Bayesian tools to meet the challenges of uncertainty, climate change and integrating molecular toxicology to population management

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Looking ahead-

Introduction to the use of Bayesian networks to determine risk and adaptive management

Lessons learned from the application of these tools.

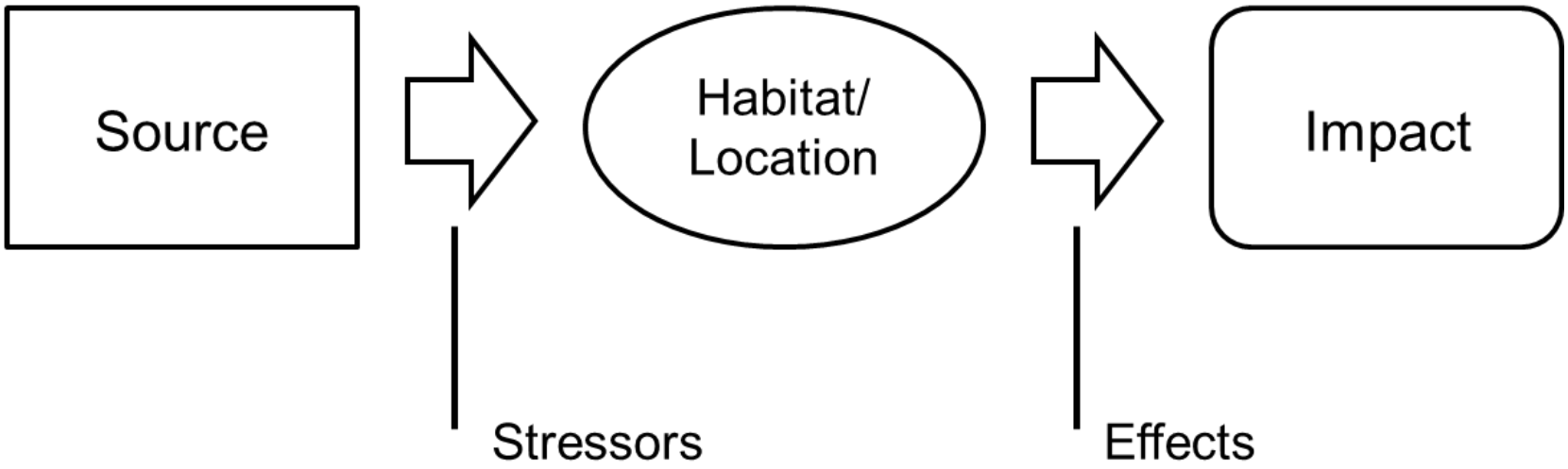
Looking ahead-

South River Case Study

The use of adverse outcome pathways to estimate pesticide and environmental effects to Chinook salmon in the Northwest.

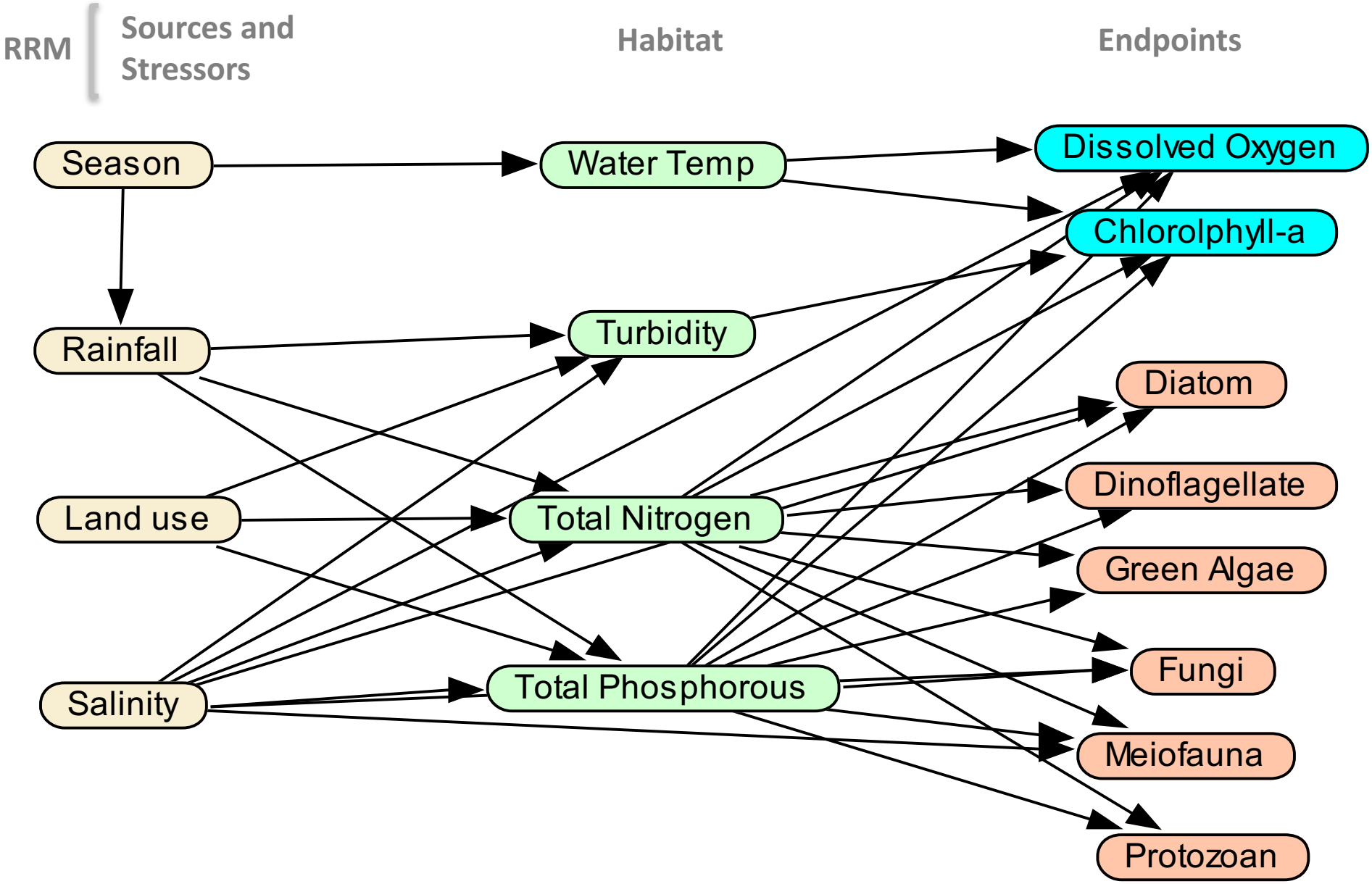
Methods-Reminder

- Relative risk model (RRM) as conceptual, organizing framework.

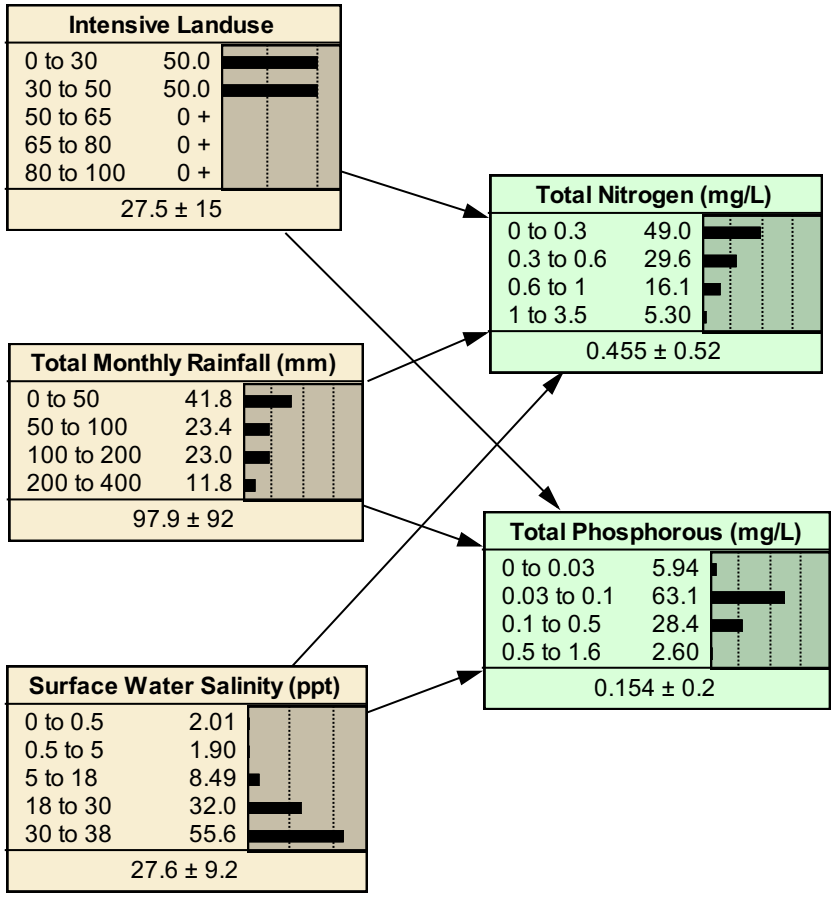


Landis and Wiegers (2005)

Conceptual Model

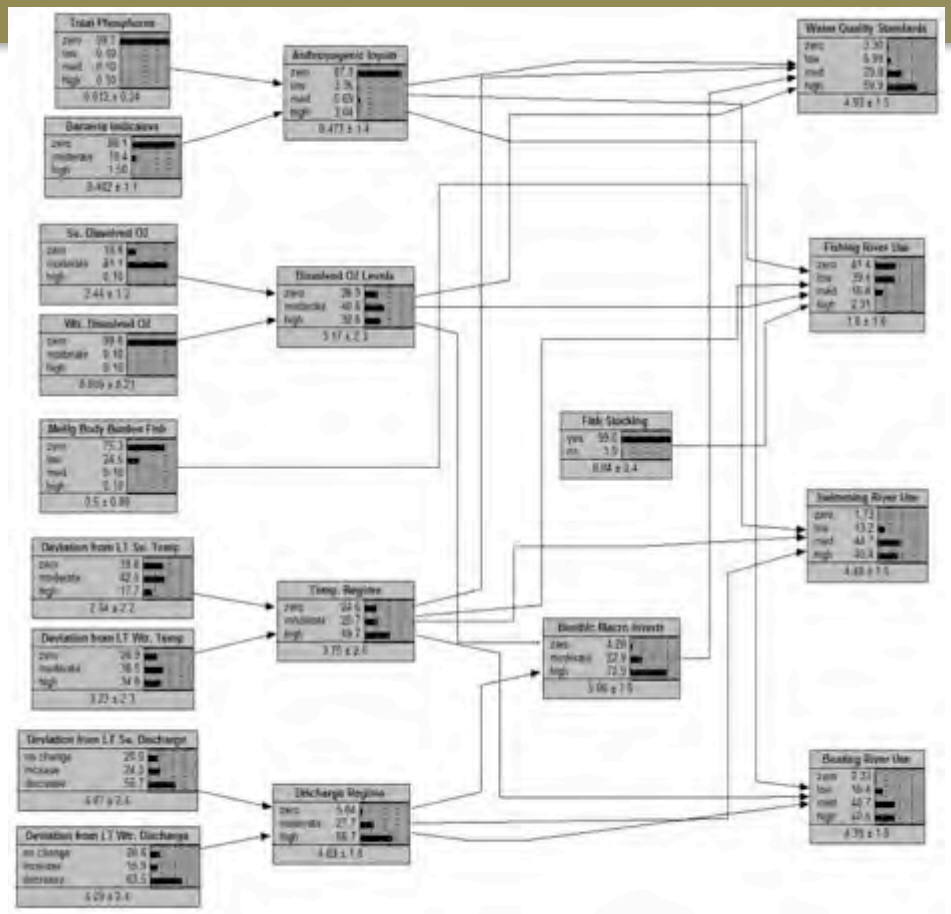


Adaptive Management also means learning



The learning is in the structure of the Bayesian network, especially the conditional probability tables.

Very short description of a Bayesian network



Inherently probabilistic

Cause-effect model

Can use a variety of evidence

Data-Data-Data

Management and BNs

Case Studies

South River, Virginia, USA —Hg the chemical but multiple other stressors.

