Organization of Course

INTRODUCTION

1. Course overview
2. Air Toxics overview
3. HYSPLIT overview

HYSPLIT Theory and Practice

4. Meteorology
5. Back Trajectories
6. Concentrations / Deposition
7. HYSPLIT-SV for semivolatiles (e.g, PCDD/F)
8. HYSPLIT-HG for mercury

Overall Project Issues & Examples

9. Emissions Inventories
10. Source-Receptor Post-Processing
11. **Source-Attribution for Deposition**
12. Model Evaluation
13. Model Intercomparison
14. Collaboration Possibilities

What Do We Need to Know, and.
How Well Do We Need to Know It?

**For most policy considerations,
the exact contributions of individual sources
do *not* need to be known.**

It is generally sufficient to know about:

- ❑ **The geographical extent of the problem**
  - relative impact of local, regional, national, continental, and/or global sources
  - don’t need exact answers, e.g., if 70% or 50% of the contributing air sources arise from within 100 km of the Lake – the policy response will be similar in either case.
  - *Only if the estimates are grossly incorrect will policy deliberations be seriously affected.*

- ❑ **Which source categories are the most significant contributors?**
  - don’t need exact answers; e.g., it does not matter that much whether municipal solid waste incinerators contribute 20% or 40% to the deposition – the policy response will likely be very similar.
  - *Again, the estimates will be of little or no use only if they are extremely inaccurate.*

	Case 1: Example PCB's	Case 2: Example PCDD/F
Emissions Inventory Status	**Poorly known**	**Moderately well known**
Comprehensive Modeling Possible?	**No (until inventory developed further)**	**Yes, to a certain extent**
Monitoring Strategy	**Short term upwind-downwind samples near suspected sources**	**Long-term samples at locations away from intense sources**
Modeling Strategy	**Back-trajectory studies to identify possible sources**	**Comprehensive modeling of all sources in inventory**

What Do We Need to Know Regarding Atmospheric Mercury?

Type of Information
Atmospheric deposition*
Source-attribution for deposition
Deposition for historical periods
Deposition for alternative future scenarios

* *consistent with the needs of subsequent analyses (e.g., ecosystem modeling) with respect to spatial, temporal, and "species" resolution (e.g., Hg(0) vs. RGM vs. Hg(p))*

Atmospheric Modeling and Uncertainties

Emissions

- Each individual source is uncertain
- Need emissions inventories to do modeling
- Need inventories even if not doing modeling!
- We can do much more
- *For most pollutants, the largest source of uncertainty*

⇩

Meteorology

- Spatial and Temporal Resolution is key
- Coarse (e.g., 180 km) vs. fine data (e.g., 5 km)
- Need a better and more accessible archiving system

⇩

Simulation of Dispersion

- Lagrangian, Eulerian, and Hybrid approaches

⇩

Chemical and Physical Transformations

- Aqueous phase, surface phase, vapor phase processes
- Thus, phase partitioning is very important
- Photolysis
- Vapor-phase hydroxyl radical reaction
- Other reactions

⇩

Deposition Processes

- Precipitation is highly non-uniform
- Dry deposition depends on surface conditions
- For some compounds, net gas exchange – depends surface concentration of pollutant
- Vapor/particle partitioning; particle deposition uncertain

⇩

Ambient Monitoring Data for Model Evaluation

- crucial!
- but not enough collected...
- better if collected away from immediate vicinity of sources

⇩

Predicted Deposition

- Source-Receptor Information preserved in modeling?
- What is overall uncertainty in predicted deposition?

HYSPLIT Source-Attribution Overview

Overall Project Structure:

- Pick time period for modeling (usually one single year), based on availability of emissions inventory data, meteorological data, and ambient monitoring data for "ground truthing"

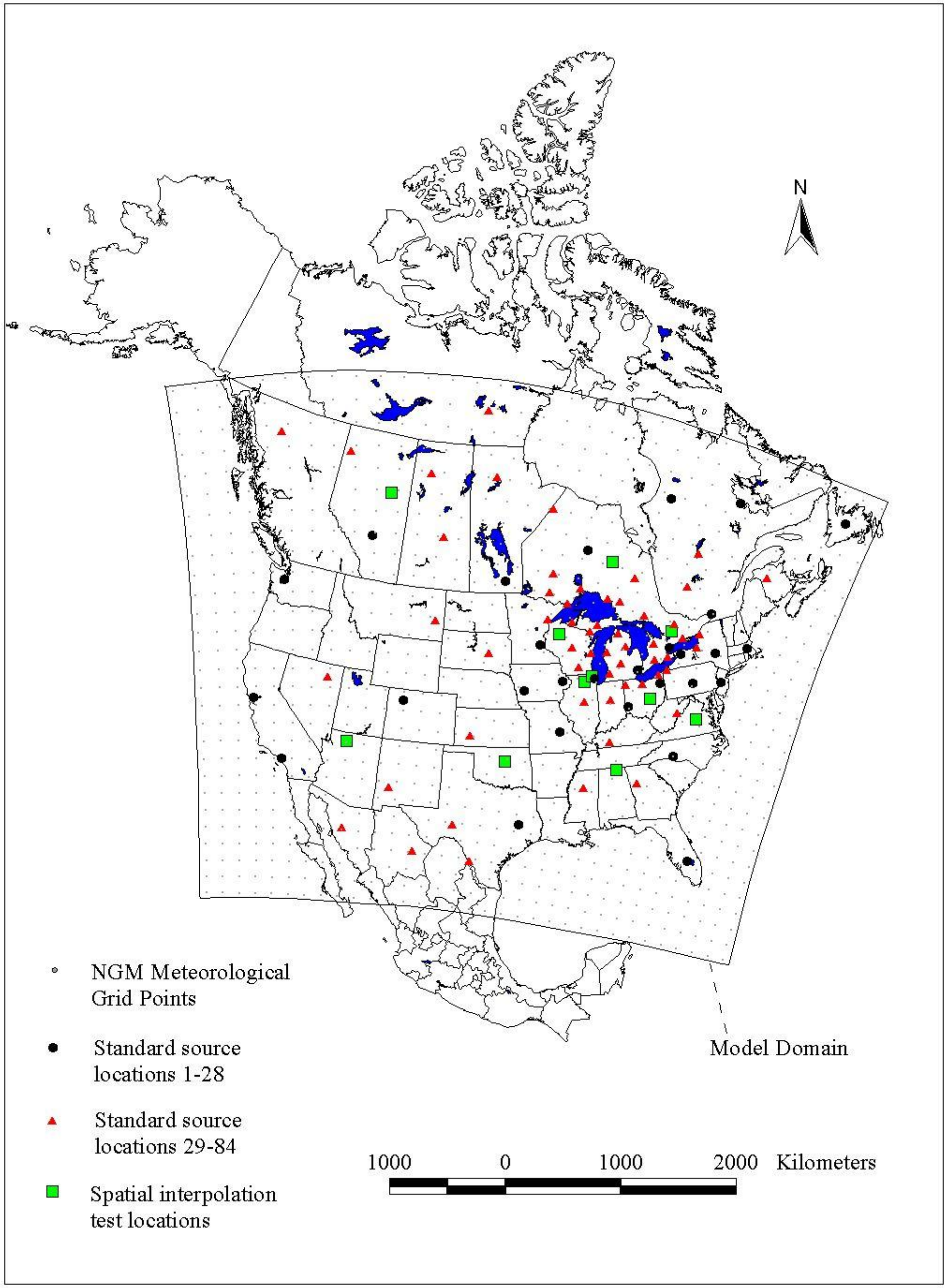
- Pick receptors of interest – these are hardwired into HYSPLIT

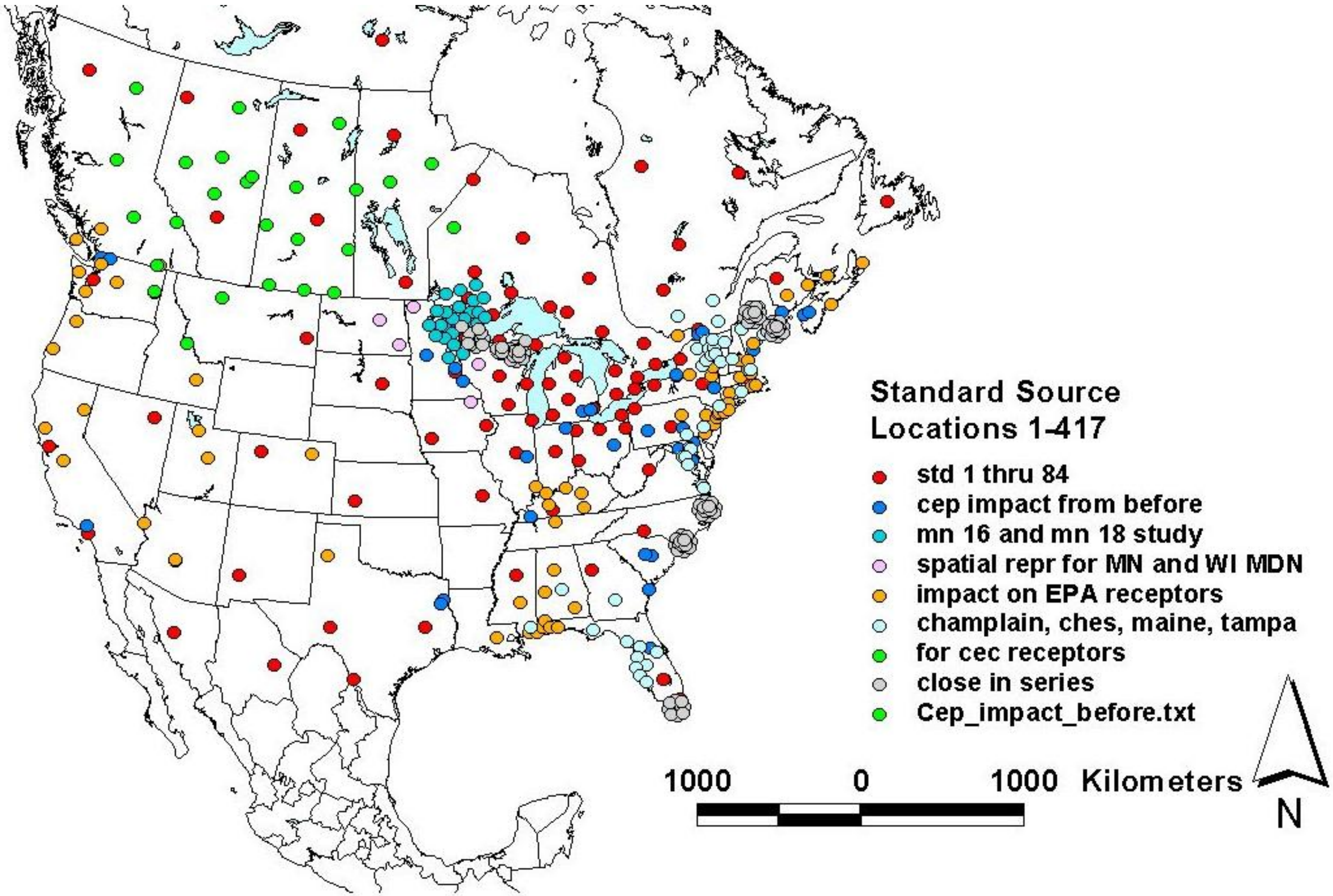
- Perform simulations from numerous real and hypothetical single sources throughout the modeling domain, for a range of species being modeled, keeping track of the deposition to selected receptors

