# 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

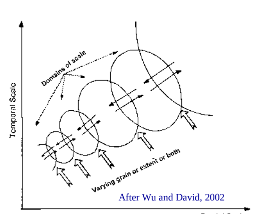
- Linking changes in watershed habitat and nutrient loading to Lake Erie ecosystem health
- Quantifying uncertainties in model predictions and the effects of uncertainties on management decisions
- Evaluating cross-scale interaction of stressors
- Developing tools to evaluate ecological risk of land-use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



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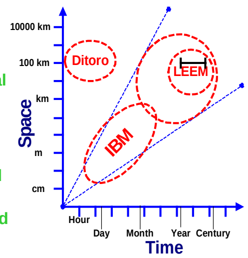
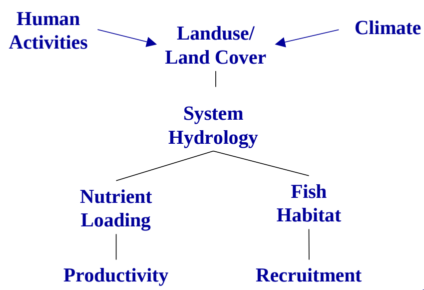


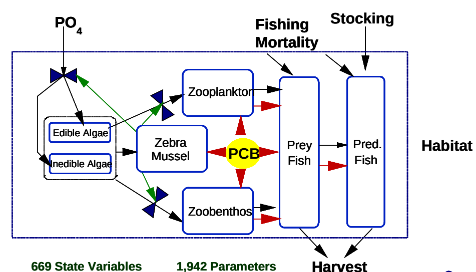

## Unified Modeling Framework

- 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

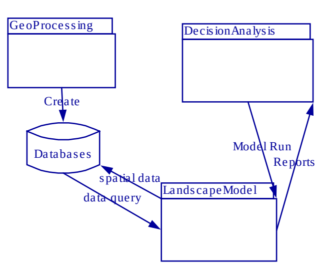
## Functional Integration of Habitat



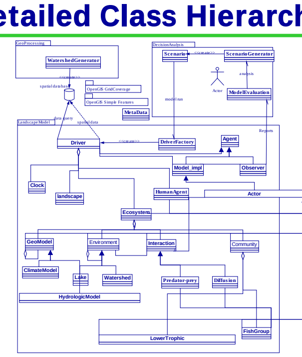

## Function Integration of Lake Erie (LEEM)




## Object View of Framework




## Detailed Class Hierarchy



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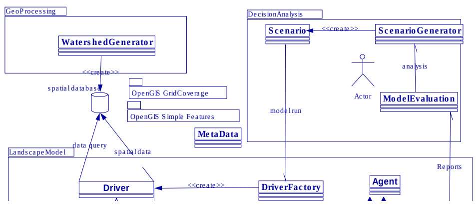


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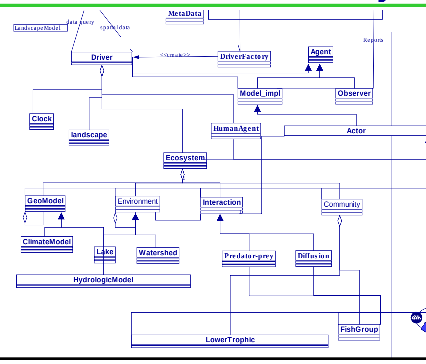
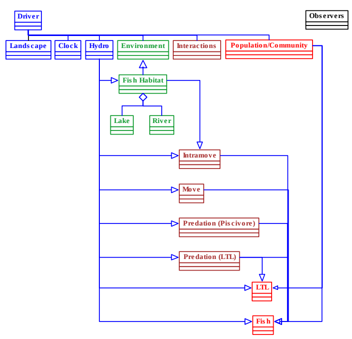



## DEVS Flow for Simulation Model




## Implement XML Based Metadata Repository

- Metadata for spatial data
  - XML specification of data for models
  - XML specification of data for queries
- Metadata for model implementation
  - Model selection
  - Model assembly
- Model driven architecture
  - Platform Independent Model
  - Platform Specific Model
  - Transformation through code generators

## Consequences for QA/QC

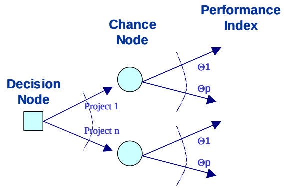
- Versioning control
- Analyses of parameter space
- Documentation of parameter estimation procedures and data sources
- Model selection criteria through contest of models. Find levels of aggregation and the limits of their applicability
- Hypothesis generation and design of monitoring strategy

## Management Domain

- Fisheries
  - Harvest quotas
  - Fish community objectives
  - Management of exotics
- Landuse change
  - Management of storm water runoff
  - Permitted changes
  - Mitigation priorities
- Instream habitat alteration
  - Riparian corridors
  - Stream bank stabilization

