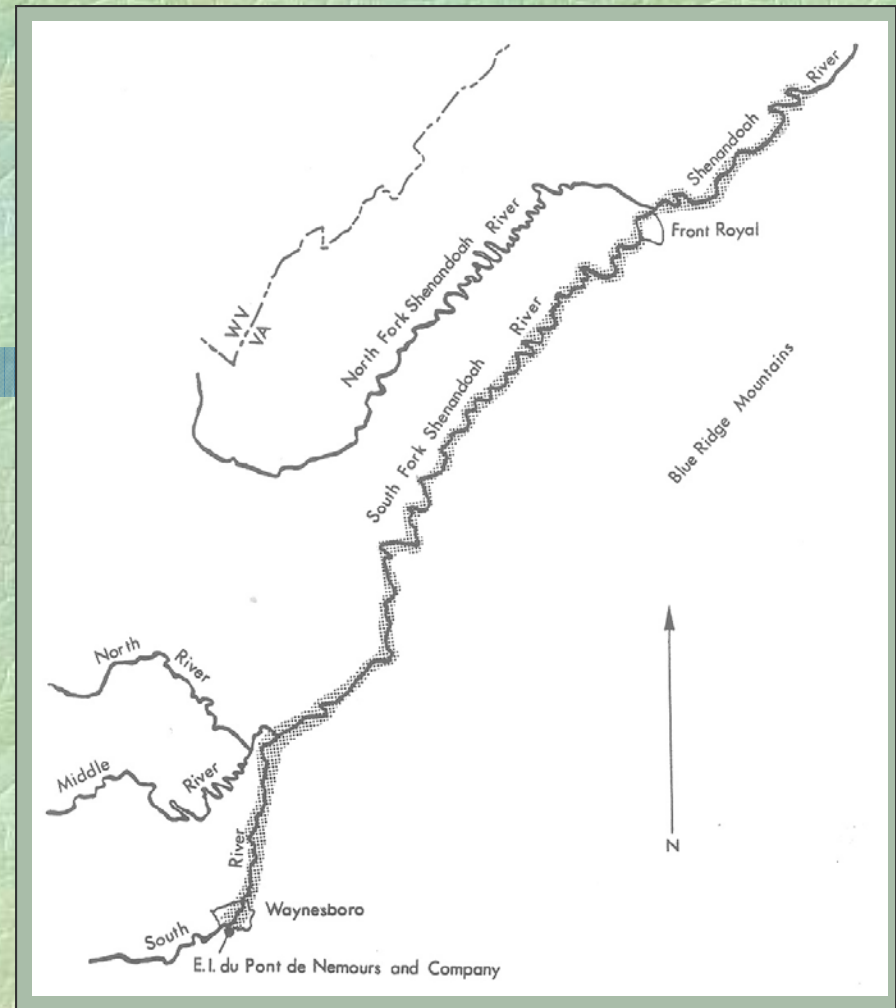


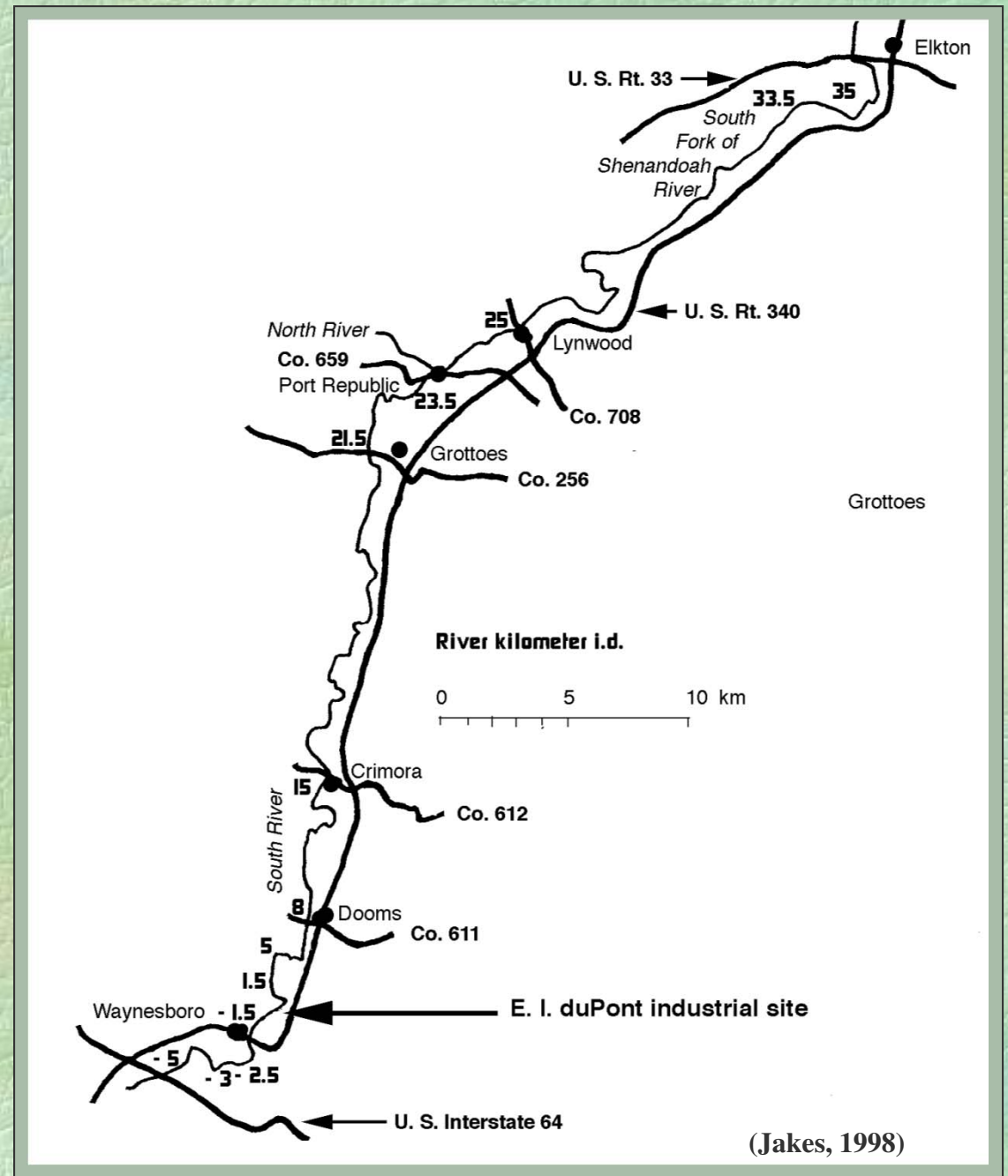
Mercury and the South River Floodplain

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First data....

