Wisconsin Environmental Modeling and Policy: Cows, Fish and Optimization

Michael C. Ferris Steven Wangen

University of Wisconsin, Madison

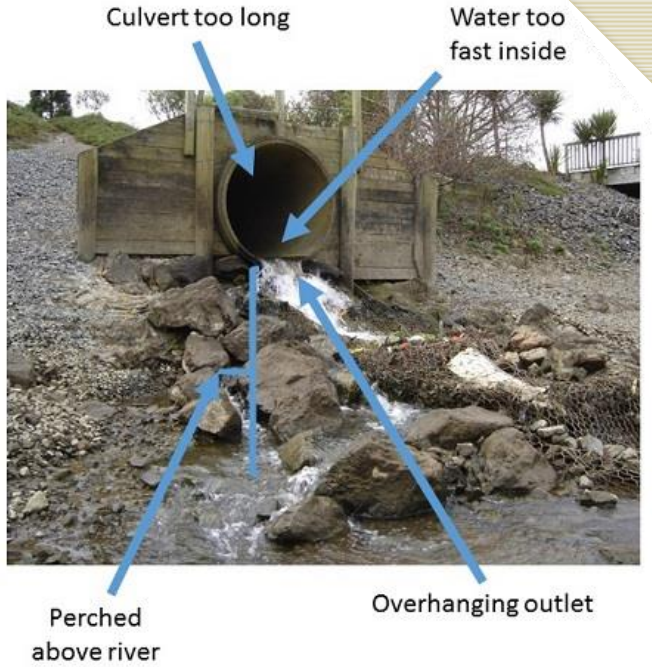
December 8, 2016

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



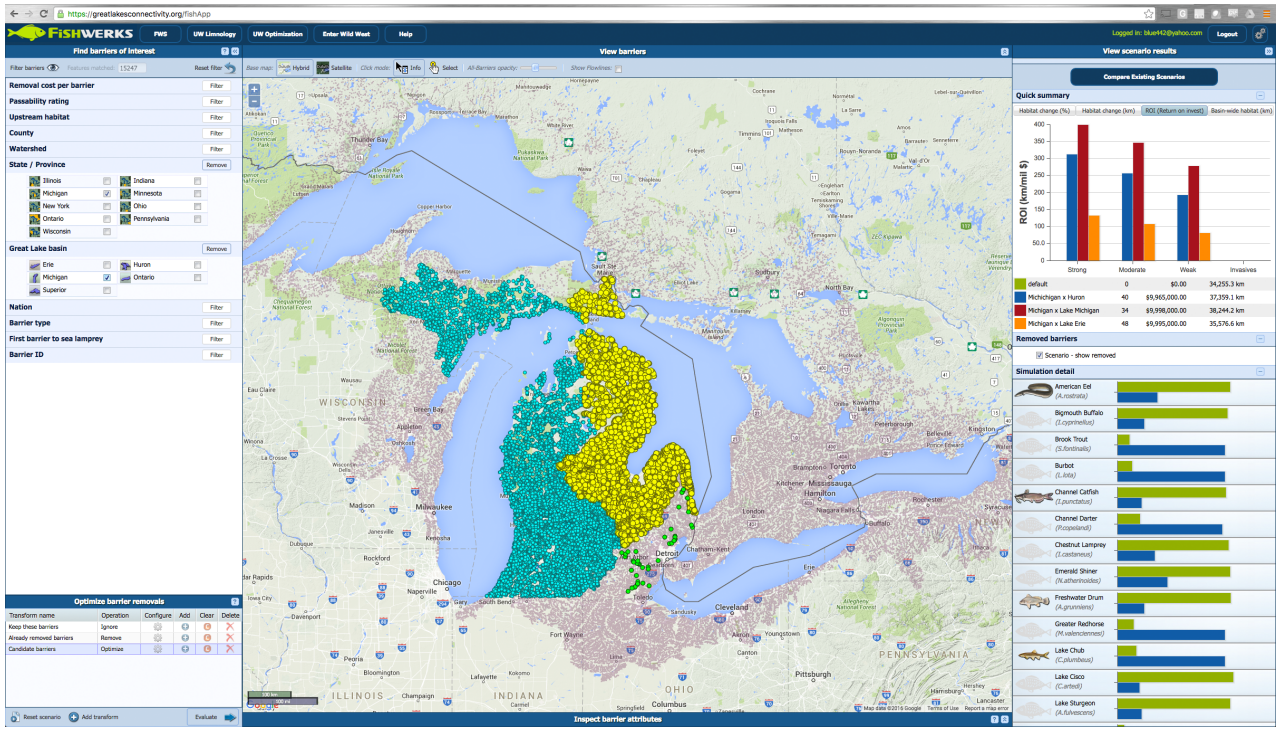
- There are over 235,000 identified barriers to migration in the Great Lakes Basin
  - Lake Michigan: >83% of tributaries inaccessible
  - Lake Huron: >86% of tributaries inaccessible
  - Lake Erie: >50% reduction of population size

