South River Mercury Project: Putting it All Together

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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/krieging 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 developed for estimations
  - 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?**