- Ralph Bolgiano, VA State Water Control Board preliminary study (1981) included some floodplain observations.
- Sampled various locations and estimated a mean floodplain soil concentration of $10.7 \mu\text{g Hg g}^{-1}$ in first 40 km downstream.
- Found one site with $34.5 \mu\text{g Hg g}^{-1}$ in soil.

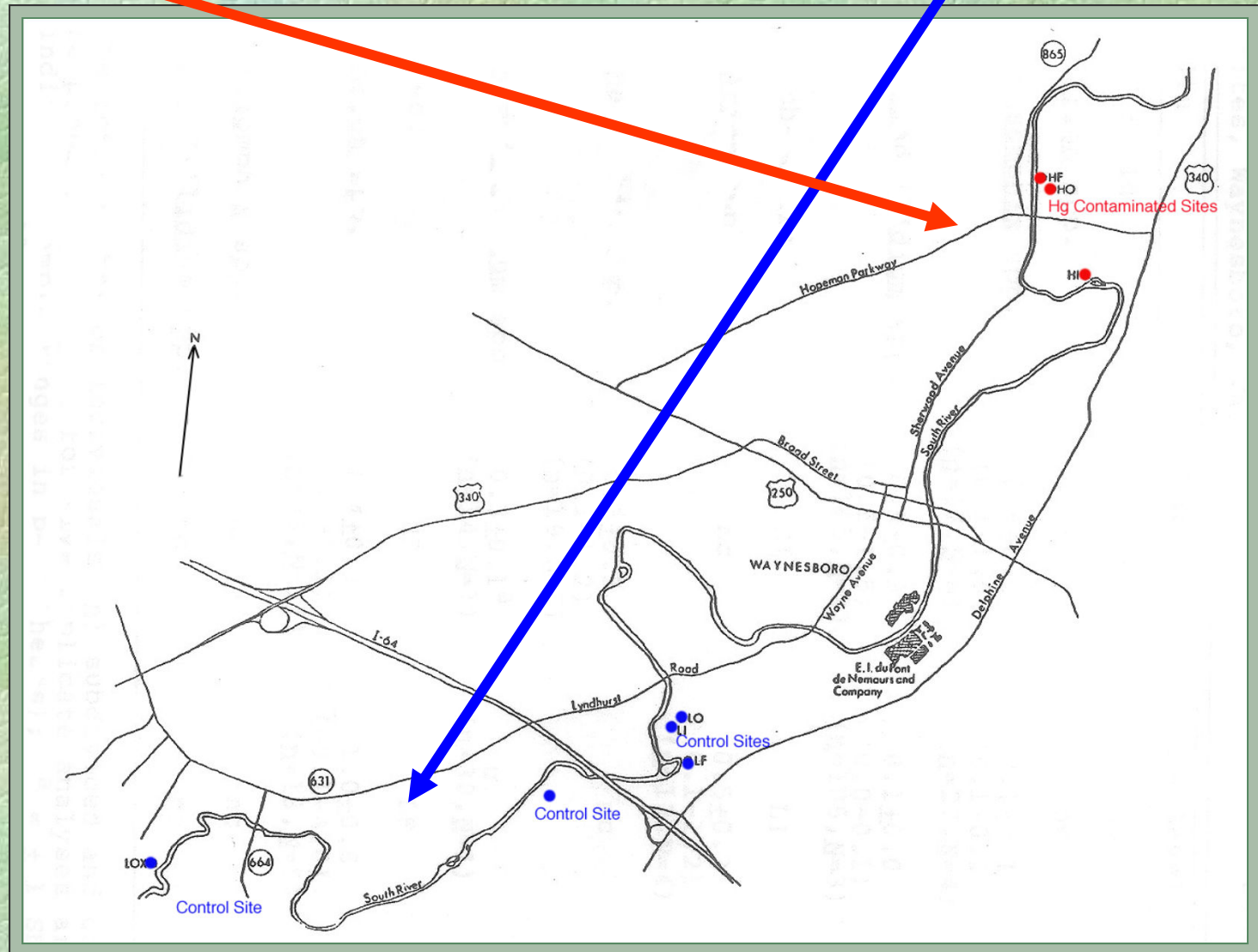


Rehabilitation Feasibility Engineering Study

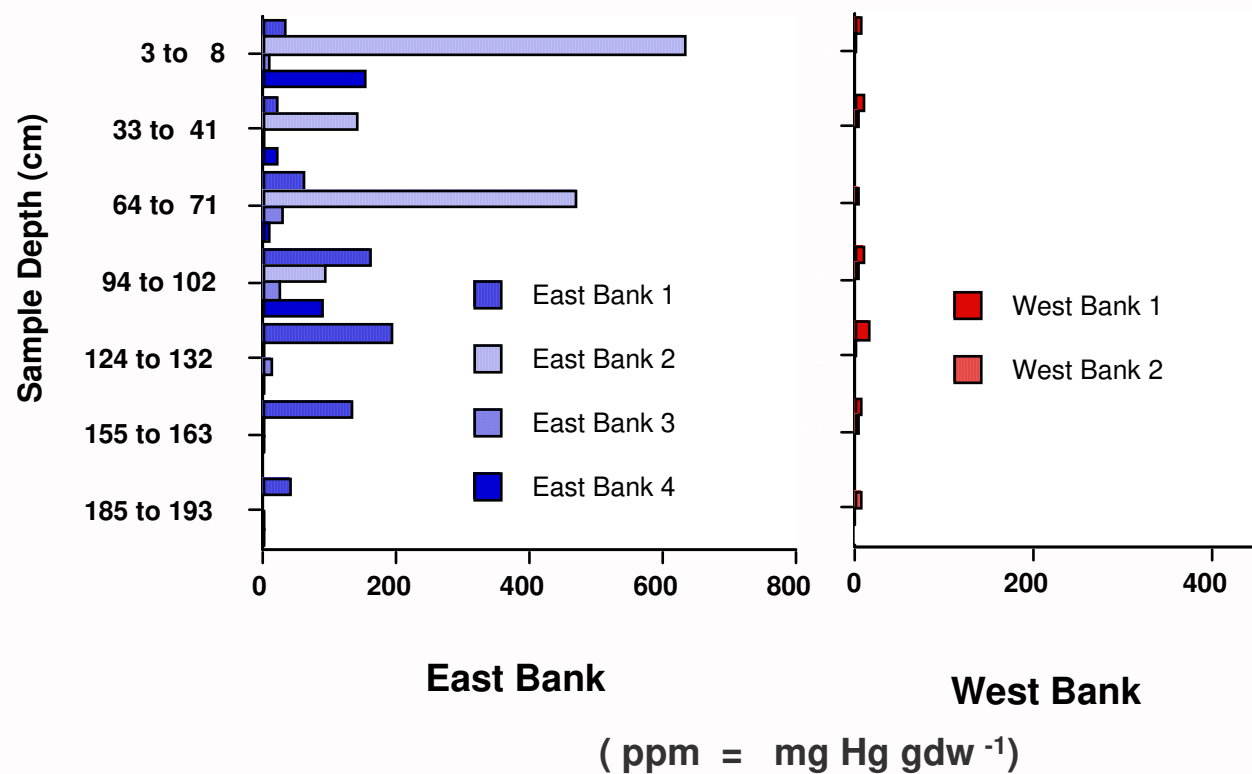
Lawler, Matusky & Skelly (1982)

- **Provided stimulus that generated my interest in the floodplain at Waynesboro**
- **Primarily focused on river**
- **Potential for terrestrial study indicated.**
 - **“about 98% of the mercury in the affected river system is contained in the floodplain where it is stabilized, i.e. substantial portions of the floodplain mercury will not return to the river”**

We selected floodplain research sites upstream and downstream from the Dupont facility.