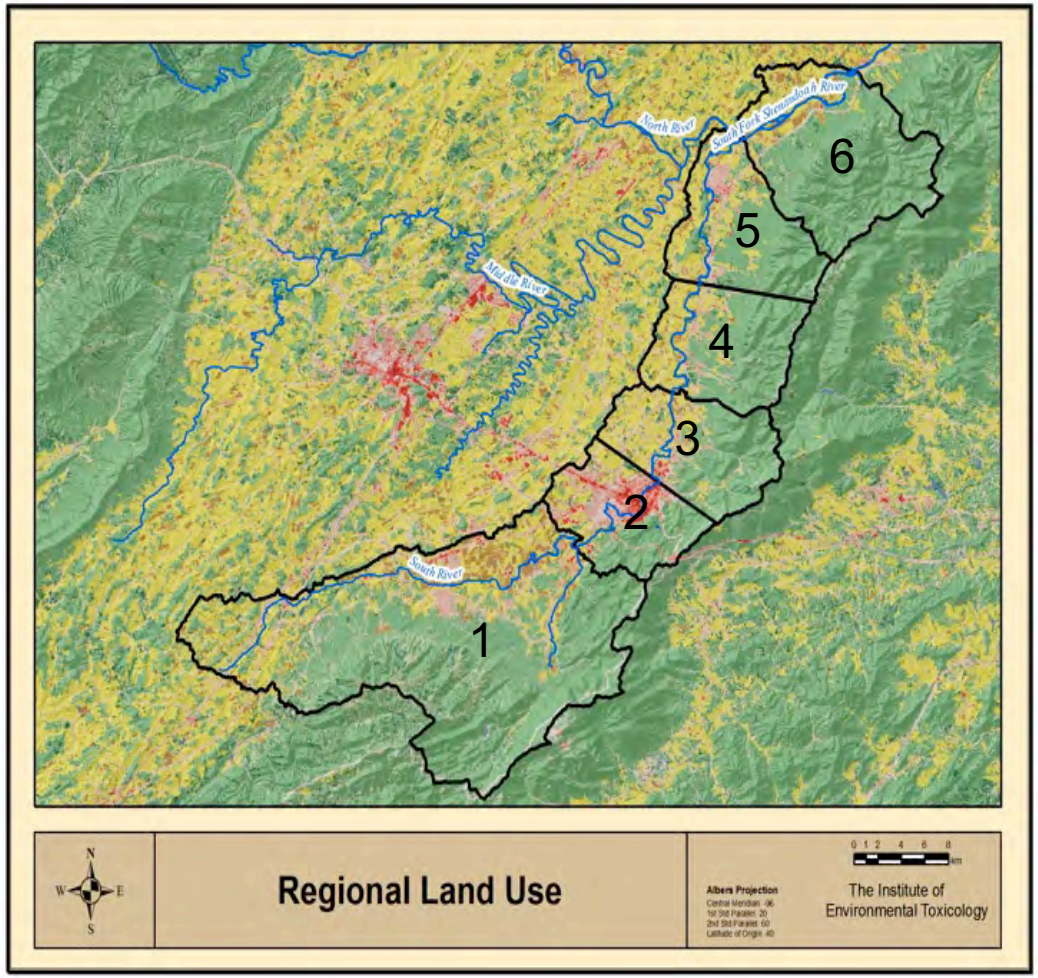
Using adverse outcome pathways to describe population dynamics for Chinook salmon in the Pacific Northwest

The case studies-South River, Virginia USA

Classic contaminated site—Hg as the initiator but a variety of stressors.

Waynesboro, Virginia USA

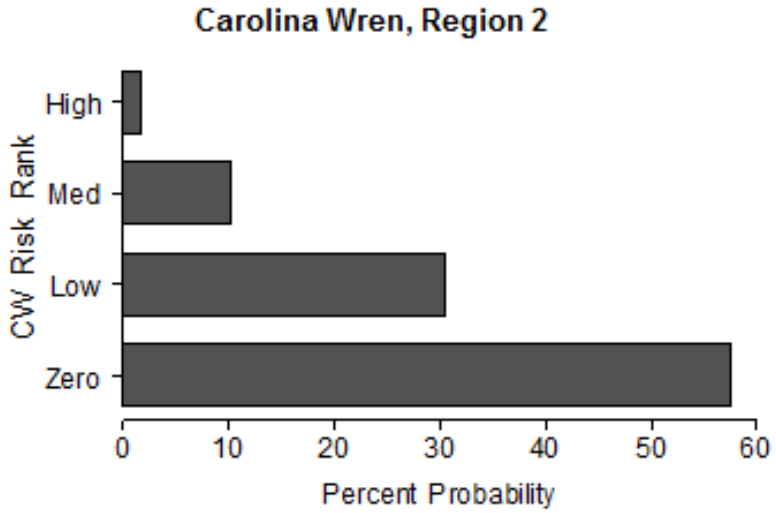
The case studies-South River, Virginia USA

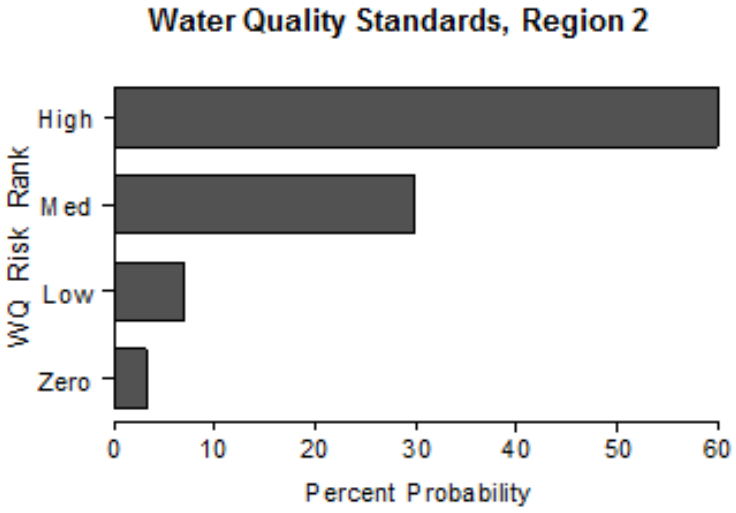


Large river system in the valleys of western Virginia

Hg, temperature, land use and other stressors.

Lessons learned-Estimate Risk

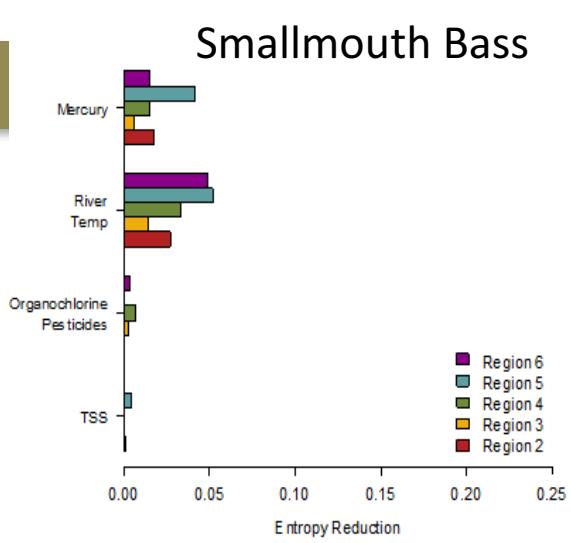


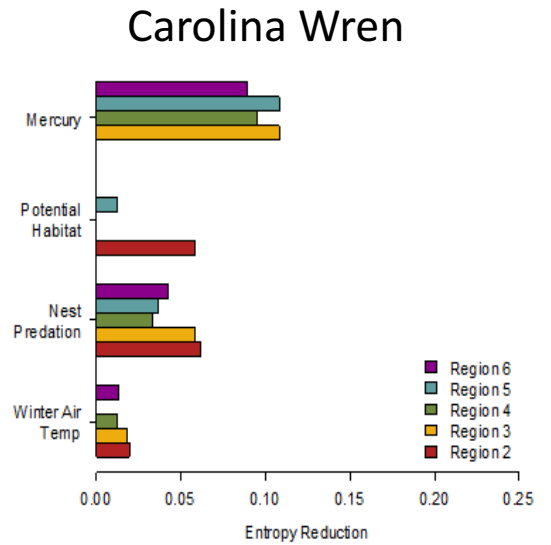


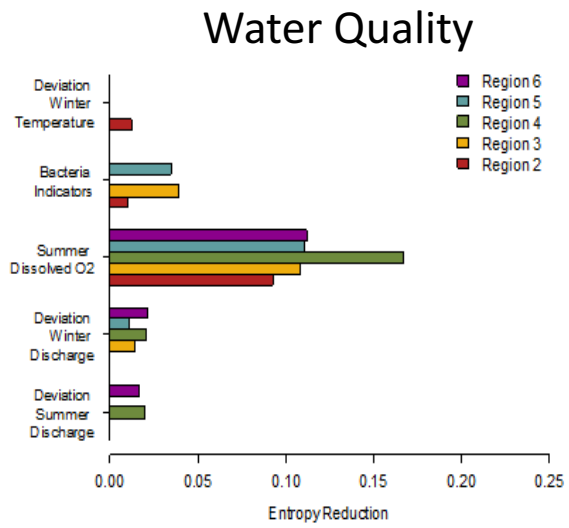
It is possible to estimate risk to multiple endpoints from multiple stressors, but the results depend upon location

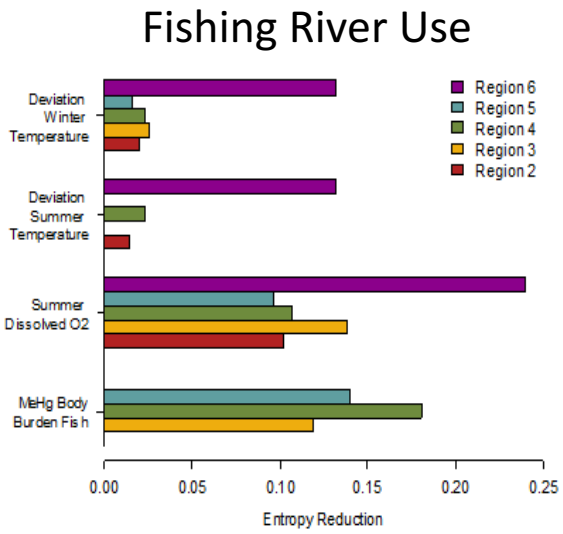
Lessons learned-Estimate Risk

The drivers of that risk change via location and endpoint.



