Ecological Modeling

Prospects for Understanding Population, Community and Ecosystem Dynamics

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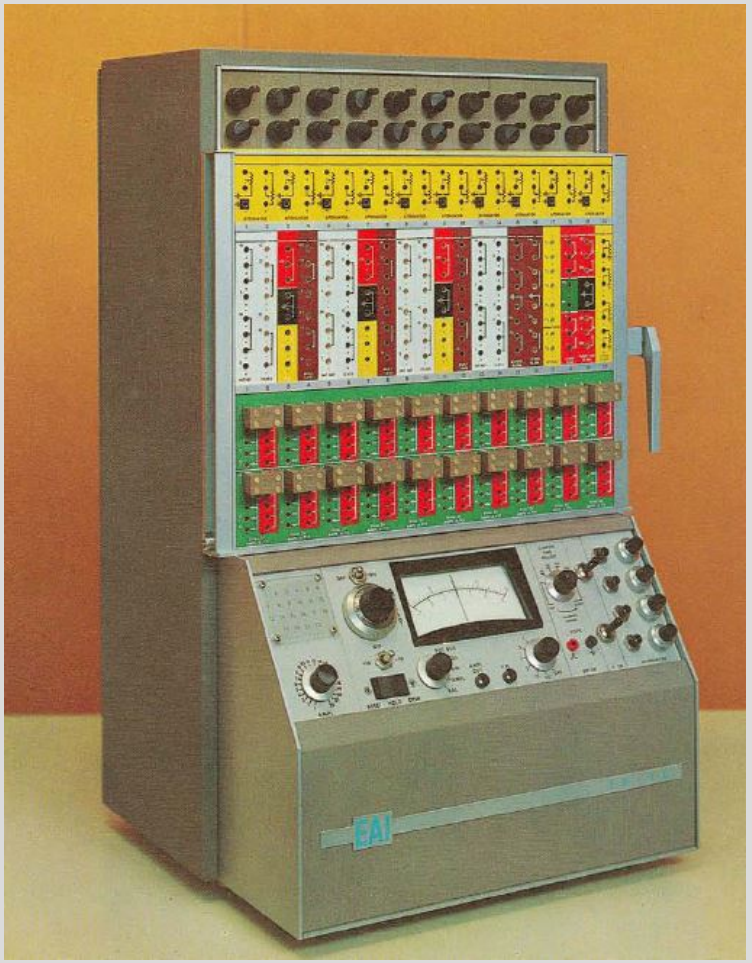
INTERNATIONAL SOCIETY FOR ECOLOGICAL MODELLING

Humble Beginnings

- GF Gause
- AJ Lotka
- KEF Watt
- HT Odum
- SE Jorgensen
- B. Patten
- RV O'Neill
- D. DiToro
- D. DeAngelis
- R. Wiegert



International Biological Program (IBP)

From 1965 – 74, The NAS organized and supervised US participation in the International Biological Program, focusing on the effect on biological communities of changes in the natural environment, and on the conservation and growth of natural resources for human benefit.

The main results of the IBP were five biome studies

- Grassland Biome
- Eastern Deciduous Forest Biome
- Coniferous Forest Biome
- Desert Biome
- Tundra Biome

The development of large scale ecosystem models was an integral part of these studies. These included:

- ELM - Grassland model
- CLEAN – Lake George model
- Lake Wingra model

WORLD3 System Dynamics Model

emissions and waste from production

natural resource regeneration

natural resources

production

population

demand

economic activity

supply

natural resource use rate

environmental degredation

concerns / need for actions (i.e regulations & legislations)

consumption

emission and waste from supply

end of pipe solutions

emission and waste from consumption

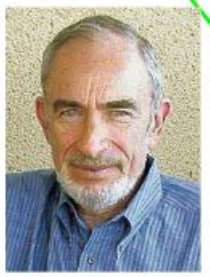
cleaner production & pollution prevention technologies

