



Power Plant Emissions in North America

CEC-IJC Consultation on Emissions
from Coal-fired Electrical Utilities

Montréal, Québec

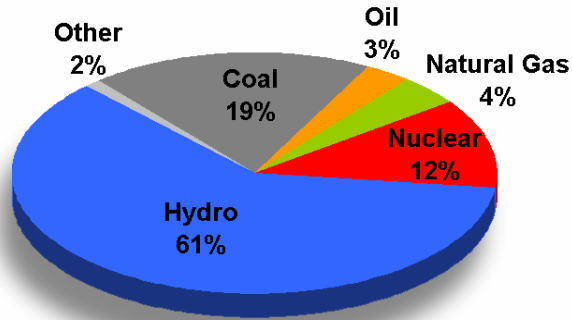
20 July 2004

Paul J. Miller

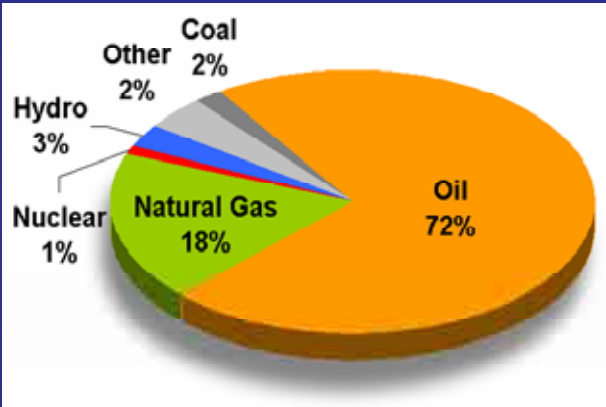
Commission for Environmental Cooperation



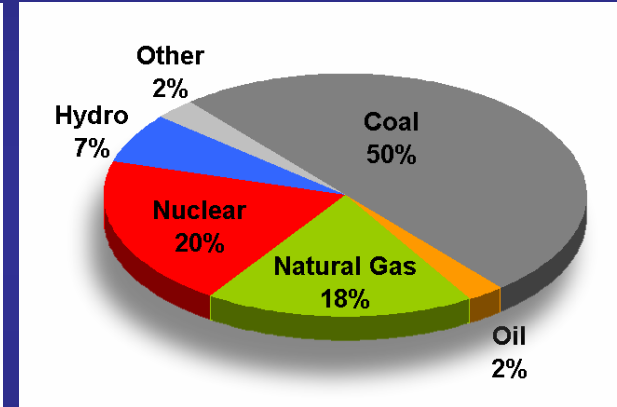
NA Generation 2002



576 billion kWh
111 GW*



199 billion kWh
37 GW*



3,858 billion kWh
819 GW*

* 2000 generation capacity from NA Energy WG



2002 Power Plant Air Pollution

Country	SO ₂ (tonnes)	NO _x (tonnes)	Mercury (kg)	CO ₂ (tonnes)
Canada	619,500	261,600	2,000	111,000,000
Mexico	1,558,000	250,800	1,300	94,480,000
United States	9,189,000	4,027,000	44,200	2,178,000,000



Electricity contribution to national air pollution

Country	SO ₂	NOx	Mercury	CO ₂
Canada	20%	11%	26%	23%
Mexico	55%	27%	3%	30%
United States	69%	22%	41%	40%



Coal share of air pollution contribution

Country (% coal gen.)	SO ₂	NOx	Mercury	CO ₂
Canada (19%)	20% (86%)	11% (81%)	26% (98%)	23% (?)
Mexico (2%)	55% (21%)	27% (47%)	3% (78%)	30% (22%)
USA (50%)	69% (97%)	22% (93%)	41% (100%)	40% (87%)

Numbers in parenthesis are coal's share of electricity sector contribution to national totals.



Per GDP Power Plant Air Pollution*

Country	SO ₂	NOx	Mercury	CO ₂
Canada	663,000	280,000	2	119,000
Mexico	1,685,000	271,000	1	102,000
U.S.	885,000	391,000	4	218,000

*Kilograms or metric tonnes (CO₂) per billion US\$



Per MWh Power Plant Air Pollution*

Country	SO ₂ (kg/MWh)	NOx (kg/MWh)	Mercury (kg/GWh)	CO ₂ (kg/MWh)
Canada	1.2	0.5	0.004	220
Mexico	9.3	1.5	0.006	500
U.S.	3.2	1.5	0.010	610

*Based on 1998 emissions and generation. Mercury output per GWh.



Air toxics 2001

- Electricity sector in Canada and US single largest source of nationally reported air toxics



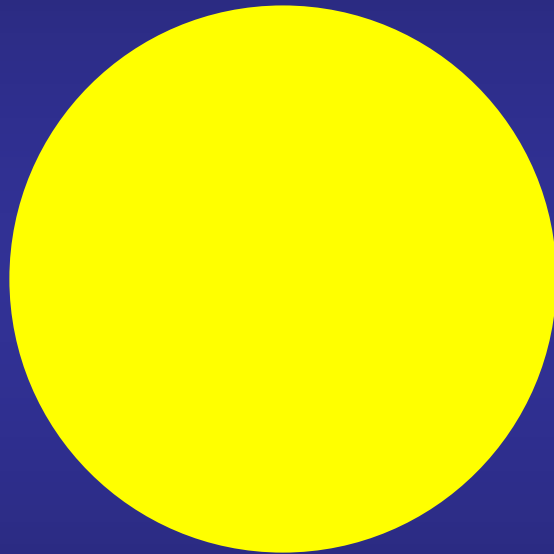


Strong future growth

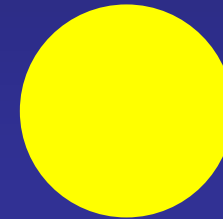
- North American electricity demand expected to rise from 2000 to 2009
 - 14% in Canada
 - 21% in US
 - 66% in Mexico