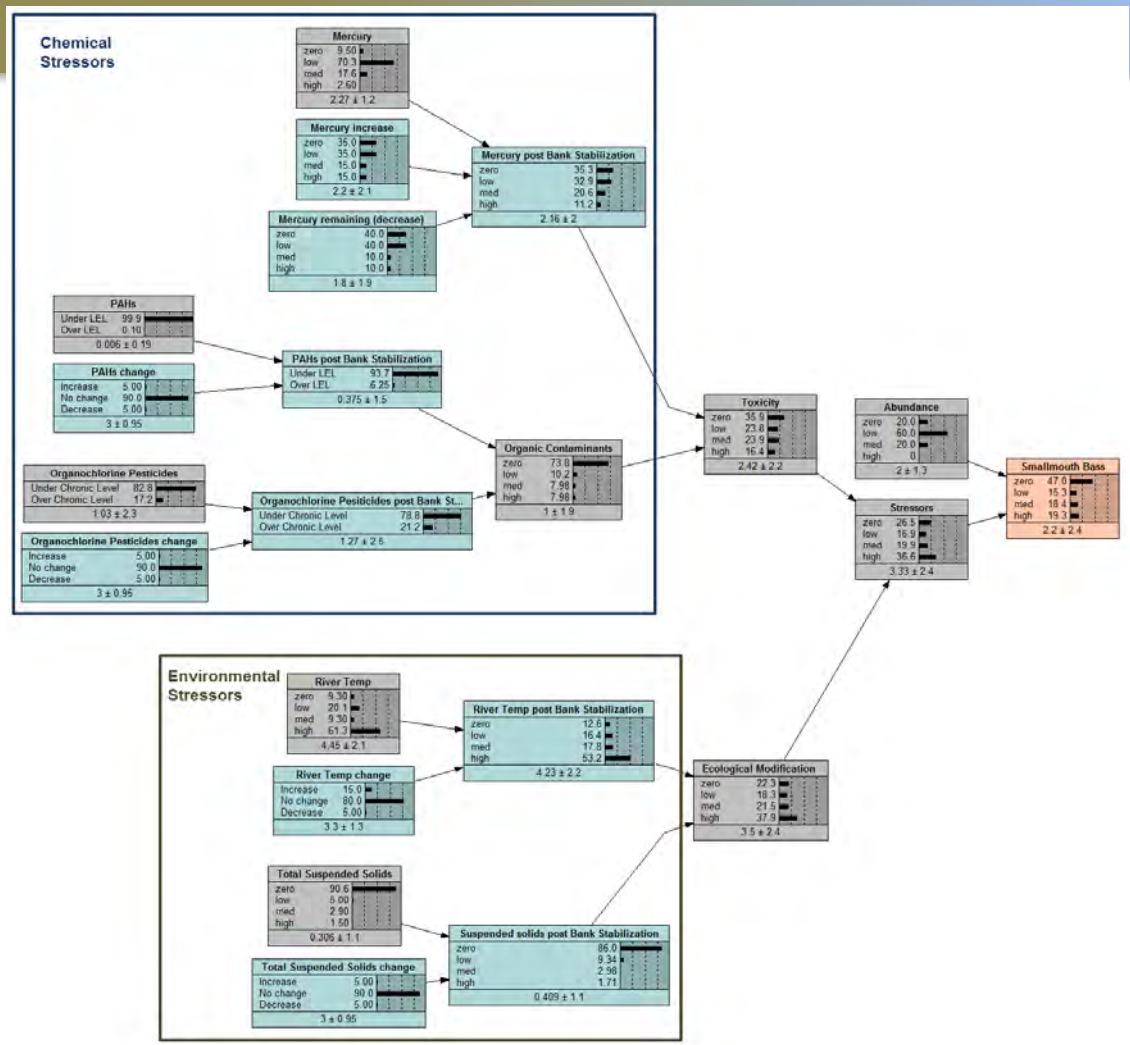




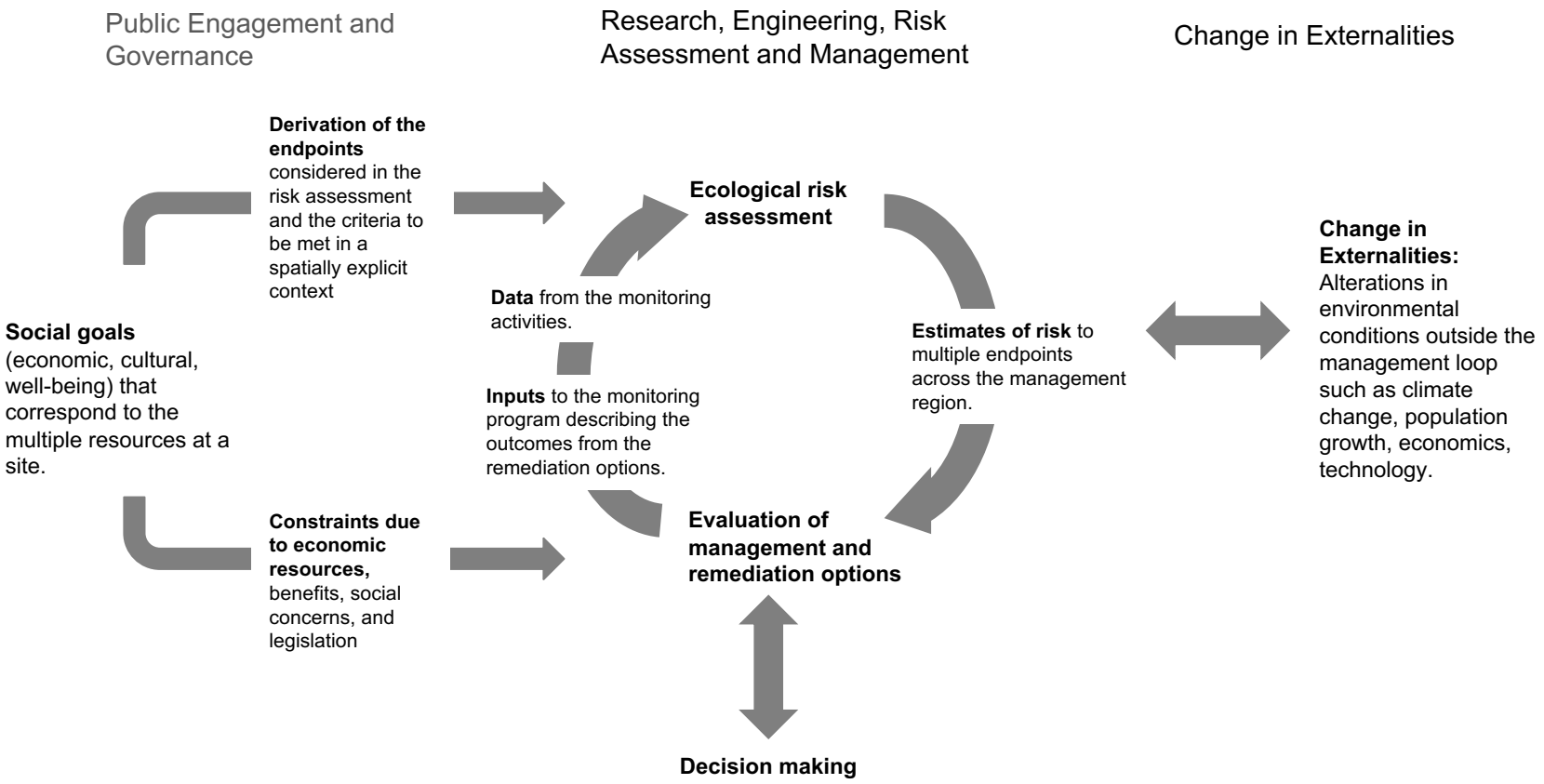


Lessons learned-Management Alternative

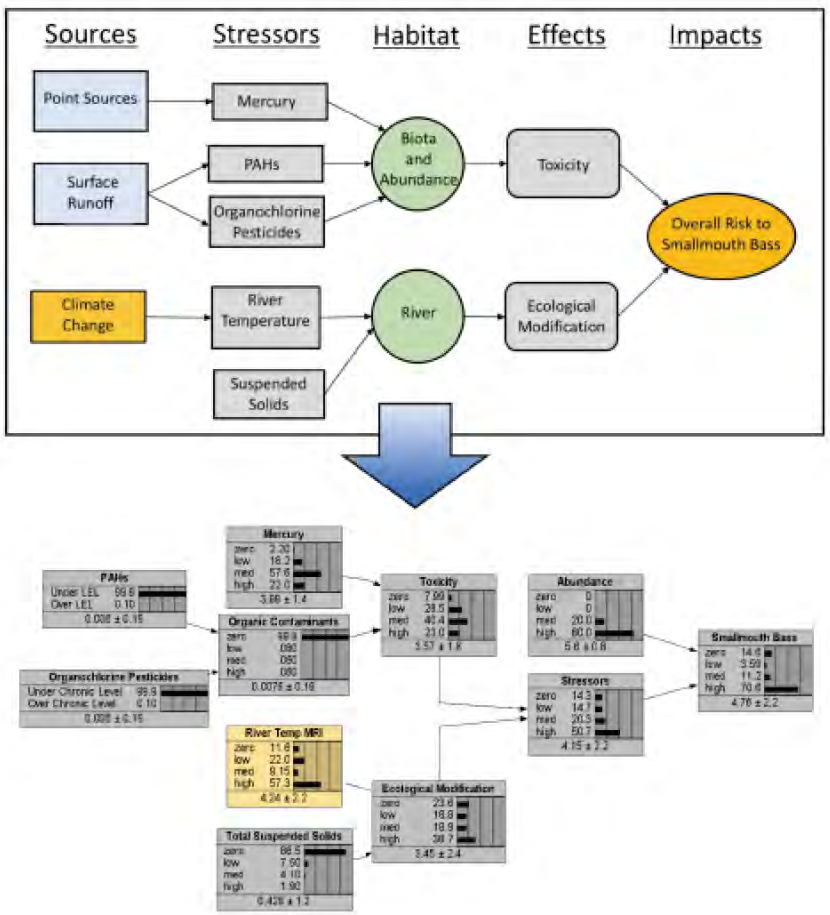
It is possible to estimate changes in risk due to proposed management alternative—Bayesian Network to estimate change in risk due to Bank Stabilization.



Lessons learned-Adaptive Management



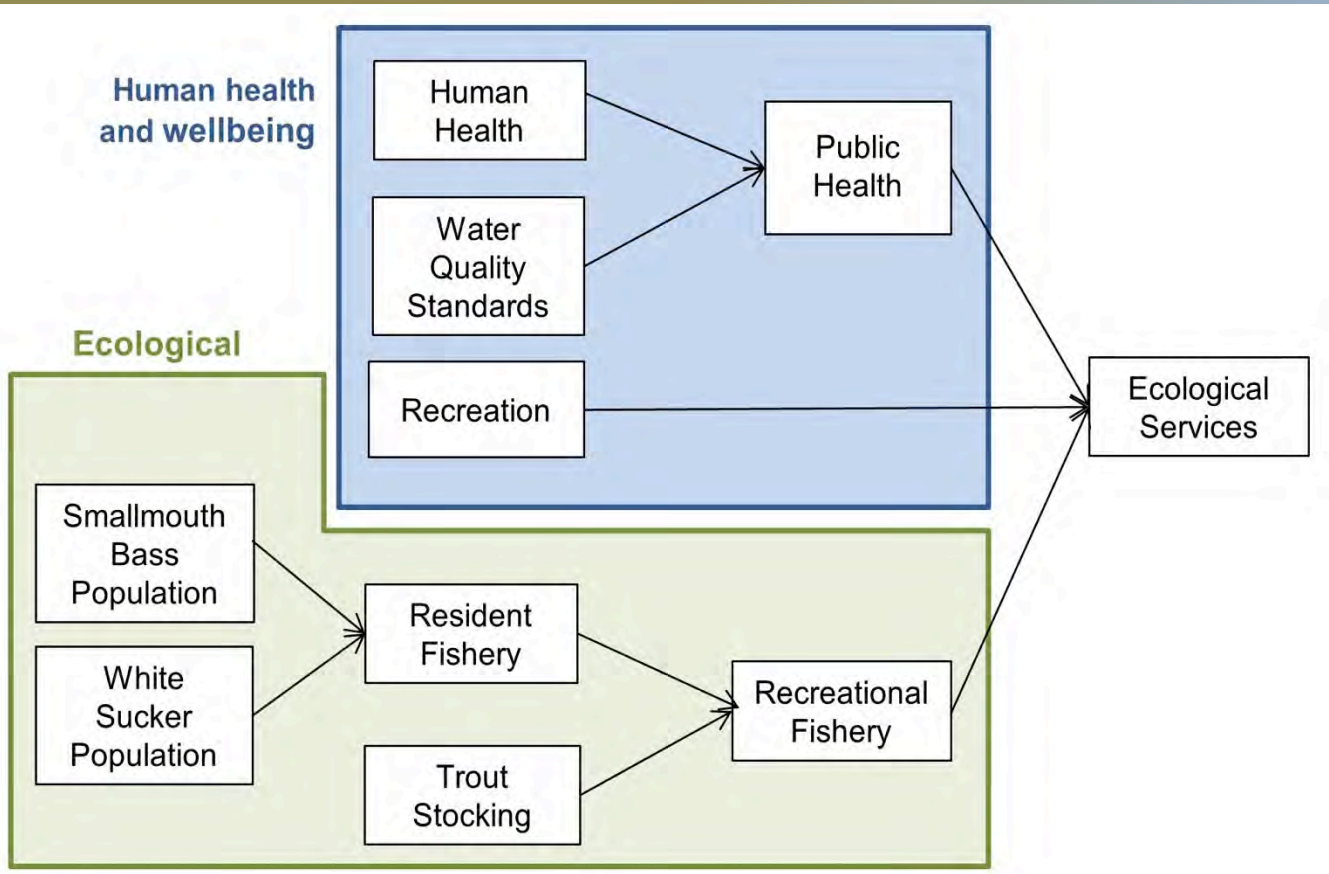
Lessons learned-Climate Change



Downscaling will be a challenge

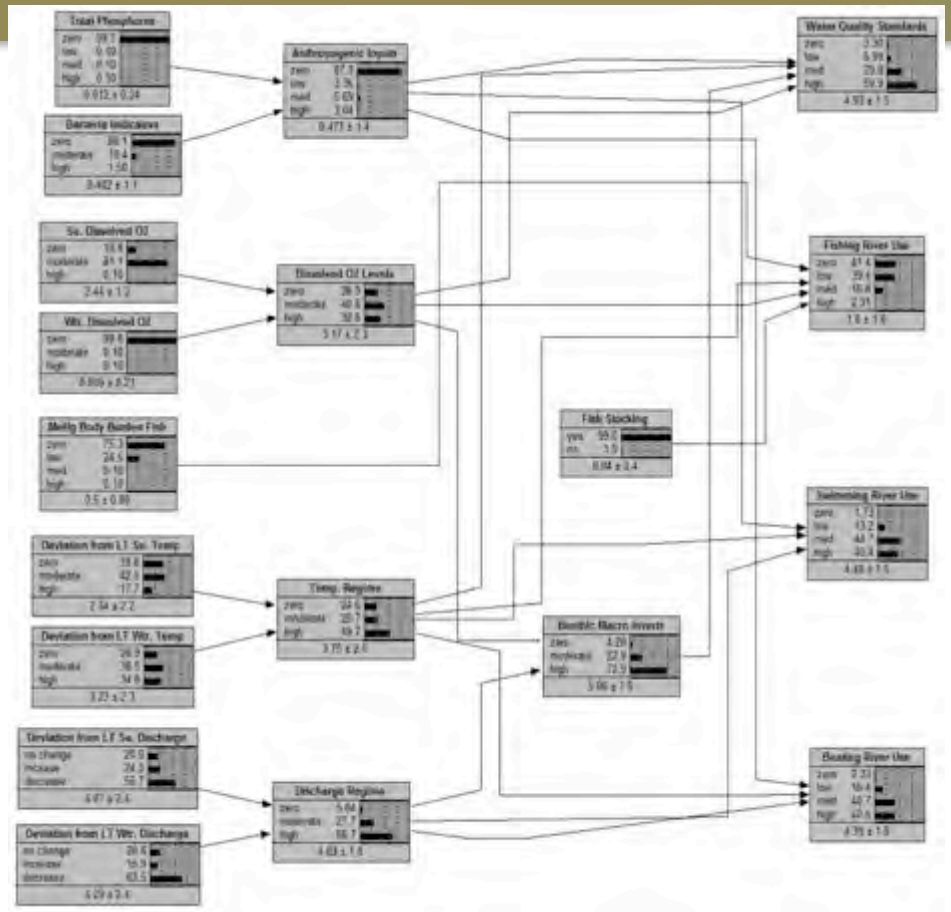
There will be winners and losers

It is possible to integrate a variety of endpoints



South River human health and ecological risk

Very short description of a Bayesian network



Entropy analysis determines important variables

Can add management alternatives (Hines and Landis 2014, Herring and Landis 2015).