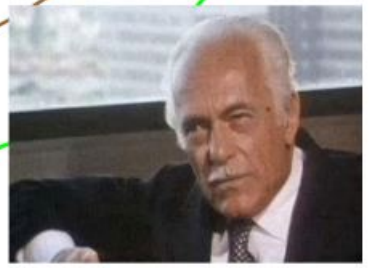
sustainable production & consumption policies

sustainable population policy

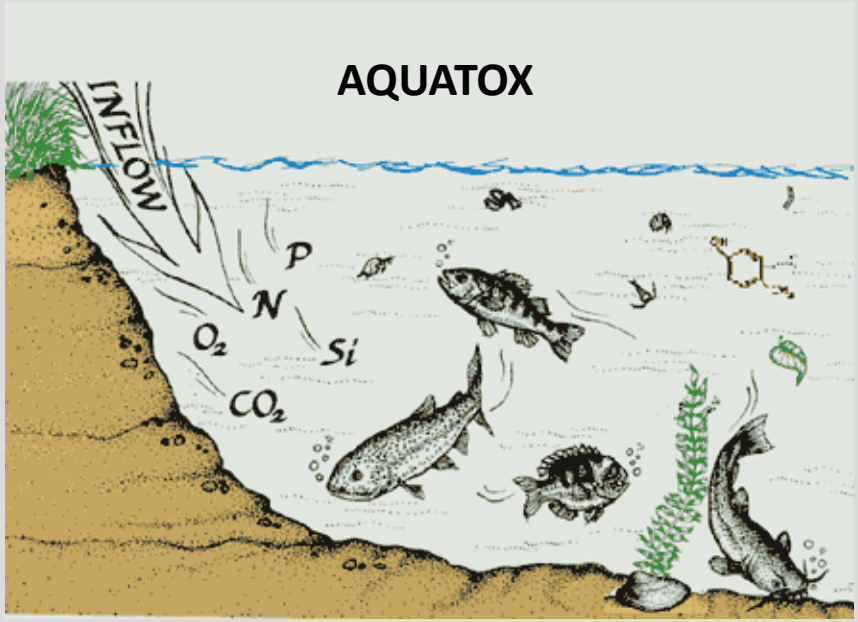
R1 R2 B1 B2 B3 B4 B5 B6

1 2 3 4





Ecosystem Model-AQUATOX



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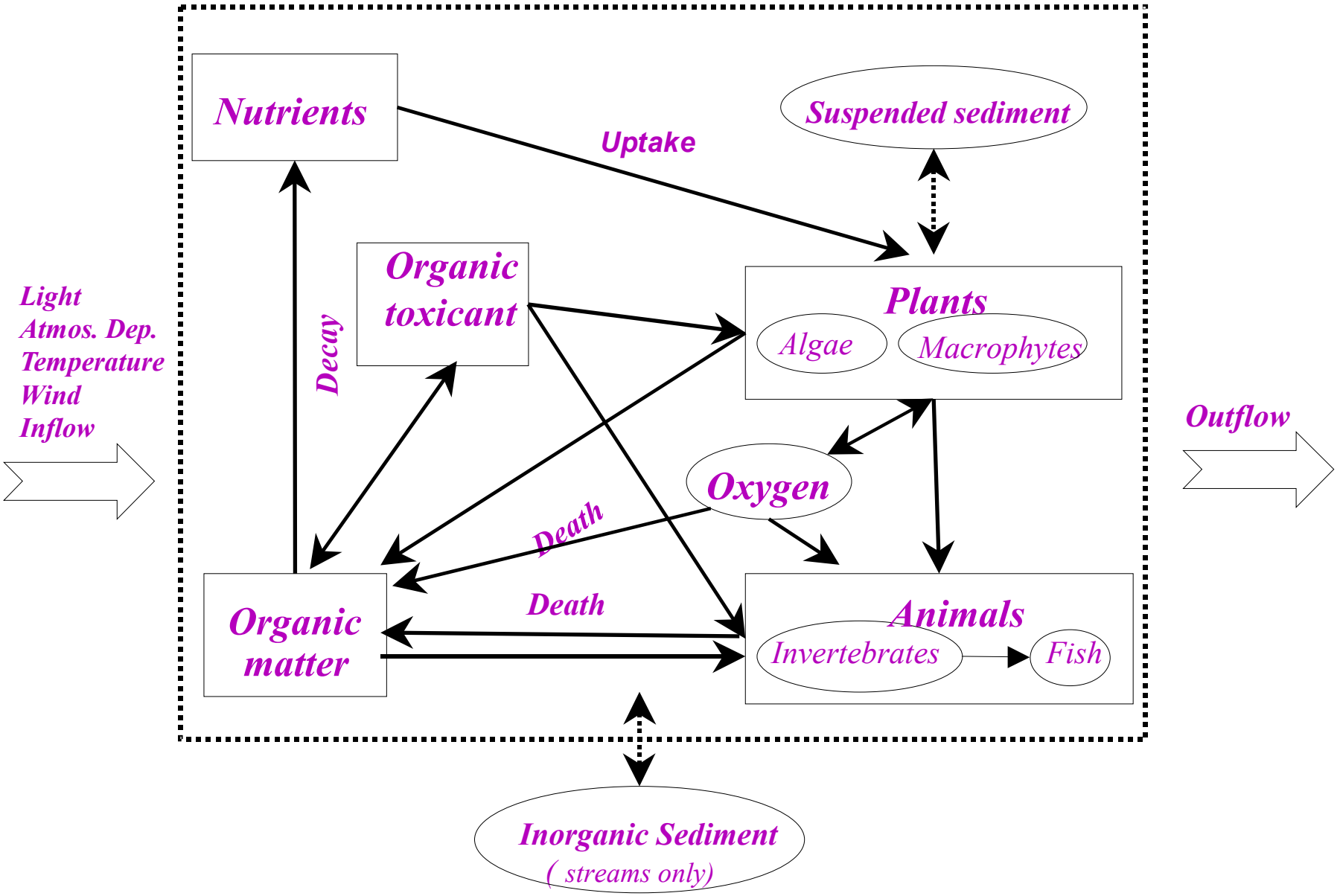
https://www.epa.gov/ceam/aquatox

