

Mass Distribution of Mercury among Ecosystem Components in the Florida Everglades

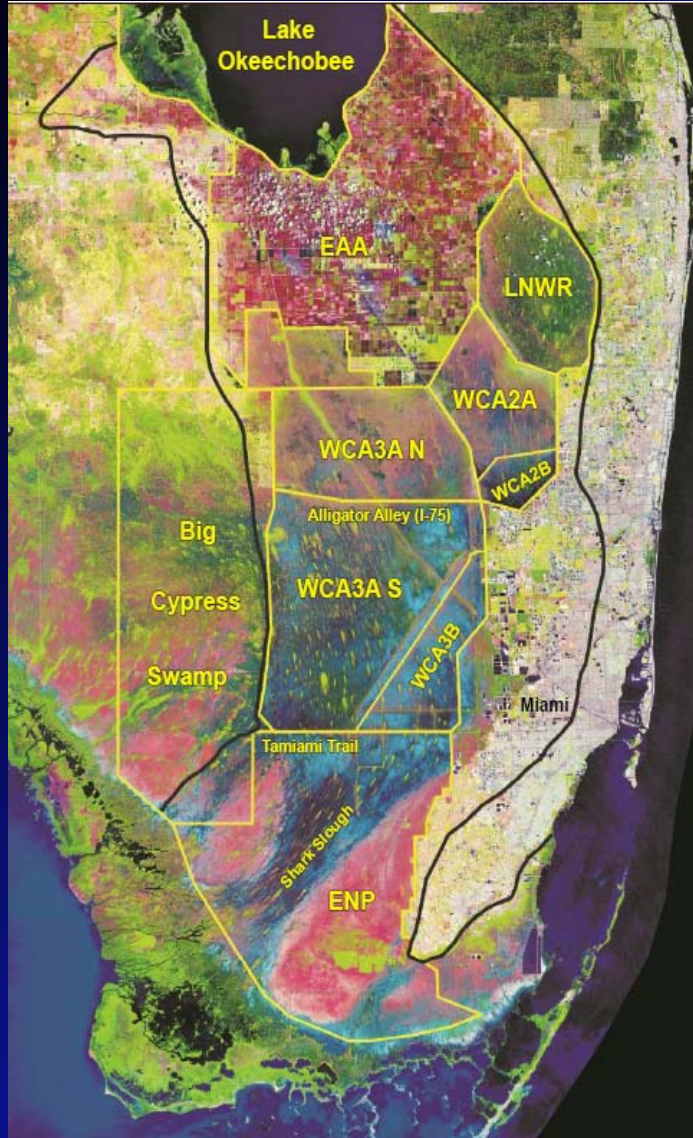
Guangliang Liu¹, G. Melodie Naja², Yong Cai¹,
Peter Kalla³, Dan Scheidt³, Evelyn Gaiser¹,
Georgio Tachiev¹, David Roelant¹

