Mercury Dry Deposition almost 2 Decades Later: Does it Matter Yet?

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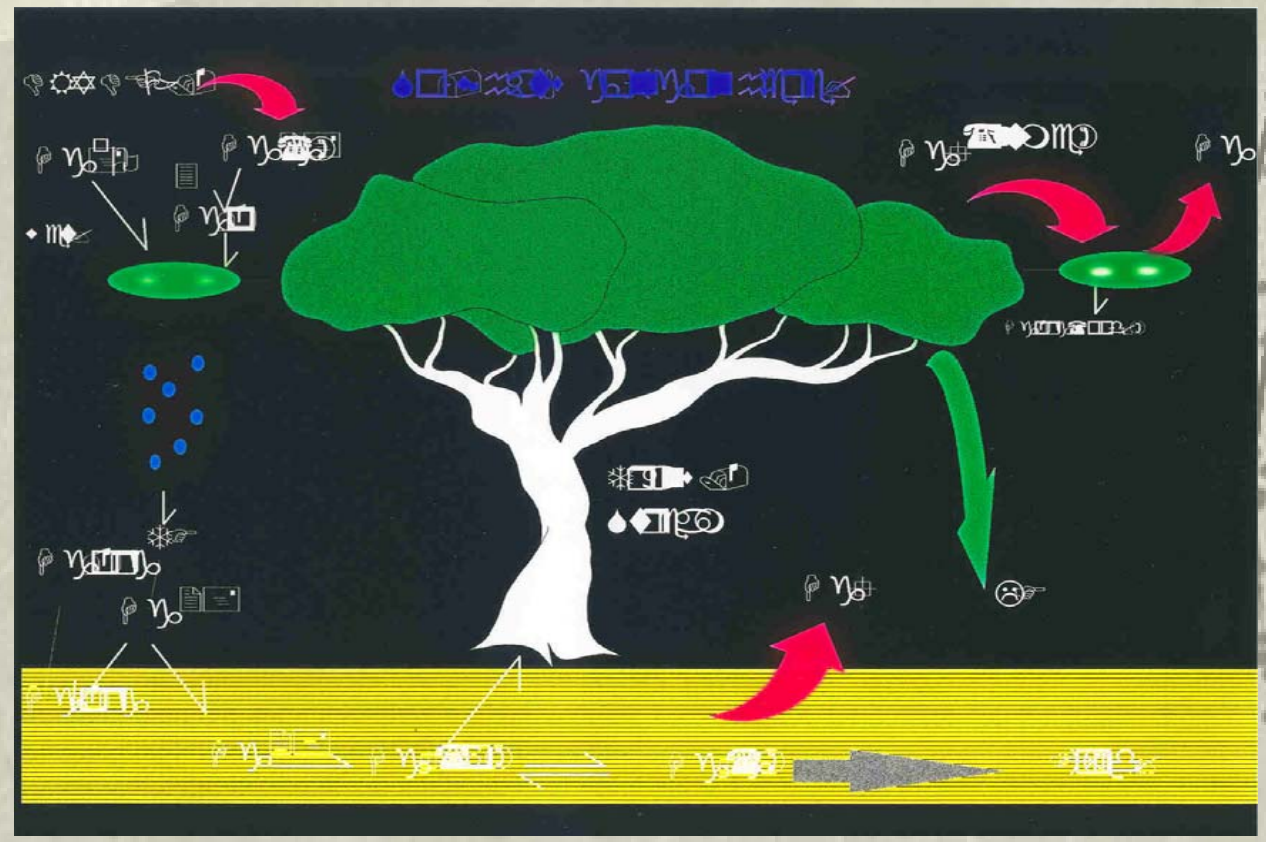
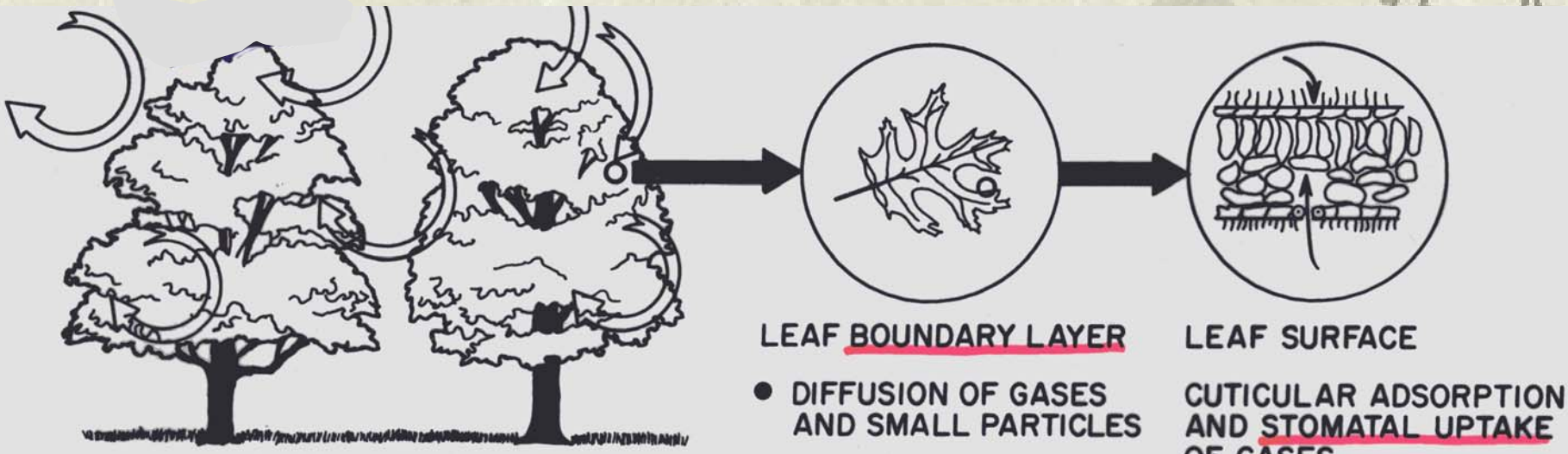


(Supported by EPA STAR # RD833378010)

Does it matter? yes, probably, unless…

- The models are wrong
- The measurements are biased
  or,
- The critical surface is water

Start with some basic concepts



FOREST CANOPY

- TURBULENT TRANSPORT OF GASES AND PARTICLES
  Rate Limiting for Hg -II
- SEDIMENTATION OF LARGE PARTICLES

LEAF BOUNDARY LAYER

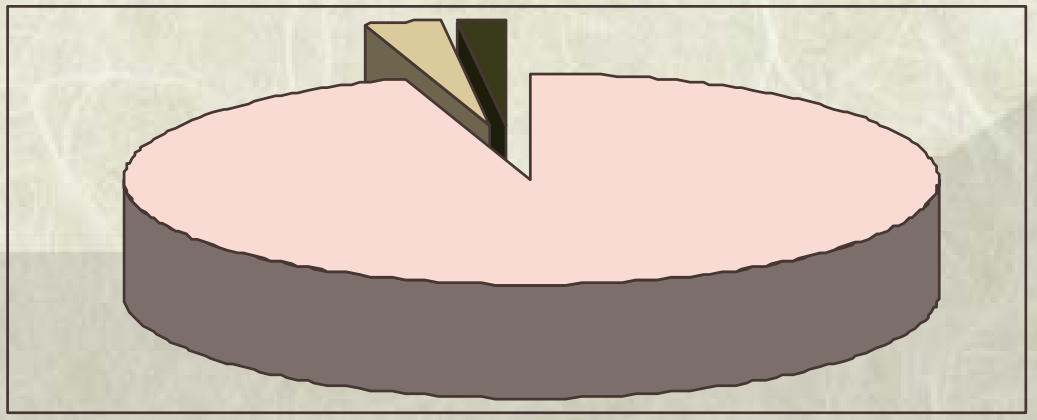
- DIFFUSION OF GASES AND SMALL PARTICLES
- IMPACTION AND SEDIMENTATION OF LARGE PARTICLES
  Rate Limiting for Hg-p