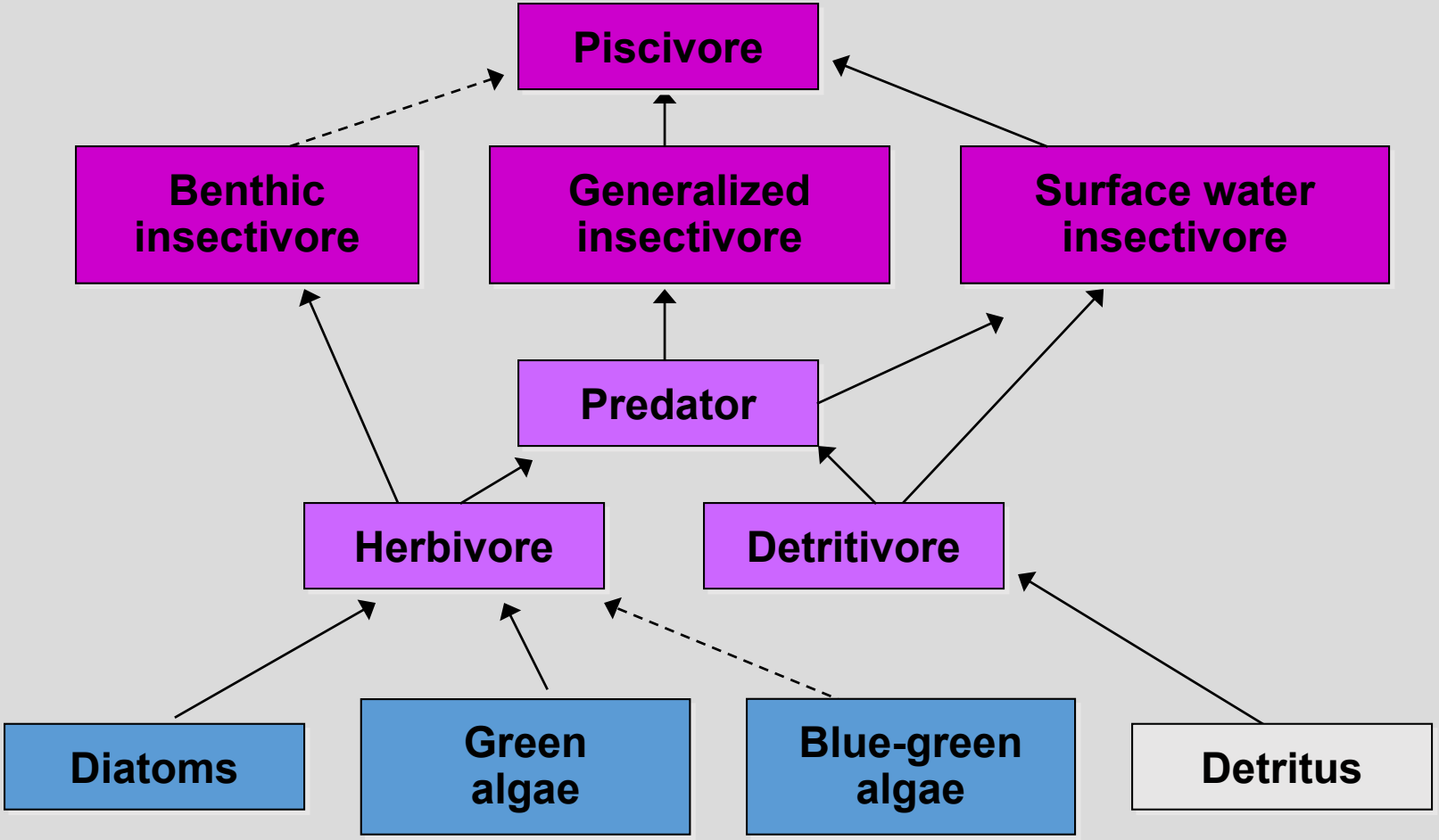
What is Aquatox ?