Next case study--Adverse Outcome Pathway

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Center for Health and the Global Environment, Harvard

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Adverse Outcome Pathway

AOPs are basically cause-effect pathways written at a molecular to organismal level.

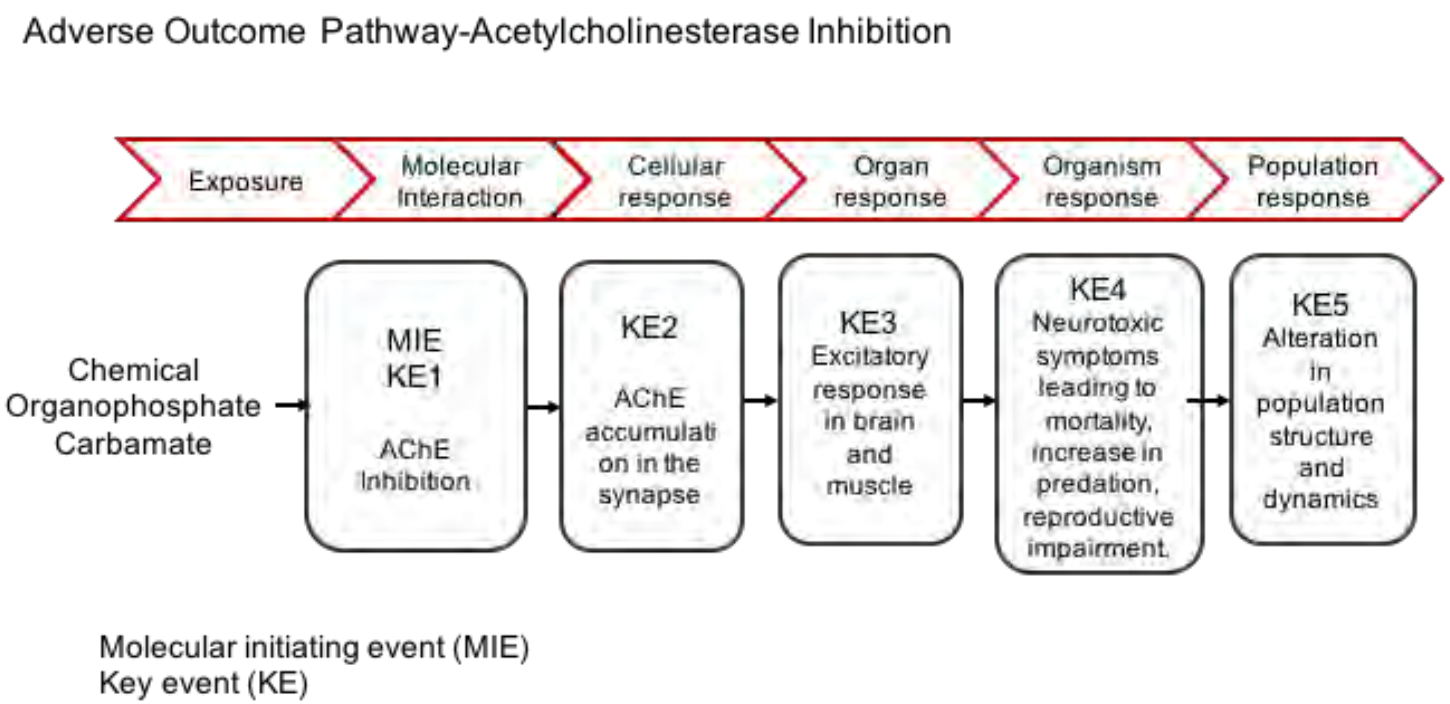
They actually have a physical basis within the organism and follows the signal from the initiation event to the appearance of a symptomology.

It is the etiology of the effect-----

Adverse Outcome Pathway

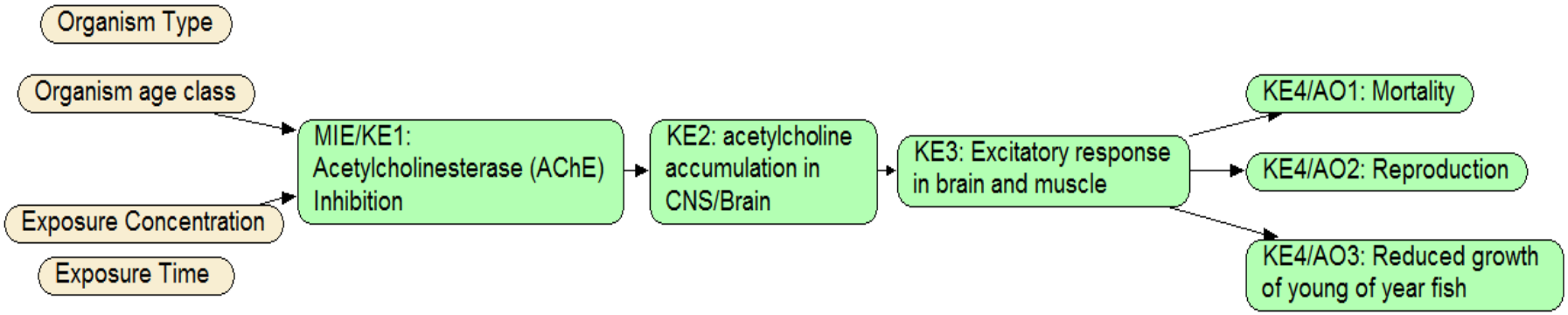
An AOP is a conceptual construct that portrays existing knowledge concerning the linkage between a direct molecular initiating event and an adverse outcome at a *biological level of organization* relevant to risk assessment.

Adverse Outcome Pathways (Russom et al 2014)



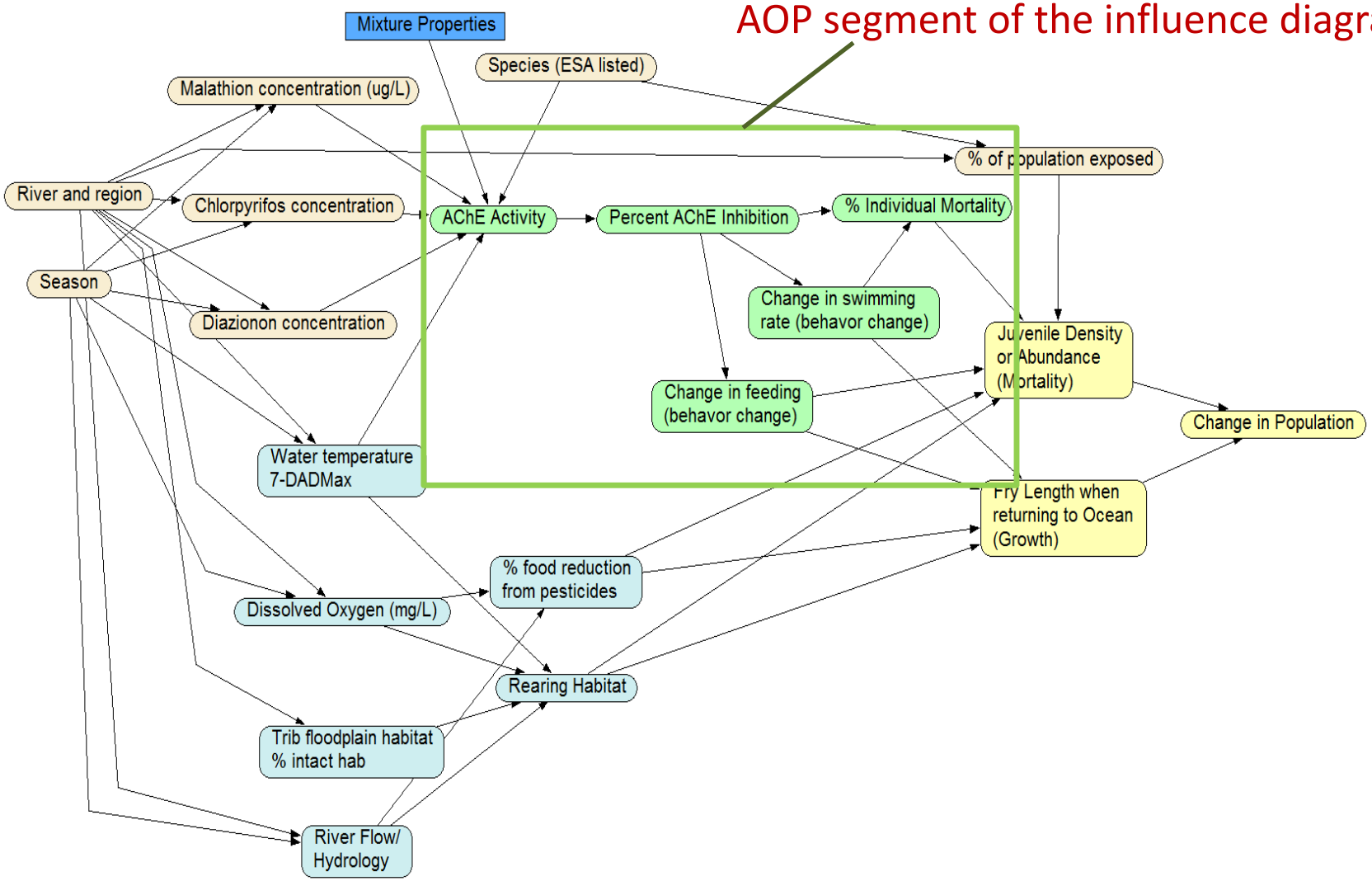
AOP turned into an influence diagram

Written using Netica.

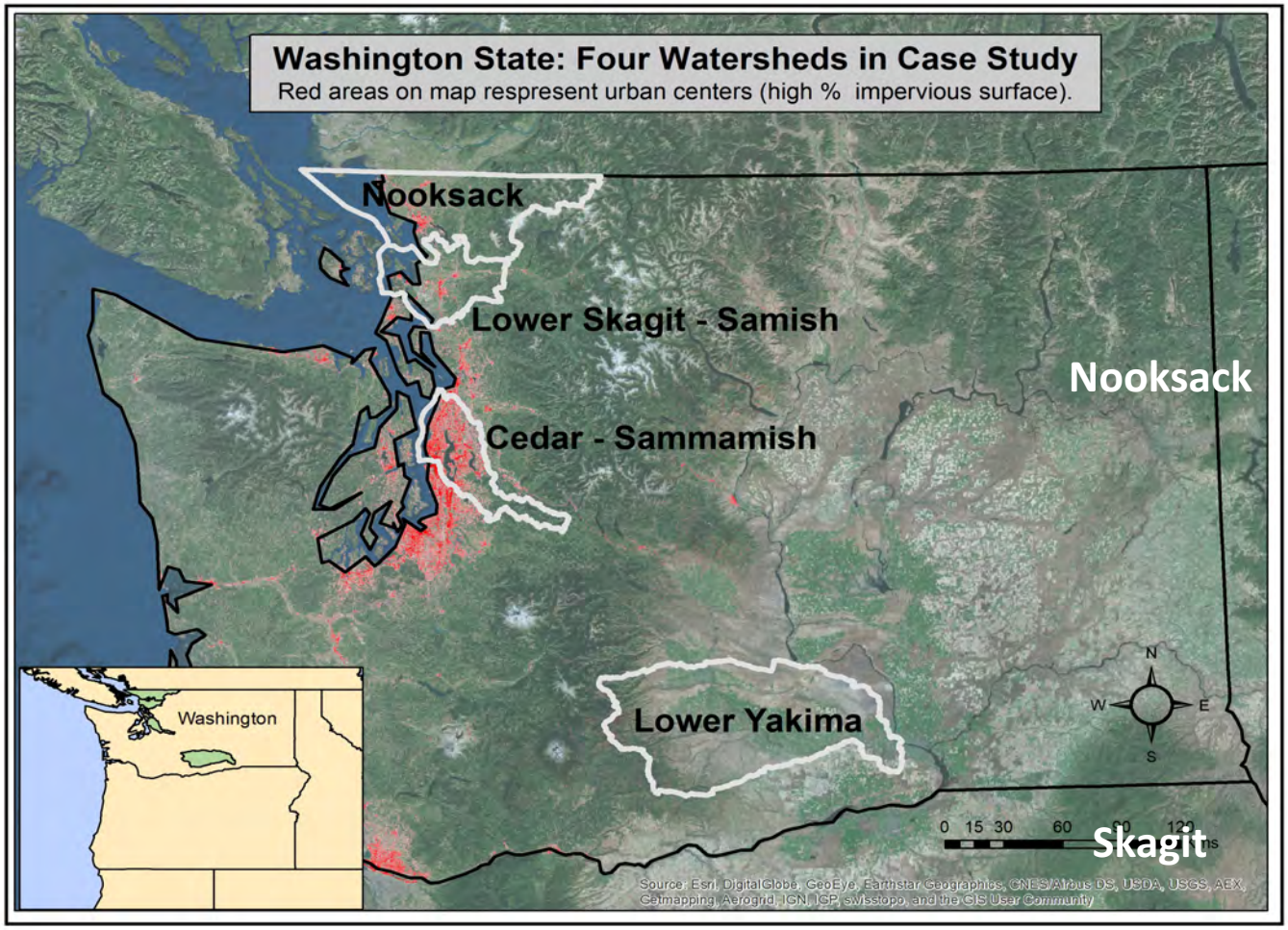


AOP is not sufficient to predict effects or risks to populations until scale and location are introduced.