¹: Florida International University

²: Everglades Foundation

³: US EPA Region 4

Hg contamination in the Everglades



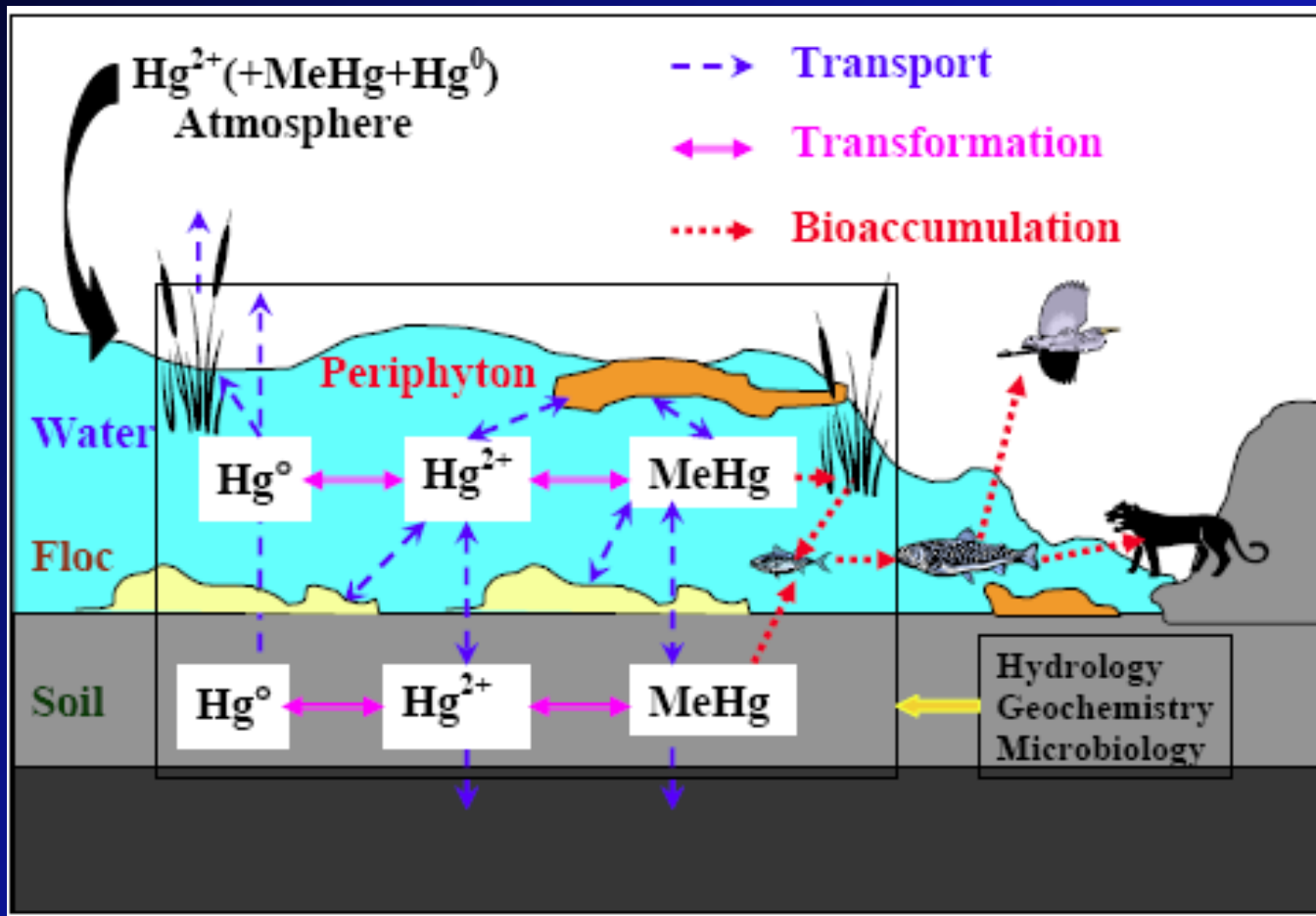
WARNING

The Florida Department of Health and Rehabilitative Services has issued a health advisory urging limited consumption of largemouth bass and warmouth caught in certain portions of the Everglades due to excessive accumulation of the element mercury.

- Fish caught in Arthur R. Marshall Loxahatchee National Wildlife Refuge Water Conservation Area () should not be eaten more than once per week by adults and no more than once per month by children under 15 and pregnant women.
- Fish caught in Water Conservation Areas 2a and 3 should not be eaten at all.

For additional information, contact the Florida Department of Health and Rehabilitative Services at (405) 355-3018.