- Using interpolation techniques, combine the above results with the actual emissions inventory to estimate the contribution of each source in the inventory to each of the receptors

- Also, estimate total deposition and concentrations at monitoring sites, and compare with actual measurements to gauge the overall modeling accuracy

- If accuracy is acceptable, report source-attribution results


N
NGM Meteorological Grid Points
Standard source locations 1-28
Standard source locations 29-84
Spatial interpolation test locations
Model Domain
1000 0 1000 2000 Kilometers


Standard Source
Locations 1-417
std 1 thru 84
cep impact from before
mn 16 and mn 18 study
spatial repr for MN and WI MDN
impact on EPA receptors
champlain, ches, maine, tampa
for cec receptors
close in series
Cep_impact_before.txt
1000
0
1000
Kilometers
N

Some Overall Mercury Modeling Results

- **Modeling domain: North America**

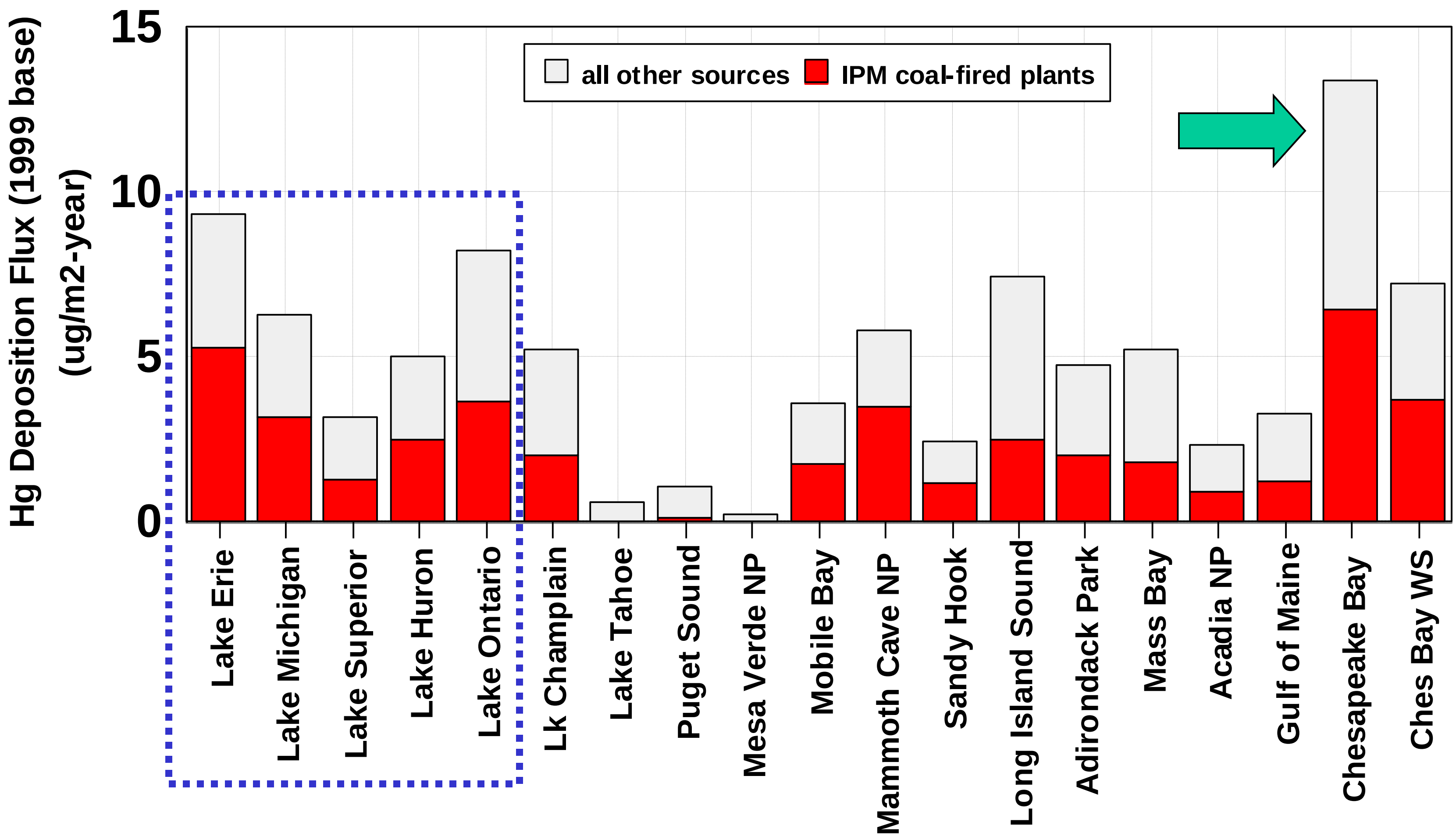
- **U.S. and Canadian anthropogenic sources**

- **1996 meterology**

- **Model evaluation:**
  - **1996 emissions**
  - **1996 monitoring data**

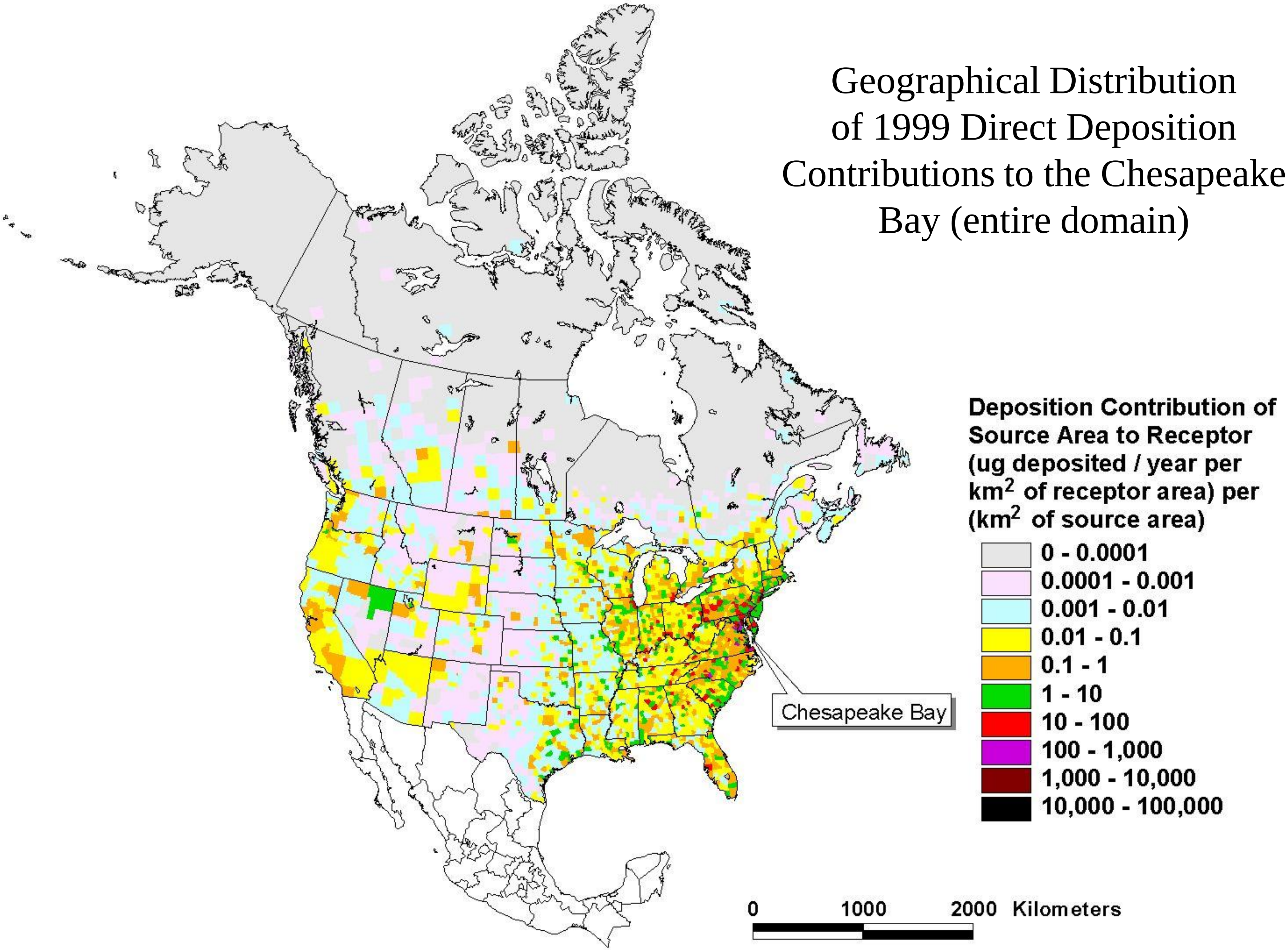
- **Results: 1999 emissions**

Mercury deposition at selected receptors arising from 1999 base-case emissions from anthropogenic sources in the United States and Canada
(IPM coal fired plants are large coal-fired plants in the U.S. only)

