

South River Mercury Project: Putting it All Together

John W. Green, Ph.D, Ph.D

Principal Consultant: Biostatistics

DuPont Applied Statistics Group

Available Data

- **Animal Tissue**
- **Plant Tissue**
- **Soils**
- **River**
- **Habitat**
- **Loading**
- **Extraction**

Animal Tissue Data

- **Fish**
 - sunfish, bass, sucker, trout, catfish, carp, darter, minnow
- **Aquatics Invertebrates**
 - crayfish, clams, 14 other species Herbivores (trichoptera , ephemeroptera, diptera, etc)
- **Terrestrial Invertebrates**
 - Detritivores (earthworm)
 - Predators (spiders)
- **Birds**
 - 30 species (water fowl and terrestrial, nesting and migratory, predatory and non-predatory)
- **Mammals**
 - bats, others
- **Reptiles and amphibians**
 - toads, frogs, salamanders, turtles, others
- **All samples have GIS coordinates, dates**

Plant Data

- **Garden study (vegetables)**
- **Algae, periphyton**
- **Aquatic plants**
- **Other terrestrial plants (??)**

Soil Data

- **Floodplain sample 2007**
- **Previous floodplain samples**
- **Garden soil samples**
- **Soils from earthworm study**
- **Riverbank**

River Samples

- **Surface water**
- **Sediment**
- **River bank**
- **Tributaries (surface water)**
- **Flux chamber studies**
- **Discharge (flow rates)**
- **Storm samples**

Habitat

- **Vegetation**
- **Land use**
- **Flooding frequency**
- **Gradient**
- **Slope of riverbank**
- **Volume of sediment deposition**
- **Erosion**
- **Habitat scoring (rapid bio-assessment protocol)**

Loading Data

- **Erosion rates**
- **Loads from erosion**
- **Pizzuto data (erosion rates and Hg loads from bank erosion)**

Extraction Data

- **Rate of mercury levels coming out of soils vs from sediments**
 - **Data indicates rate of extraction from soils is faster than from sediments**
 - **Relevant to source of mercury to river**

Current Statistical Analyses

- **Animal tissue**
 - Fish, other aquatic species
- **Plant tissue**
 - Algae, vegetables (garden study)
- **River samples**
 - Surface water, sediment
- **Soil samples**
 - 2007 Floodplain study

Animal Tissue Models

- **Fish:**
 - ANCOVA modeling year, RRM (sampling station), adjusting for fish size
 - Separately by species
 - Identified hot spots (e.g., Dooms, Crimora), annual variations, trends in time and RRM
- **Clams, crayfish, other aquatic species**
 - Correlations among species
 - Principal component analysis
 - Identified influence of habitat, storm, discharge rates, vegetation, sediment and water column Hg levels, seasons on animal tissue levels

Plant Tissue Models

- **Algae, periphyton**
 - **Correlations with other animal and plant species, sediment and surface water Hg levels**
 - **Principal component analysis**
 - **Identified influence of habitat, storm, discharge rates, vegetation, sediment and water column Hg levels, seasons on animal tissue levels**
- **Garden Study**
 - **ANCOVA**
 - **Relates Hg level in vegetables to soil Hg level**
 - **Assess uptake rate of Hg from soil by veg. type**

River Sample Statistics

- **Correlations among sediment and water Hg levels, animal and plant species, other chemical analytes**
- **Principal component analysis of water column and sediment**
 - **Identified influence of habitat, storm, discharge rates, vegetation, seasons, year, other analytes**

Soil Sample Models

- **Regression models relating Hg level in surface THg and MeHg to**
 - **Flooding frequency**
 - **Landuse**
 - **Distance from river**
 - **Elevation**
 - **Soil composition**
 - **RRM**

Expanded Soil Sample Model

- **More sophisticated predictive spatial regression/kriging models being developed**
 - **Relating Hg level in surface THg and MeHg to same explanatory variables allowing quantification of Hg burden and predicting hot spots**

Grand Soil Sample Model

- **Extend the above methodology to bring in influences of river features (e.g., meanders), correlate with terrestrial animal and plant tissue samples, other habitat info**
 - **PC analysis will be one addition**
 - **Relating Hg level in surface THg and MeHg to same explanatory variables allowing quantification of Hg burden and predicting hot spots**

Expanded River Model

- **Expand previous PC models for water column, sediment, aquatic plant and animal species to**
 - **Include floodplain results, river bank data, river features (e.g., meanders), GIS coordinates, other terrestrial samples**
 - **Correlate terrestrial and river samples**
 - **Include possibility of spatial/temporal lags**
 - **Develop best overall understanding of Hg burden in the river**

Questions

- **Are floodplain samples correlated with river samples?**
 - Informal analysis says yes. Comprehensive model should refine this apparent connection.
- **Where are the hot spots?**
 - Can we account for them?
 - Current river and floodplain models identify some hot spots.
 - Comprehensive model needed to correlate results and incorporate other types of data
- **Are terrestrial animal samples correlated with floodplain samples?**

Questions

- **What is mercury burden in the floodplain?**
 - Current floodplain model does not address this.
 - Spatial / krieging model being developed
 - That or grand soil sample model should answer
- **What seasonal/annual variations exist in animal, floodplain, water, sediment samples?**
 - **Current river models address last two items.**
 - **Comprehensive model may refine understanding**
 - **Seasonal/annual data not available on some sources**
 - **What would such variation tell us?**

Questions

- **Is there evidence of storm action in Hg levels in water, floodplain?**
 - **Current river models address this**
 - **Expanded models bring other information**
 - **We have some data not available when earlier river model was developed**
 - **Storm data on floodplain and terrestrial animals limited**

Questions

- **Is there evidence of Hg in wetlands, tribs, riverbanks as sources?**
 - **Floodplain data suggests wetlands not major source of Hg to river**
 - **Trib data primarily surface water concentrations in low volume**
 - **Riverbank data may be important**
 - **Preliminary results suggests this as possible major source of Hg to river.**

Grand Model

- **Multivariate response spatial/temporal regression model with**
 - water, sediment, soil, animal, plant Hg levels as responses
 - other factors identified above as explanatory variables
 - tied together with food web model
- **to**
 - Obtain comprehensive relationships among results
 - Relate hot spots to recognizable environmental features
 - e.g., habitat, discharge rates, seasons
 - Estimate of Hg burden on ecosystem
 - Correlate THg to MeHg

NOTE: Multivariate approach presents serious challenges*

***Missing data patterns will not allow unified model for all species**

Grand Model

- **Principal Component Analysis**
 - Tool to reduce dimensionality of problem, identify collinearities, and stabilize model
 - Identify key variables in regression model
- **Use grand model or species-specific models and toxicity data from literature to understand Hg impact on animals**

Grand Model

- **Probabilistic risk assessment (PRA) exposure and hazard models**
 - **quantify the uncertainties regarding**
 - **Hg burden in the environment**
 - **potential for harm to animals (including humans)**
 - **Newman's food web models will be basis for PRA approach re animal species**
 - **“Grand” model may be input to PRA**

Conclusion

- **Models will help evaluate the impact of possible actions, e.g.,**
 - **Will “removal” of meanders (e.g., Oxbow) as source reduce Hg levels in river?**
 - **Will “removal” of riverbanks (*in toto* or selectively) as source reduce Hg levels in river?**