Cont'd

- 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

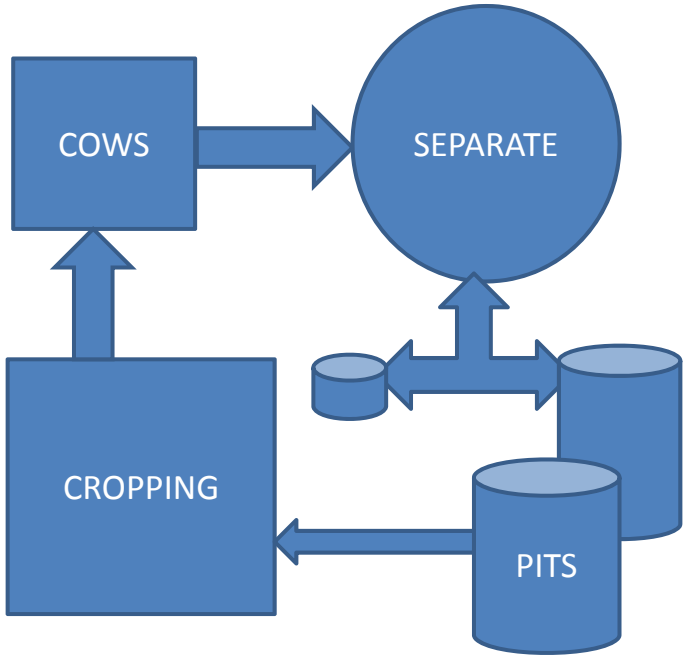
- Increasing passability increases risk for the spread of invasive aquatic species (e.g. Sea Lamprey)

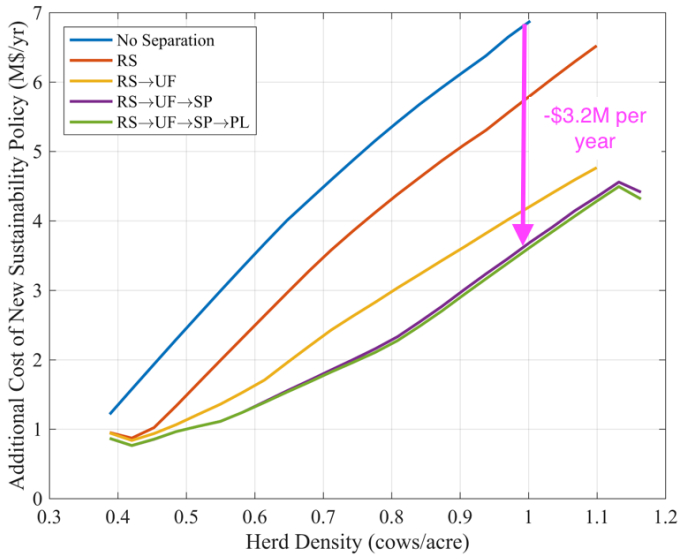
Fishwerks: A decision support tool



- 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`
- Data integration, connecting stream and road systems, enhances outcome

Biomass Research and Development Initiative (BRDI)

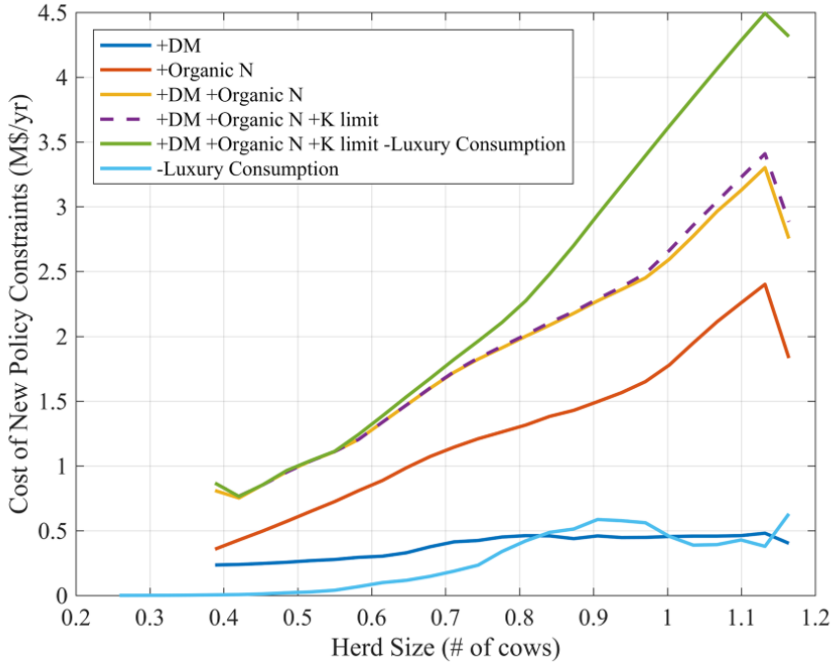




- Whole farm (complex interacting) mathematical model
- Long term sustainable (environment and financial)
- Economic/Logistic Optimization, with phosphorus runoff, other environmental restrictions
- Incorporates data analytics (e.g. WI regulatory SNAP+)
- Interconnected complex system linked by domain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