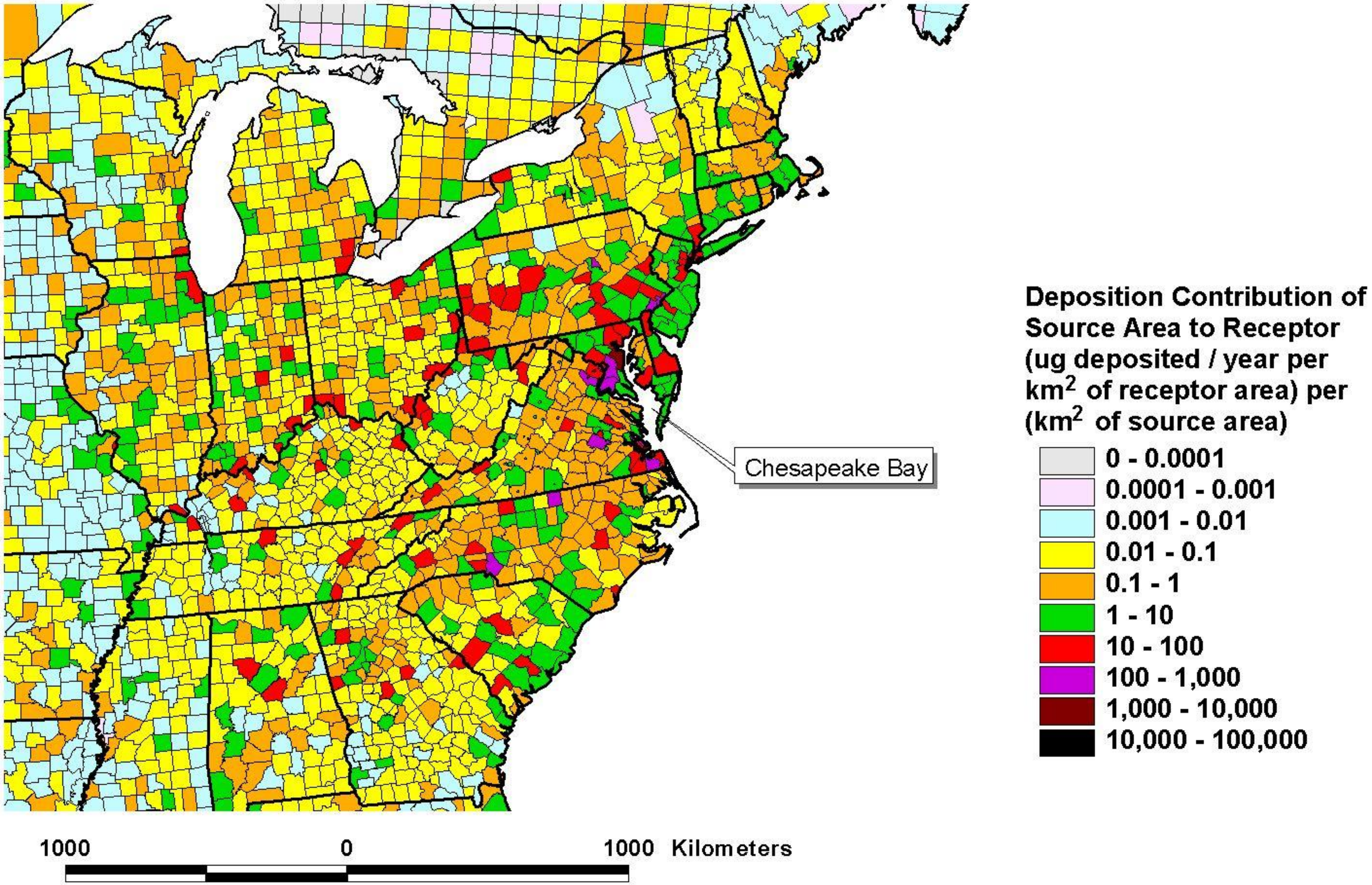


Example of Detailed Results: 1999 Results for Chesapeake Bay

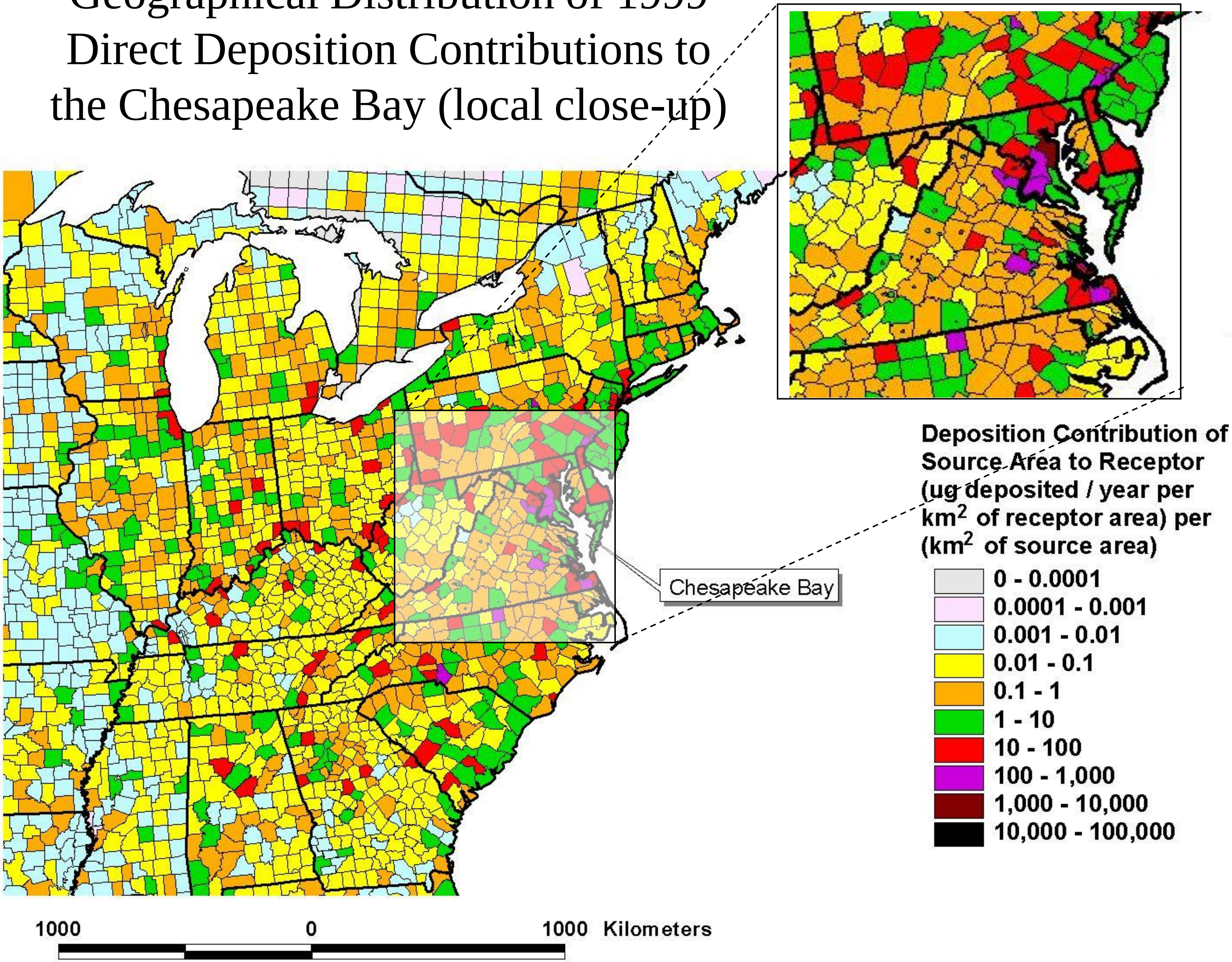
Geographical Distribution of 1999 Direct Deposition Contributions to the Chesapeake Bay (entire domain)



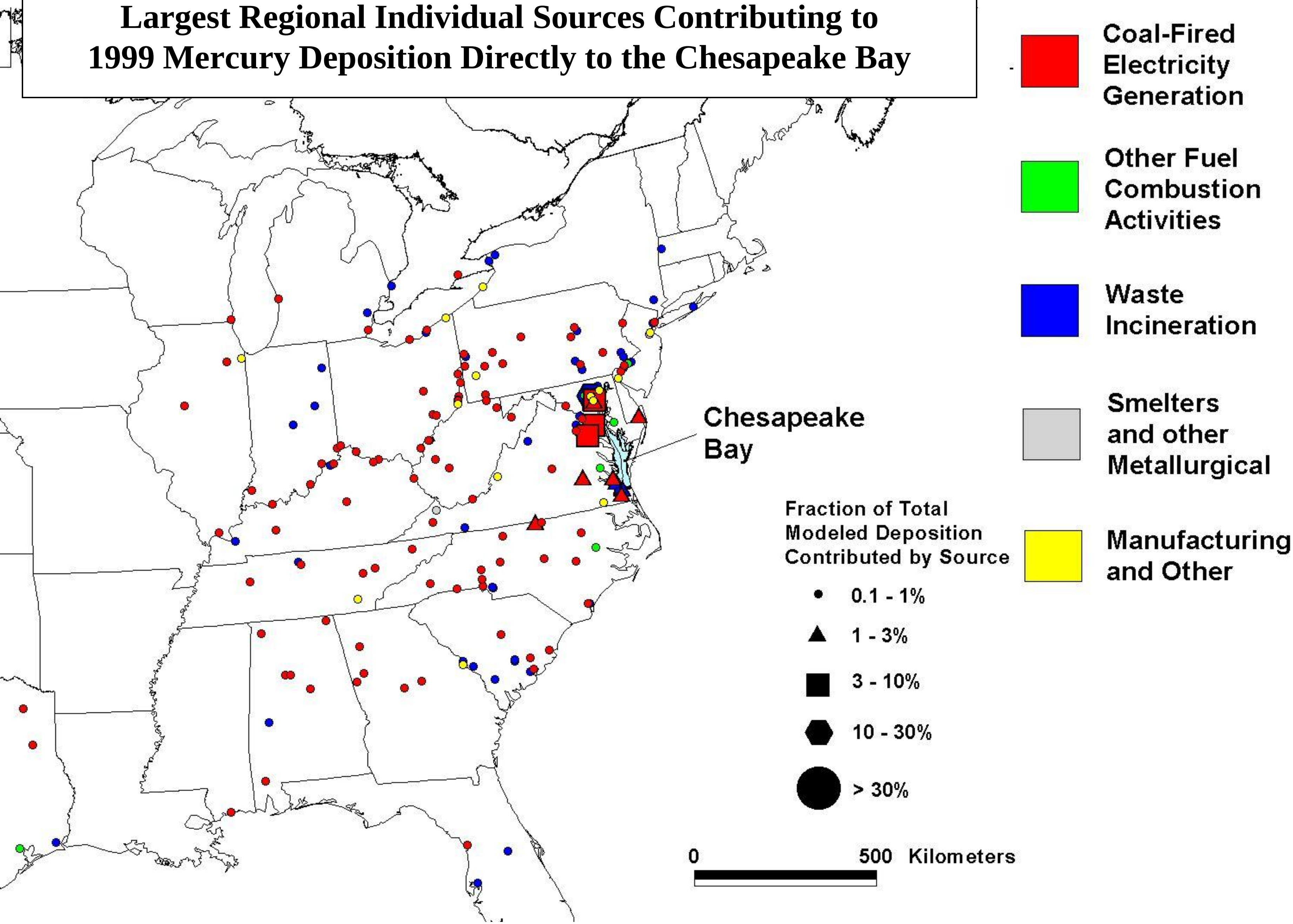
Geographical Distribution of 1999 Direct Deposition Contributions to the Chesapeake Bay (regional close-up)