- Process-based ecosystem simulation model for ponds, lakes, reservoirs, streams, and rivers
- Integrates environmental fate and ecological effects processes
- Direct and indirect food chain, nutrient, and ecotoxicologial effects
- Chemical fate and bioaccumulation of organics

AQUATOX MODEL STRUCTURE



Food web


Piscivore
Benthic insectivore
Generalized insectivore
Surface water insectivore
Predator
Herbivore
Detritivore
Diatoms
Green algae
Blue-green algae
Detritus

AQUATOX Features

- Multiple stressors - nutrients and organic toxicants
- Multiple chemicals
- Age-structured fish populations
- Biota represented by guilds
- Variable loadings of chemicals and nutrients
- Point and non-point source loadings
- Monte-Carlo risk and uncertainty analysis
- Complete mixing or thermal stratification

Processes in AQUATOX

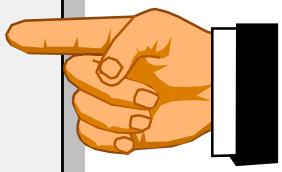
Ecological

- Feeding, assimilation
- Growth, emergence, promotion
- Mortality
- Acute and chronic toxicity
- Trophic interactions

Environmental Fate

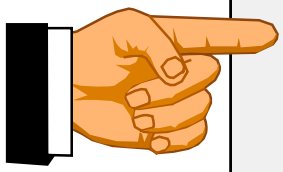
- Nutrient cycling
- Oxygen dynamics
- Kinetic partitioning to water, biota, and sediments
- Chemical Transformations
- Gill uptake
- Dietary uptake

- Site characteristics
- Biological Processes
- Chemical characteristics
- Library or user-supplied input