AOP that now includes ecology…not magic.



Site Based Approach-Chinook Streams in Washington State



Specific case study

Nooksack

Skagit

Data sources for case study and collaborators

Abigail Nickelson, WA Department of Agriculture
Cathy Laetz, NOAA Fisheries
Julann Stromberg, NOAA Fisheries/Ocean Associates

Contributing Agencies-Data on Sites and Exposure-Response
Northwest Fisheries Science Center, NOAA
USGS
WA Department of Agriculture
WA Department of Ecology
City of Bellingham
Noocksack Salmon Enhancement Association
King County DNR
King Conservation District
Skagit Conservation district
Yakima Tribal DNR
Samish Tribal DNR

AOP turned into an influence diagram

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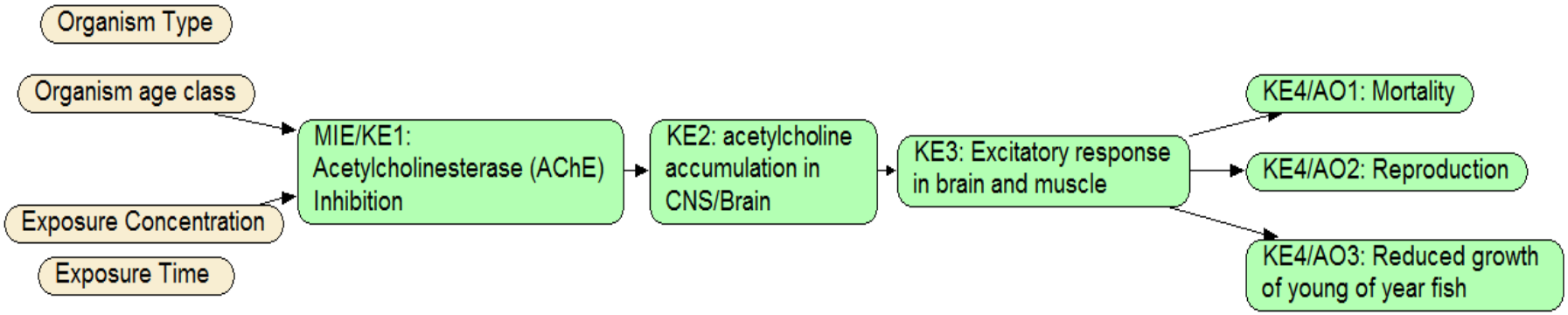
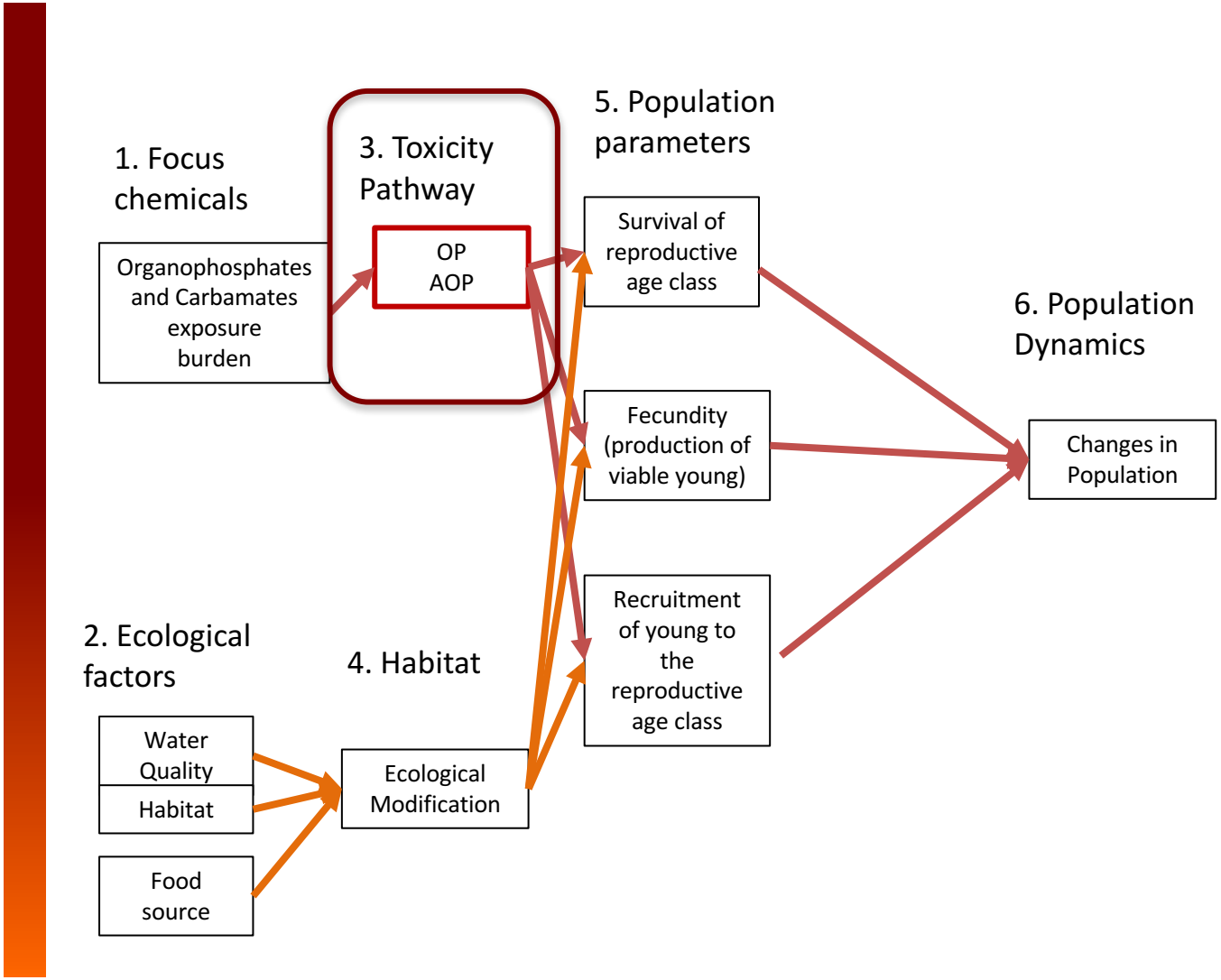
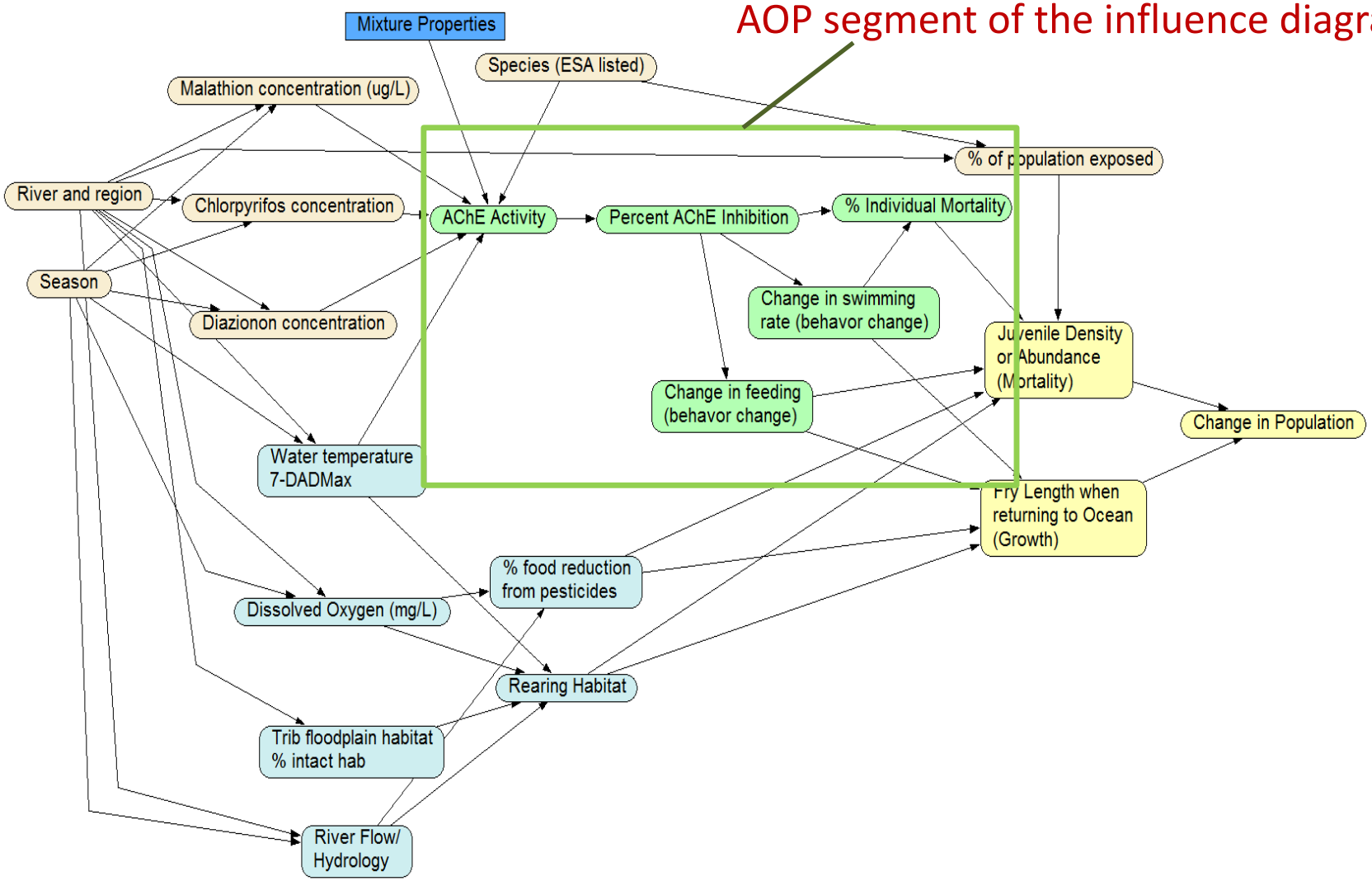


AOP is not sufficient to predict effects or risks to populations until scale and location are introduced.