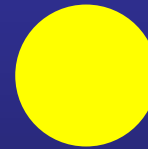
2002 Power plant SO₂



US = 9,189



Mexico = 1,558

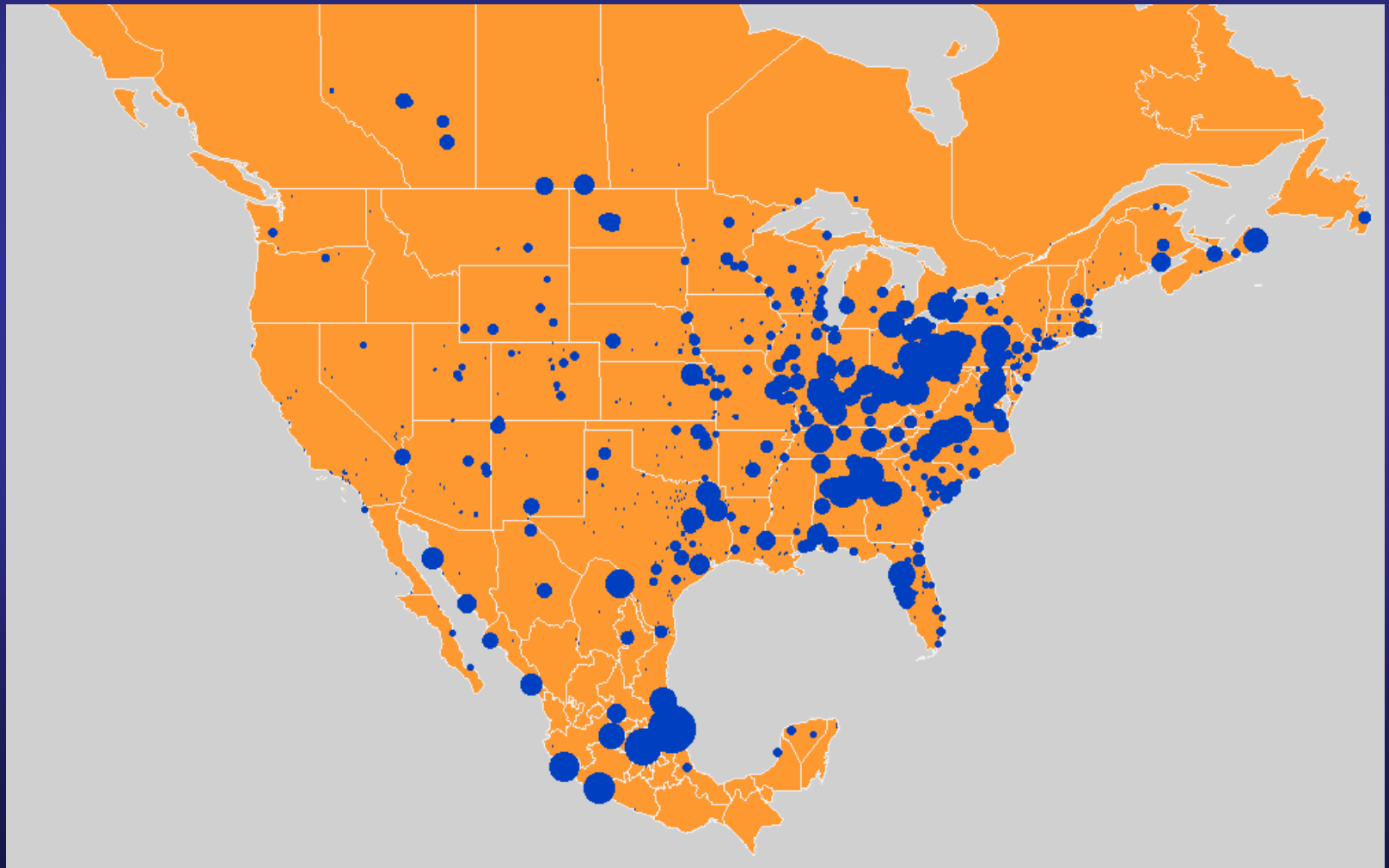


Canada = 620

Thousand metric tonnes



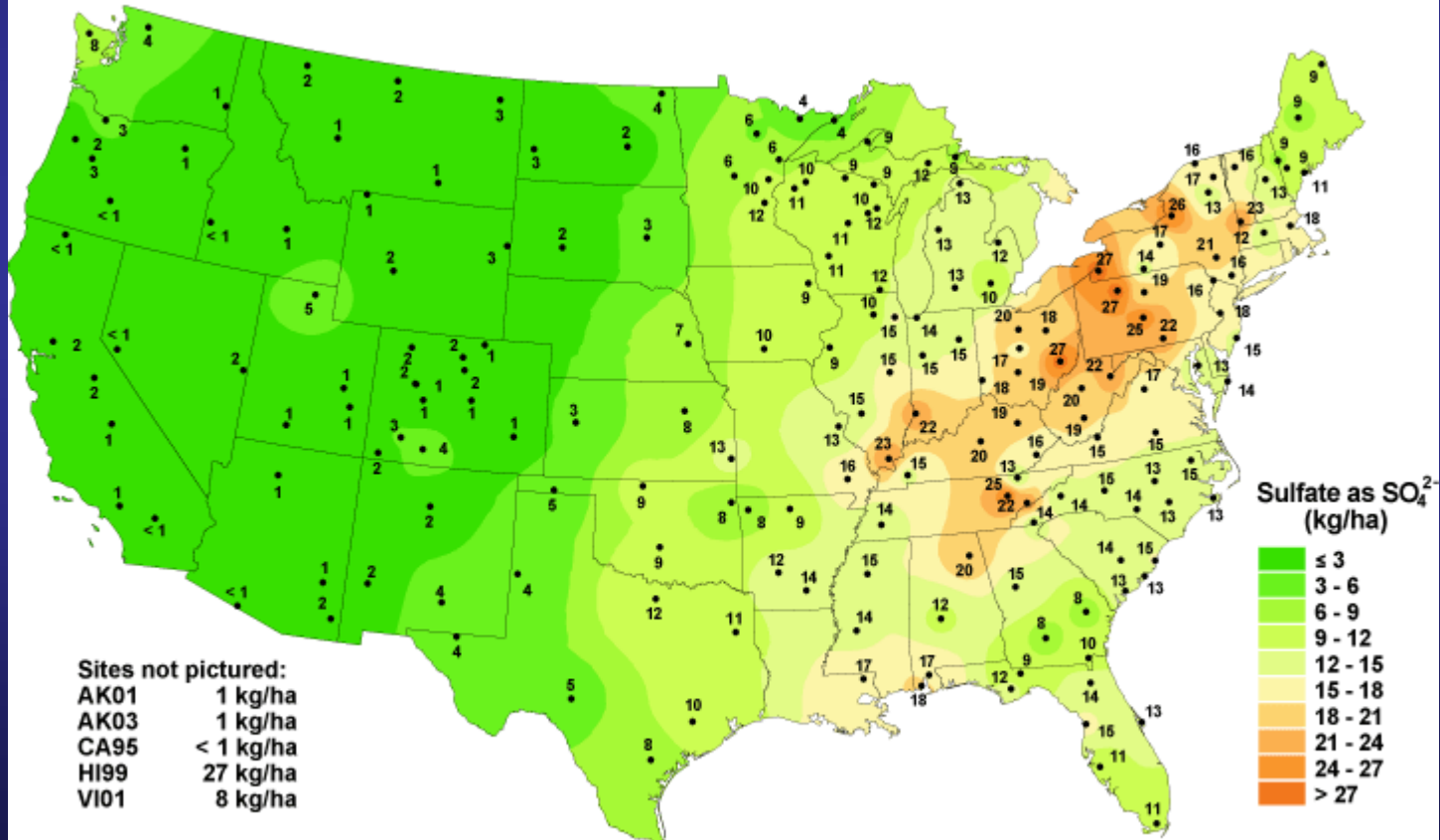
SO₂ Power Plant Map





Sulfate deposition

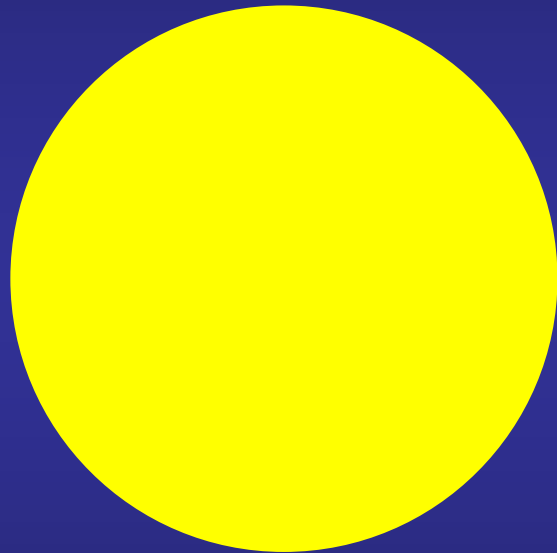
Sulfate ion wet deposition, 2002



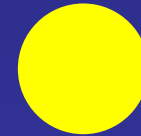
National Atmospheric Deposition Program/National Trends Network
<http://nadp.sws.uiuc.edu>