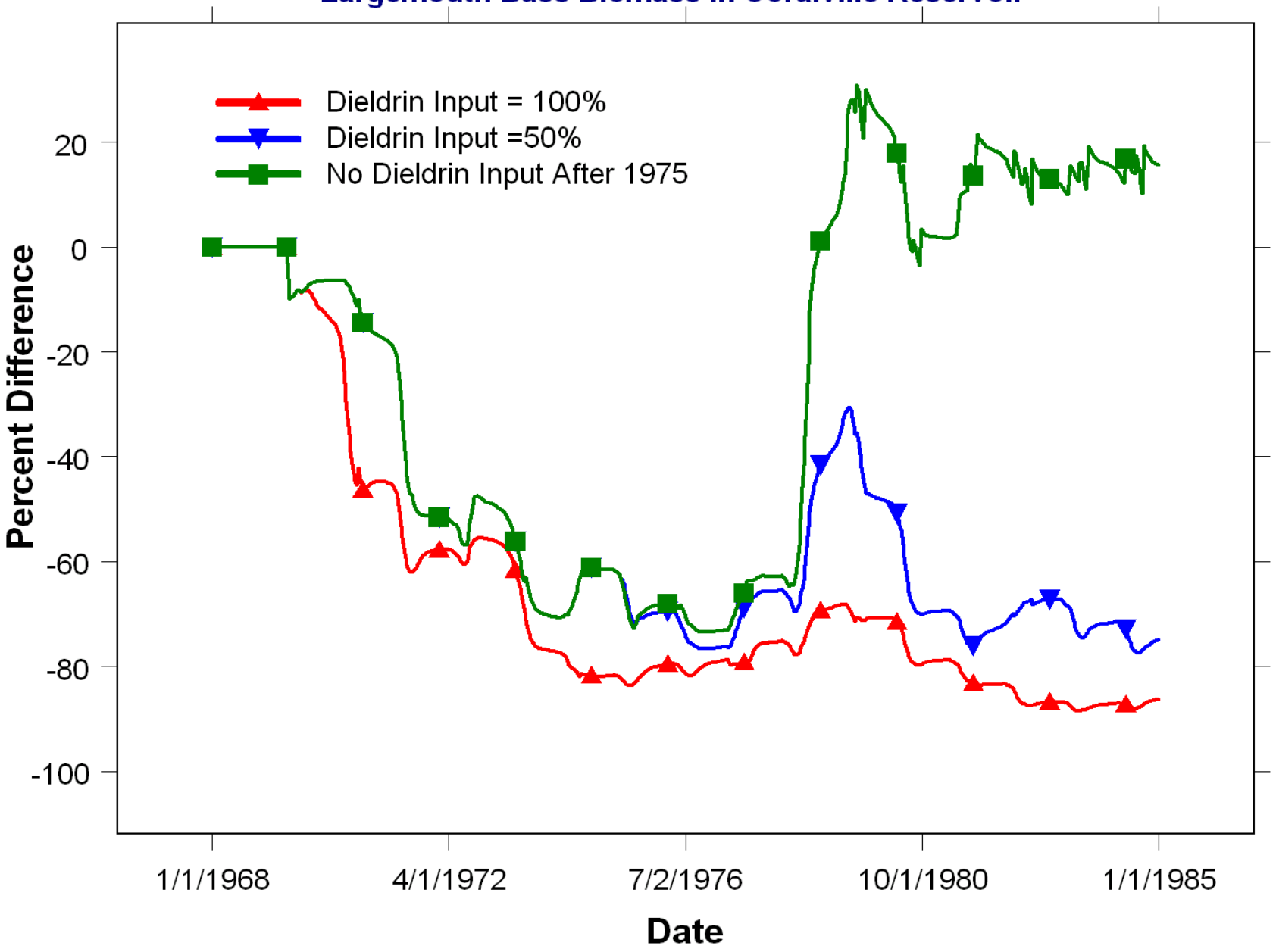


AQUATOX Inputs

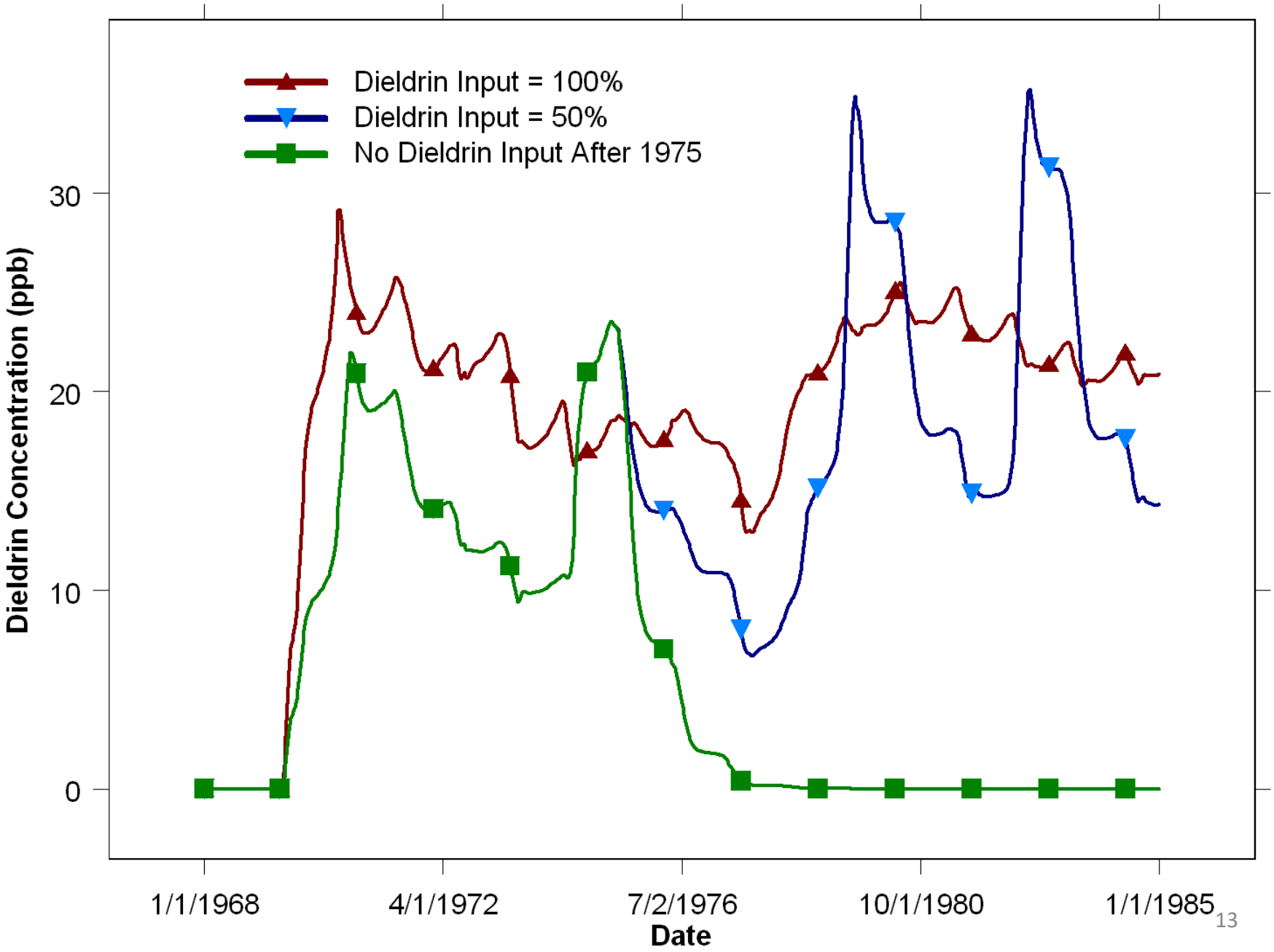
AQUATOX Outputs



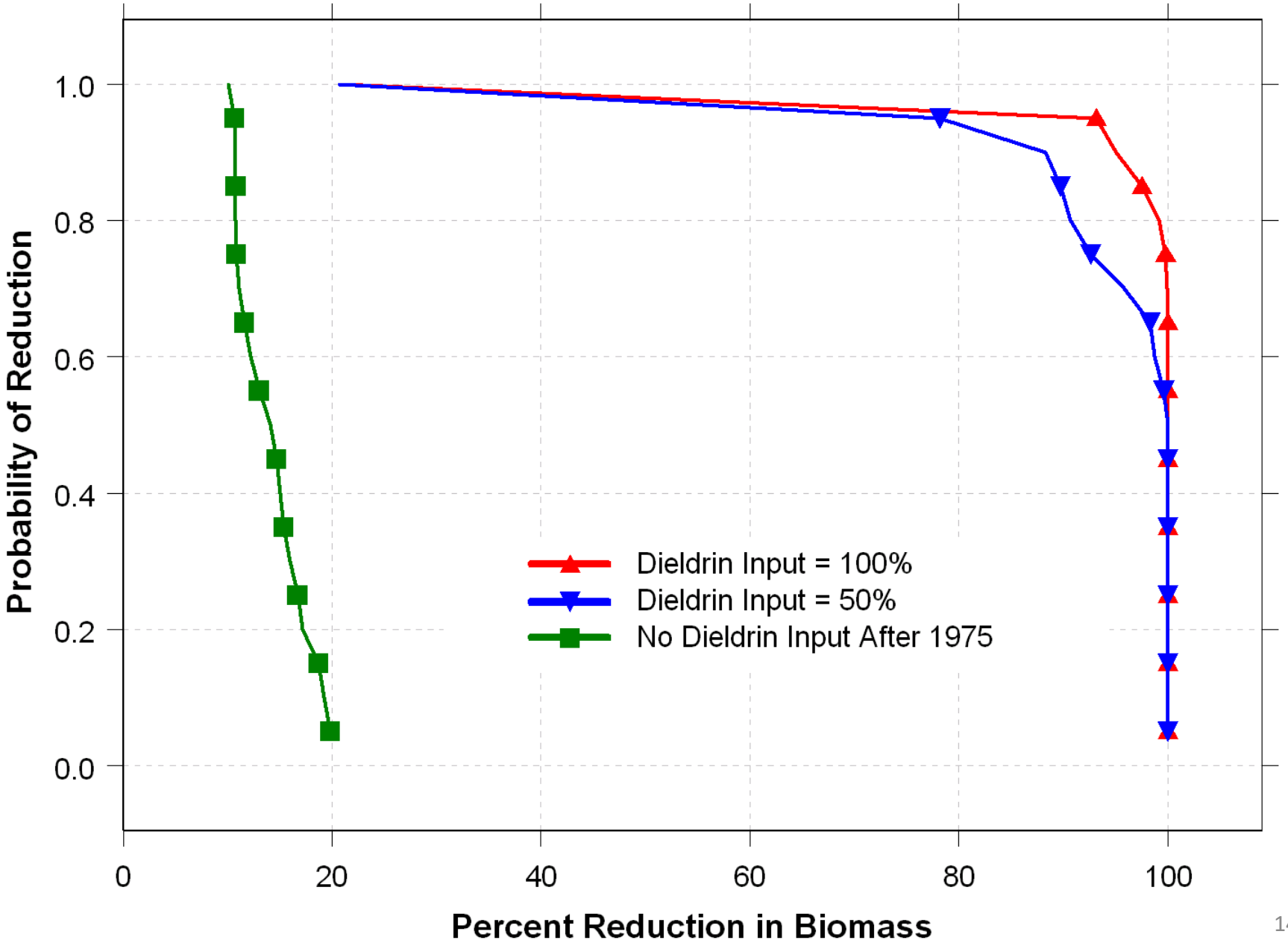
- Biomass
- Concentrations - Water and Biota
- Process rates
- Direct and indirect effects


Recovery From Dieldrin Exposure
Largemouth Bass Biomass in Coralville Reservoir
Dieldrin Input = 100%
Dieldrin Input =50%
No Dieldrin Input After 1975
20
0
-20
-40
-60
-80
-100
Percent Difference
1/1/1968
4/1/1972
7/2/1976
10/1/1980
1/1/1985
Date

Dieldrin Body Burden in Largemouth Bass



Risk to Largemouth Bass from Dieldrin



Future Trends in Ecological Modeling

- Ecology is transitioning from a data poor science to a data rich science – there will be an increasing need to effectively utilize this information to formulate and test models