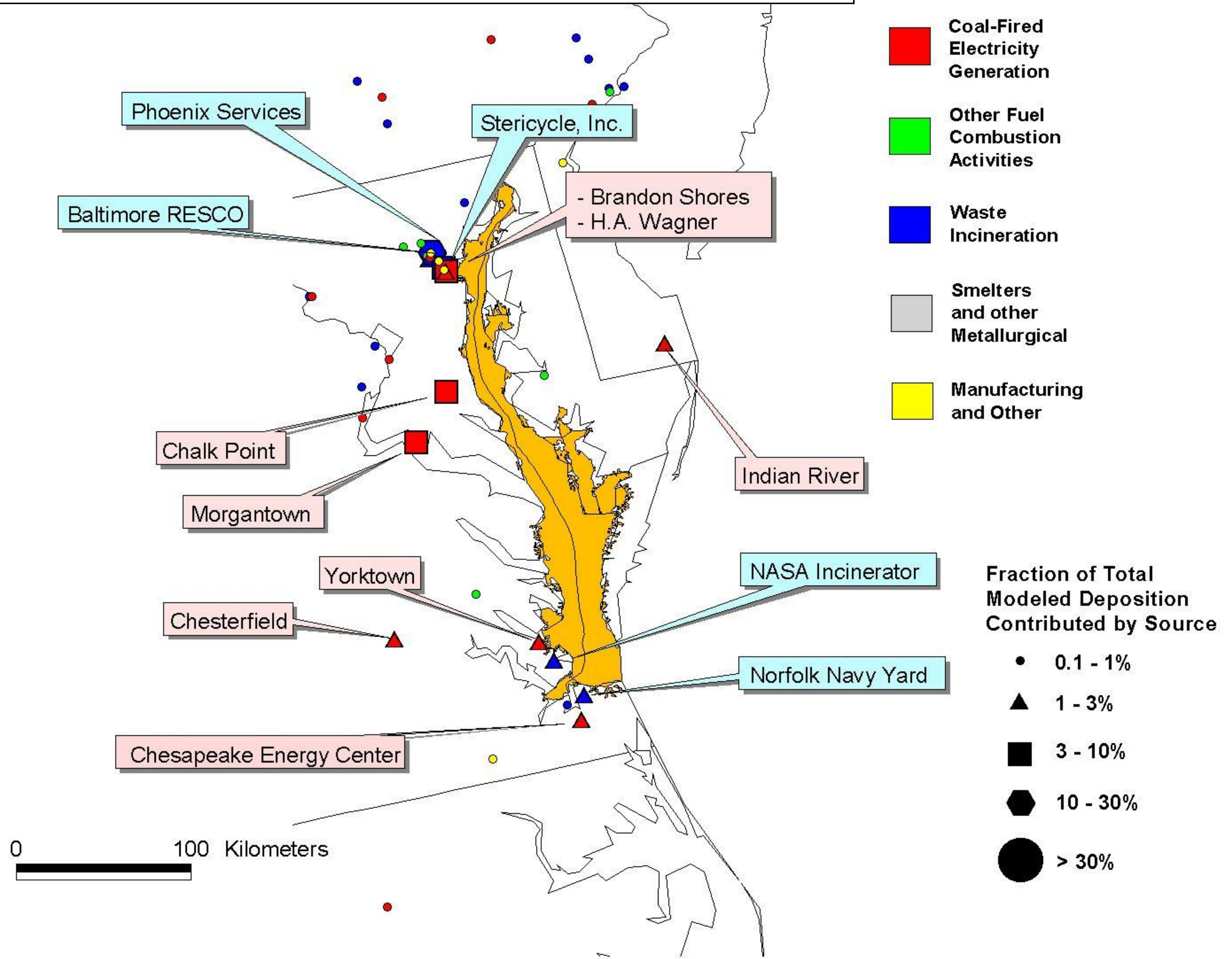
Geographical Distribution of 1999 Direct Deposition Contributions to the Chesapeake Bay (local close-up)



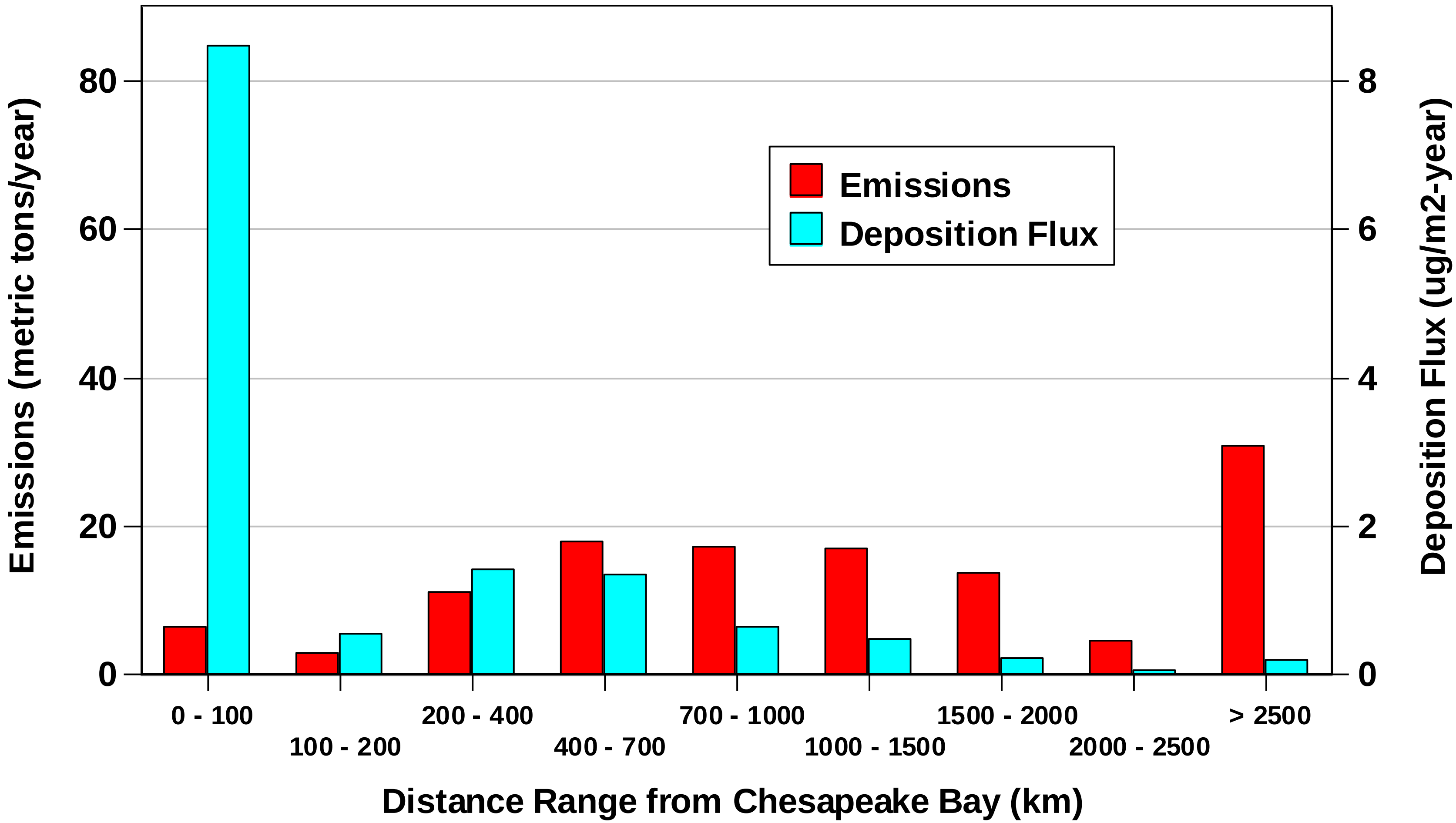
Largest Regional Individual Sources Contributing to 1999 Mercury Deposition Directly to the Chesapeake Bay