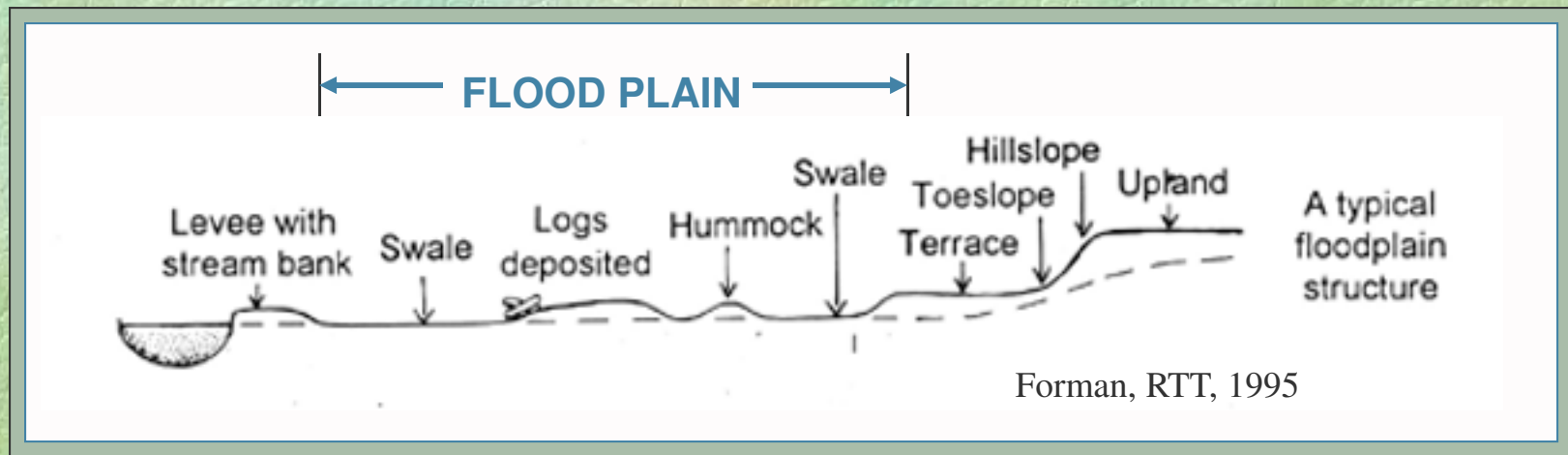


Riverbank [Hg] at original point source



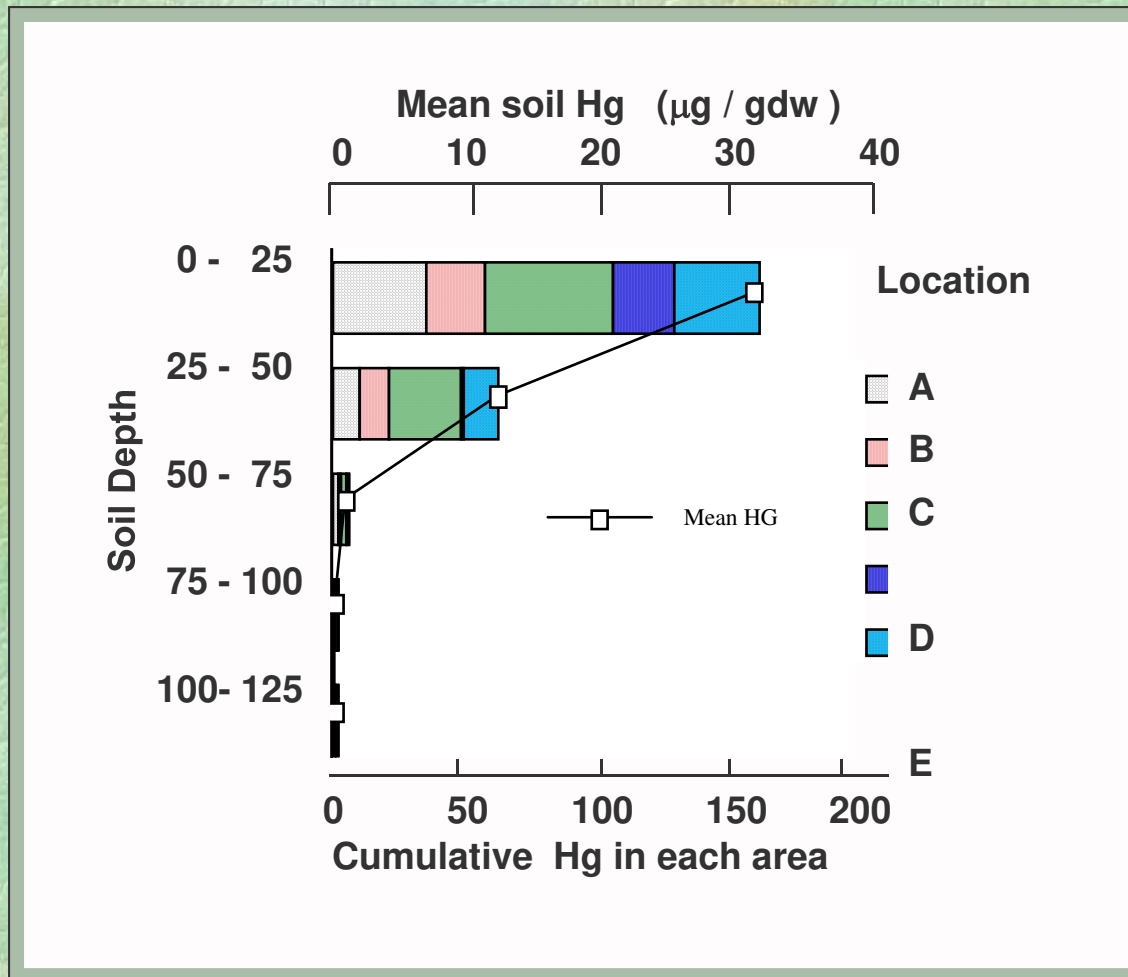
Lawler, Matusky & Skelly (1982)

Our field sites have all been on the floodplain

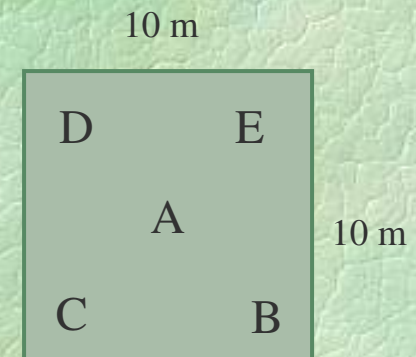


- River bank deposition of Hg reaches depths greater than one meter.
- Floodplain deposits of Hg are often concentrated at shallower depths

Floodplain Forest Soil Hg Concentration Profile ($\mu\text{g Hg gdw}^{-1}$)