2002 Power plant NOx



US = 4,027



Mexico = 251

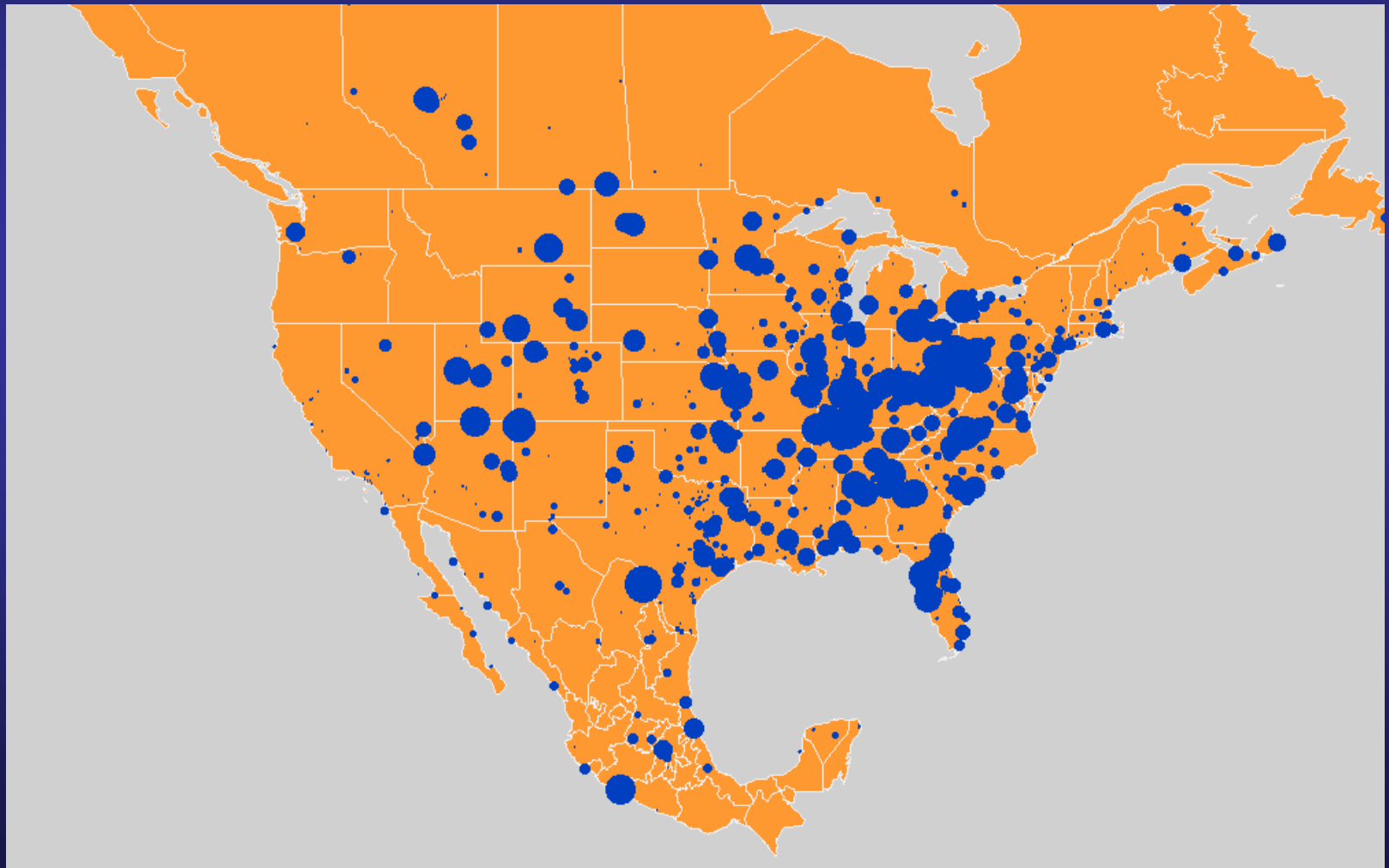


Canada = 262

Thousand metric tonnes

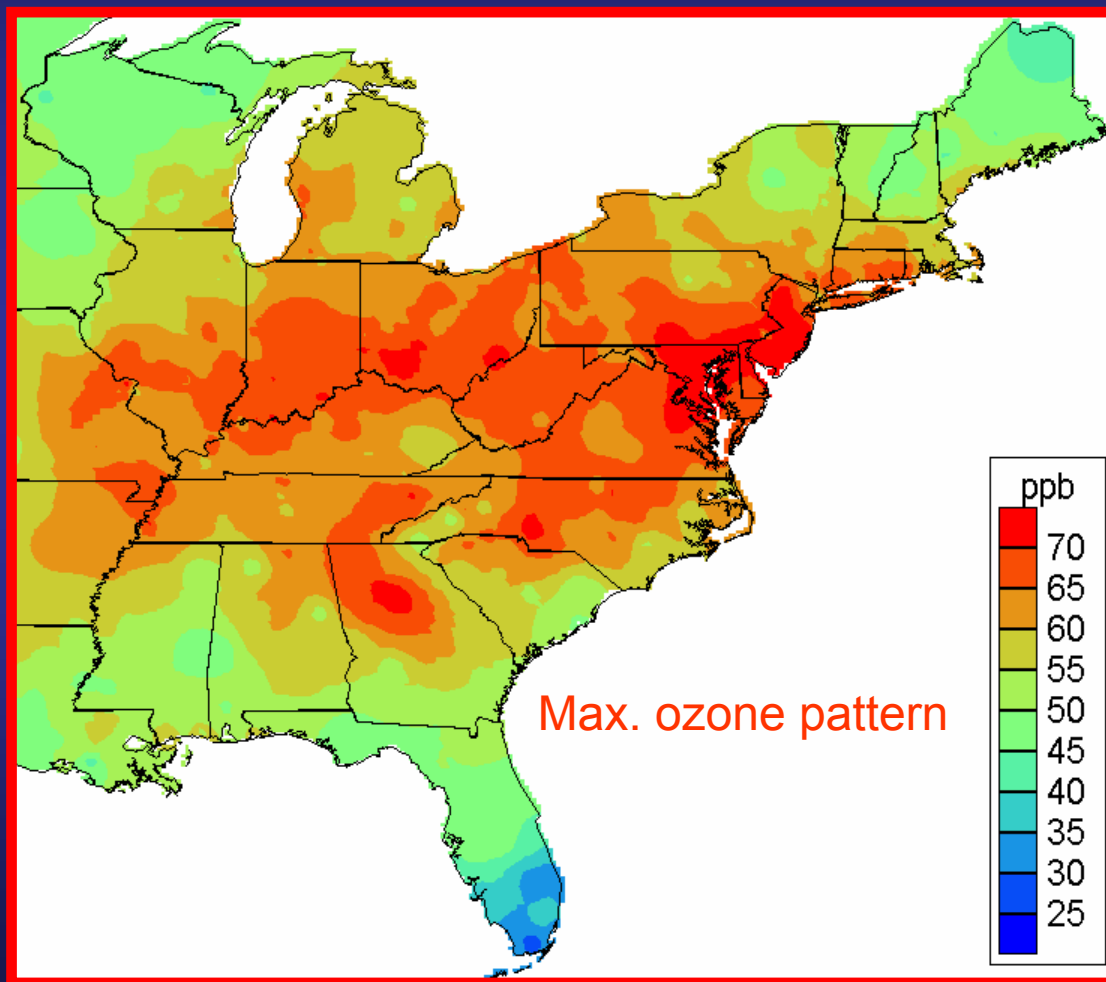


