Designing an Integrative Monitoring and Modeling Program of the Environmental Response to Changing Mercury Deposition to North America

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Considerations in Study Design

- The Source of the Change in Deposition. The detection of change in local/regional/continental deposition due to anthropogenic inputs can be confounded by changes in natural emissions or re-emission; of by changes in other parts of the globe. Multiple sites are therefore needed.
- Timing of Detecting Change. Timescales of response to changes in atmospheric deposition will differ for different metrics and are not well known, and may differ for different ecosystems. Indicators need to respond on a variety of timescales
- Site Location Differences. These need to be considered, as detailed above
- Modeling will be an important part of integration and future projection of the information obtained. Consideration needs to be given to the modeler's wants
- Indicator Criteria are needed to choose scientifically rational indicators

The Indicators

Indicators should be:

- Comparable across ecosystems
- Integrate variability in space and time
- Relatively simple to interpret
- Easy to sample, process and analyze
- Already measured or part of existing databases
- Responsive to Hg loading on a relatively short timescale
- Detect, or reflect, changes in MeHg production
- Reflect changes in exposure

Not just measuring mercury. Goal is to assess changes in mercury concentrations in important environmental "compartments"

AND

to differentiate those changes from the effects of other environmental changes (e.g. wetland destruction/restoration, sulfate deposition, etc.)

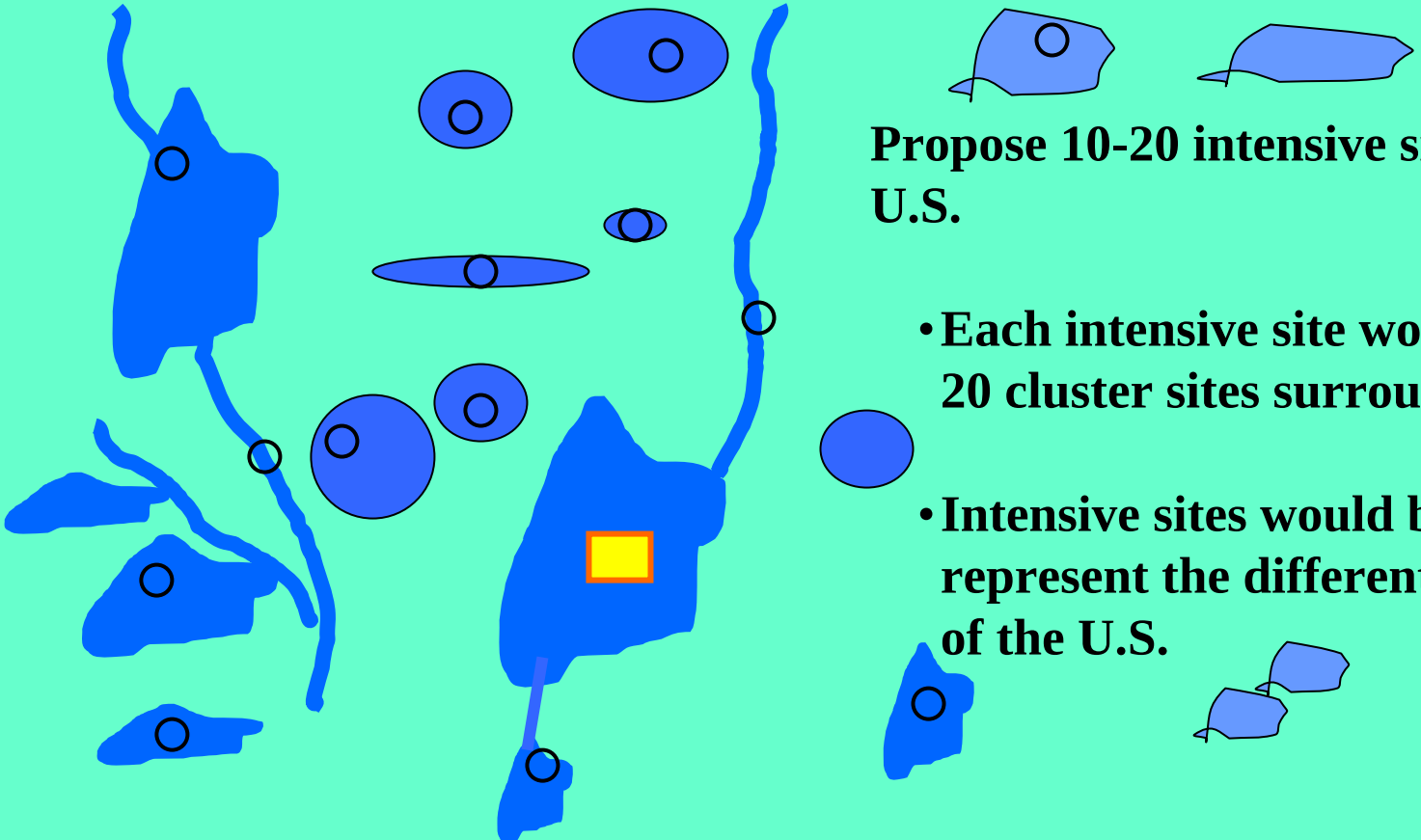
From Mason et al. (2005)