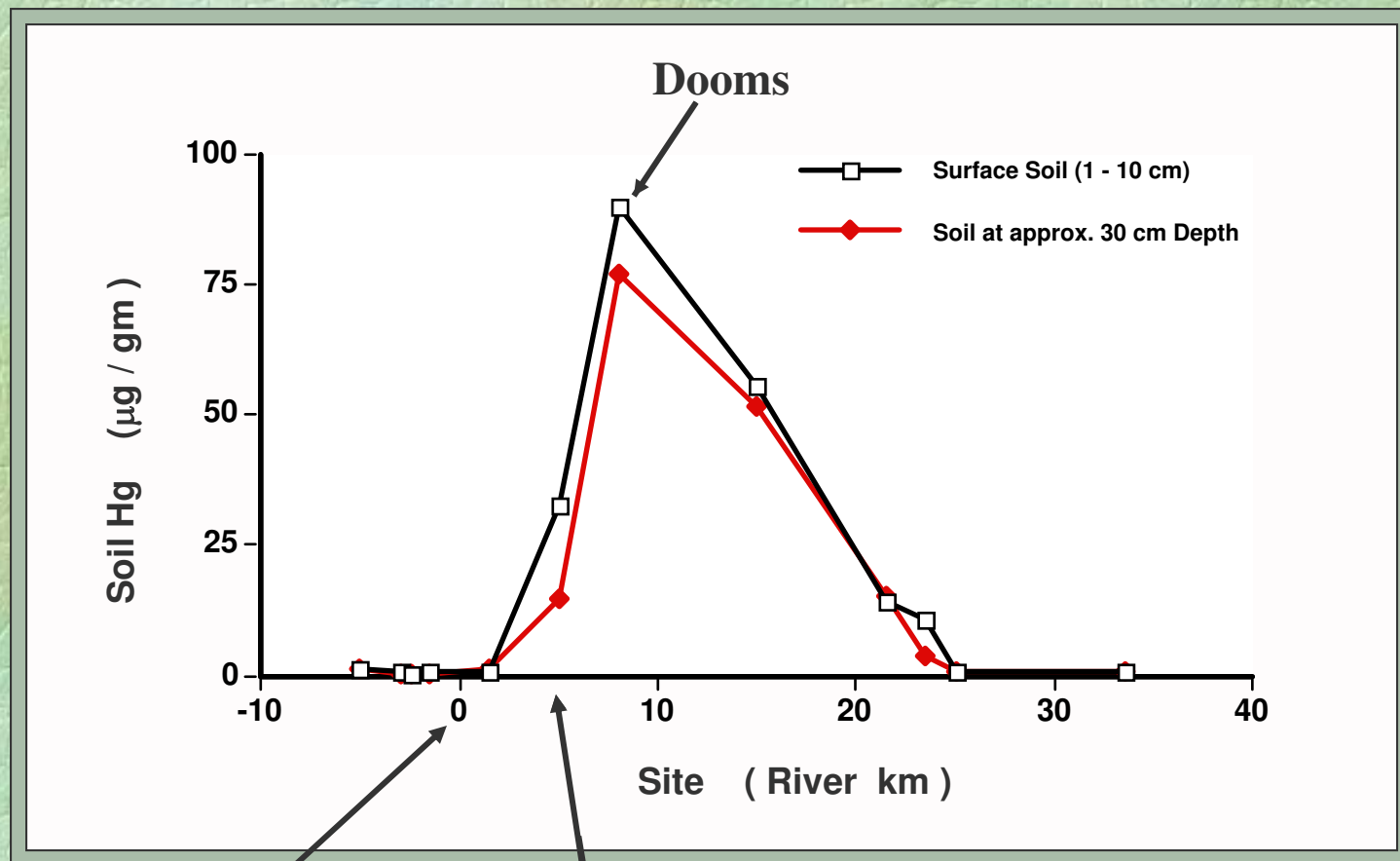


Hopeman Parkway
Contaminated Site



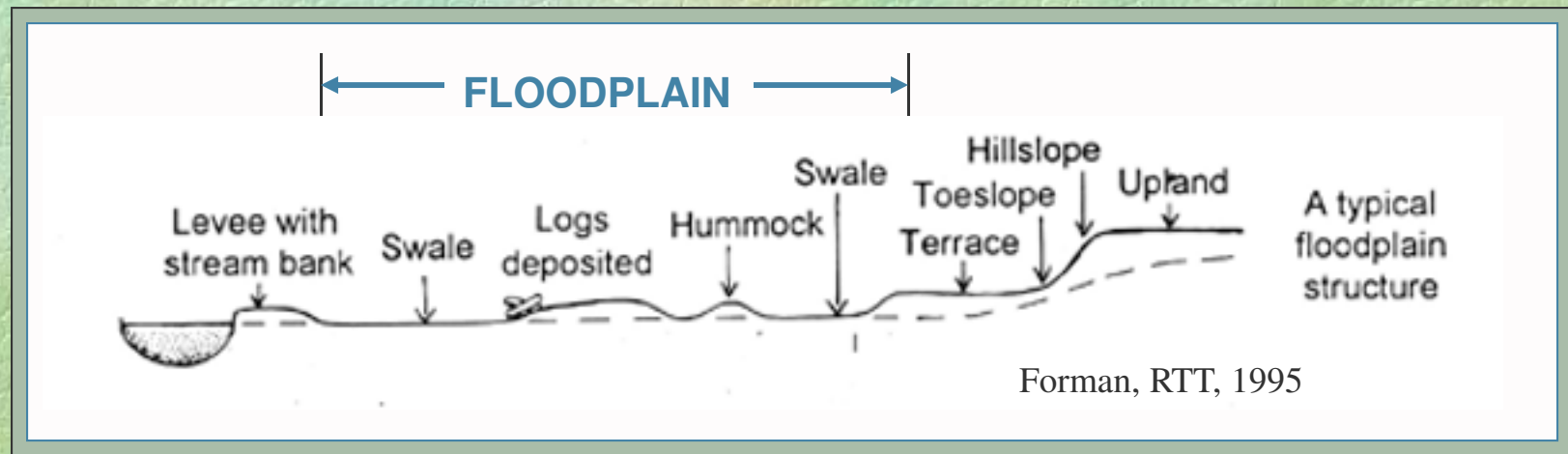
Mastrota, 1984 unpublished study

Floodplain Soil Hg Concentration South River ($\mu\text{g Hg gdw}^{-1}$)