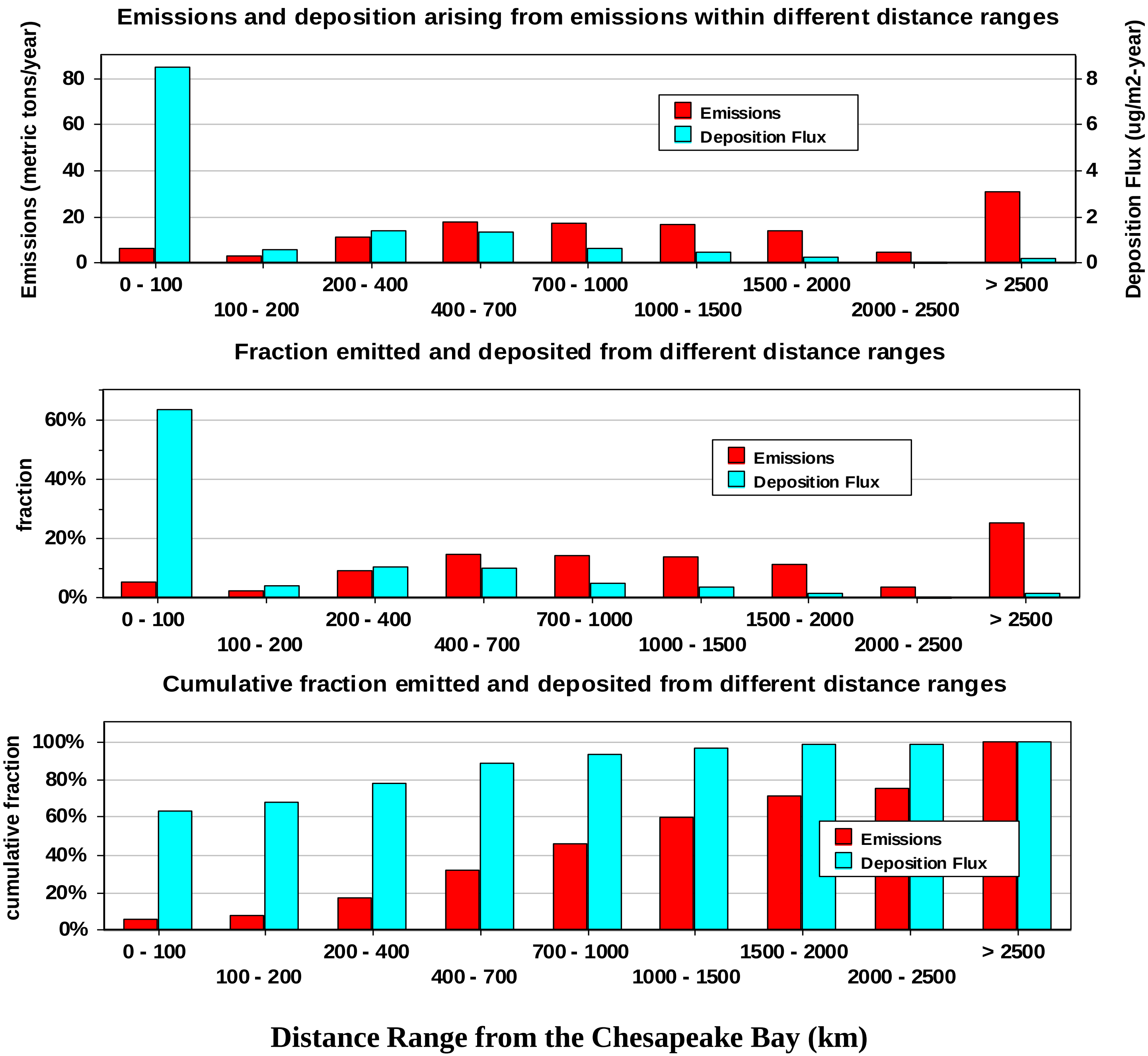


Largest Local Individual Sources Contributing to 1999 Mercury Deposition Directly to the Chesapeake Bay

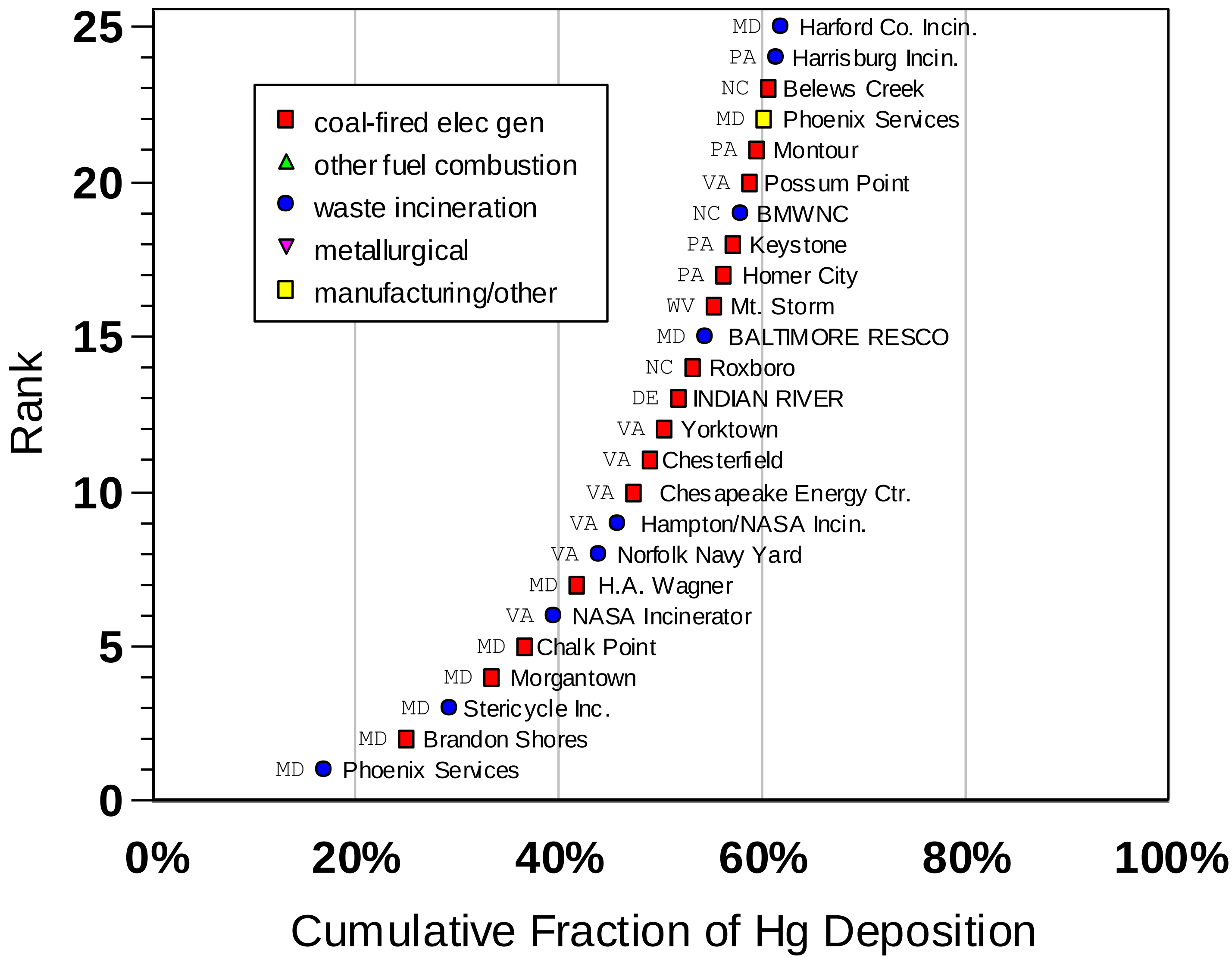


Emissions and Direct Deposition Contributions from Different Distance Ranges Away From the Chesapeake Bay

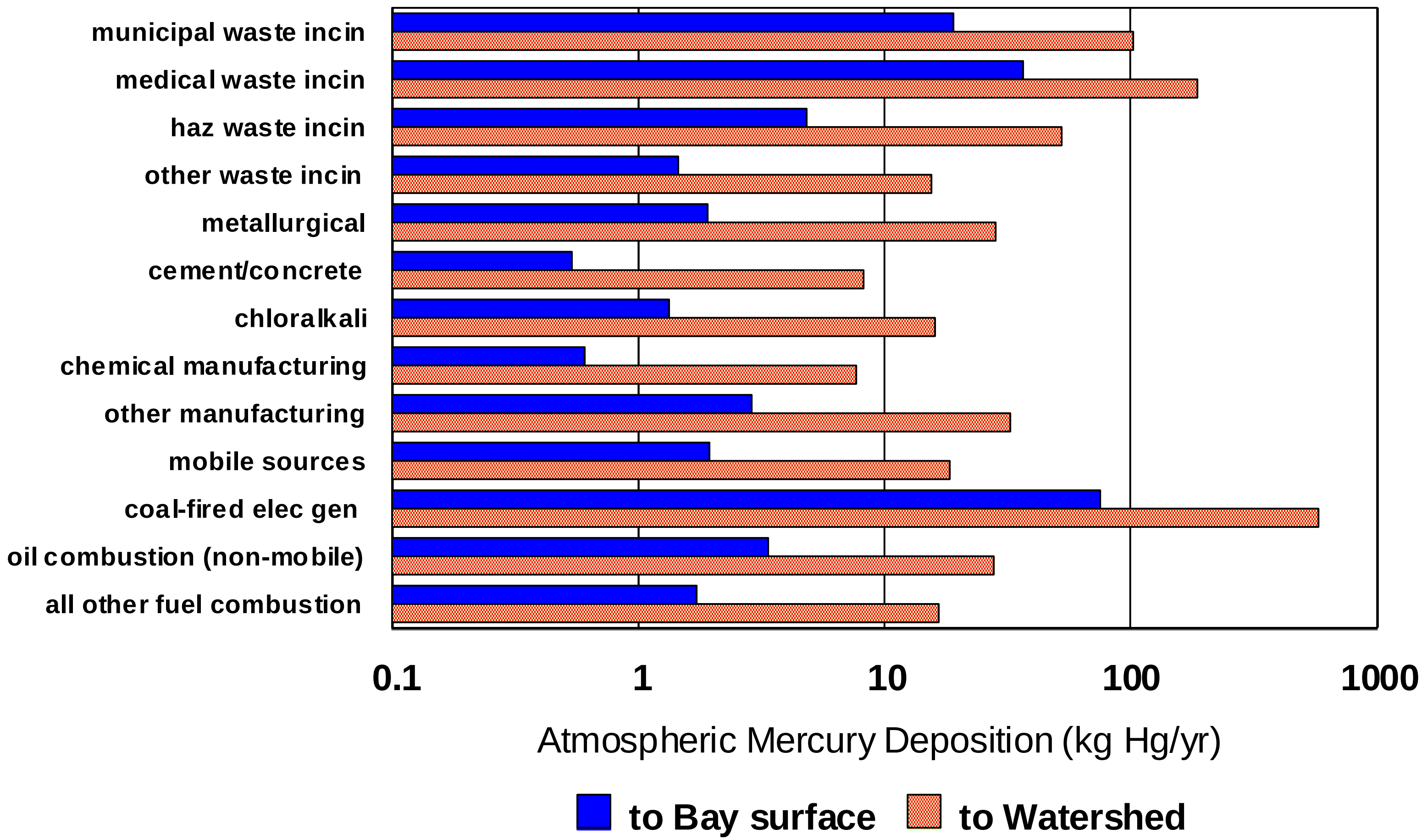



Emissions and deposition arising from emissions within different distance ranges
Emissions (metric tons/year)
Deposition Flux (ug/m2-year)
Emissions
Deposition Flux
0 - 100
100 - 200
200 - 400
400 - 700
700 - 1000
1000 - 1500
1500 - 2000
2000 - 2500
> 2500
Fraction emitted and deposited from different distance ranges
fraction
Cumulative fraction emitted and deposited from different distance ranges
cumulative fraction
Distance Range from the Chesapeake Bay (km)