From Mason et al. (2005)

Proposed Design

Propose a combination of "intensive sites" and "cluster sites":

- **Intensive sites are those where detailed studies will be done to track changes and assess the cause of any changes**
- **Cluster sites will allow data from the intensive sites to be extrapolated to a broader area, and extrapolate results of the detailed investigations across ecosystems of similar atmospheric input**



Propose 10-20 intensive sites in the U.S.

- **Each intensive site would have 15-20 cluster sites surrounding it**
- **Intensive sites would be chosen to represent the different ecoregions of the U.S.**

The Indicators

Air & Deposition

- Continuous speciated atmospheric concentrations
- Total wet and dry Hg deposition &flux
- Total Hg weekly wet deposition/flux
- Total and methyl Hg in throughfall
- Total and methyl Hg in litterfall
- Total Hg in snowpack
- Mercury evasion/flux
- Watersheld inputs/yields

Water and Sediment

- Total and MeHg in soil
- Forest floor surveys
- Total and MeHg, %MeHg in sediments (seasonal)
- Instantaneous sediment methylation/demethylation rate
- Total and methyl Hg accumulation in cores
- Total and methyl Hg in surface water (seasonal)
- Water column Hg & MeHg profiles

Indicators in green would be monitored at intensive sites only

Mason et al. (2005)
Harris et al. (2007)

The Indicators, cont.

Aquatic Biota

- Total and MeHg in phyto/zooplankton
- Total and MeHg in estuarine benthic invertebrates
- Total and methyl Hg in whole prey fish (YOY)
- Total Hg in muscle of piscivorous fish

Indicators in green would be monitored at intensive sites only

Wildlife

Total Hg in blood, feathers, eggs (as appropriate)

Potential Indicator Species

- Comparison across habitats: Belted kingfisher
- Terrestrial: Racoon, Bicknell's thrush
- Riverine: Mink
- Lake: Common loon
- Lake/coastal: Herring gull, Common tern
- Wetland: Tree swallow
- Estuarine: Sharp-tailed & seaside sparrows
- Marine nearshore: Harbor porpoise
- Marine off-shore: Storm petrel

Mason et al. (2005)
Harris et al. (2007)

Models

- Atmospheric fate and transport and deposition, exchange at the air-biosphere interface
- Watershed processing and transport to aquatic systems
- Biogeochemical cycling, including net methylation, and ecosystem bioaccumulation
- Health risk assessment
- Global, regional and local scale models are needed

Concluding Remarks

- Change is already occurring, so programs should be initiated ASAP
- Implementing a plan of this nature would allow detection of change in deposition as well as its impact across diverse ecosystems
- An overall monitoring strategy is coupled with focused and definitive study (intensive sites, modeling studies) at a small number of locations to provide enough information to make proper longer-term predictions
- Modeling studies will allow the extrapolation across ecosystems and allow scenario projection. However, model accuracy requires detailed information with spatial and temporal coverage