LEAF SURFACE

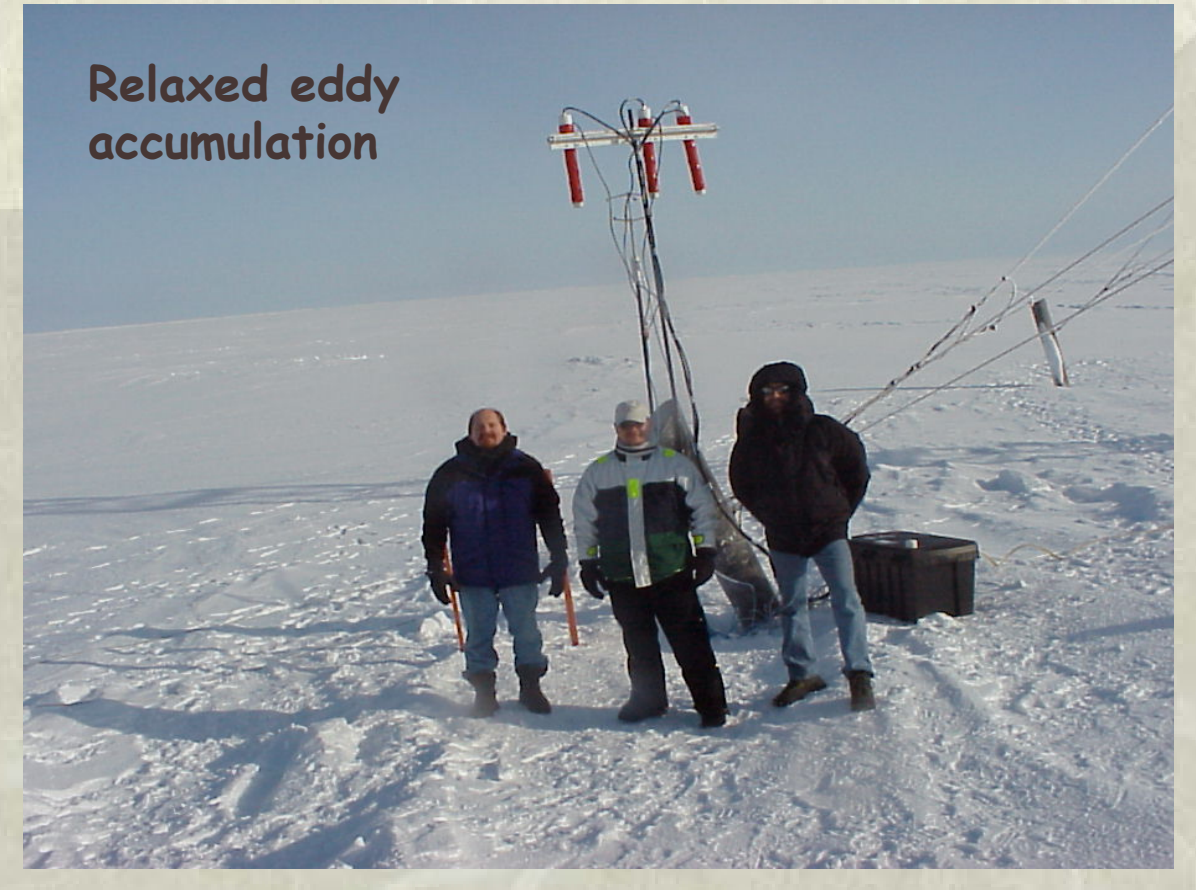
CUTICULAR ADSORPTION AND STOMATAL UPTAKE OF GASES
Rate Limiting for Hg°

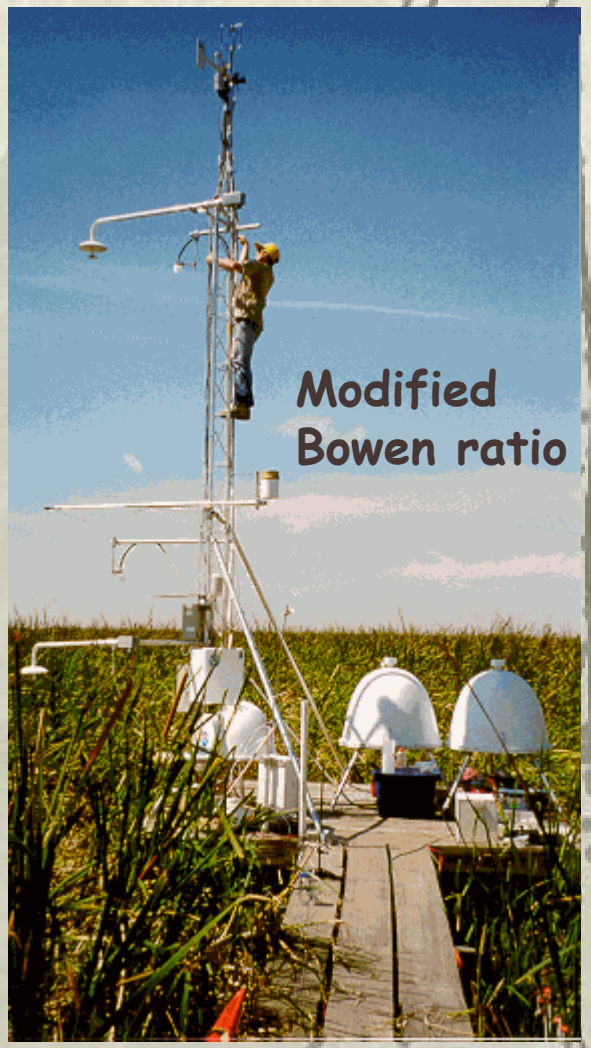
ADAPTED FROM FOWLER (1980)

Does speciation matter?



A handful of Vd's have been derived from direct field measurements, and we now have plenty of [Hg] data





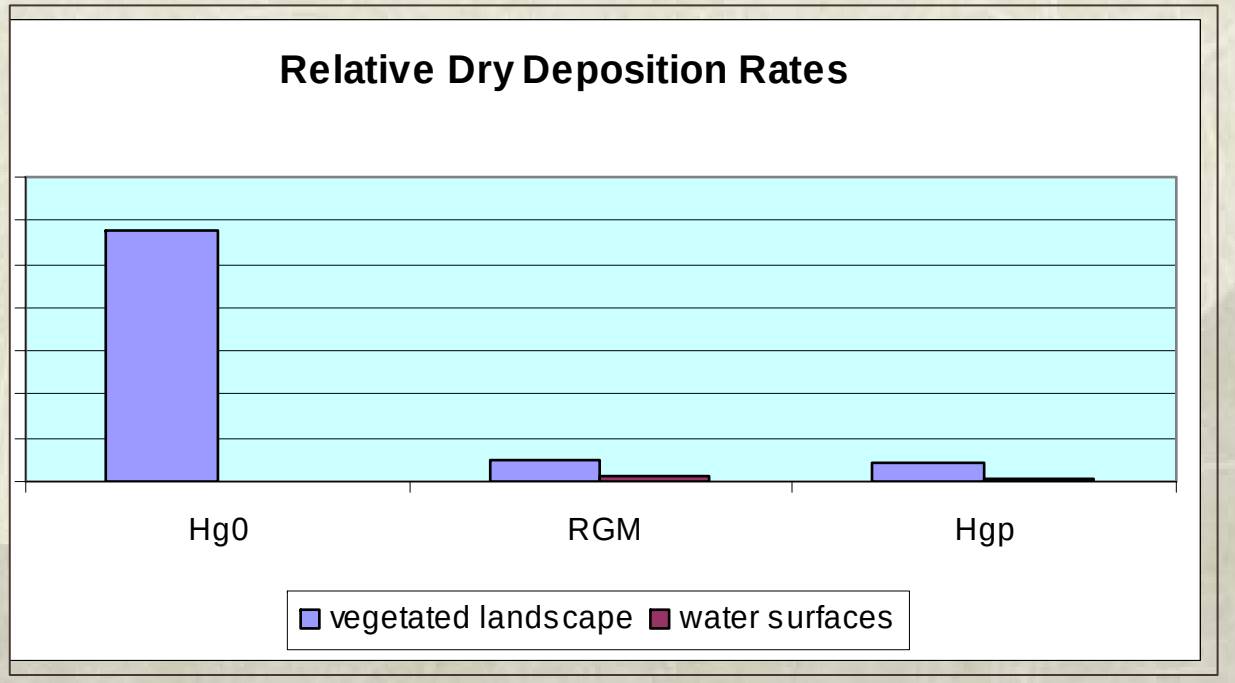
$$Flux = [Hg] \cdot V_d$$

Consider some typical values (rough surfaces)