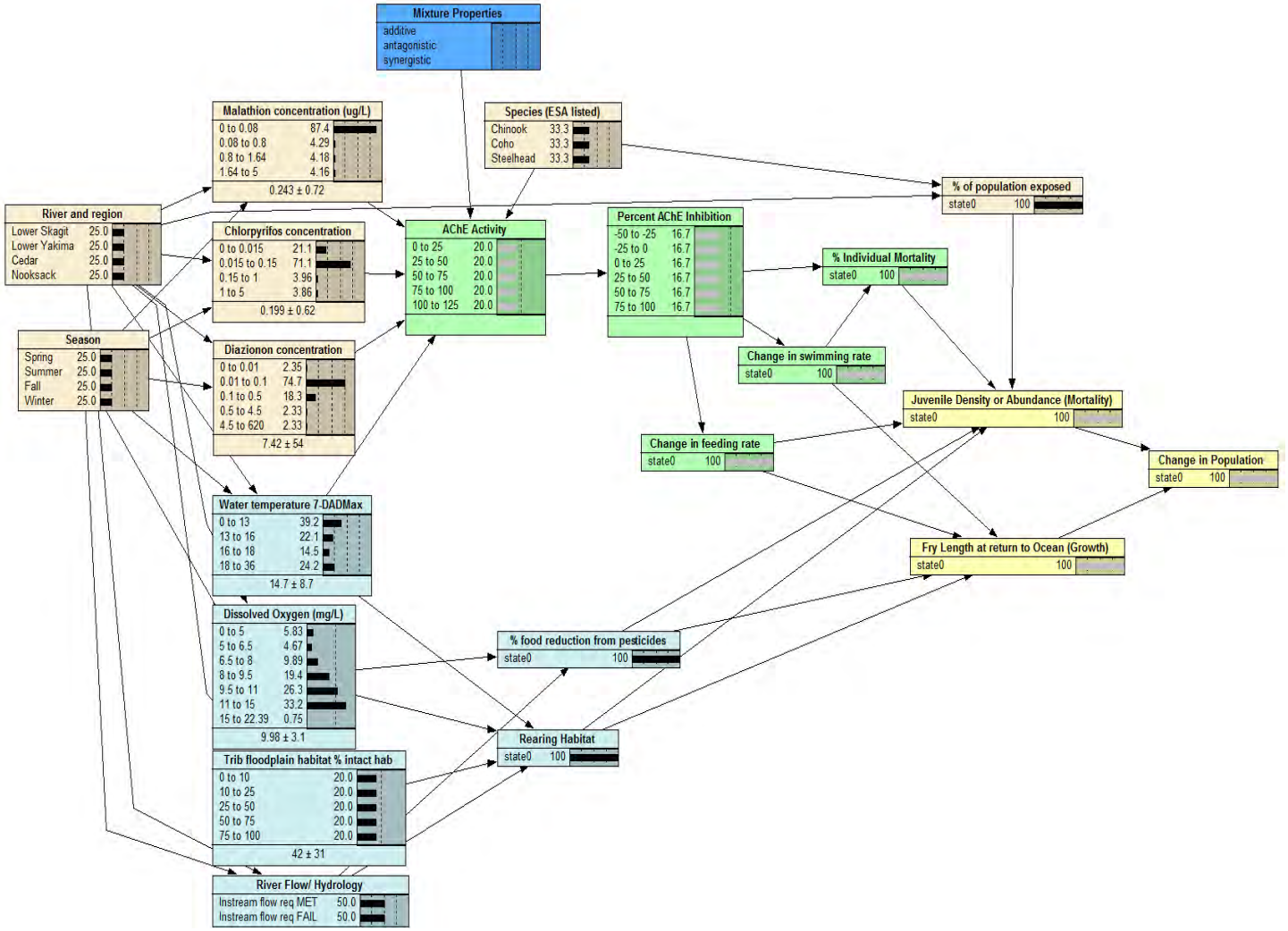
Now to construct a cause-effect conceptual model-influence diagram-see where the AOP is….



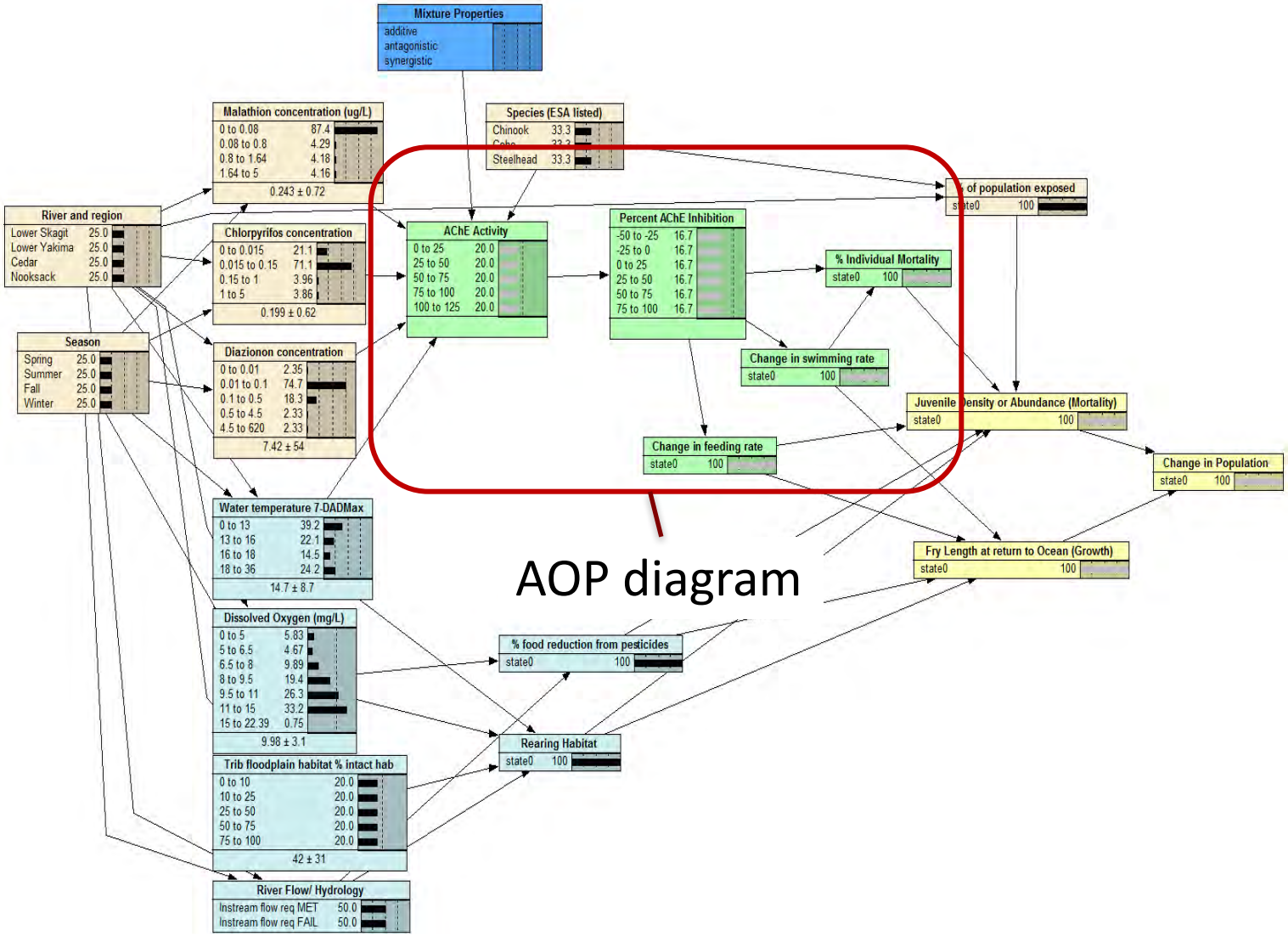
AOP that now includes ecology…not magic.



Now the influence diagram as expressed as a Bayesian network as expressed in Netica.

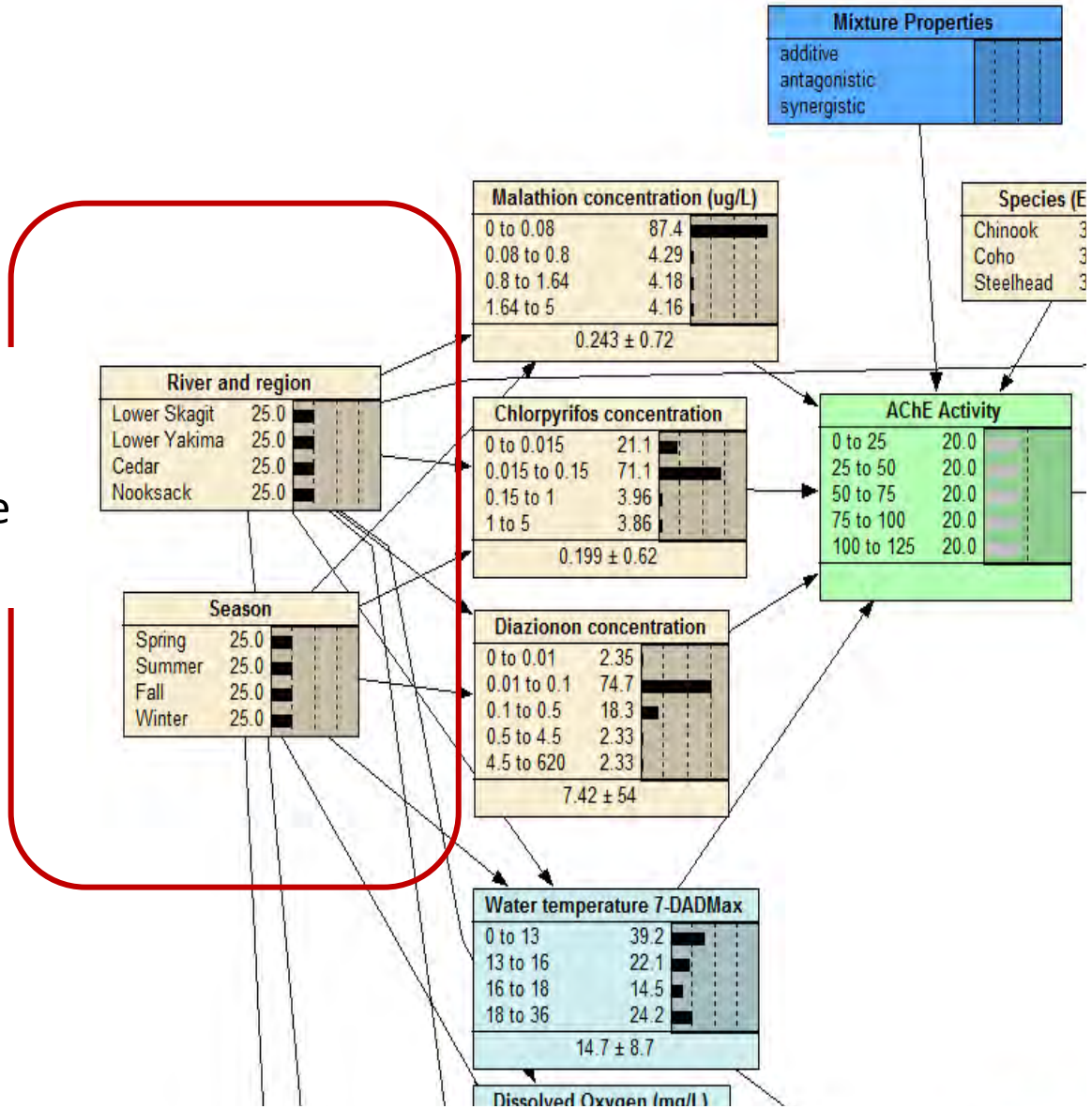


Here are the pieces.

