Regional Scale Modeling for Multiple Stressors of Lake Erie

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State of Lake Erie Ecosystem

- Lake Erie is structurally and functionally unhealthy (i.e. impaired)
- Limited resilience
- Structural instability
- Prevailing stress complex is currently unmanageable
- Fish community unstable with cascade of effects
- Management uncertainty
- Confusion about important regulatory mechanisms

Project Goals

- Develop a regional-scale, stressor-response model for the management of the Lake Erie ecosystem
  Stressors: land use changes, nutrients, habitat alteration, flow regime modification, exotic species, and fisheries exploitation
- Incorporate model into a multi-objective decision making tool for use by Lake Erie managers

Project Task Structure

- Linking changes in watershed habitat and nutrient loading to Lake Erie ecosystem health
- Quantifying uncertainties in model predictions and the effects of uncertainties on management decisions
- Evaluating cross-scale interaction of stressors
- Developing tools to evaluate ecological risk of land-use changes
- Identifying and evaluate critical break-points in ecosystem and management integrity

Users

- Fisheries managers
  - Lake Erie Committee (GLFC)
  - State and Provincial natural resource agencies
- Water quality managers
  - IJC (US EPA and Environment Canada)
  - EPA’s TMDL process
- Planning and development agencies
  - Ohio Balanced Growth Initiative
  - Joyce Foundation funded initiative with watershed partnerships

Current Challenges

- Modeling
  - Explicit incorporation of scaling issues
  - Development of a hierarchical modeling architecture
- Database development
  - Coordinating geodatabases
  - Framework for upscaling and downscaling
  - Incorporation of dynamic land cover changes

After Wu and David, 2002
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Unified Modeling Framework

- Overall functional integration of habitat and Lake Erie ecosystem health
  - Linking landscape to whole lake processes
  - Determine cross-scale additivity of stressors
- **Database component**
  - Fine scale classification of landscape
  - Biologically informed aggregation of landscape features
- **Ecological model**
  - Hierarchical
  - Linked to management

Functional Integration of Habitat

- **Human Activities**
- **Landuse/Land Cover**
- **Climate**
- **System Hydrology**
- **Nutrient Loading**
- **Fish Habitat**
- **Productivity**
- **Recruitment**

Function Integration of Lake Erie (LEEM)

- Additional diagrams and flowcharts related to the integration of various factors affecting Lake Erie's ecosystem.
Example of Decision Process

- Open Loop
- Closed Loop

Walleye Spawning Example

- Functional analysis of walleye spawning
  - Identification of habitat preferences for adults
  - Mapping of habitat supply
  - Prediction of larval mortality
- Linking landuse change to critical habitat features
- Prediction of consequences of alteration to reproductive success

Functional Analysis of Walleye Spawning
Functional Analysis of Walleye Spawning

Short-term Outcome Issues

- Extrapolating from multiple scales of analysis
  Functional approaches to landscape hierarchies
- Interaction of multiple stressors
  Linking watershed hydrology to whole lake effects at a range of spatial and temporal scales
- Range of decision making alternatives
  Priorities for mitigation, functional identification of priority conservation areas, and decision support system for land-use planning
- Intermediate products
  Multi-modeling framework based on open DEVS standards

Long-term Outcome Issues

- Ways to reduce uncertainty
  Explicitly embracing uncertainty is the best way to reduce it
- Seminal contribution
  Assessment of cross-scale additivity of stressors
- Application of model to monitoring
  • Value of information
  • Linking monitoring to expectations at various scales of resolution

Functional Analysis of Walleye Spawning

Simulated Timing of Walleye Spawning (after Jones et al., in press)
Functional Analysis of Walleye Spawning

Dry Year  
Wet Year

Chagrin River