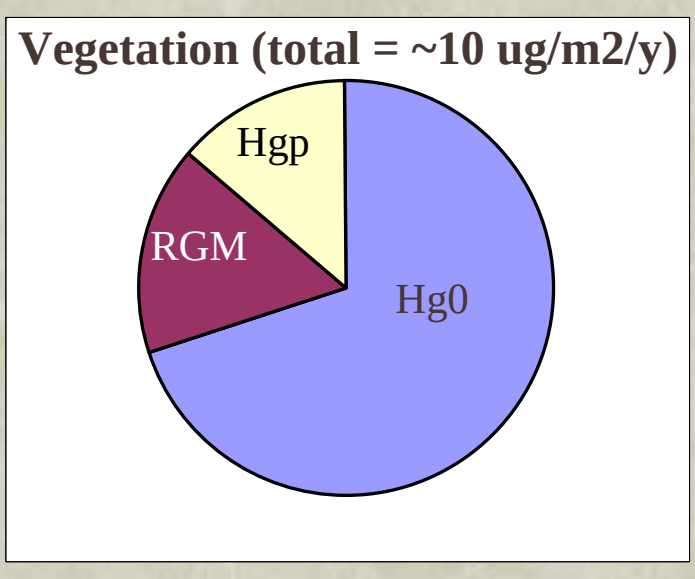
Vd (cm/s)	Hg(0)	HgII	Hgp
~min	0?	0.2	0.01
typical	0.05	1	0.3
~max	0.2	3	0.5

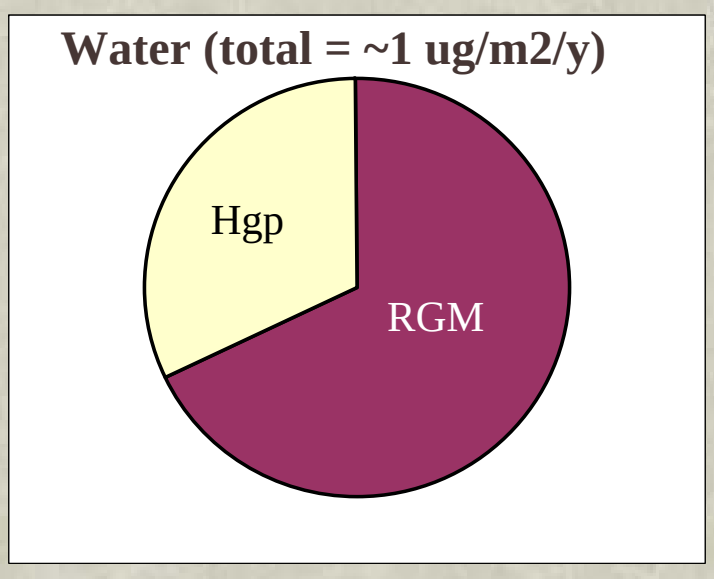
Conc.	Hg(0)	HgII	Hgp
(pg/m^3)	1600	5-10	10-30

Modeled: (Bullock 2007, Zhang et al 2003, 2001, Lindberg et al 1992)
Measured: (Brooks 2007, Lyman & Gustin 2007, Lynam & Keeler 2006, Skov et al 2006, Poissant et al 2004, Lindberg et al 2002)