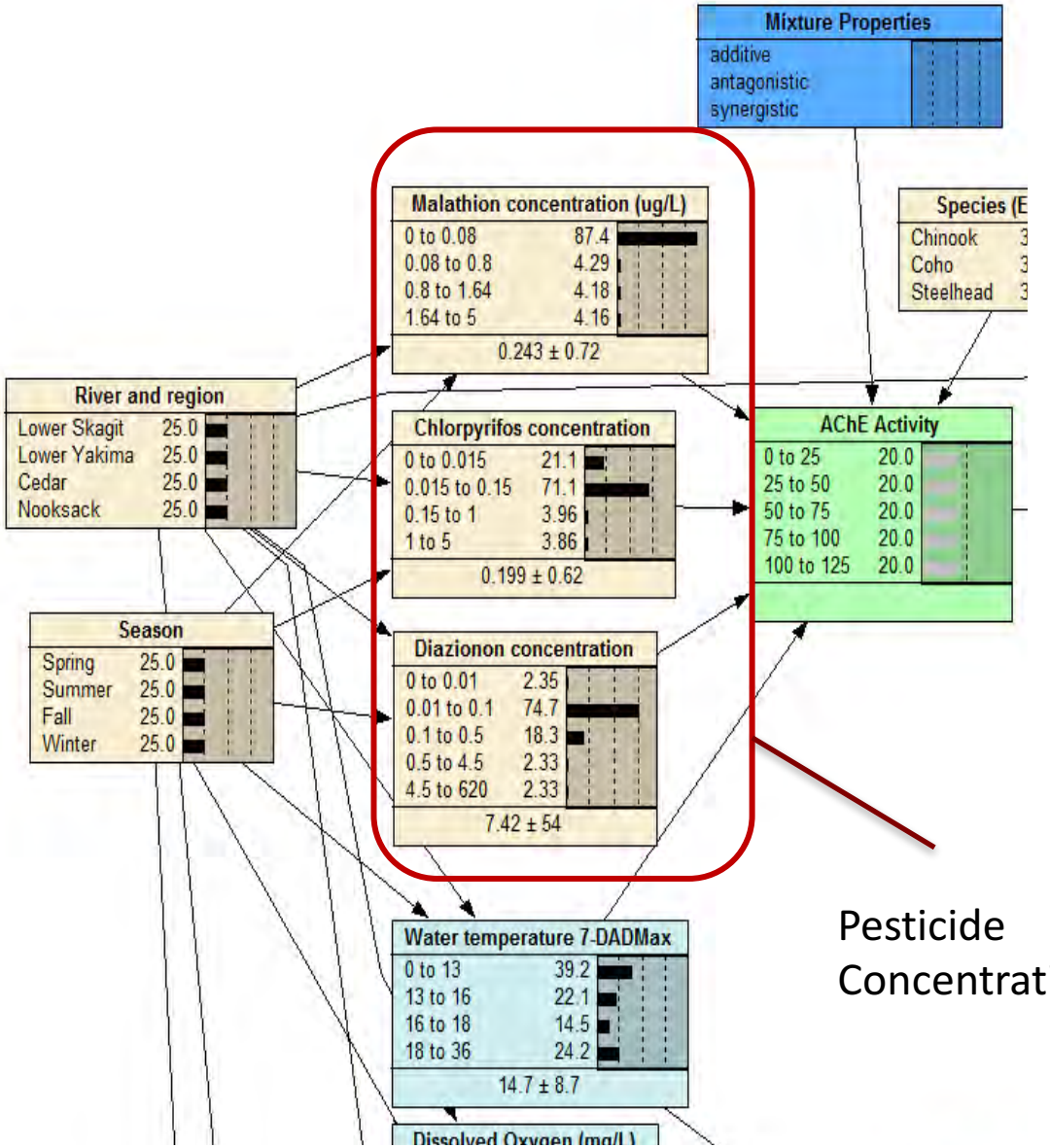


These nodes are set from site specific data for each of the 4 watersheds

The River and the season



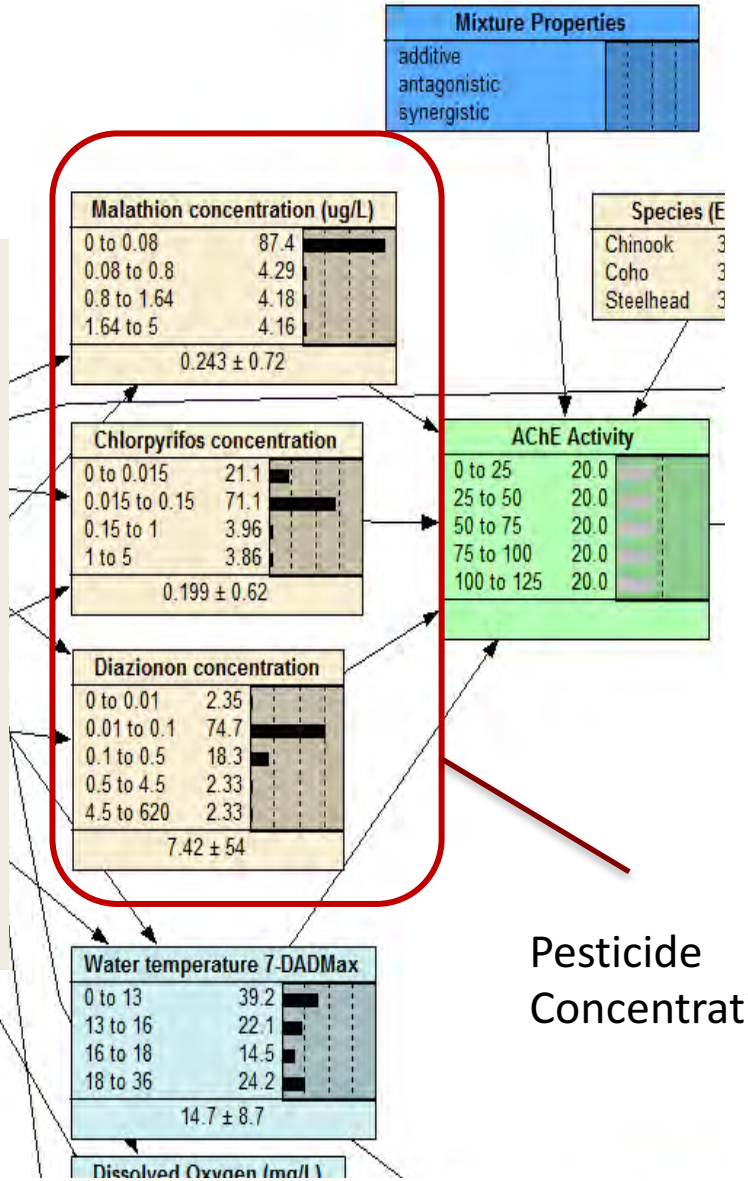
Pesticide concentrations are parent nodes and specific to the river.



Pesticide Concentrations

Data Driven Distributions

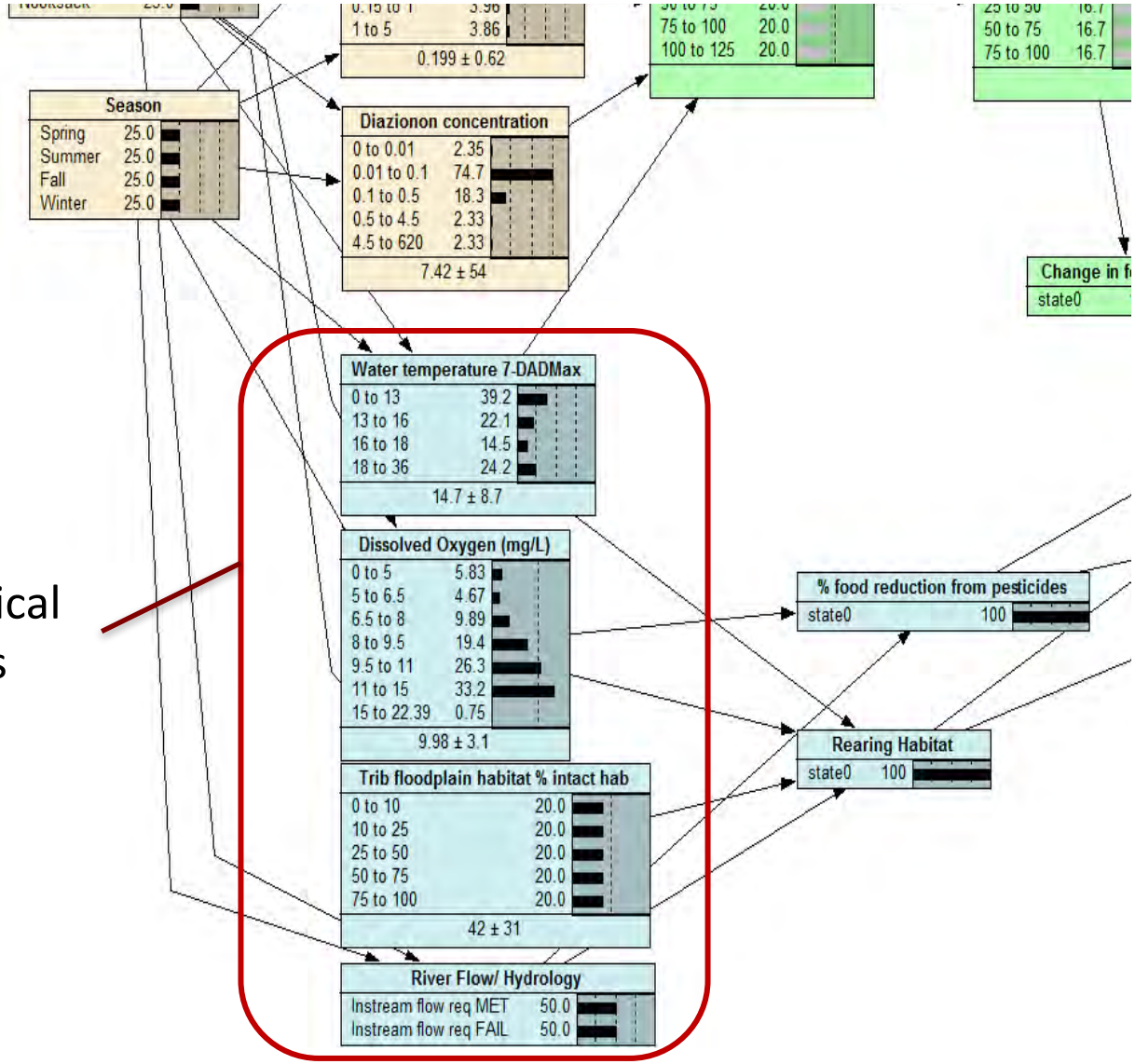
USGS
WA Department of Agriculture
WA Department of Ecology
City of Bellingham
Nooksack Salmon Enhancement Association
King County DNR
King Conservation District
Skagit Conservation district
Yakima Tribal DNR
Samish Tribal DNR



Pesticide Concentrations

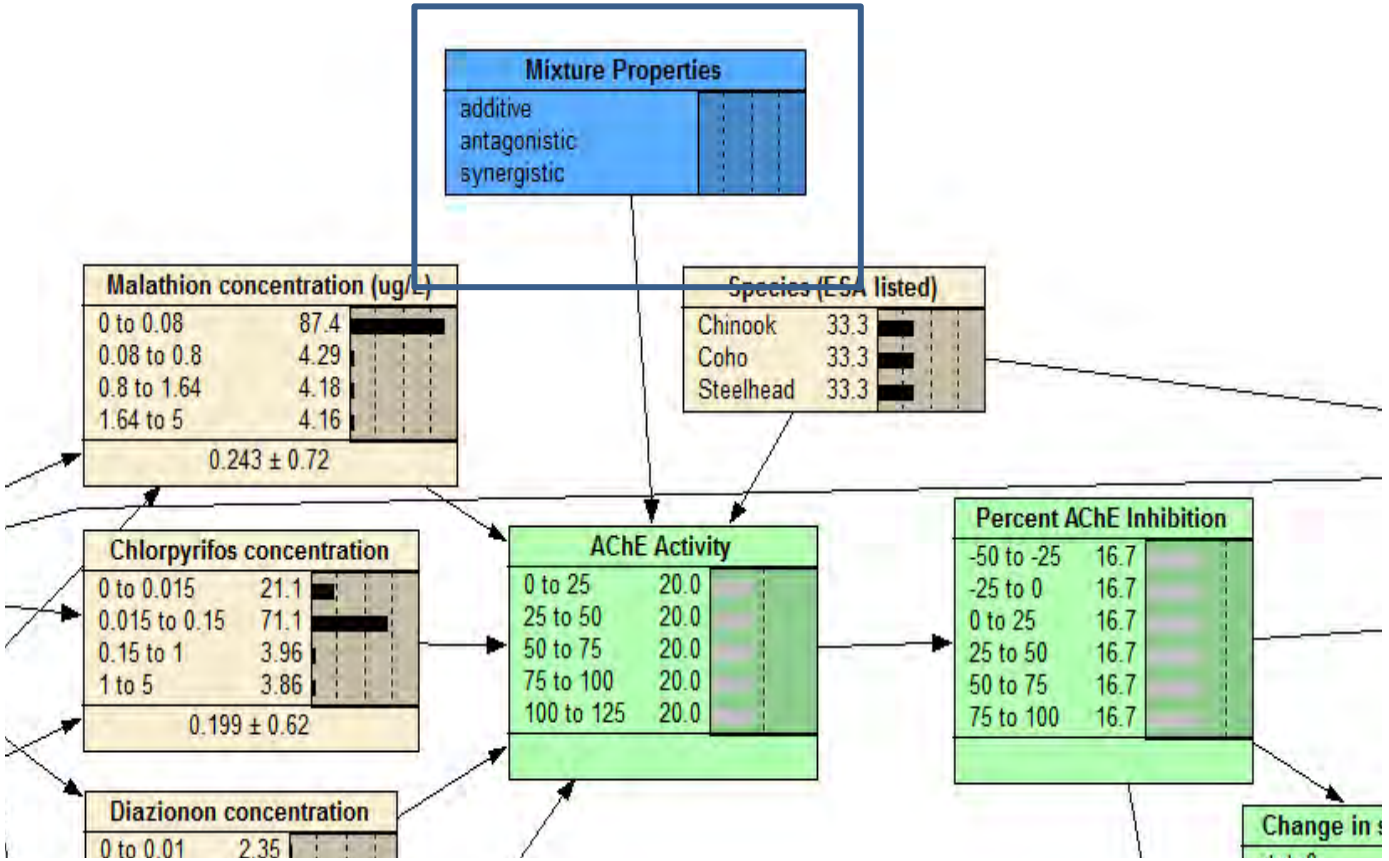
Part of the model describes the environment ….

