improvement
- Build appropriate models, fast enough solution for expert interaction, visualize results
- Two examples: Fishwerks and ANMODS
Overview

- Anadromous fish migrate from the sea upstream into freshwater to spawn.
- Natural & man-made barriers break stream connectivity and prevent fish from penetrating deep into inland lakes and rivers.

There are over 235,000 identified barriers to migration in the Great Lakes Basin:

- Lake Michigan: >83% of tributaries inaccessible
- Lake Huron: >86% of tributaries inaccessible
- Lake Erie: >50% reduction of population size
Barriers can be mitigated to allow for fish passage:
- Removal of dams, improved road crossings, fish passageways

However, they are very expensive – Average costs for fixes:
- Dams: $100,000 - $650,000 each
- Others: $30,000 - $150,000 per project

Limited funds necessitate ideal selection of projects
- Difficult to assess where funds should be used
- Country/State/County lines make appropriation difficult

Increasing passability increases risk for the spread of invasive aquatic species (e.g. Sea Lamprey)
Fishwerks: A decision support tool

- Great Lakes basin scale data visualization
- 250,000+ interdependent barriers on a river network
- Crowd sourcing data

- Complex optimization for budget constraints, specific fish guilds, invasives
- Adopted by Fish and Wildlife Service
  [www.greatlakesconnectivity.org](http://www.greatlakesconnectivity.org)
- Data integration, connecting stream and road systems, enhances outcome
Biomass Research and Development Initiative (BRDI)

- Whole farm (complex interacting) mathematical model
- Long term sustainable (environment and financial)
- Economic/Logistic Optimization, with phosphorus runoff, other environmental restrictions
- Incorporates data analytics (e.g. WI regulatory SNAP+)
- Interconnected complex system linked by domain data with verifiable outcome
Nutrient management = water quality problem

- Nitrogen, as nitrate (NH3), leaches through soil into underground wells/aquifers
- Nitrate poisoning is the leading cause of blue baby syndrome (Methaemoglobinaemia – decreased ability of blood to carry vital oxygen)
- Phosphorus tends to pollute surface waters (rivers, lakes, streams, etc) through runoff
- Nitrogen and phosphorus from agricultural sources contribute to eutrophication, causing harmful algal blooms, fish kills

Risky problem, verifiable outcome, discover value and tradeoffs