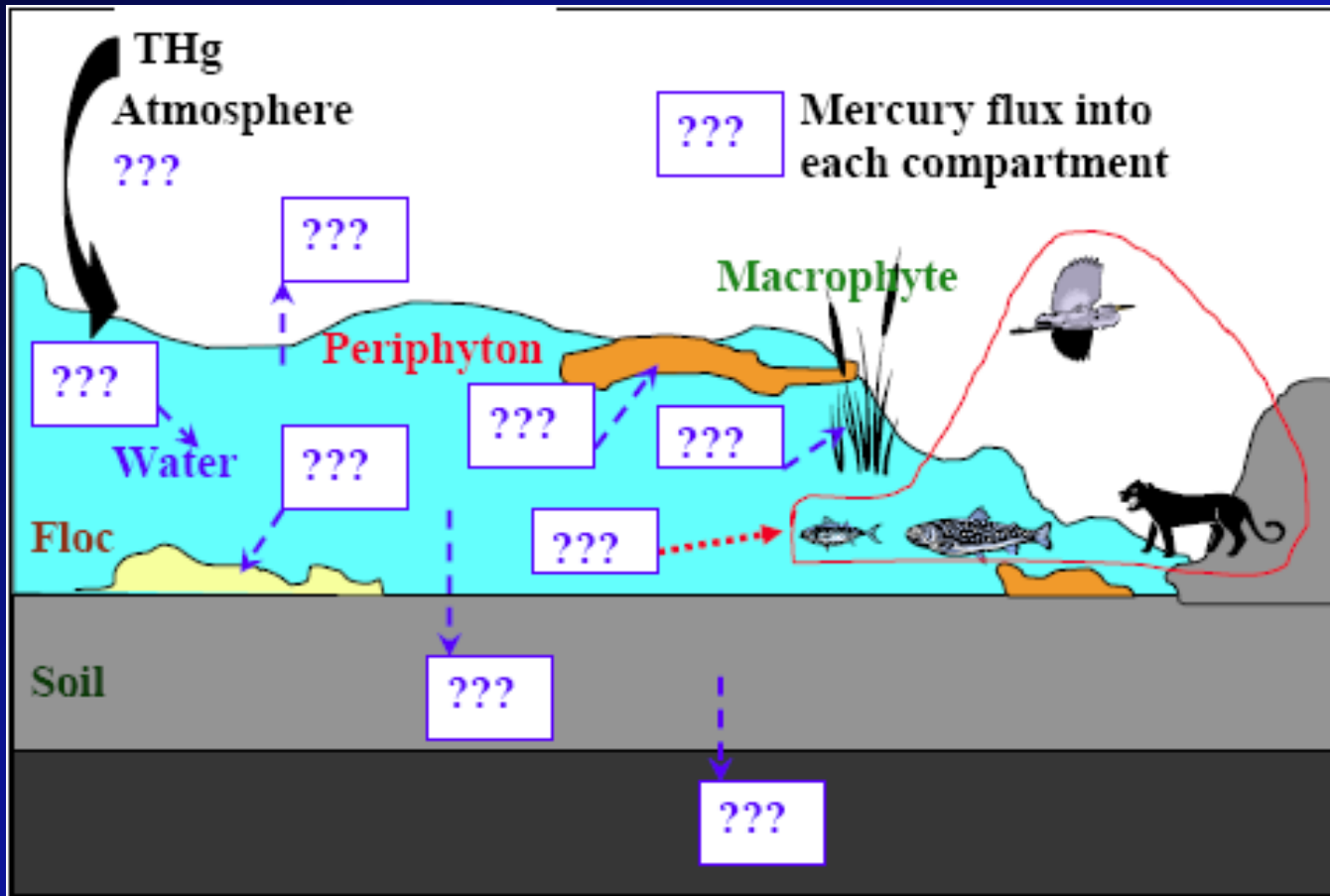




Mercury Cycling in the Florida Everglades

Question

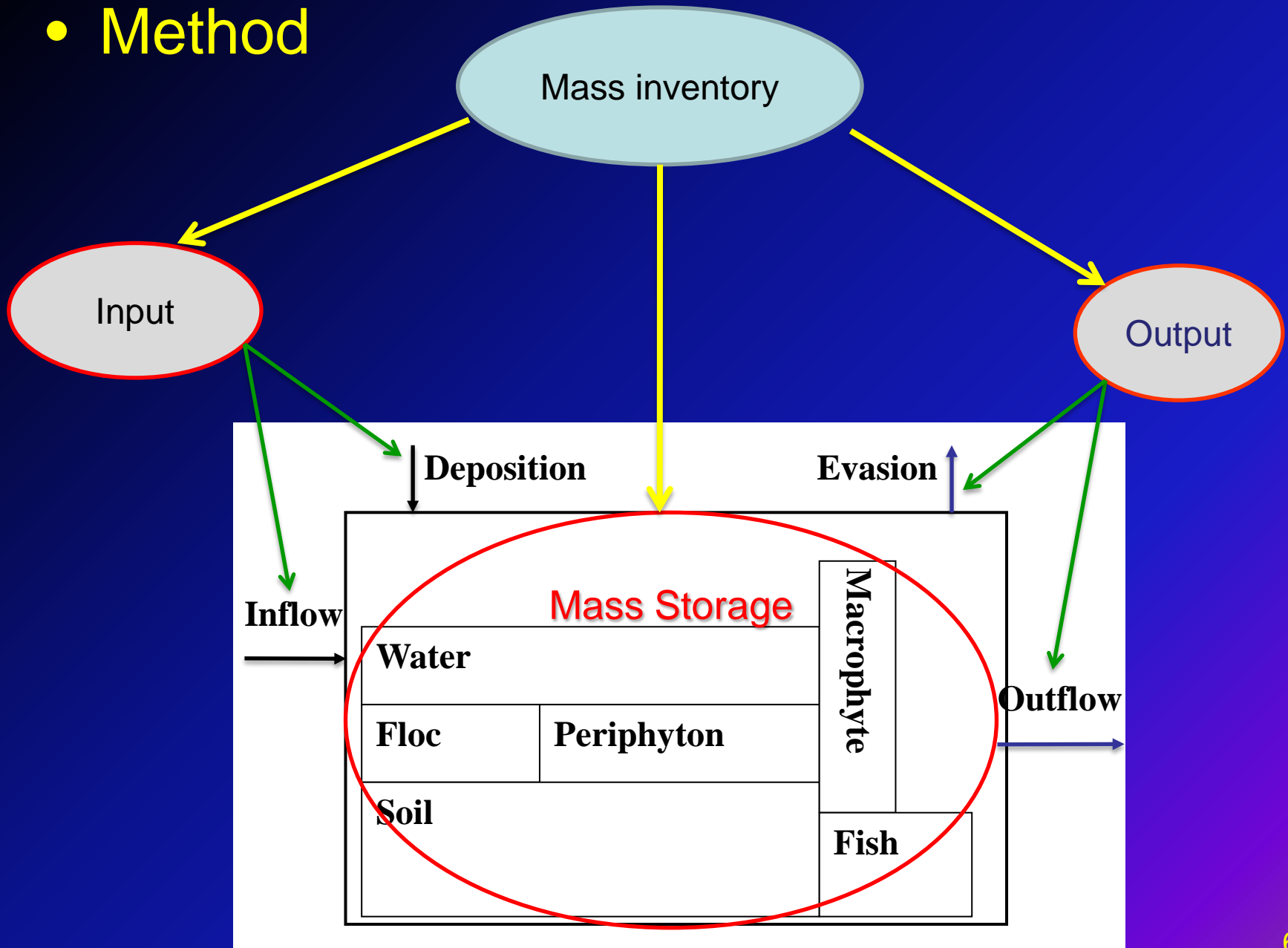
How much Hg is present in each ecosystem component in the Everglades?