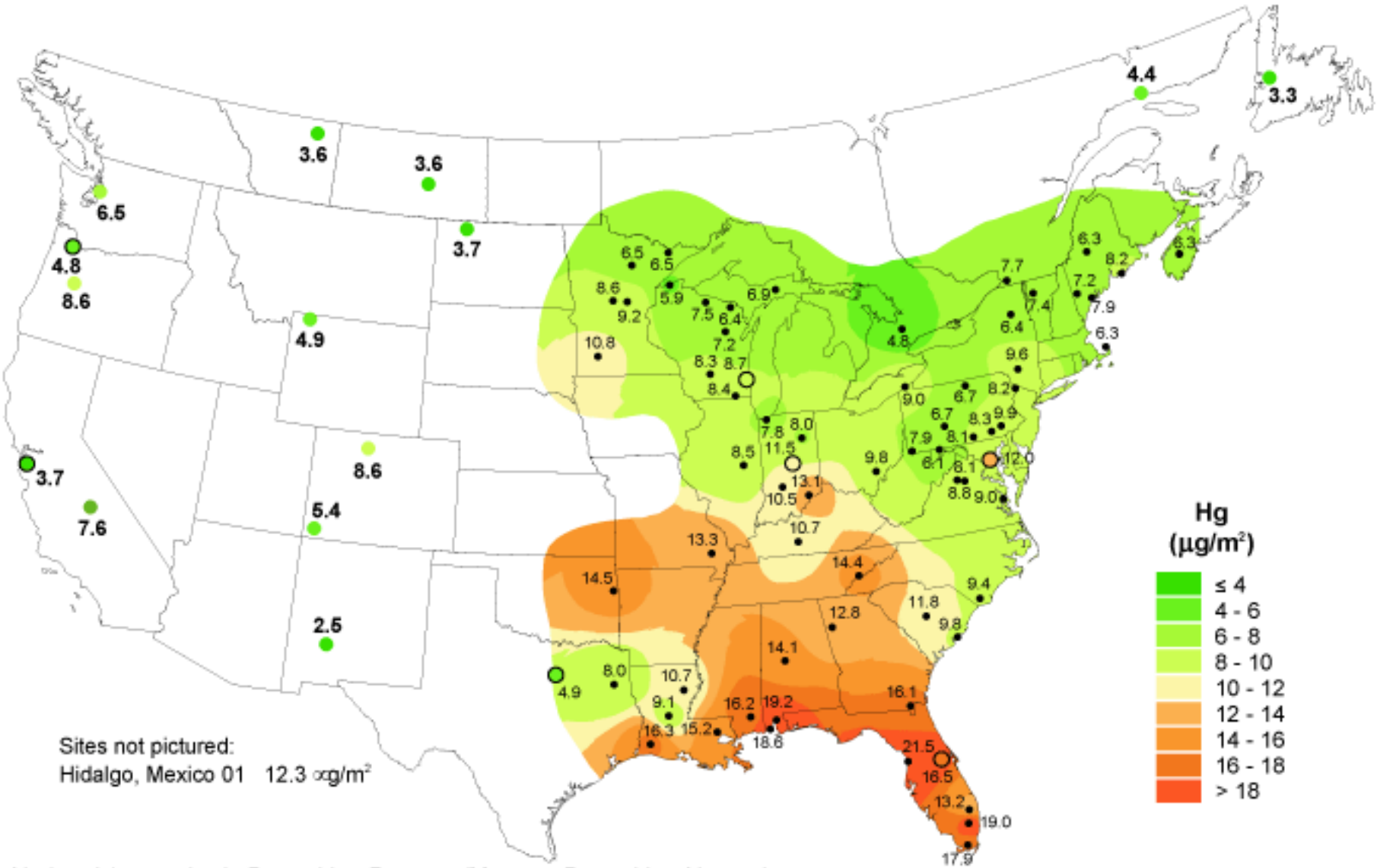


Est'd Annual Dry Deposition Fluxes



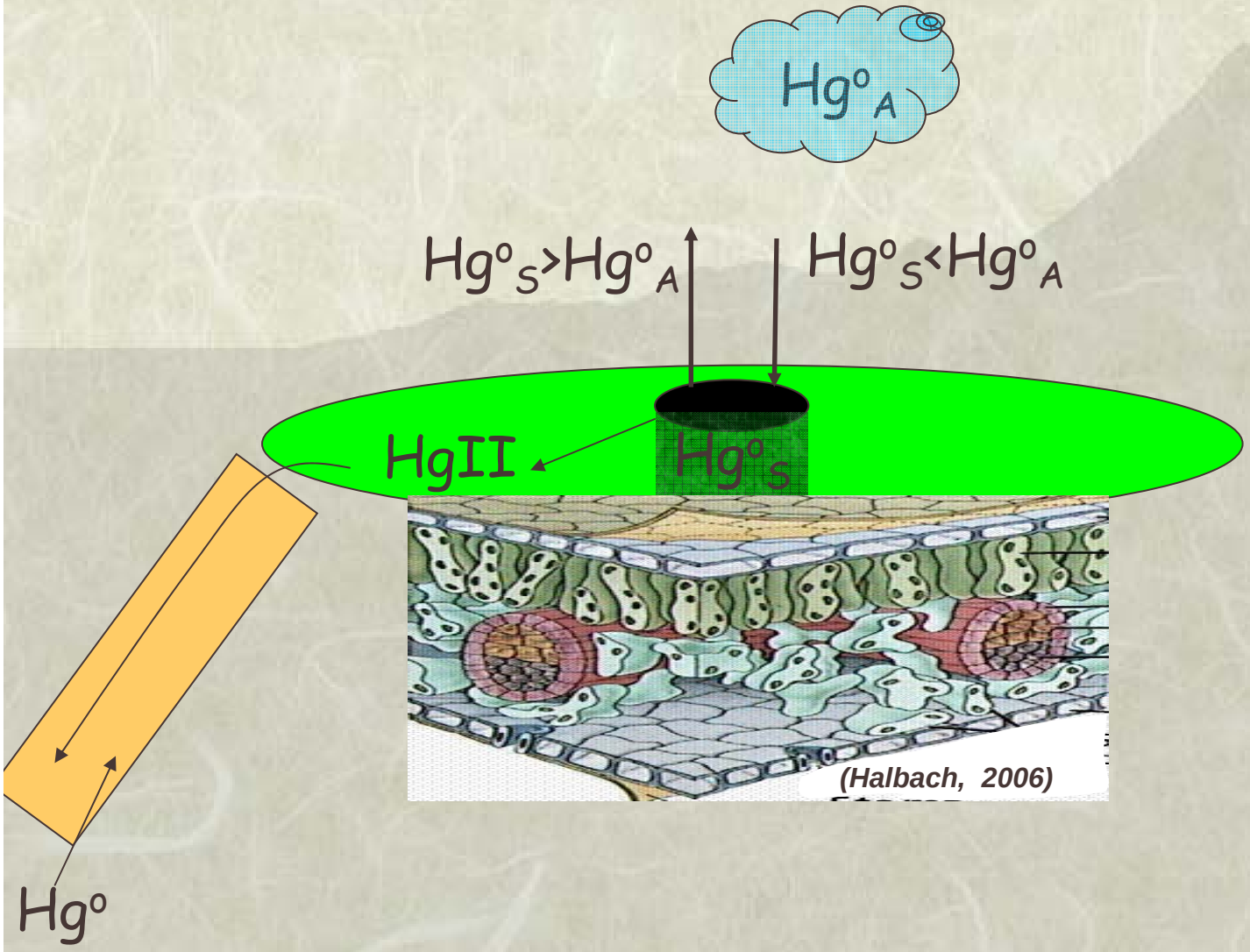


Total Mercury Wet Deposition, 2005

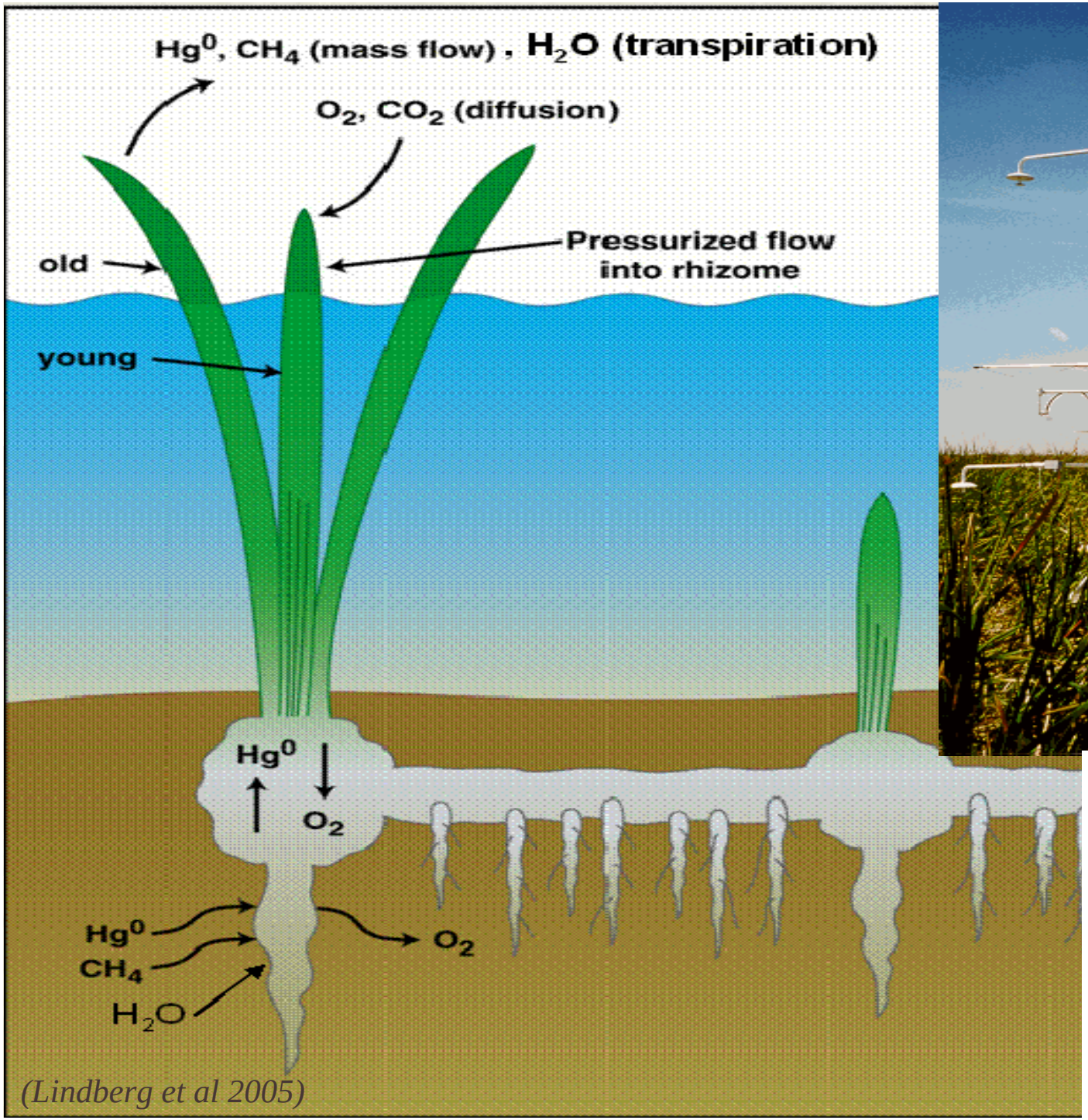


National Atmospheric Deposition Program/Mercury Deposition Network

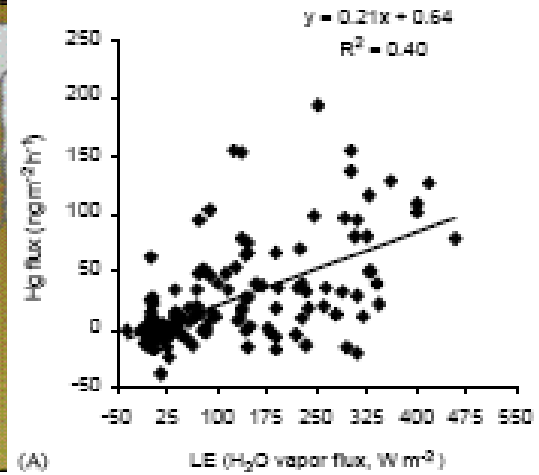
Hg^o, like NH_3, exhibits a compensation point*