NOx Power Plant Map





NOx makes ozone

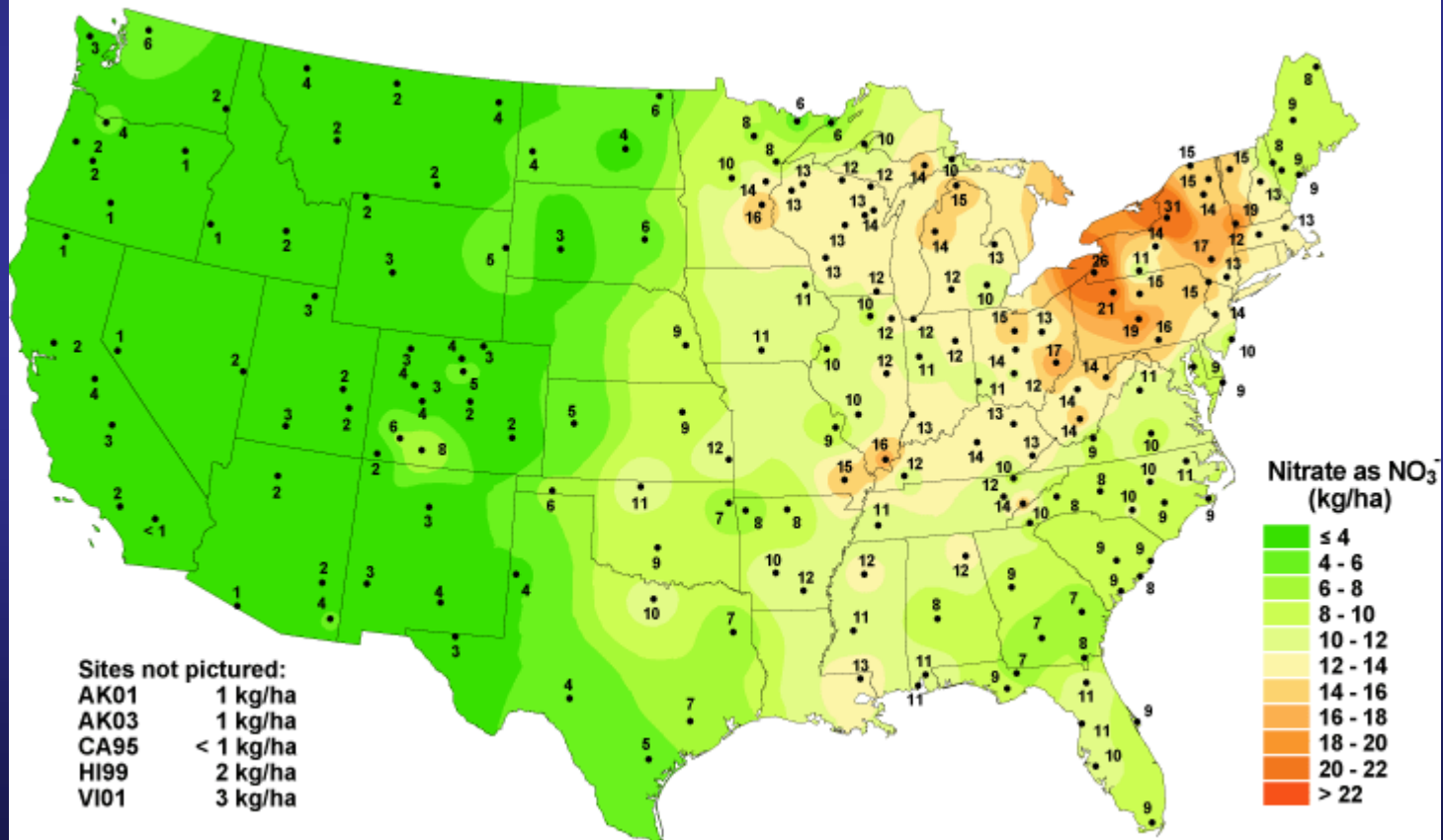


Based on daily 1-hour maximum O₃ 1991-95 monitoring data from AIRS, CASTNet, and other sources