Objective

- To establish mass inventory for THg and MeHg in the four management units of the Everglades.
 - WCA 1
 - WCA 2
 - WCA 3
 - ENP

- Method



❖ Mass Storage (at sampling: Nov 2005)

Water:

$$M_{SW}^{THg} = \frac{\sum_{i=1}^n C_{SWi}^{THg} \times d_{SWi}}{\sum_{i=1}^n \left(\frac{1}{\pi_i}\right)} \times A \times 10^3$$

THg concentration

Water volume

THg mass

inclusion probability

Soil:

$$M_{SD}^{THg} = \frac{\sum_{i=1}^n \frac{C_{SDi}^{THg} \times d_{SDi} \times BD_{SDi}}{\pi_i}}{\sum_{i=1}^n \left(\frac{1}{\pi_i}\right)} \times A \times 10^6$$

Floc:

$$M_{FC}^{THg} = \frac{\sum_{i=1}^n \frac{C_{FCi}^{THg} \times d_{FCi} \times BD_{FCi}}{\pi_i}}{\sum_{i=1}^n \left(\frac{1}{\pi_i}\right)} \times A \times 10^6$$

Periphyton:

$$M_{PE}^{THg} = \frac{\sum_{i=1}^n \frac{C_{PEi}^{THg} \times BM_{PEi}}{\pi_i}}{\sum_{i=1}^n \left(\frac{1}{\pi_i}\right)} \times A$$

Macrophyte:

$$M_{PE}^{THg} = \frac{\sum_{i=1}^n \frac{C_{PEi}^{THg} \times BM_{PEi}}{\pi_i}}{\sum_{i=1}^n \left(\frac{1}{\pi_i}\right)} \times A$$

Fish:

$$M_{FS}^{THg} = \frac{\sum_{i=1}^n \frac{C_{FSi}^{THg} \times W_{FSi} \times BM_{FSi}}{\pi_i}}{\sum_{i=1}^n \left(\frac{1}{\pi_i}\right)} \times A$$

❖ Input

(during 2005 wet season: May-Nov)

Deposition:

THg deposition Wet deposition Dry deposition

$$M_{BD}^{THg} = M_{WD}^{THg} + M_{DD}^{THg}$$

Inflows:

Mean THg Conc Total water inflows

$$M_{IF}^{THg} = \bar{C}_{IF}^{THg} * \sum_i V_{IF}^i$$

❖ Output

(during 2005 wet season: May-Nov)

Evasion:

$$M_{EV}^{THg} = 2(ng / m^2 / h) * 10(h / d) * 180(d) * A$$

Management unit	Inflow Structures	Outflow Structures
WCA 1	G310, G301, G300, G251, S362, ACME1, ACME2	S10, G94, S39, G301
WCA 2	S10, S7, G335	S34, S38, S11
WCA 3	S11, S8, S9, S140, S150, S190	S12, S31, S142, S333, S343, S344, G69
ENP	S12, S18, S174, S332, S333-S334	C111, Taylor River Slough, Shark River Slough, Trout Creek, Taylor Creek,

Outflows:

Mean THg Conc Total water outflows

$$M_{OF}^{THg} = \overline{C}_{OF}^{THg} * \sum_i V_{OF}^i$$

Databases

- EPA Everglades R-EMAP (2005)
- MDN
- USGS ACME
- SFWMD DBHRDRO
- Others

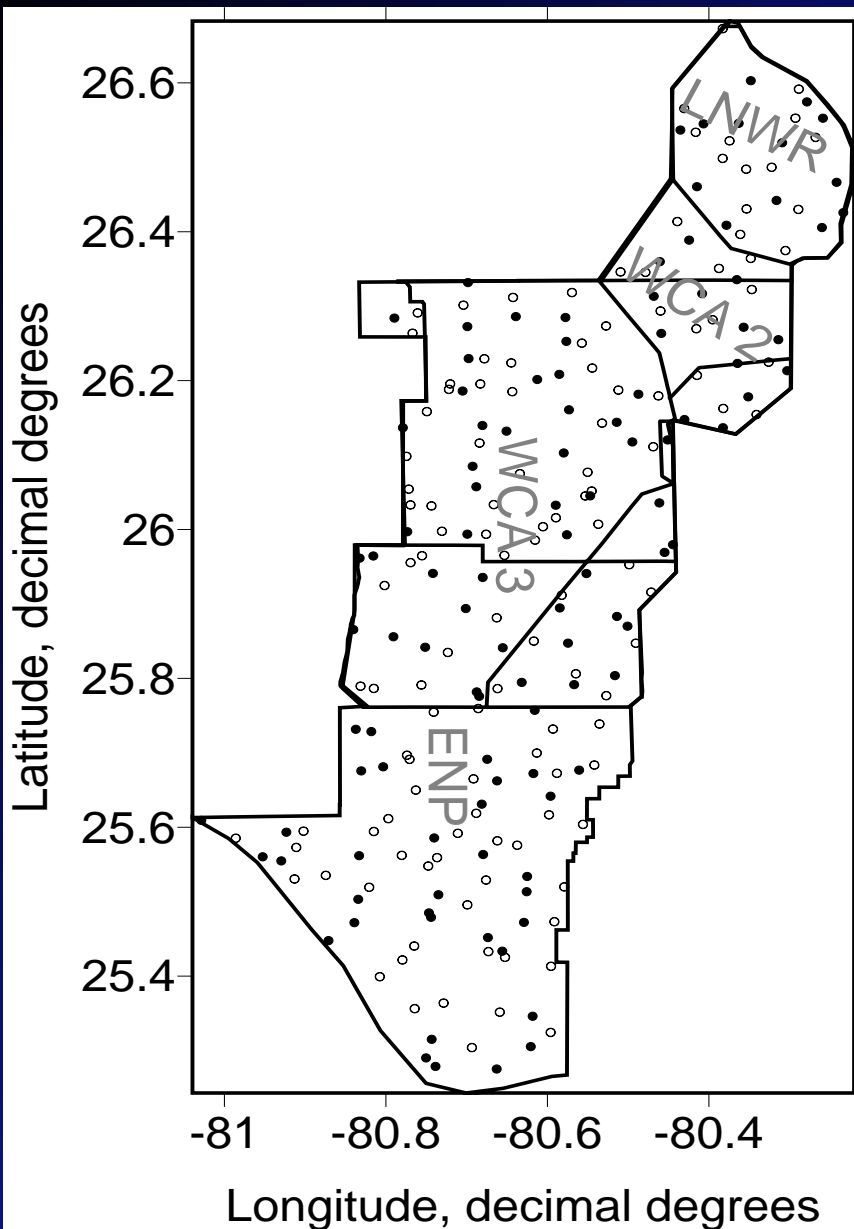
- 2005 R-EMAP

Ecosystem-wide sampling

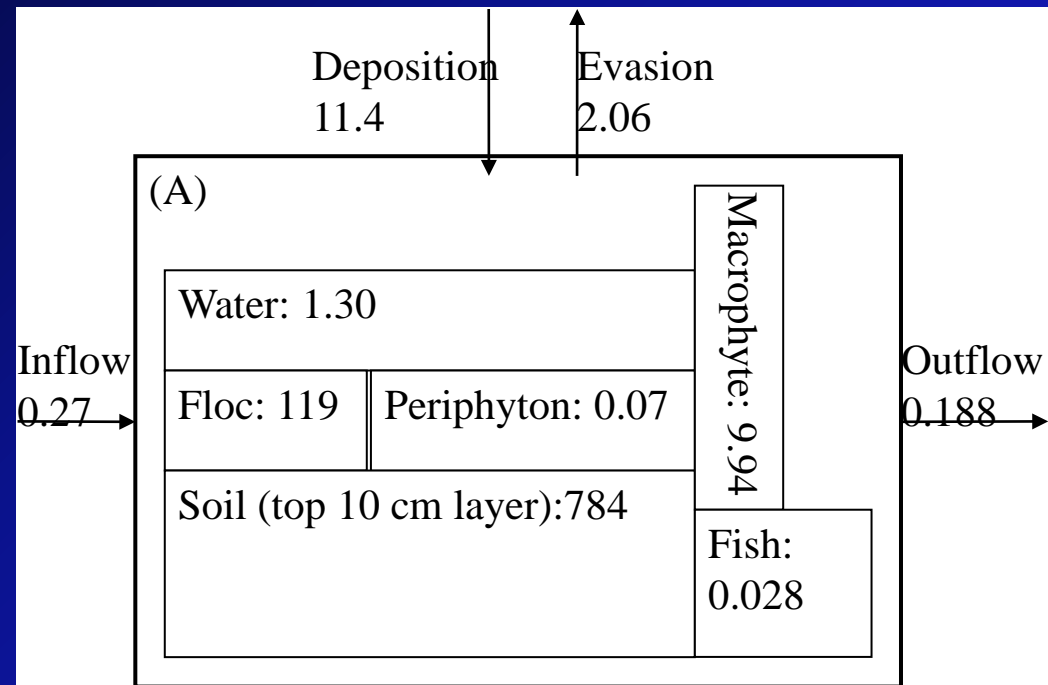
Probability sampling design