## Example of Decision Process

- Open Loop
- Closed Loop

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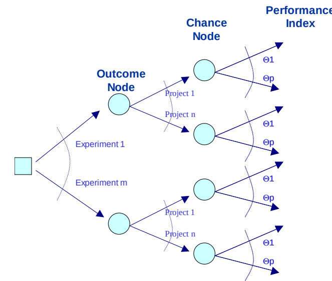
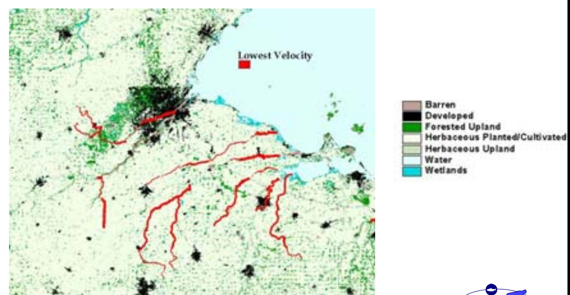



## Walleye Spawning Example

- 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

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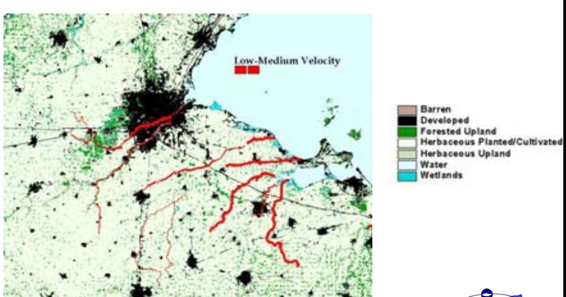


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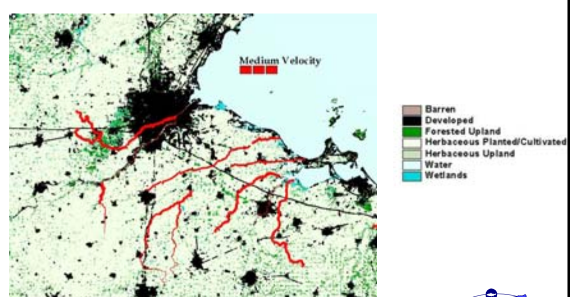

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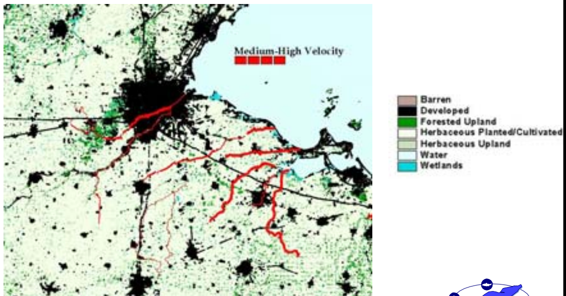


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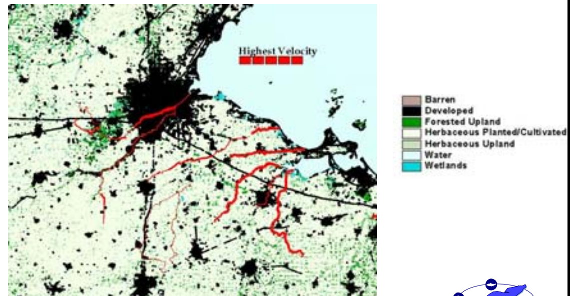


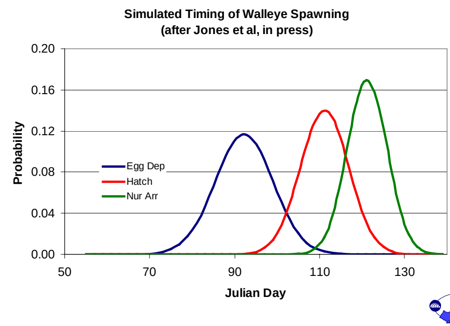

## Short-term Outcome Issues

- **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

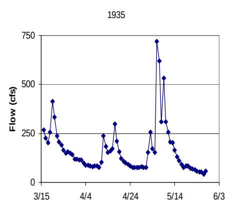
- **Ways to reduce uncertainty**
  Explicitly embracing uncertainty is the best way to reduce it
- **Seminal contribution**
  Assessment of cross-scale additivity of stressors
- **Application of model to monitoring**
  - Value of information
  - Linking monitoring to expectations at various scales of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

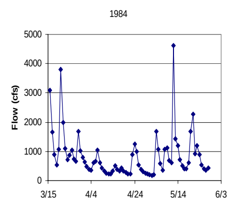
## Functional Analysis of Walleye Spawning



## Functional Analysis of Walleye Spawning

**Dry Year** **Wet Year**




Chagrin River

## Functional Analysis of Walleye Spawning