Nitrate deposition

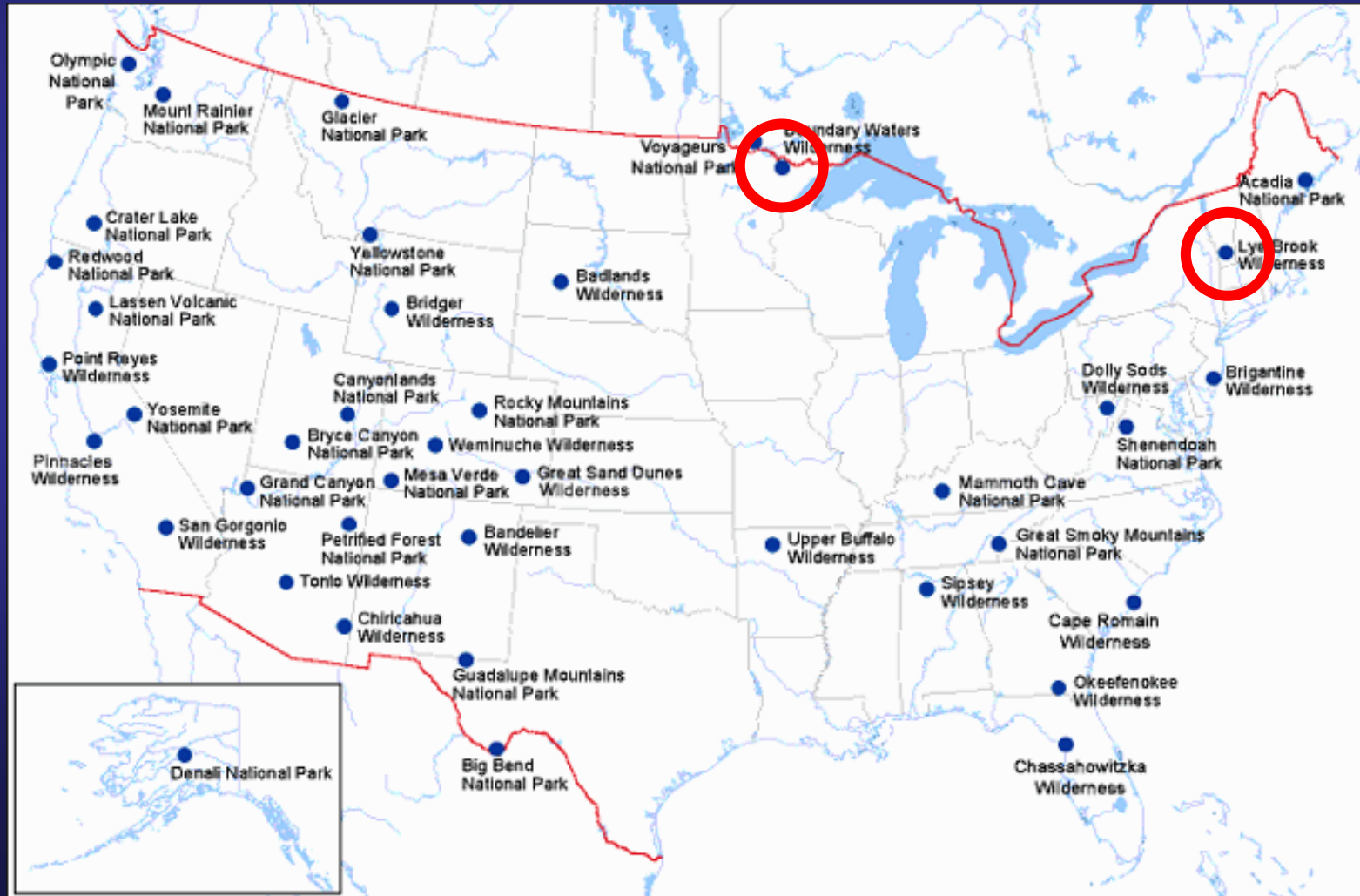
Nitrate ion wet deposition, 2002



Sites not pictured:
AK01 1 kg/ha
AK03 1 kg/ha
CA95 < 1 kg/ha
HI99 2 kg/ha
VI01 3 kg/ha