Closed circle: May, 109

Open circle: November, 119



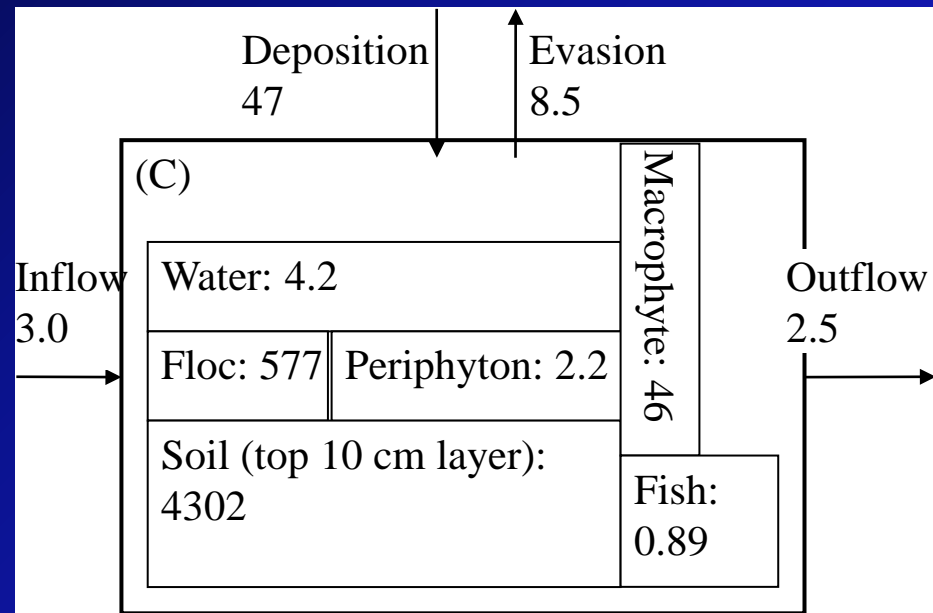
- Results



WCA 1

THg mass (kg)
inventory

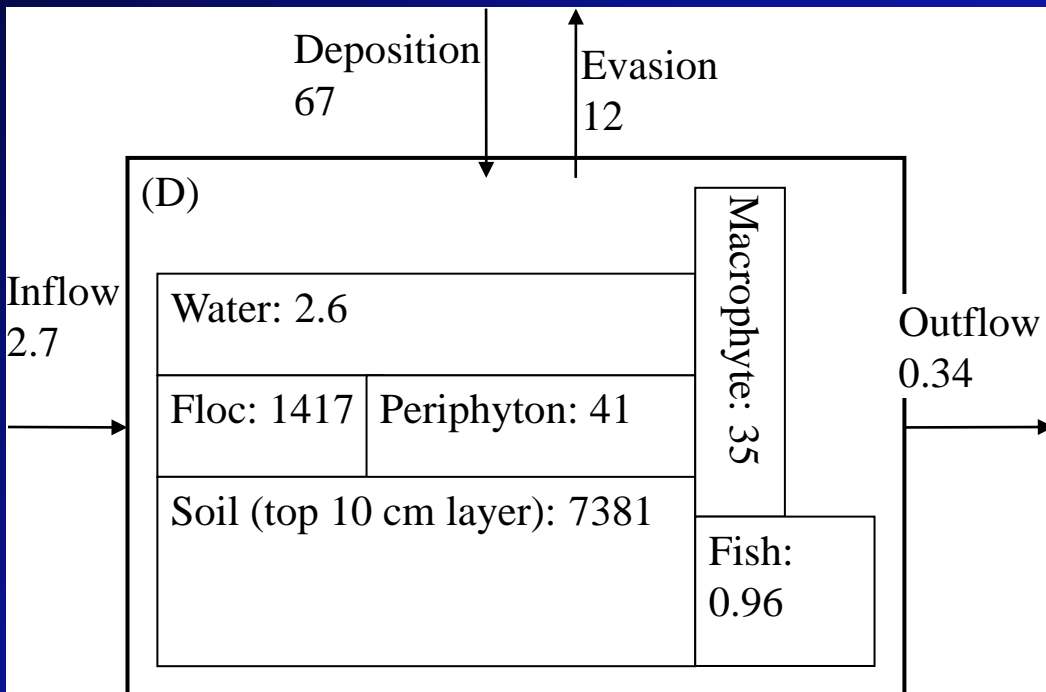
WCA 2



WCA 3

THg mass (kg)
inventory

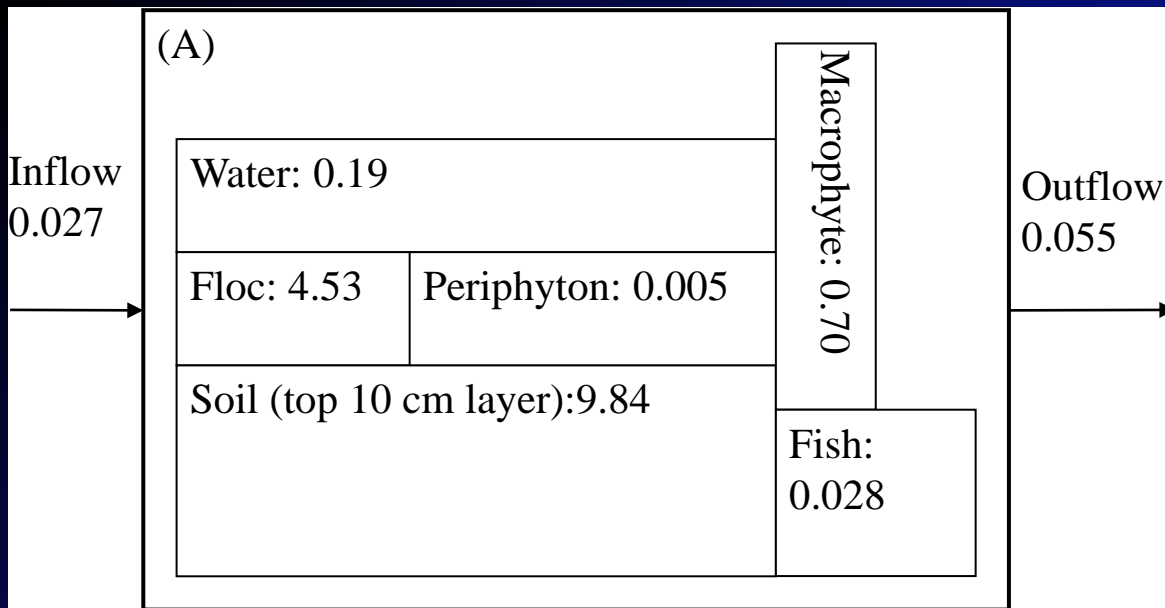
ENP



THg mass (kg) inventory