Jakes, 1998 unpublished study

Our field sites have all been on the floodplain

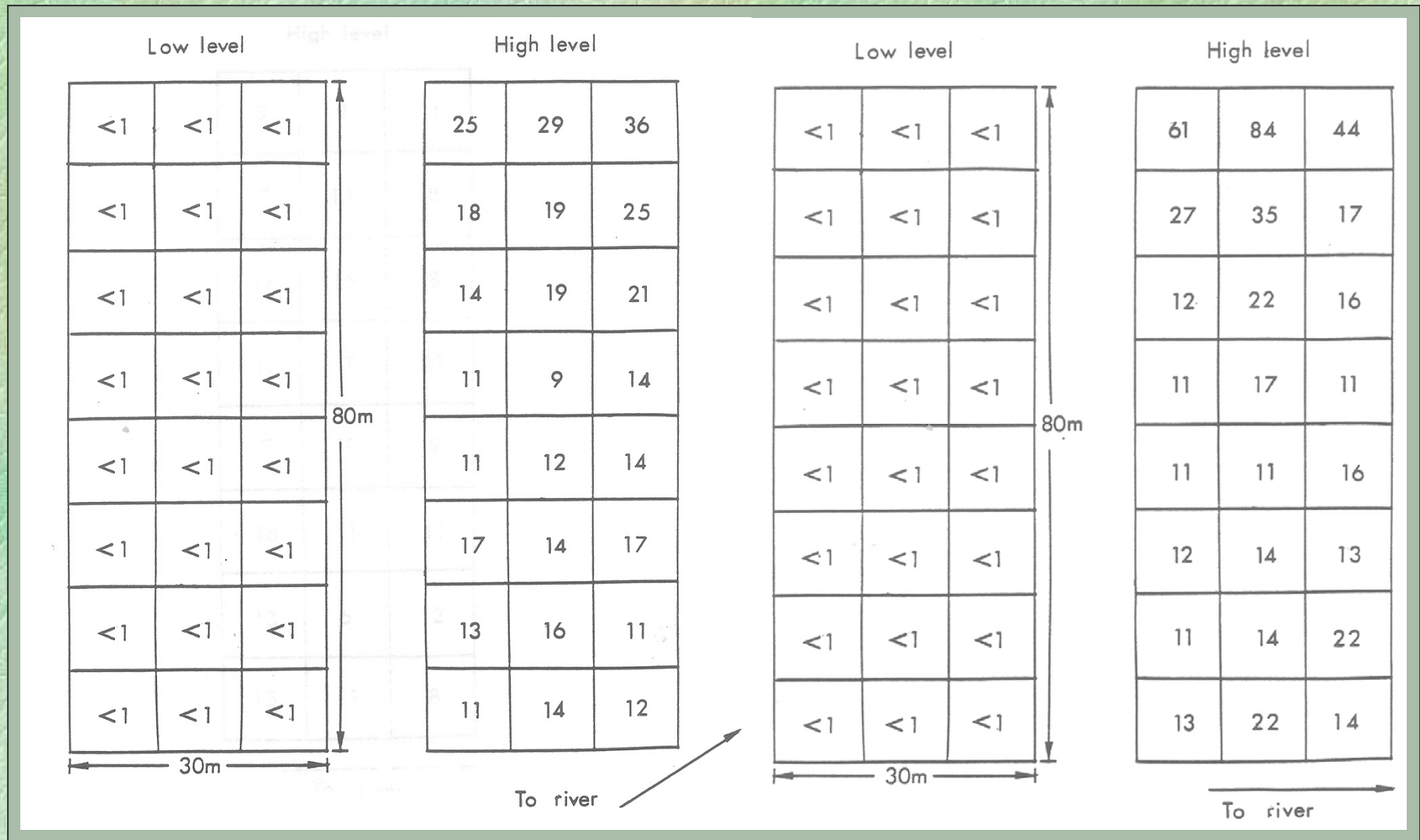


- ❧ River bank deposition of Hg reaches depths greater than one meter.
- ❧ Flood plain deposits of Hg are concentrated at shallower depths