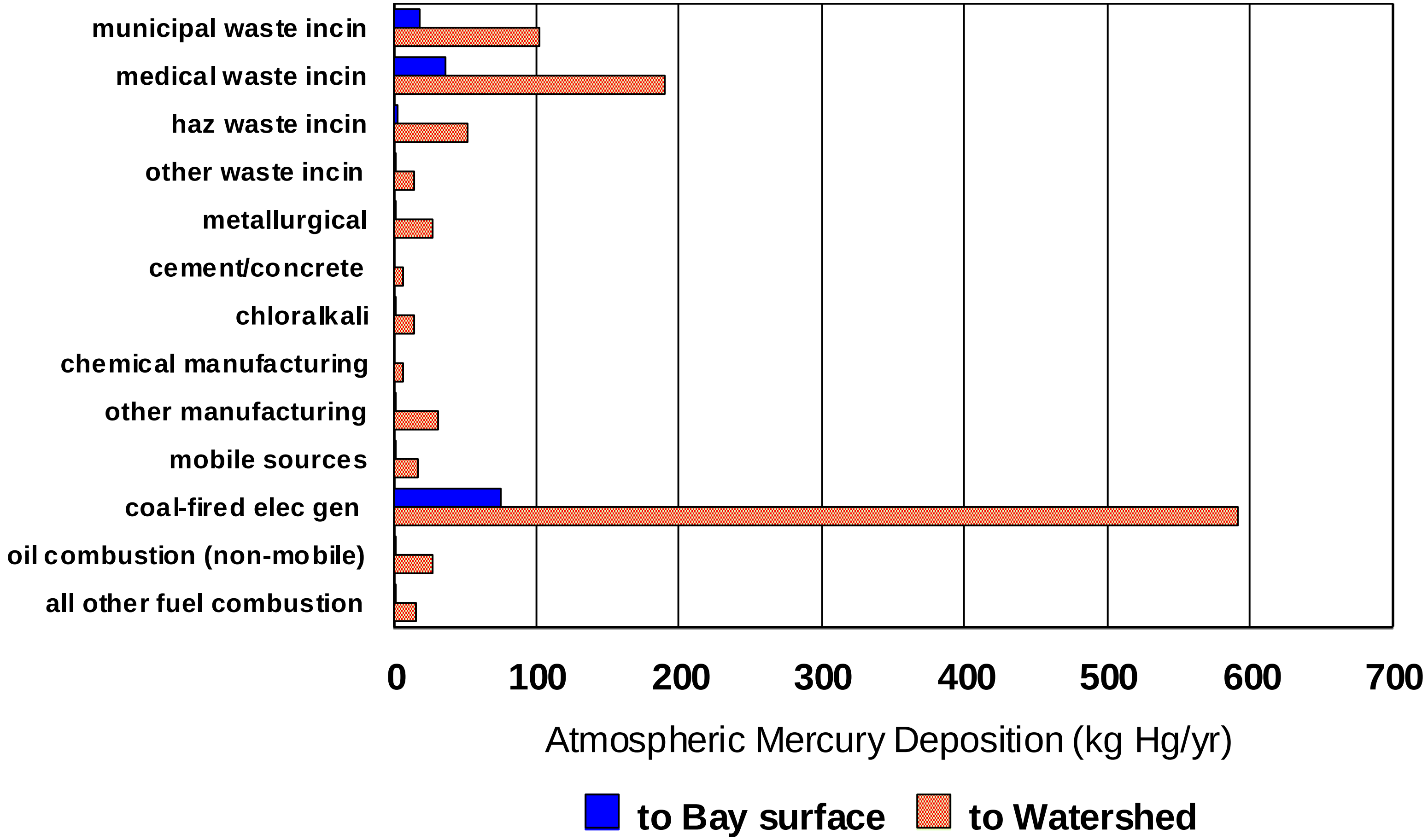
Top 25 Contributors to 1999 Hg Deposition Directly to the Chesapeake Bay



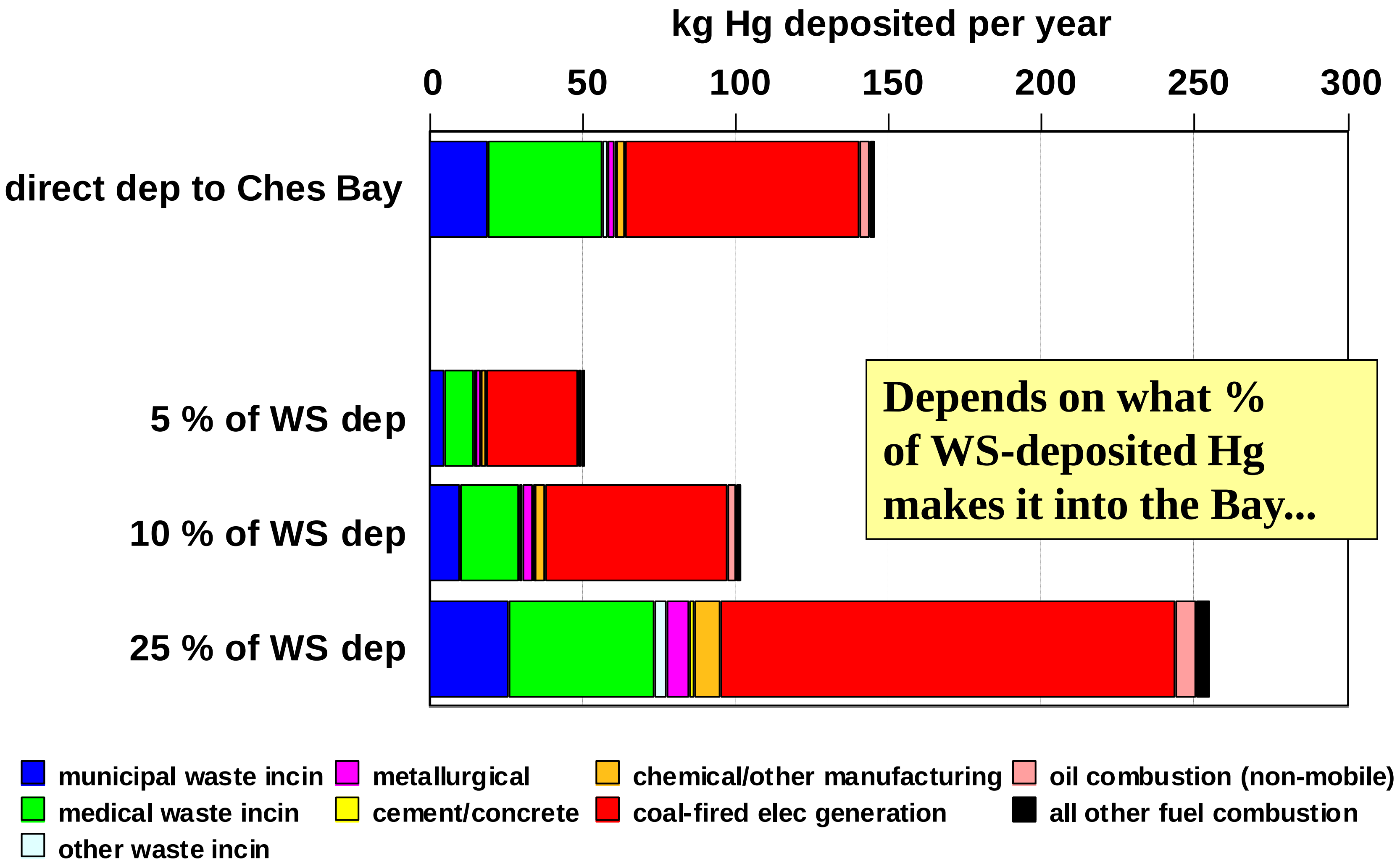
Deposition to the Chesapeake Bay and to its Watershed (~1999) (logarithmic graph)



Deposition to the Chesapeake Bay and to its Watershed (~1999) (linear graph)