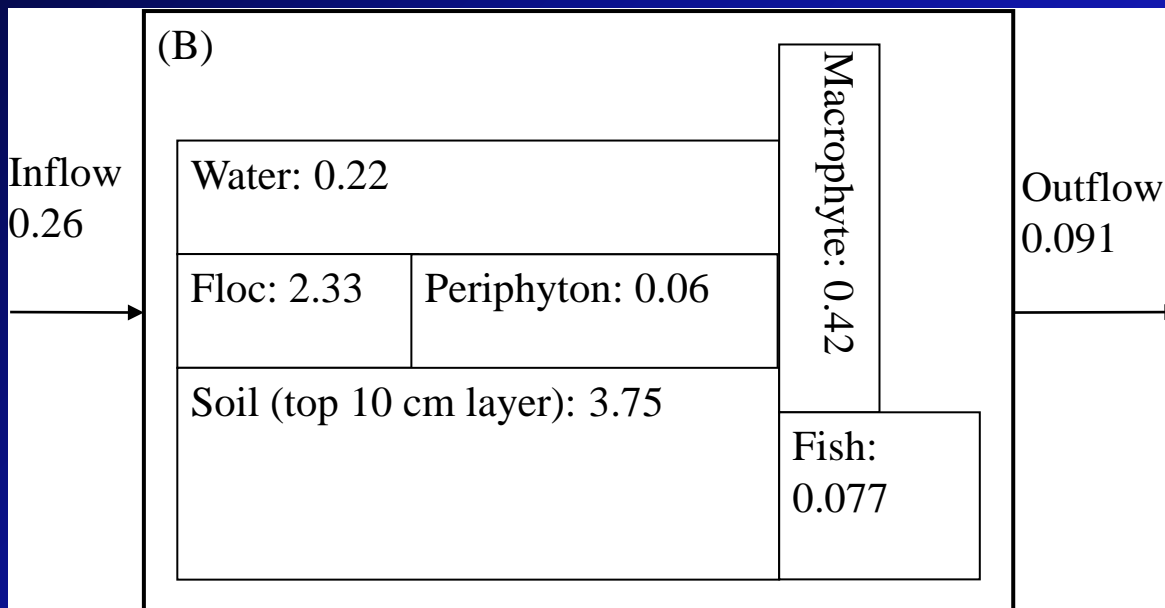
Compartment	In (kg)	Out (kg)	Total accumulated (kg)	Legacy Hg (kg)	Legacy Hg / area (g/m ²)
WCA 1	11.7	2.2	9.4	914	1.6
WCA 2	11.8	2.9	8.9	1138	2.1
WCA 3	50.3	11.1	39.2	4931	2.1
ENP	69.9	12.4	57.5	7602	2.3

- Legacy Hg is huge
- Soil and floc are main sinks
- THg transport is limited
- Inputs > outputs