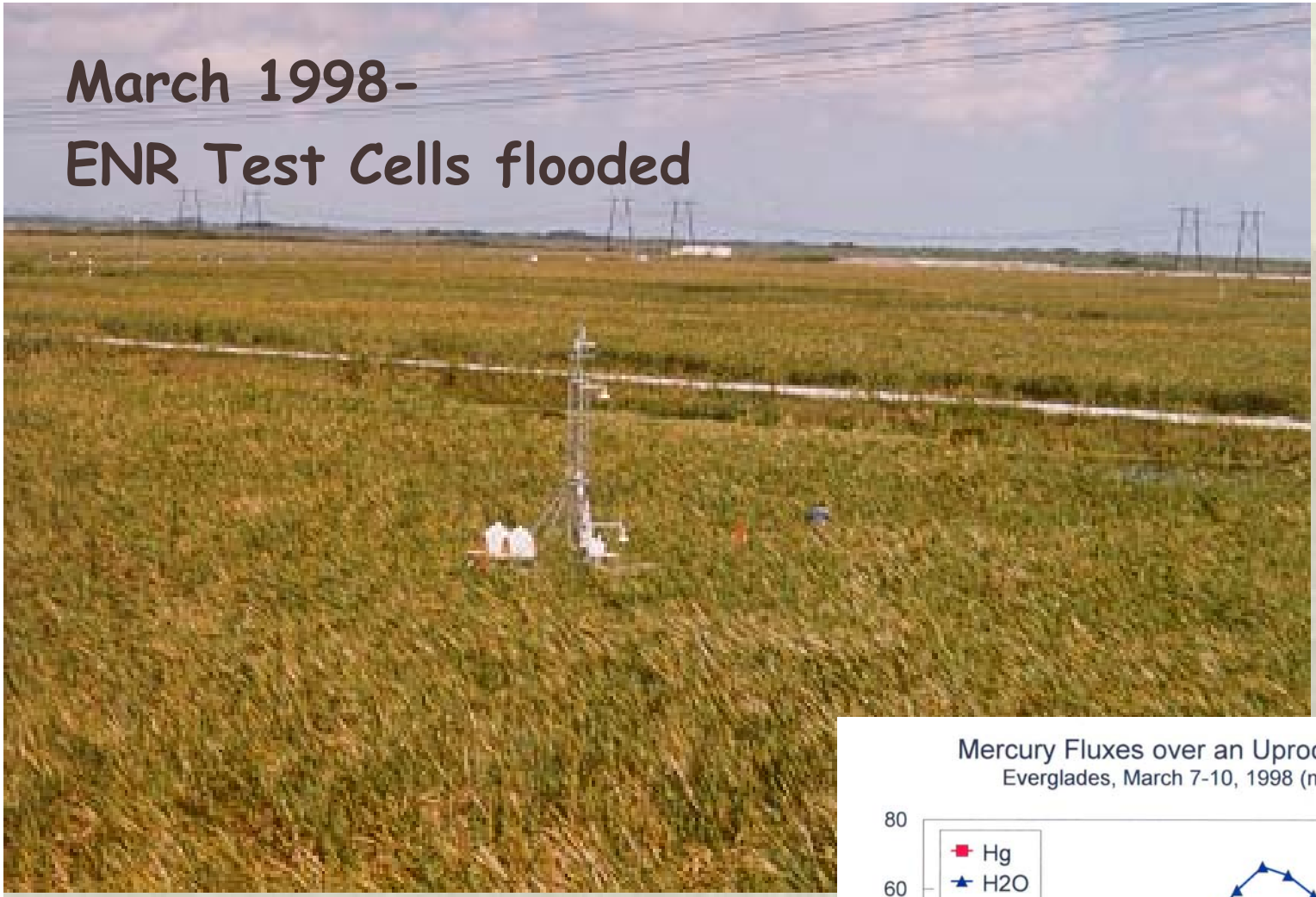
*(Hanson et. al. 1995)

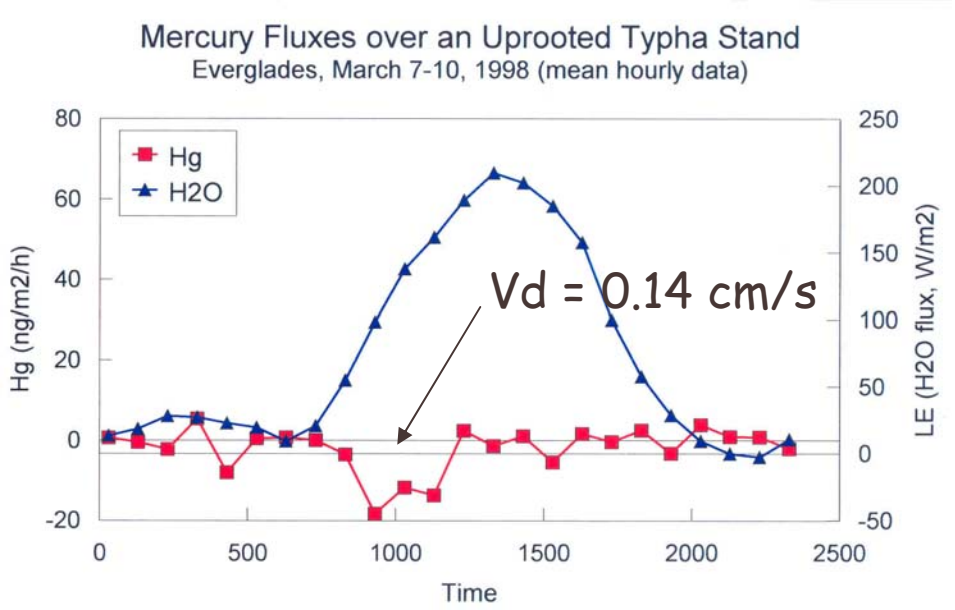


(Lindberg et al 2005)



March 1998-
ENR Test Cells flooded





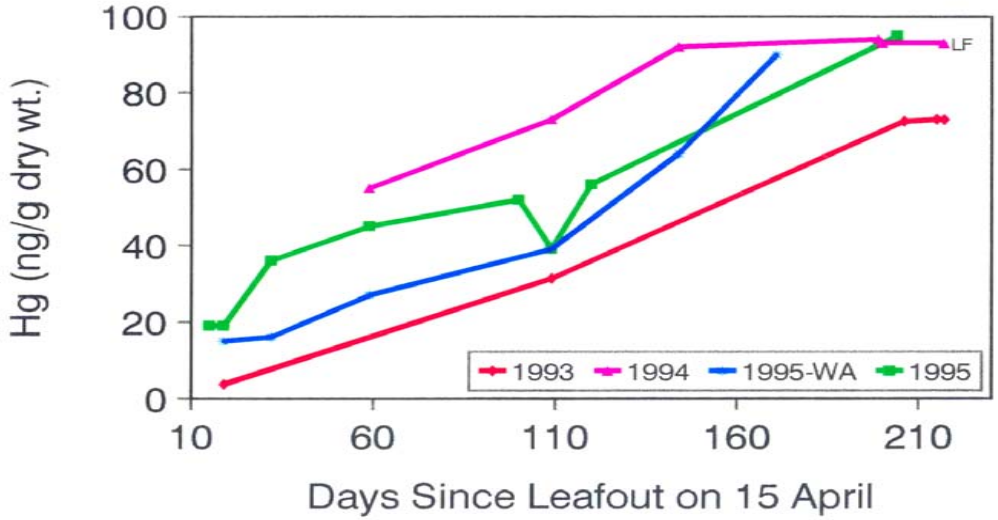
(Lindberg et al 2002)

UNR & DRI studies confirm that atmospheric uptake is a major source of Hg in foliage, but soils also contribute

(Ericksen et al 2003, Frescholz et al 2003, Millhollen et al 2006)

Temporal Trends in Foliar Hg

Walker Branch Forest (1993, 1994, 1995)