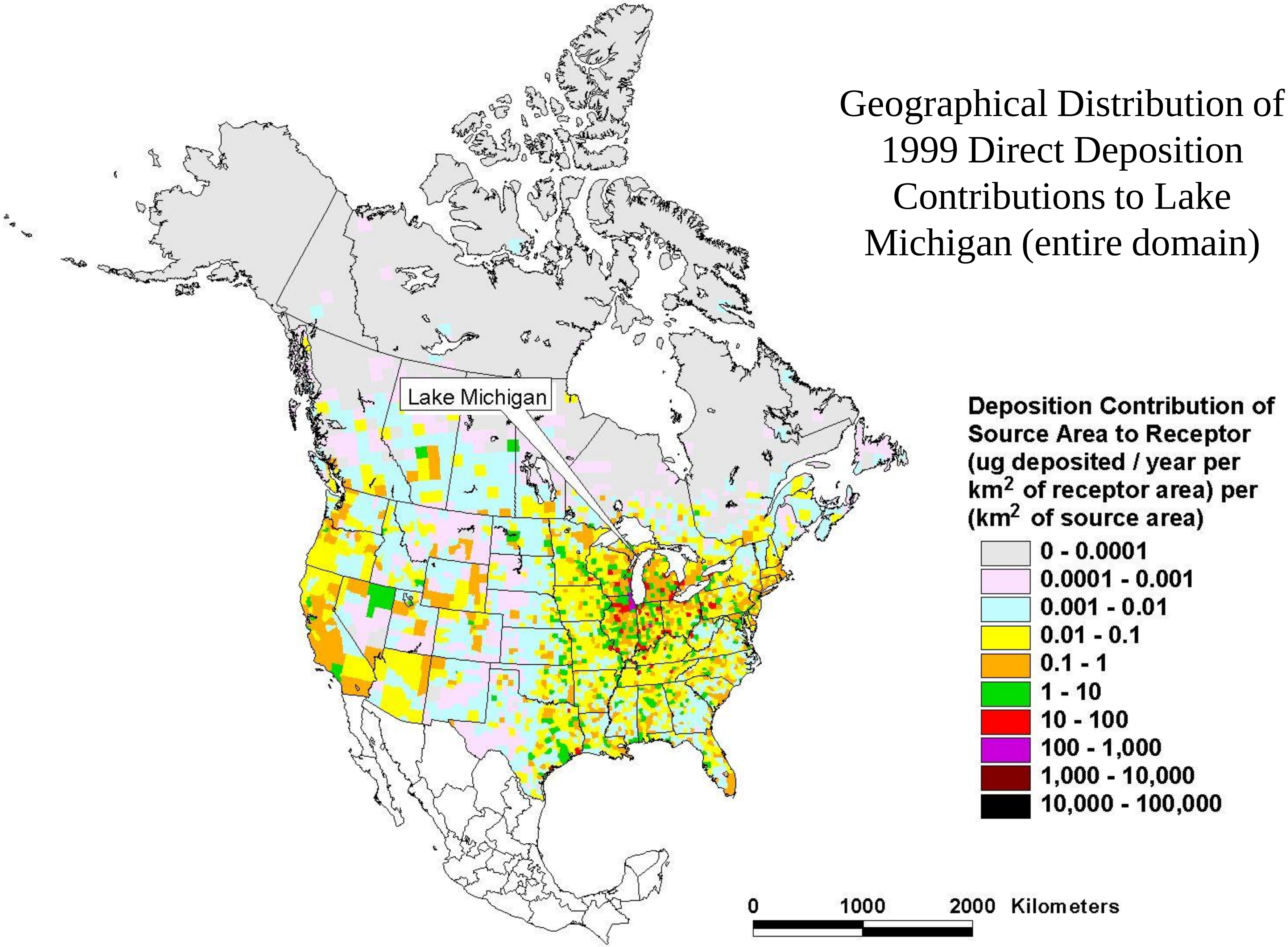


What is Relative Importance of Hg Deposited Directly to Chesapeake Bay Surface vs. Deposition to Watershed (?)

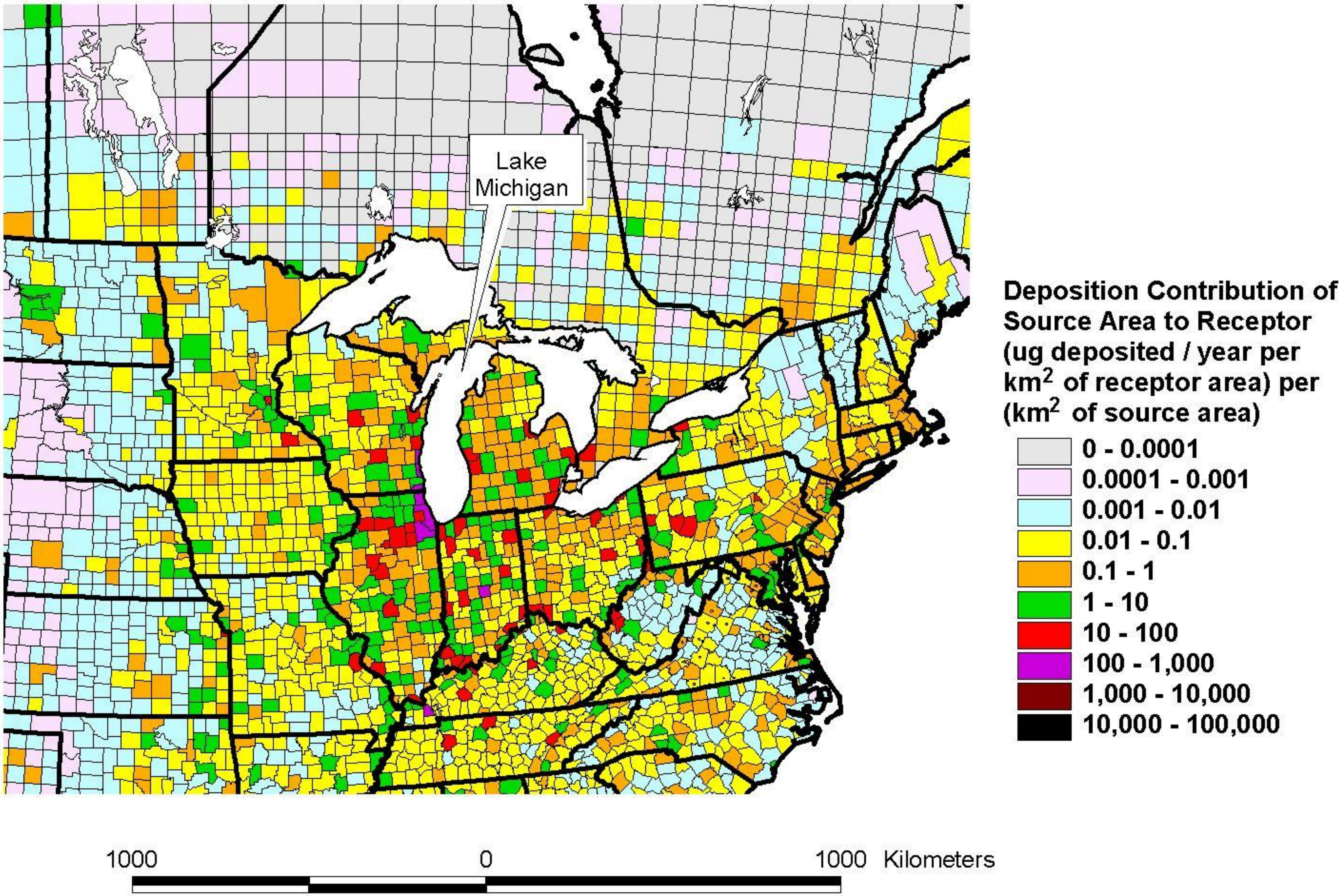


Another Example of Detailed Results: Lake Michigan

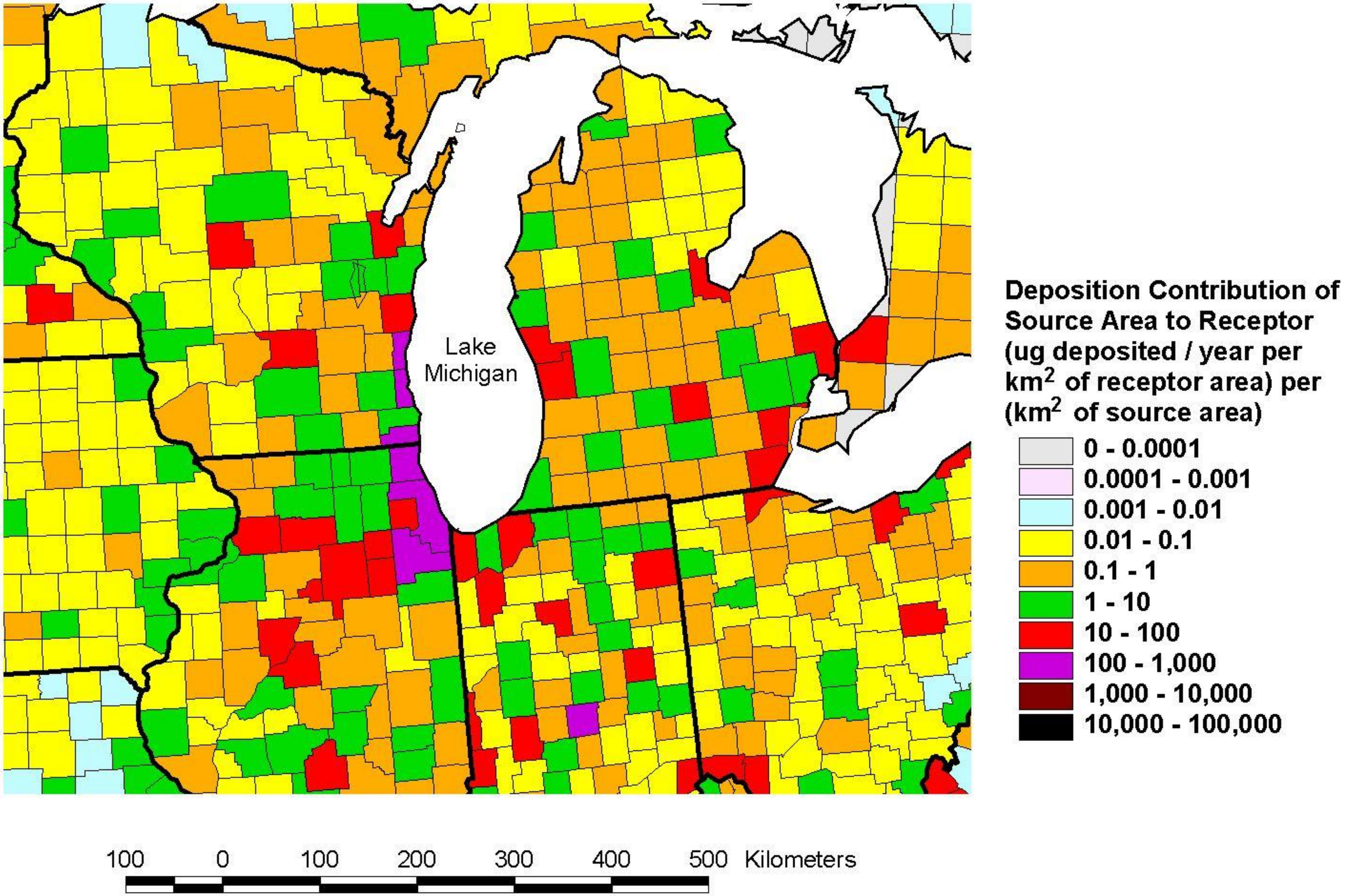
Geographical Distribution of 1999 Direct Deposition Contributions to Lake Michigan (entire domain)