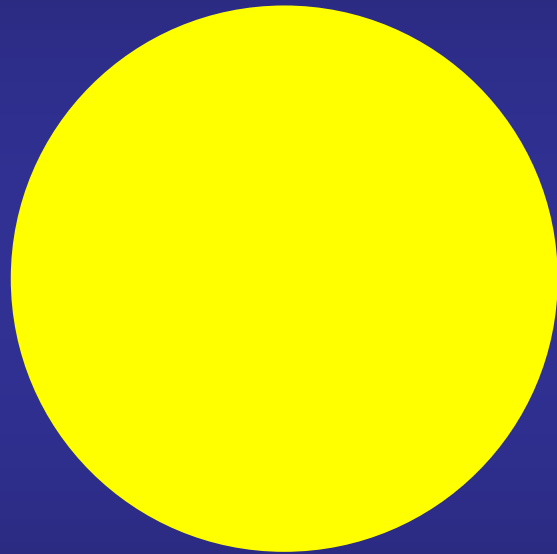


Visibility





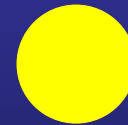
2002 Power plant mercury



US = 44.2



Mexico = 1.3

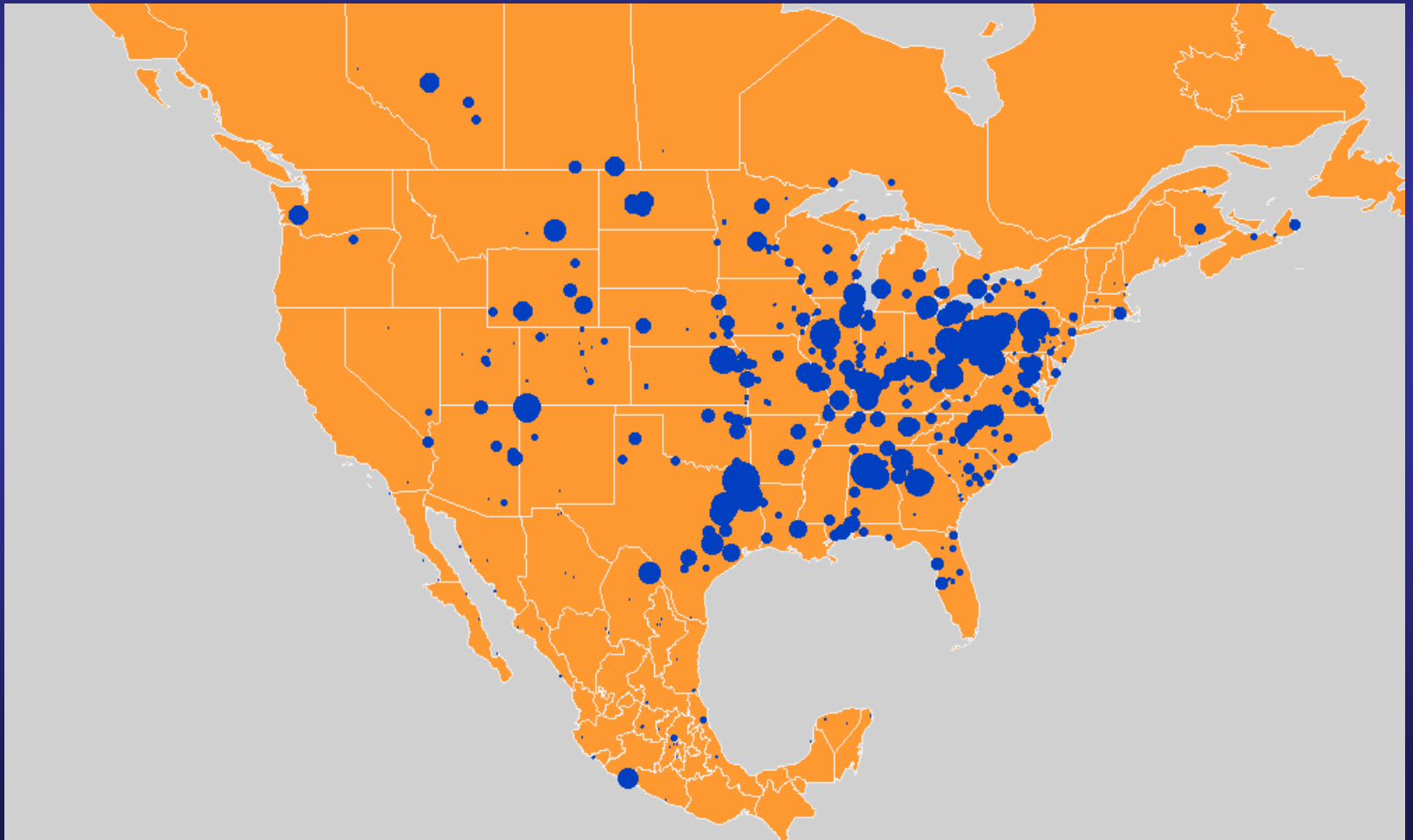


Canada = 2.0

Metric tonnes



Hg Power Plant Map



Species of Hg is important in transport



Elemental Mercury: Hg(0)

- *not* very water soluble
- long atmospheric lifetime (~ 0.5 - 1 yr); globally distributed



Reactive Gaseous Mercury (“RGM”): Hg(II)