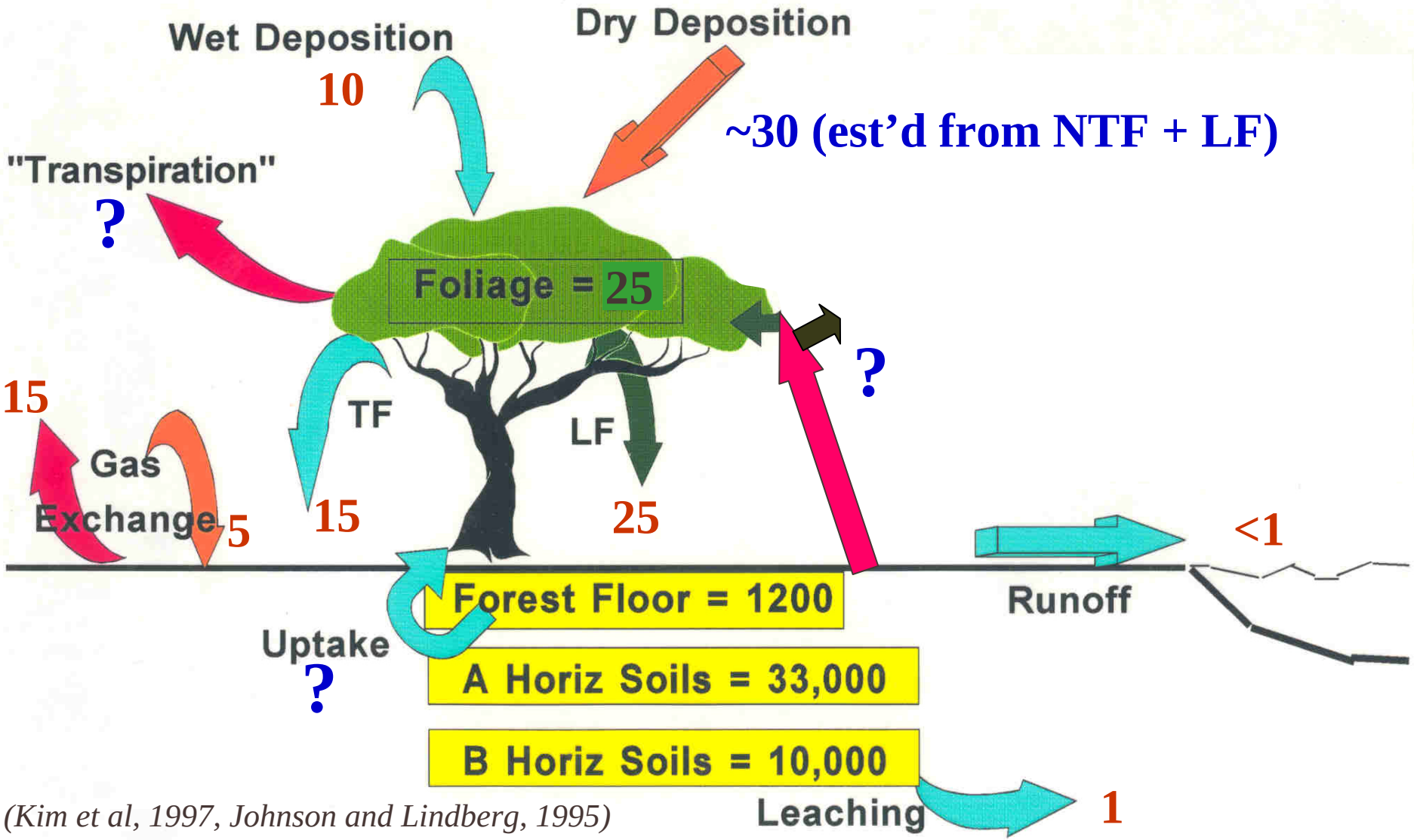


(Lindberg, 1996)

Biogeochemical Cycling of Hg:

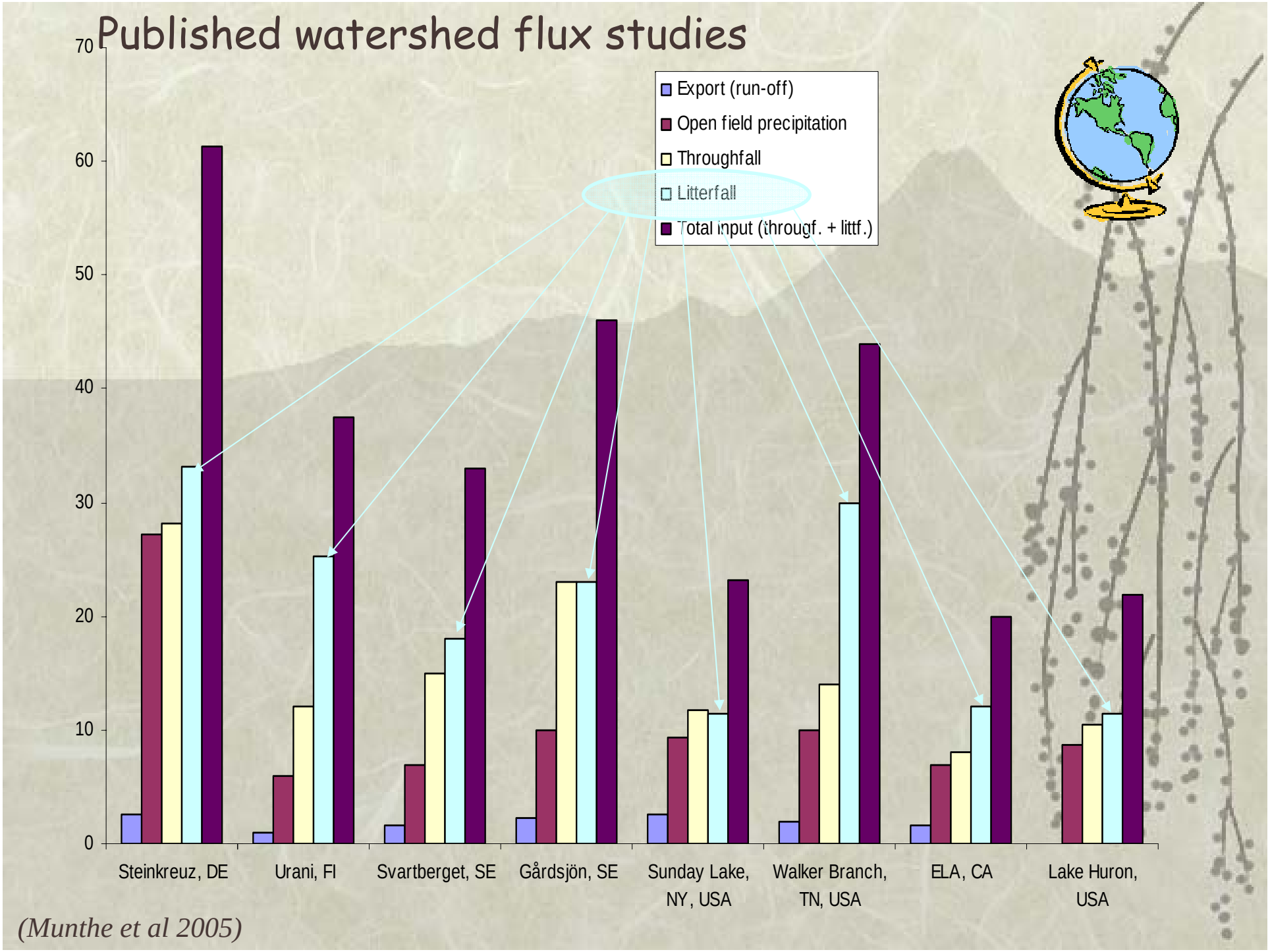
Annual Budget for the Walker Branch Watershed Forest

(fluxes = $\mu g/m^2/y$; pools = $\mu g/m^2$)



(Kim et al, 1997, Johnson and Lindberg, 1995)

Published watershed flux studies



(Munthe et al 2005)

Global vegetation Hg uptake

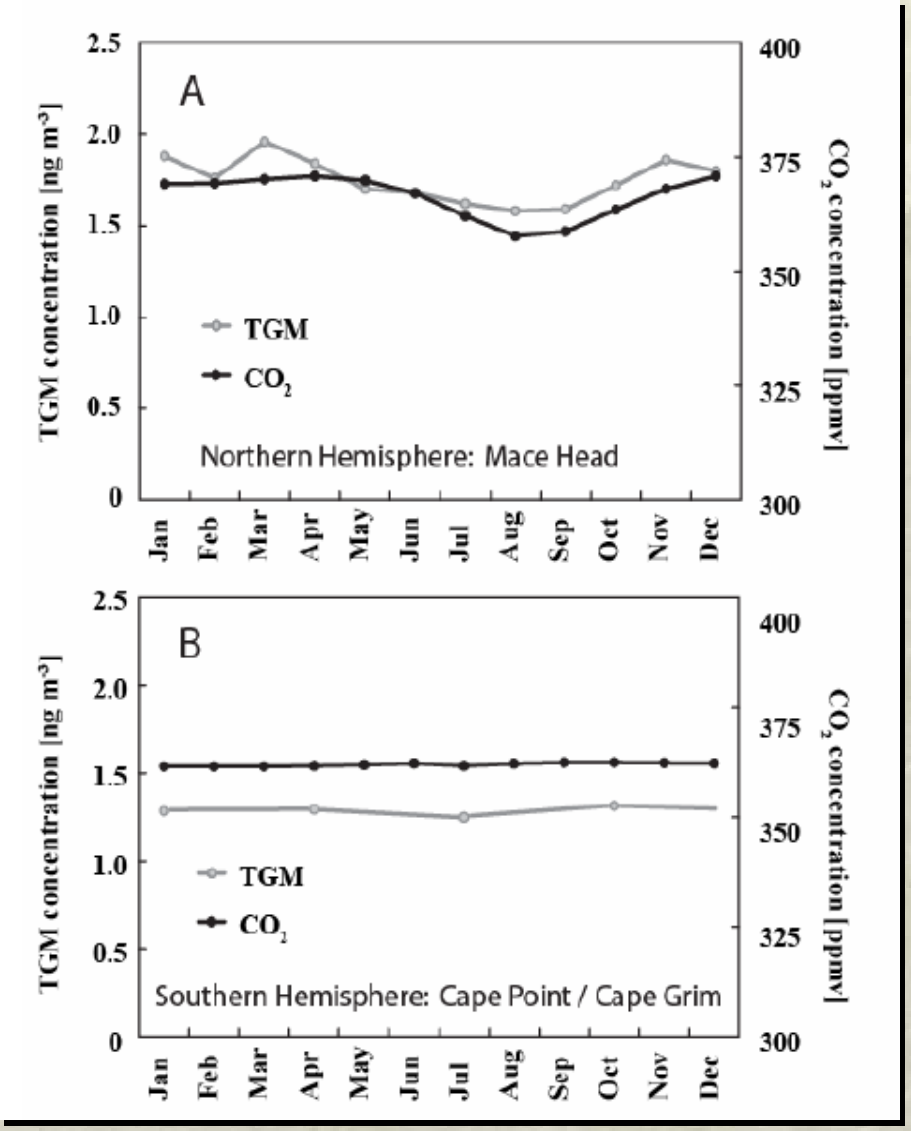
- Calculation of global annual Hg plant uptake based on published tissue Hg concentrations and NPP data*