- Models will become more complex as computational power increases
- Modularity and connectivity will become of primary importance
- Characterization and communication of model results will require increased attention to visualization, uncertainty analysis, and system resilience
- Modeling tools and simulation packages will become even more ubiquitous

Resources

EPA Center for Exposure Assessment Modeling
https://www.epa.gov/ceam

AQUATOX Model
https://www.epa.gov/ceam/aquatox

SLAMM Model
https://coast.noaa.gov/digitalcoast/tools/slamm.html

Organizations

ISEM – International Society for Ecological Modelling
https://www.isemworld.org/

IEMSs – International Environmental Modelling and Software Society
https://www.iemss.org/

ISEE – International Society for Ecological Economics
http://www.isecoeco.org/

CSDMS – Community Surface Dynamics Modeling System
https://csdms.colorado.edu/wiki/About_CSDMS

IIASA – International Institute for Applied Systems Analysis
https://iiasa.ac.at/

SESYNC – National Socio-Environmental Synthesis Center
https://www.sesync.org/

Journals

Ecological Modelling
https://www.sciencedirect.com/journal/ecological-modelling

Environmental Modelling and Software
https://www.sciencedirect.com/journal/environmental-modelling-and-software

Ecological Economics
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Ecological Informatics
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Ecological Complexity
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