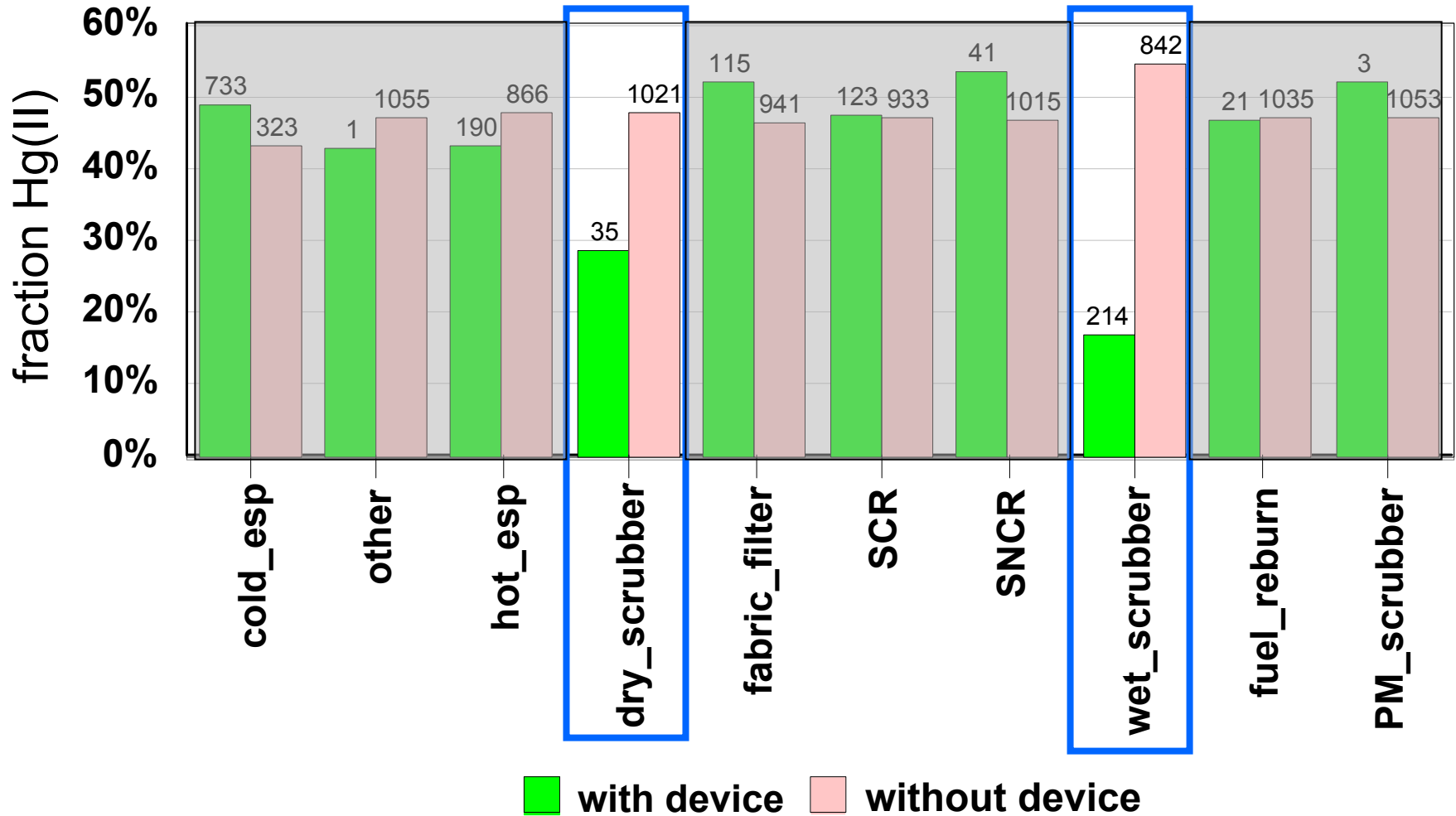
- water soluble
- short atmospheric lifetime (~ 1 week or less)
- more local and regional effects



Particulate Mercury: Hg(p)

- not pure particles of mercury...species largely unknown (in some cases, may be Hg(0)?)
- moderate atmospheric lifetime (perhaps 1~ 2 weeks)
- local and regional effects

Hg(II) fraction vs. air pollution control device for Hg(II) ("RGM") for mercury emissions from U.S. coal-fired electricity generation