Annual Global NPP (Pg C/yr)	**60**			
Annual Biomass Production (=NPP*2; Pg/yr)	**120**			
	50% Forests/shrublands 60		**50% Grasslands/others 60**	
Annual Above-ground Biomass Production (Pg/yr)	**55% of 60: 33**		**45% of 60: 27**	
	30% Leaves 9.9	**70% Wood 23.1**	**100% leaves 27**	**0% Wood --**
Tissue Hg Concentration (ppb)	**24**	**6**	**24**	**--**
Annual Atmospheric Hg Uptake (Mg Hg/yr)	**237.6**	**138.6**	**648.0**	**--**
Sum	**1024.2**			

- Atmospheric Hg Pool (0-5km) ~3,000 Mg**
- Above-ground Vegetation Pool ~1,000 Mg*

*(Obrist, 2007) **(Banic et al 2003)

Plant Hg uptake



Hypothesis in Obrist 2007*:

"Plant Hg Pump might be strong enough to affect atmospheric Hg levels and lead to atmospheric Hg oscillations in the Northern Hemisphere

**Obrist (Biogeochemistry 85: 119-123)*

Data from Ebinghaus et al. (Atmos Environ 2002) and Baker et al. (Atmos Environ 2003)

EPA Star Program on Consequences of Global Change for Air Quality

Effects of global change on the atmospheric mercury burden and mercury sequestration through changes in ecosystem carbon pools

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Yiqi Luo (Co-PI) – University of Oklahoma, Norman

Dale Johnson (Co-PI) – University of Nevada

Steve Lindberg (Co-PI) – University of Nevada

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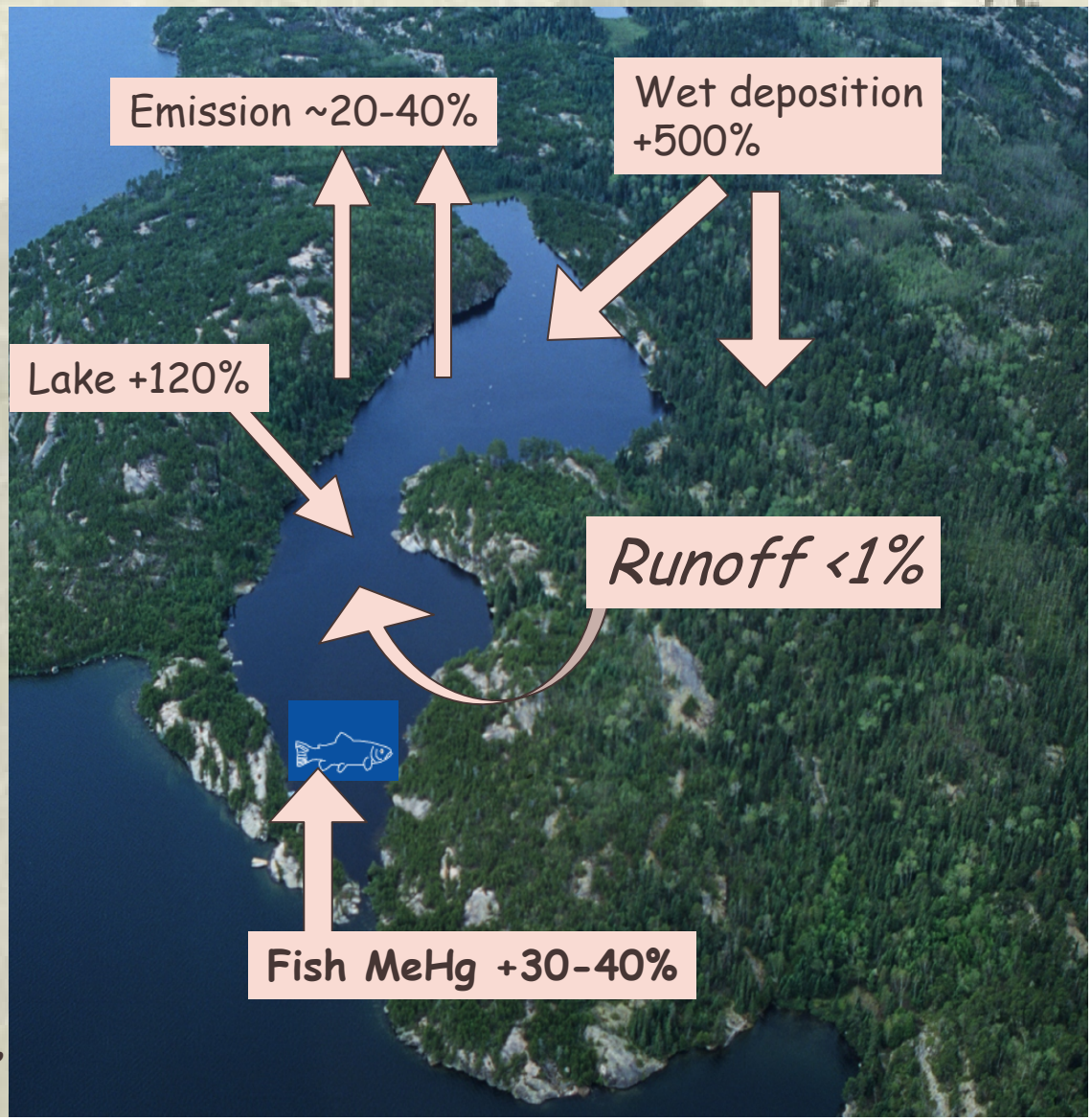
METAALICUS

^{198}Hg, ^{202}Hg, ^{200}Hg

- Wet deposition was increased from ~5 to ~30 ug/m^2/y with HgII stable isotopes for 6y