- ❧ **There is extensive horizontal heterogeneity in the Hg deposition at the contaminated sites.**

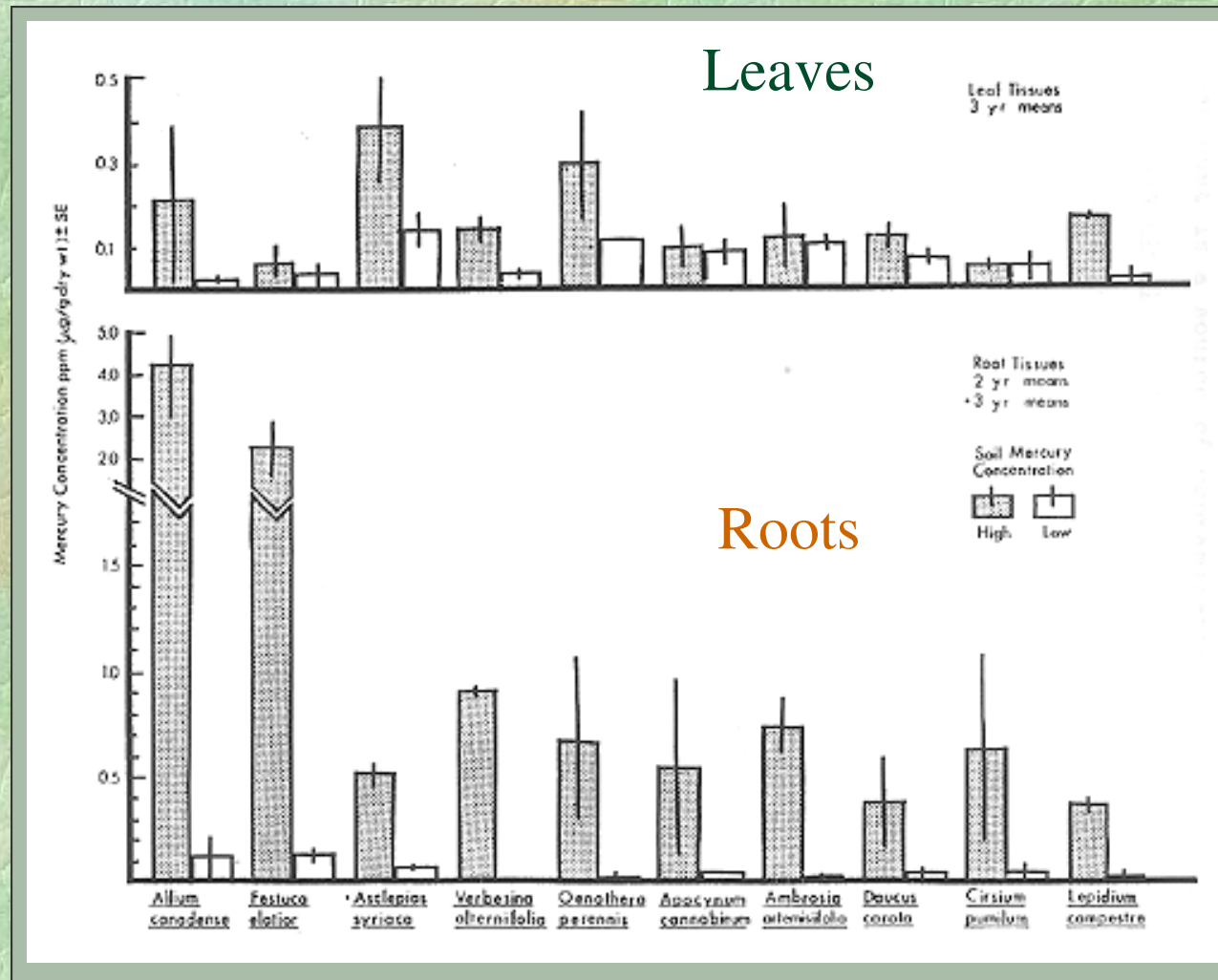
Floodplain Soil Hg Concentration ($\mu\text{g Hg gdw}^{-1}$)