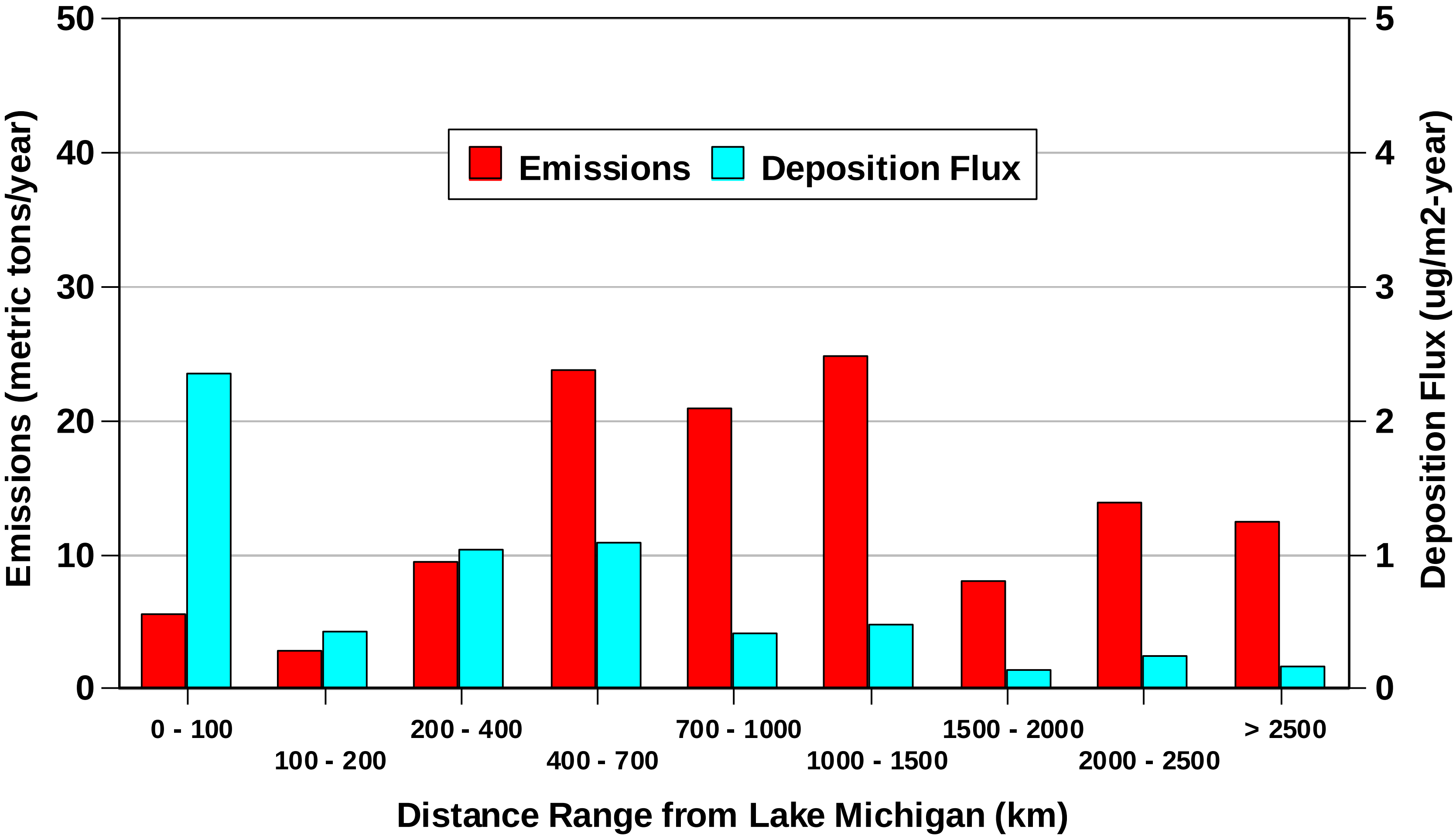
Geographical Distribution of 1999 Direct Deposition Contributions to Lake Michigan (regional view)

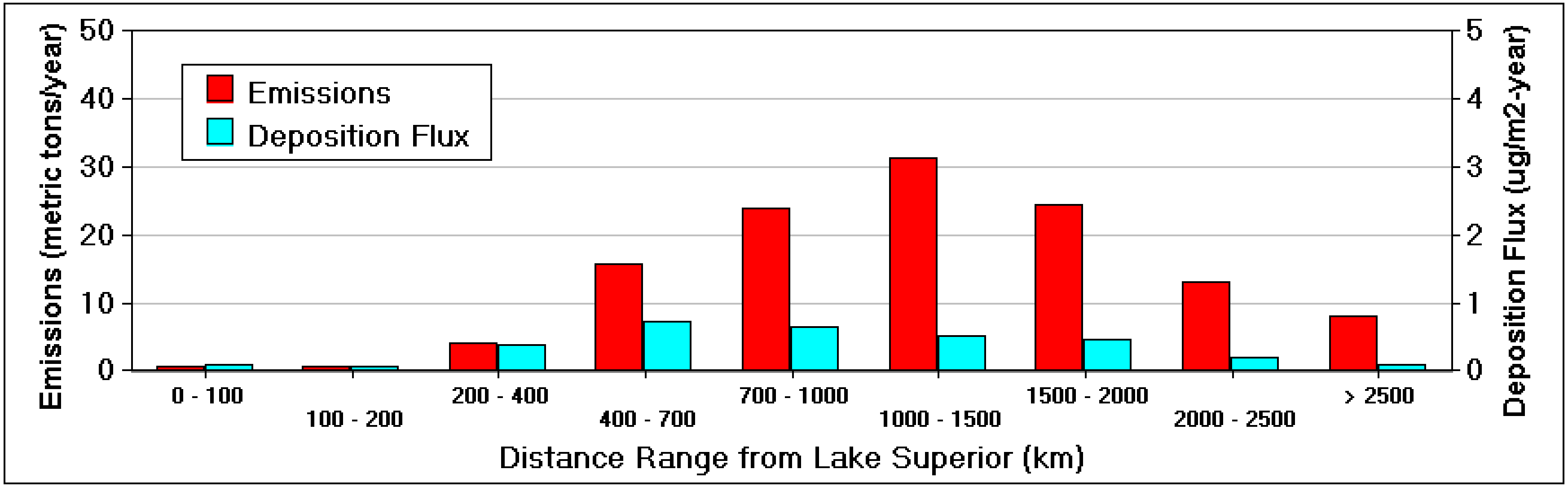


Geographical Distribution of 1999 Direct Deposition Contributions to Lake Michigan (more local view)

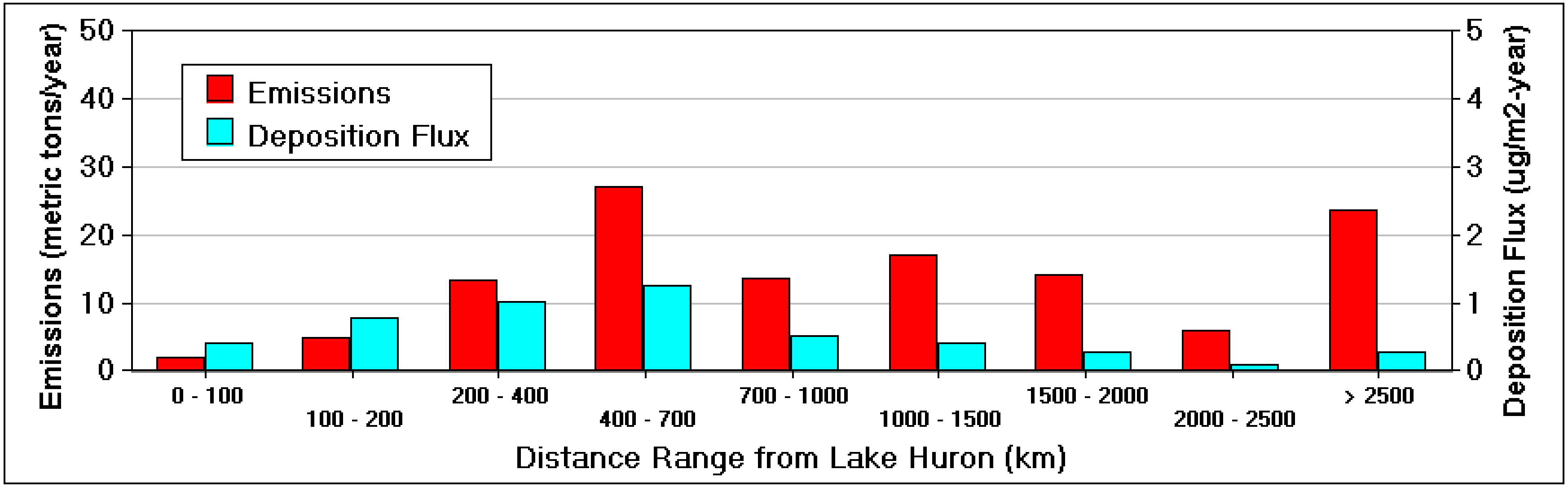


Emissions and Deposition Contributions from Different Distance Ranges Away From Lake Michigan





Emissions (metric tons/year)
50
40
30
20
10
0
Emissions
Deposition Flux
0 - 100
100 - 200
200 - 400
400 - 700
700 - 1000
1000 - 1500
1500 - 2000
2000 - 2500
> 2500
Distance Range from Lake Superior (km)
5
4
3
2
1
0
Deposition Flux (ug/m2-year)



Emissions (metric tons/year)
50
40
30
20
10
0
Emissions
Deposition Flux
0 - 100
100 - 200
200 - 400
400 - 700
700 - 1000
1000 - 1500
1500 - 2000
2000 - 2500
> 2500
Distance Range from Lake Huron (km)
5
4
3
2
1
0
Deposition Flux (ug/m2-year)

Top 25 Contributors to 1999 Hg Deposition Directly to Lake Michigan