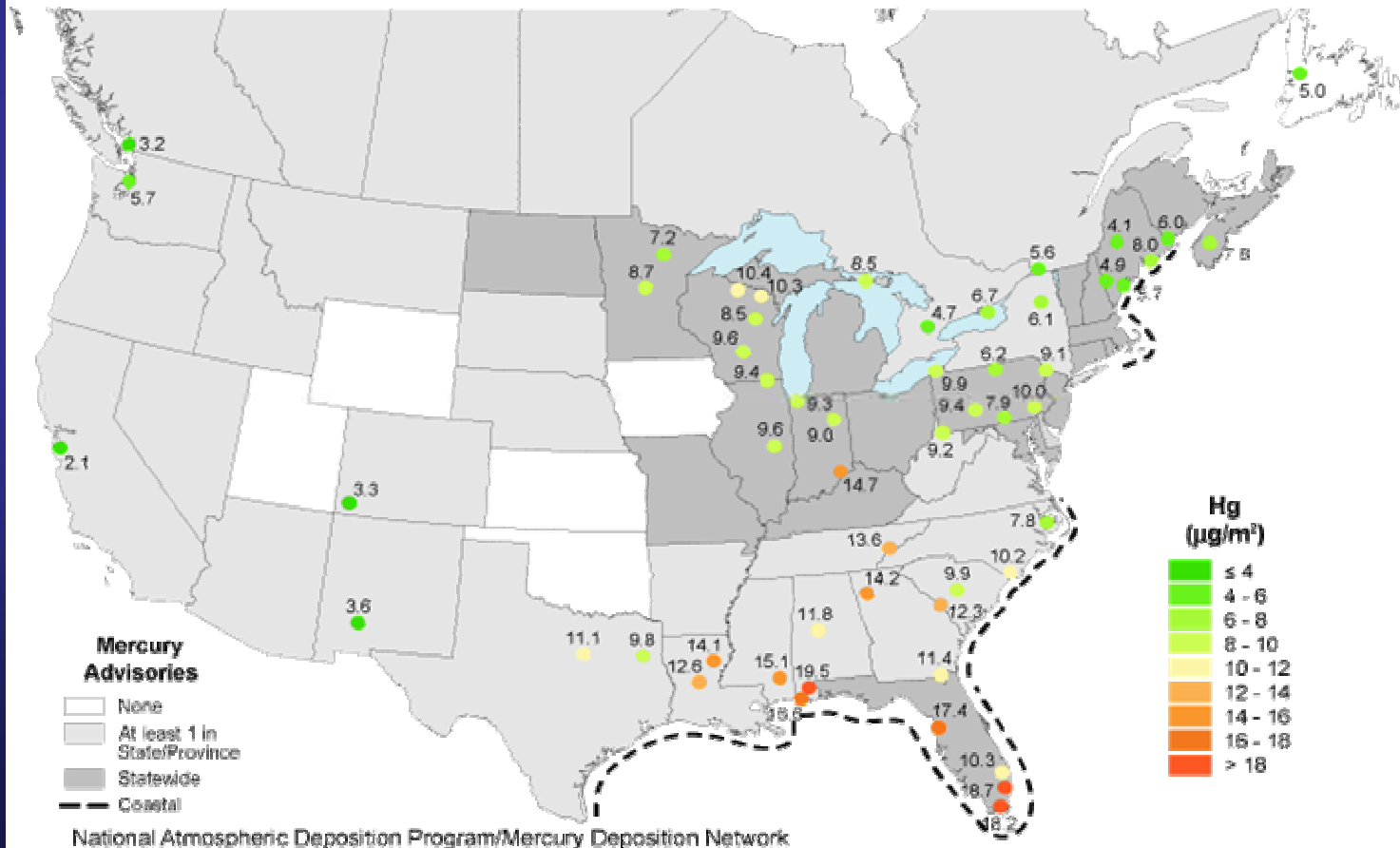


numbers above bars are the number of records



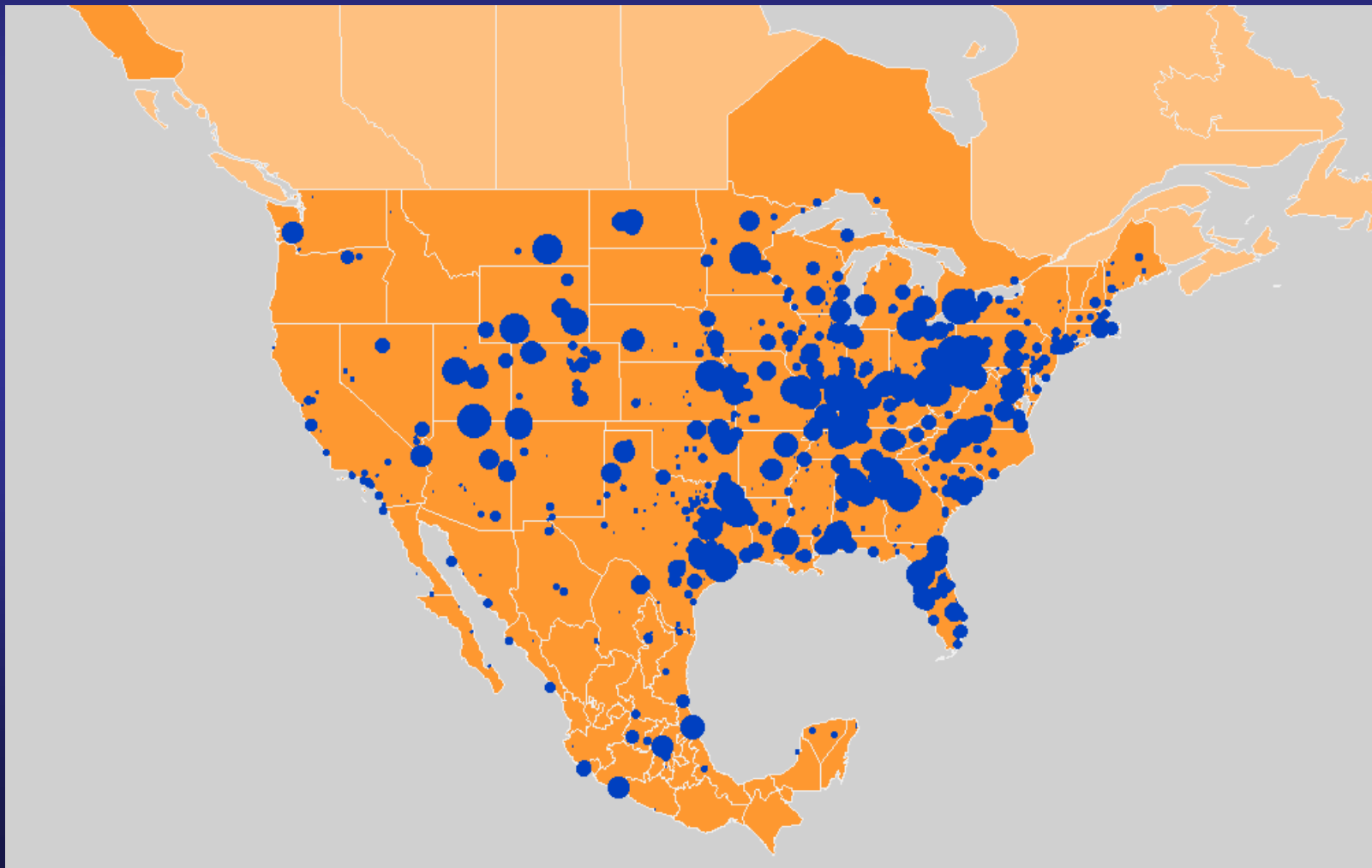
Hg deposition

Total Mercury Wet Deposition, 2002





CO₂ Power Plant Map





2002 NA PP Report in progress

Paul J. Miller

CEC Air Quality Program

393 rue St-Jacques Ouest, Bureau 200

Montréal, Québec H2Y 1N9 (CANADA)

Tel: 514-350-4326

Fax: 514-350-4314

Email: pmiller@ccemtl.org