Old Field Ecosystems

Forested Ecosystems

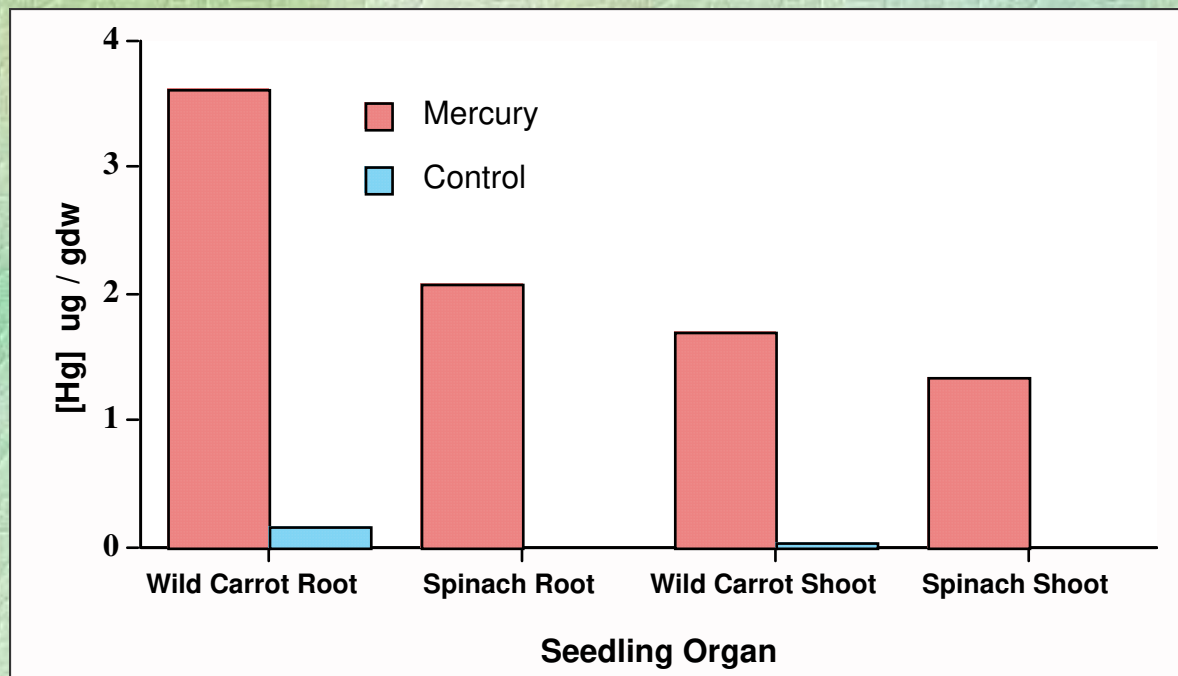


Acid washed herb tissue from contaminated old field sites contains Hg, particularly in roots.



Can Hg be translocated?

Growth chamber study with 3 month old plants shows it is possible to move Hg into the shoot internally when control and Hg-soil* plants are adjacent.

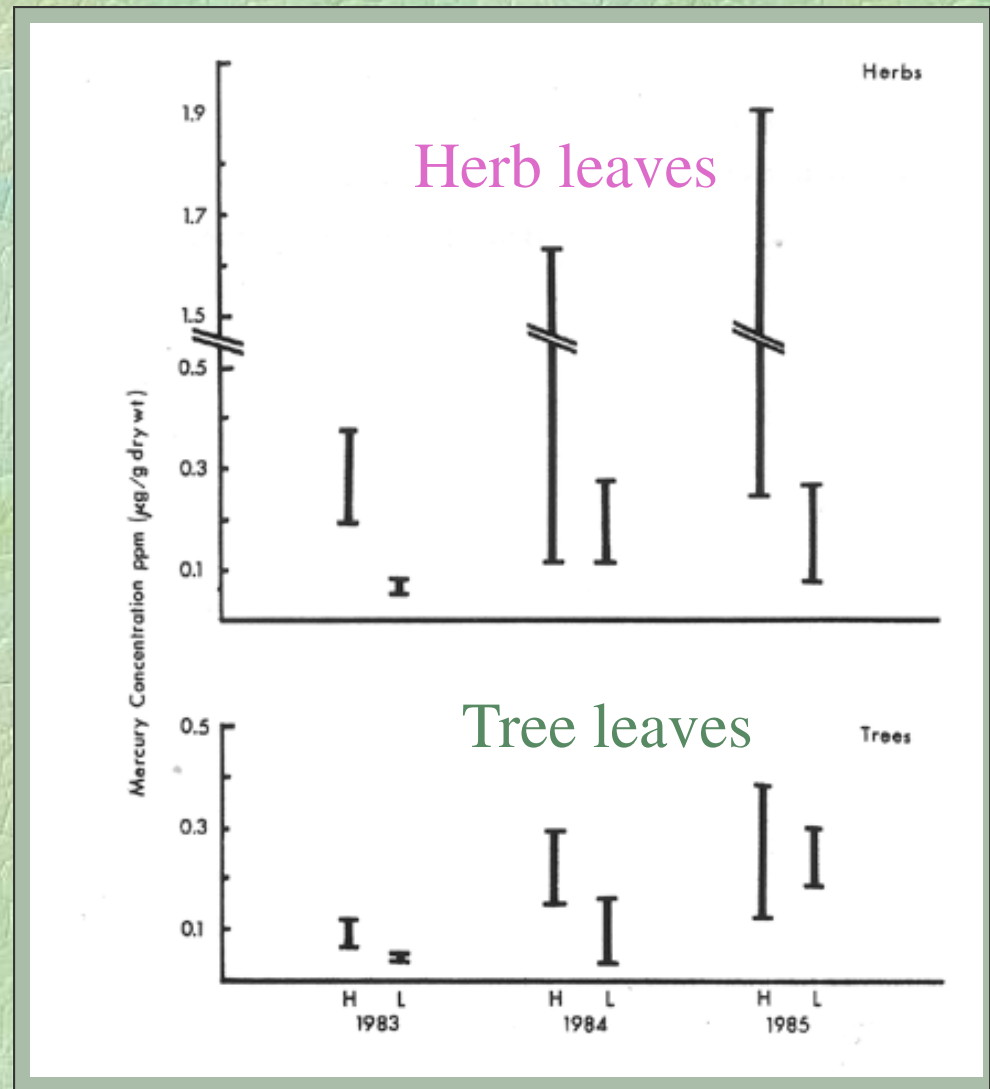


* Soil contains $9 \mu\text{g Hg gdw}^{-1}$
Roots and shoots acid washed prior
To digestion and analysis.

Seagle, 1997 MS thesis

Leaf tissue in the forest sites contains more Hg in trees than in herbs.