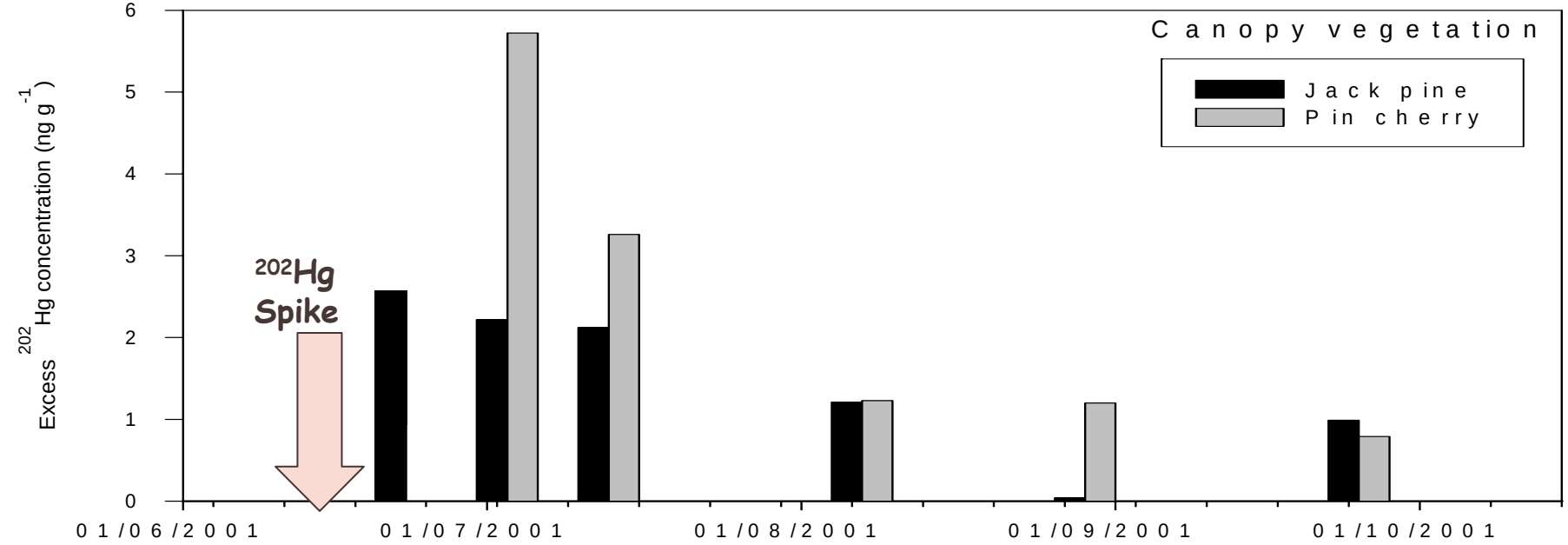
METAALICUS 3-Year LOADING SUMMARY*

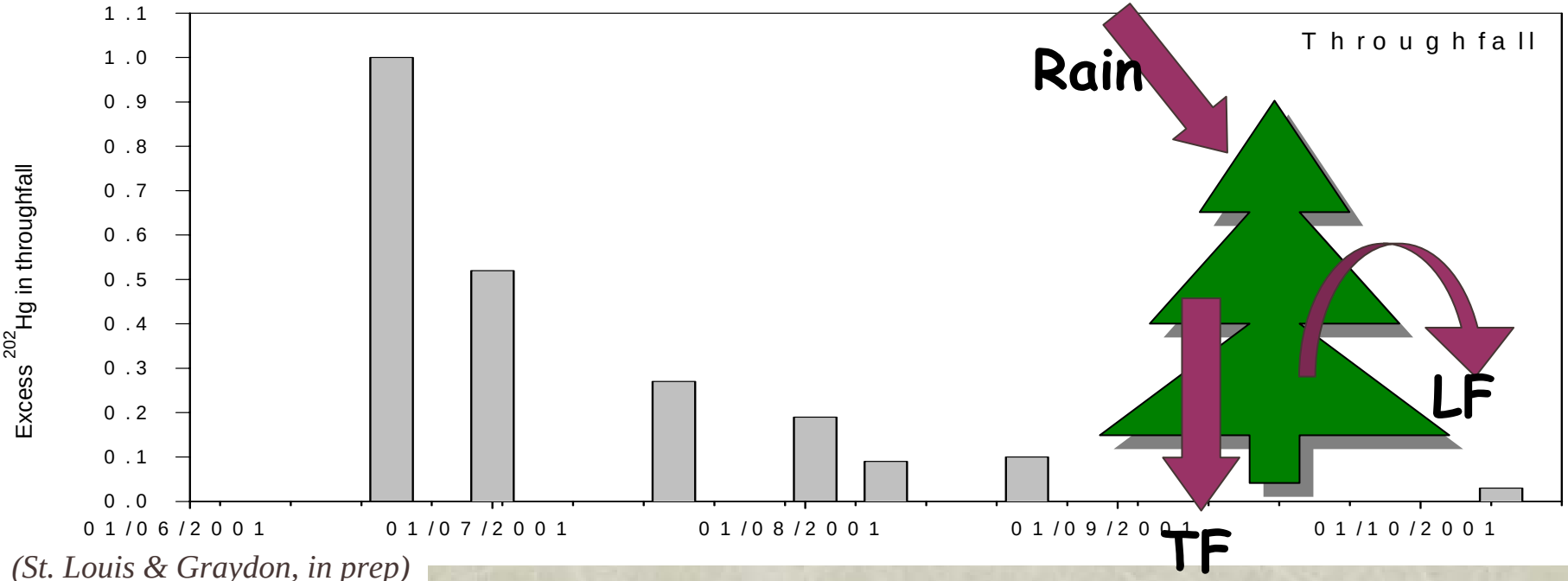
- Good Hg mass balance achieved
- Significant emission of iso. Hg^0 to the atmosphere (20-40%)
- Rapid increase in MeHg in water, sediments, & biota
- *3-y delay & very small increase in runoff Hg*
- *Behavior of isotope in canopy has implications for LF & TF studies*



(Harris et. al. Proc. National Academy of Science, in press)

Behavior of Isotope in Canopy

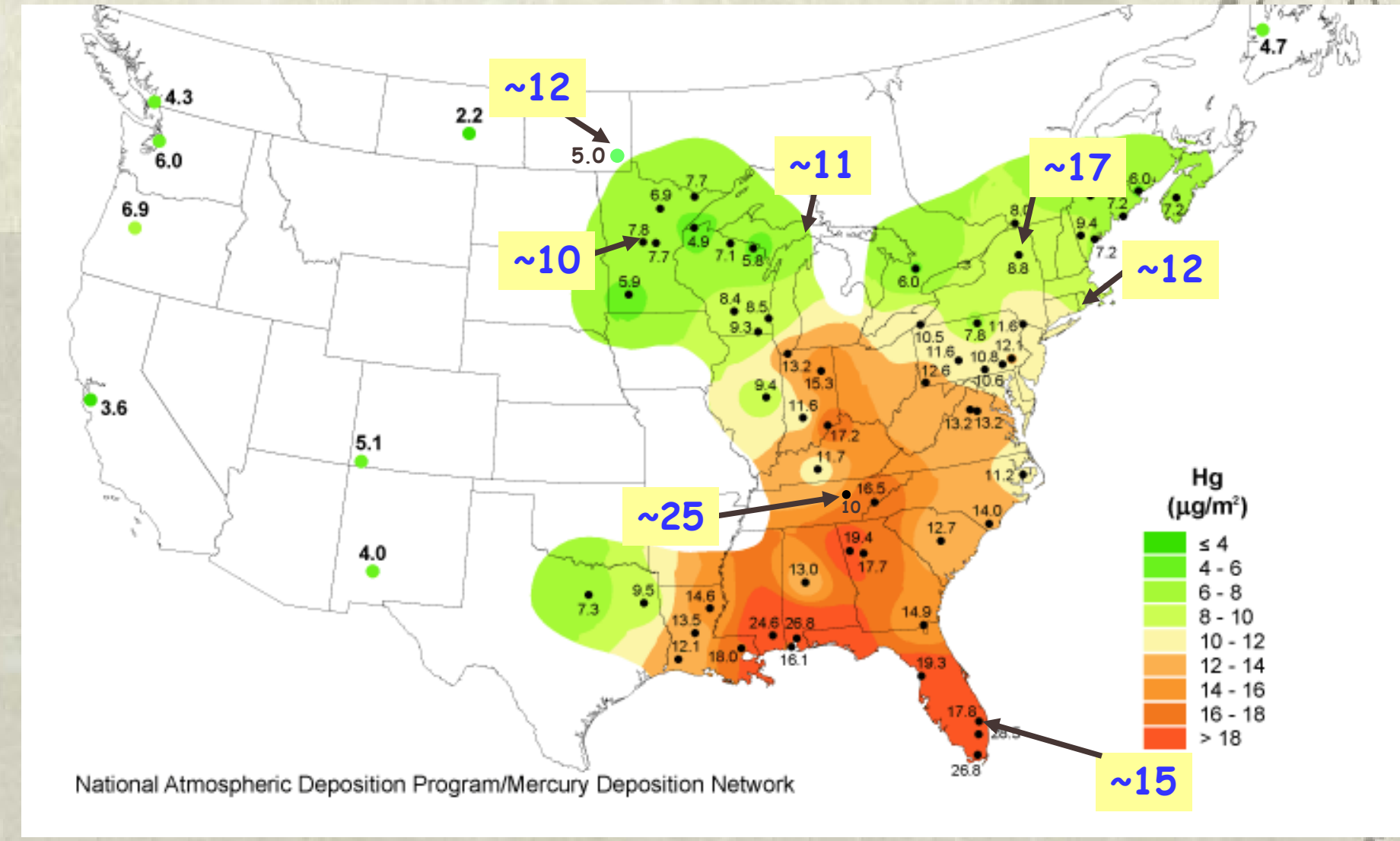




(St. Louis & Graydon, in prep)

Does dry deposition matter?

Annual Hg fluxes in LF (μg/m2)



(Driscoll 2007, Bash 2007, Swain 2004, St Louis 2004, Rea 2002, Lindberg 1998)