Ecological Factors



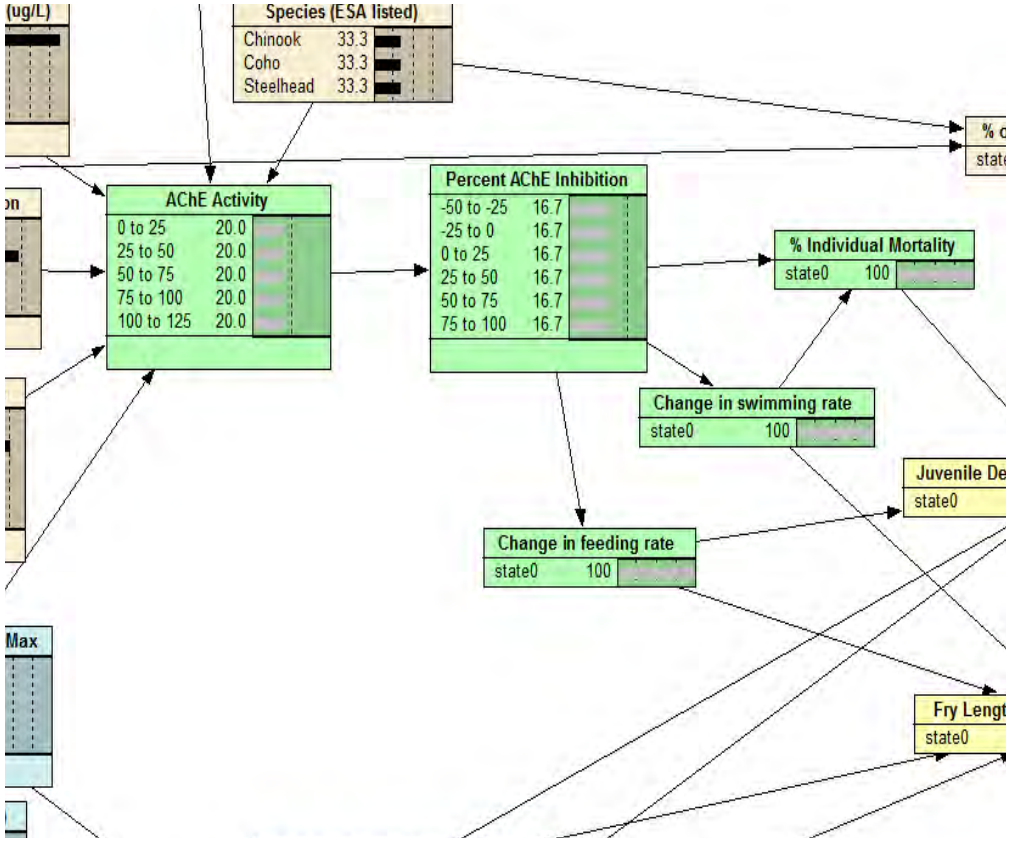
Mixtures of Pesticides do result in synergistic Interactions

Synergistic relationships may be accounted for already in the d-r curves or this node can be used to "set" whether each relationship is additive, synergistic, or antagonistic.



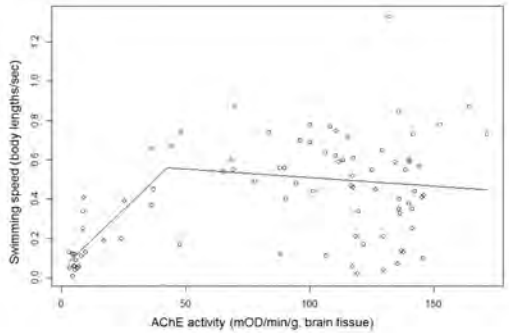
Interactions of the pesticides with the AOP

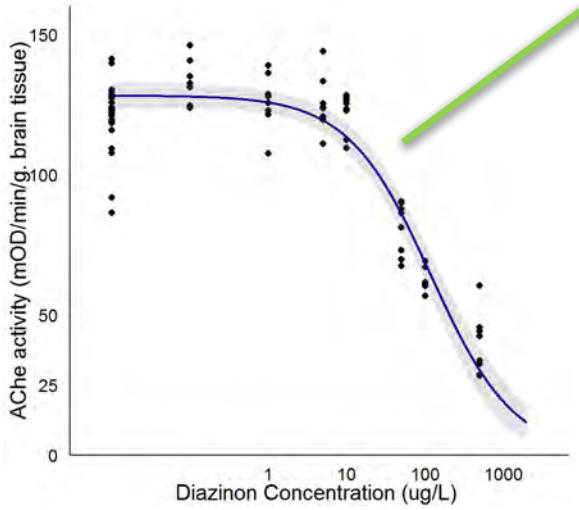
The conversion from chemical concentration to effects incorporate exposure-response curves for AChE inhibition (Diazinon illustrated), inhibition versus physiological effect (swimming rate illustrated) and finally a factor for the mixture effects of the three OPs).

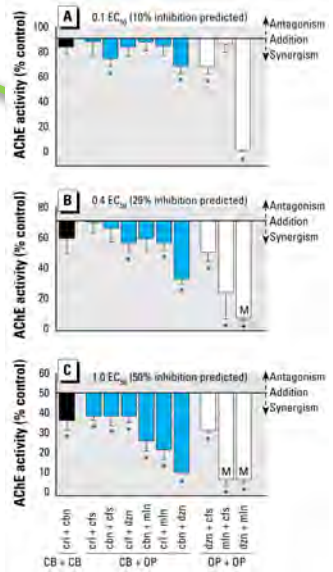


Exposure-Response relationship

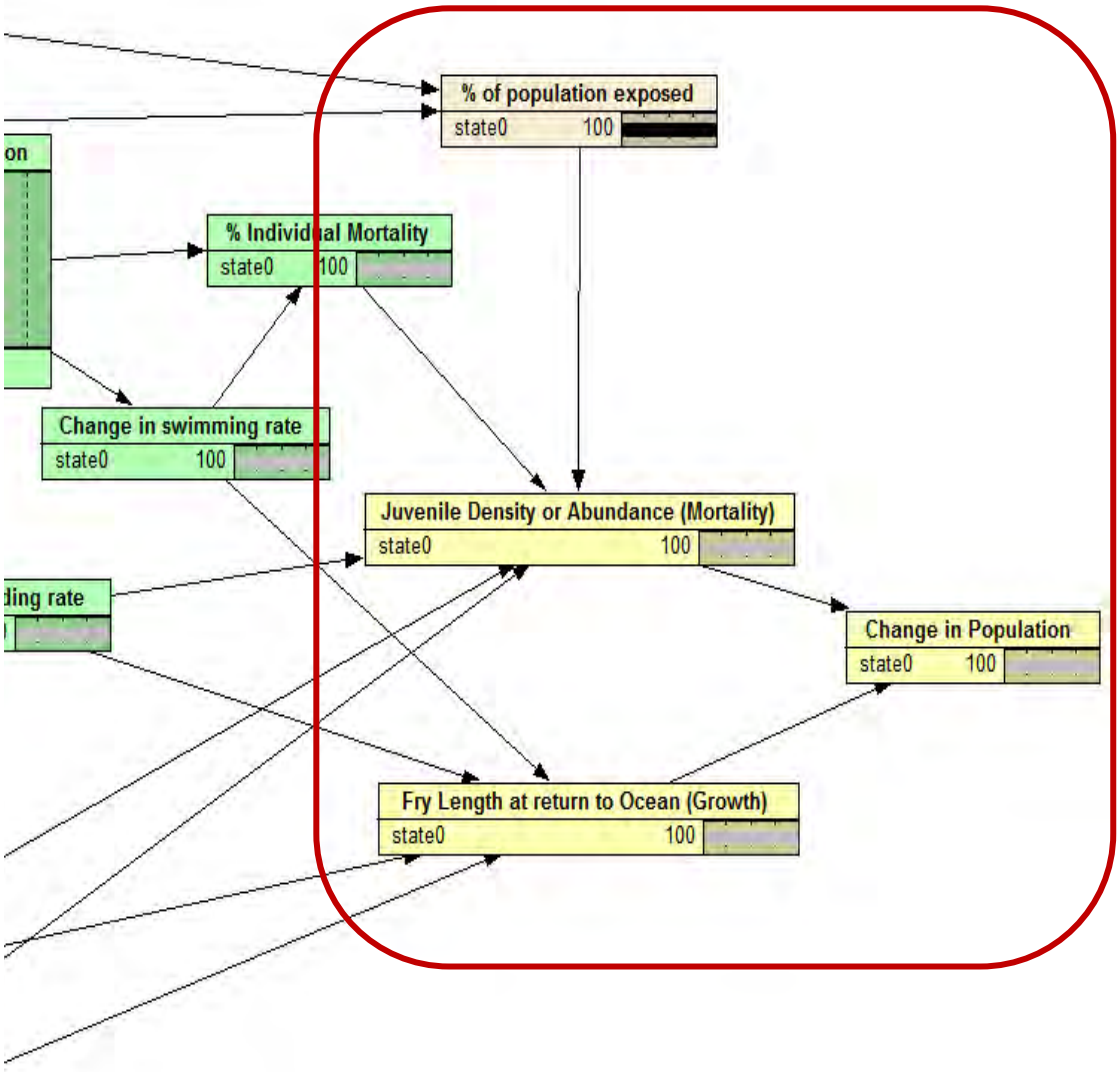
Exposure-response models-from Laetz et al 2009 and other datasets. Combines AChE inhibition, swimming and synergism.







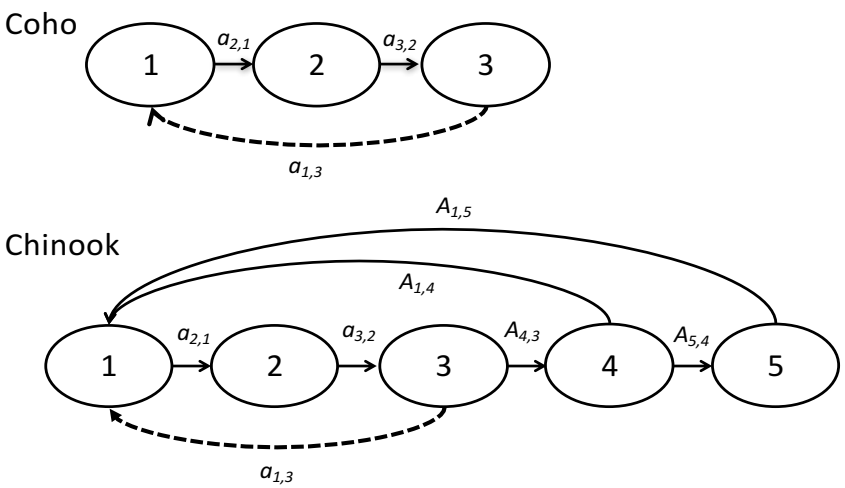
Population Parameters



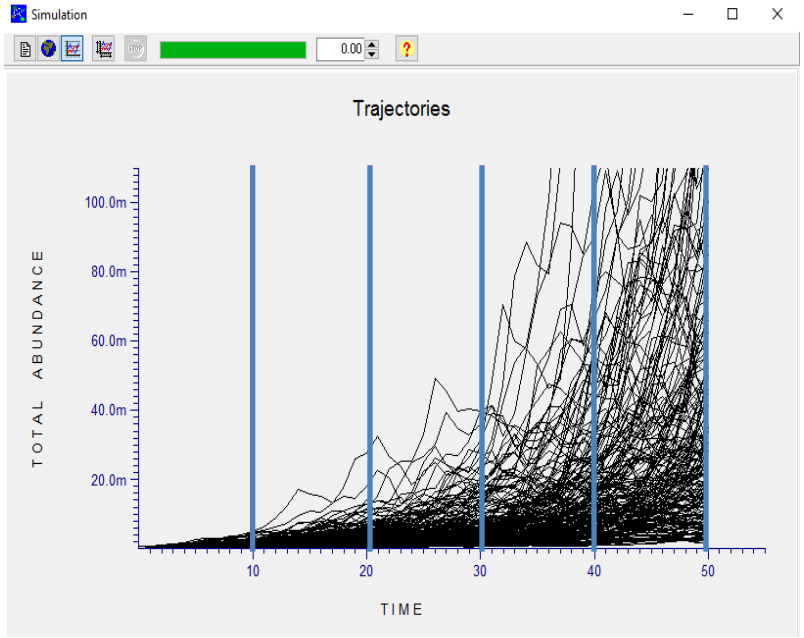
Now for the population modeling turning abundance and fry length into population dynamics.

RAMAS modeling to produce population trajectories-an example from Coho and Chinook

Population model based on Baldwin et al (2009) and Spromberg and Scholz (2011) to estimate changes in population and patches



Baldwin et al 2009



Individual trajectories from the same initial conditions used to set the conditional probability tables.

Update

We have run the latest model for one pesticide at at time.

Toxicology and the Environment are important variables the rank of importance changes with location, season and the time into the future.

The full story in May 2017 at SETAC Brussels.