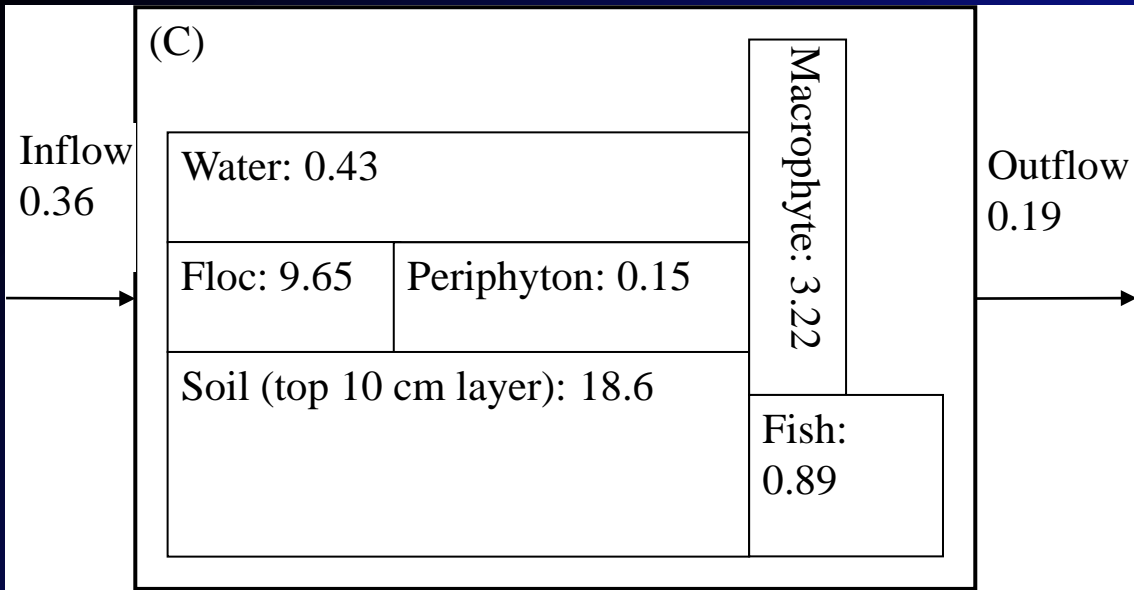


WCA 1

MeHg mass (kg)
inventory

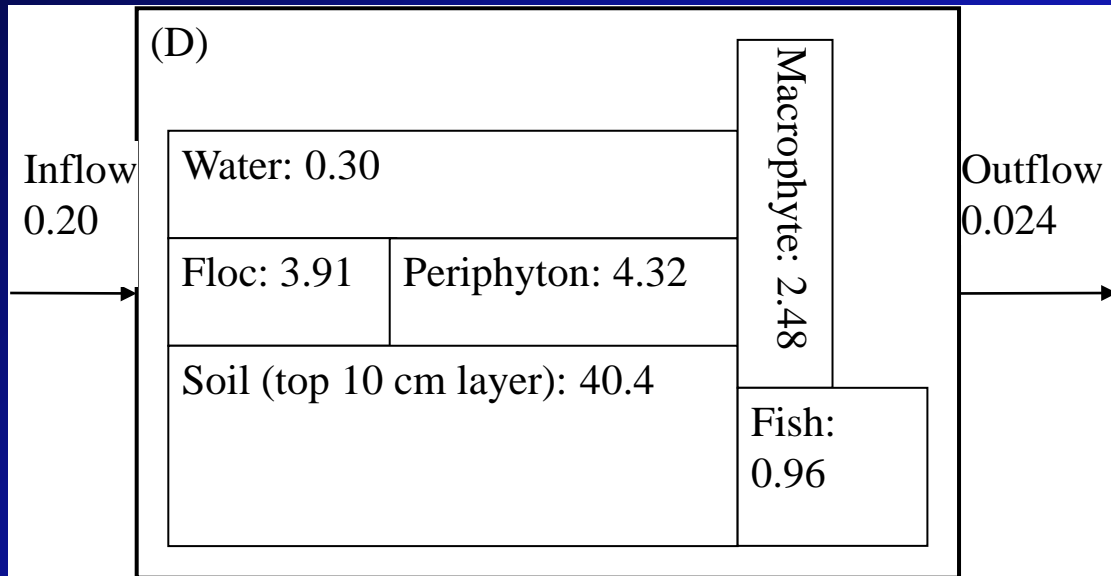


WCA 2



WCA 3

MeHg mass (kg)
inventory



ENP

MeHg mass (kg) inventory

Compartment	In (kg)	Out (kg)	Accumulated (kg)	Legacy (kg)	Legacy MeHg / area (g/m ²)
WCA 1	0.027	0.055	0.028	15	0.027
WCA 2	0.26	0.091	0.17	6.8	0.012
WCA 3	0.36	0.19	0.17	32	0.014
ENP	0.20	0.024	0.18	51	0.015

- **Large legacy MeHg**
- **Soil, floc, and macrophyte are main sinks**
- **Transport across management unit may be limited, except for WCA 2**

Uncertainty - THg

		WCA 1	WCA 2	WCA 3	ENP
Water	Mass storage (kg)	1.3	1.6	4.2	2.6
	Uncertainty (%)	17	17	7.3	11
Soil	Mass storage (kg)	784	1015	4302	7381
	Uncertainty (%)	10	15	4.1	6.7
Floc	Mass storage (kg)	119	115	577	141
	Uncertainty (%)	42	37	30	31
Periphyton	Mass storage (kg)	0.067	0.64	2.2	41
	Uncertainty (%)	25	25	10	14
Mosquitofish	Mass storage (kg)	0.028	0.077	0.89	0.96
	Uncertainty (%)	17	25	11	11

Uncertainty - MeHg

		WCA 1	WCA 2	WCA 3	ENP
Water	Mass storage (kg)	0.19	0.22	0.43	0.30
	Uncertainty (%)	33	19	12	14
Soil	Mass storage (kg)	9.8	3.8	18	40
	Uncertainty (%)	37	29	12	18
Floc	Mass storage (kg)	4.5	2.3	9.6	3.9
	Uncertainty (%)	57	57	30	30
Periphyton	Mass storage (kg)	0.0050	0.057	0.15	4.3
	Uncertainty (%)	28	28	11	19

Summary

- Everglades is a sink for Hg, with Hg legacy in WCA1, WCA2, WCA3 and ENP being 749 kg, 1250 kg, 3920 kg and 9340 kg, respectively.
- Different patterns in mass storage between THg and MeHg
 - THg: Soil >> floc
 - MeHg: Soil > floc > macrophyte
- Transport of Hg across regions plays a limited role in Hg cycling, except for WCA 2

Acknowledgements

- EPA Office of Research and Development
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