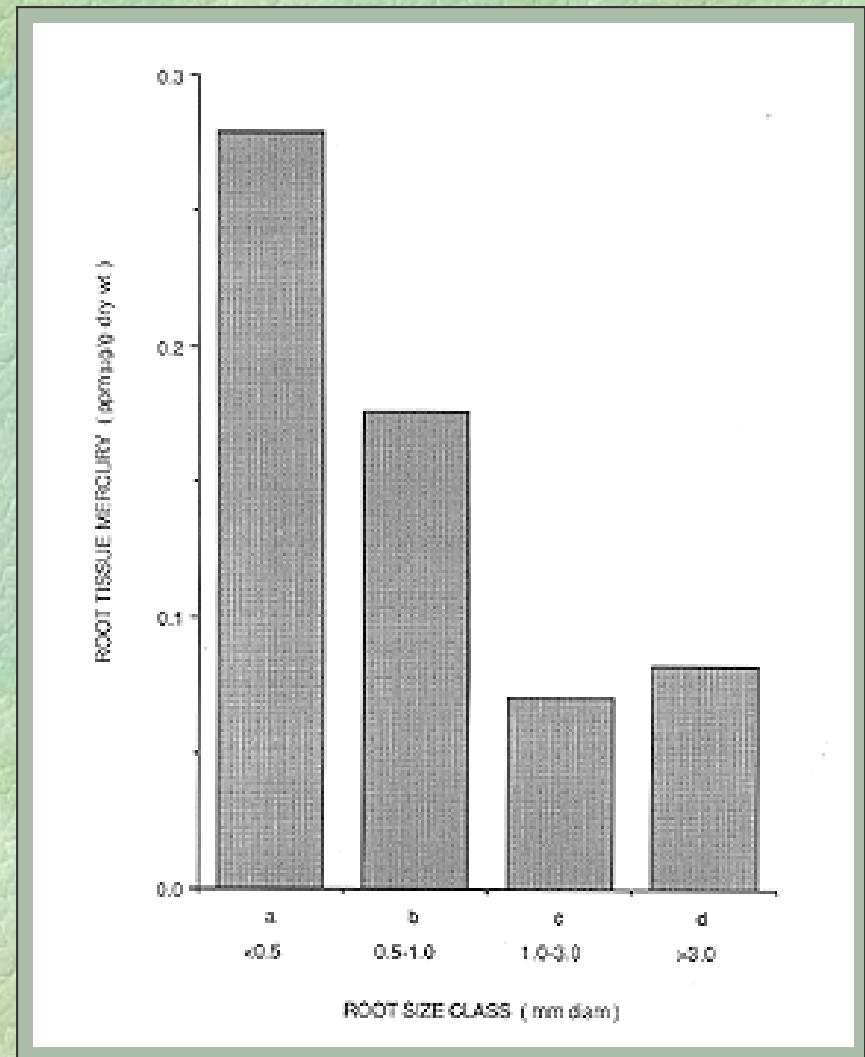
- ❧ The bars represent the range for various species
- ❧ While some of the Hg in field and forest herbs may be translocated, much is thought to come from dust deposition
- ❧ Note that tree leaf concentrations are similar for Hg (H) and control (L) sites.



Goldenrod roots from contaminated sites were acid washed, sorted by size and analyzed.

- Roots collected from control sites had undetectable Hg.
- Soil Hg in field where the plants were growing ranged from 11.5 to 25.8 $\mu\text{g Hg gdw}^{-1}$
- The root Hg concentrations are inversely proportional to root size
- Surface area is important to Hg association
- Even though tissues were acid washed, some Hg might be adsorbed rather than internal

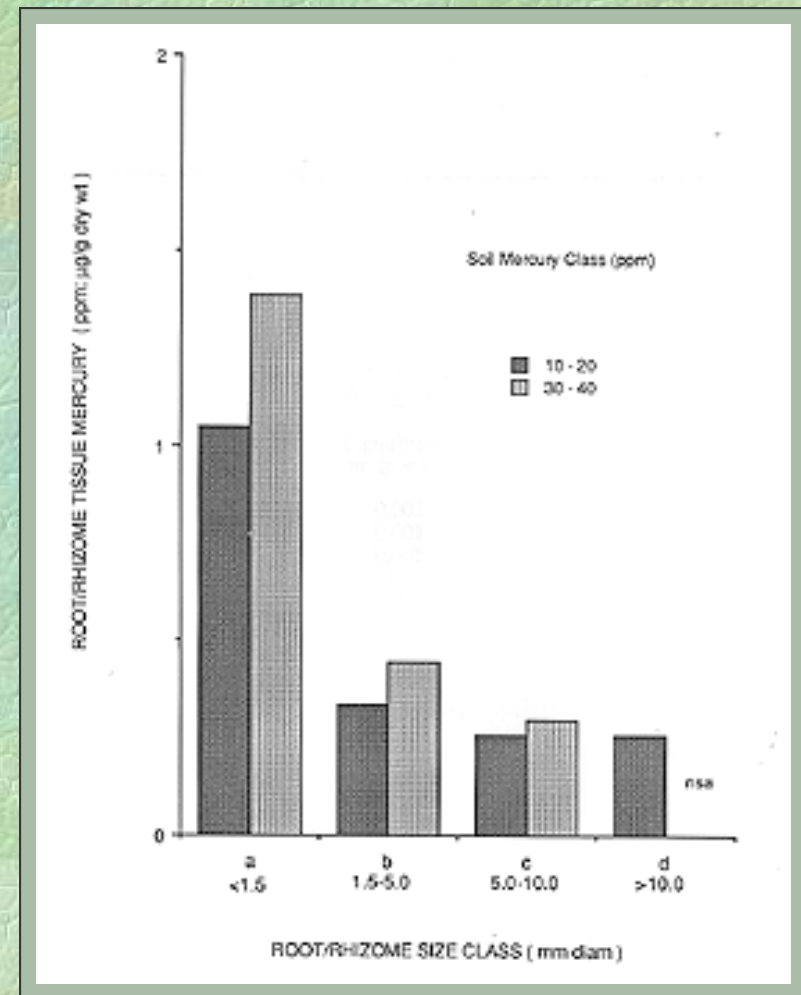
Rohrer, 1987



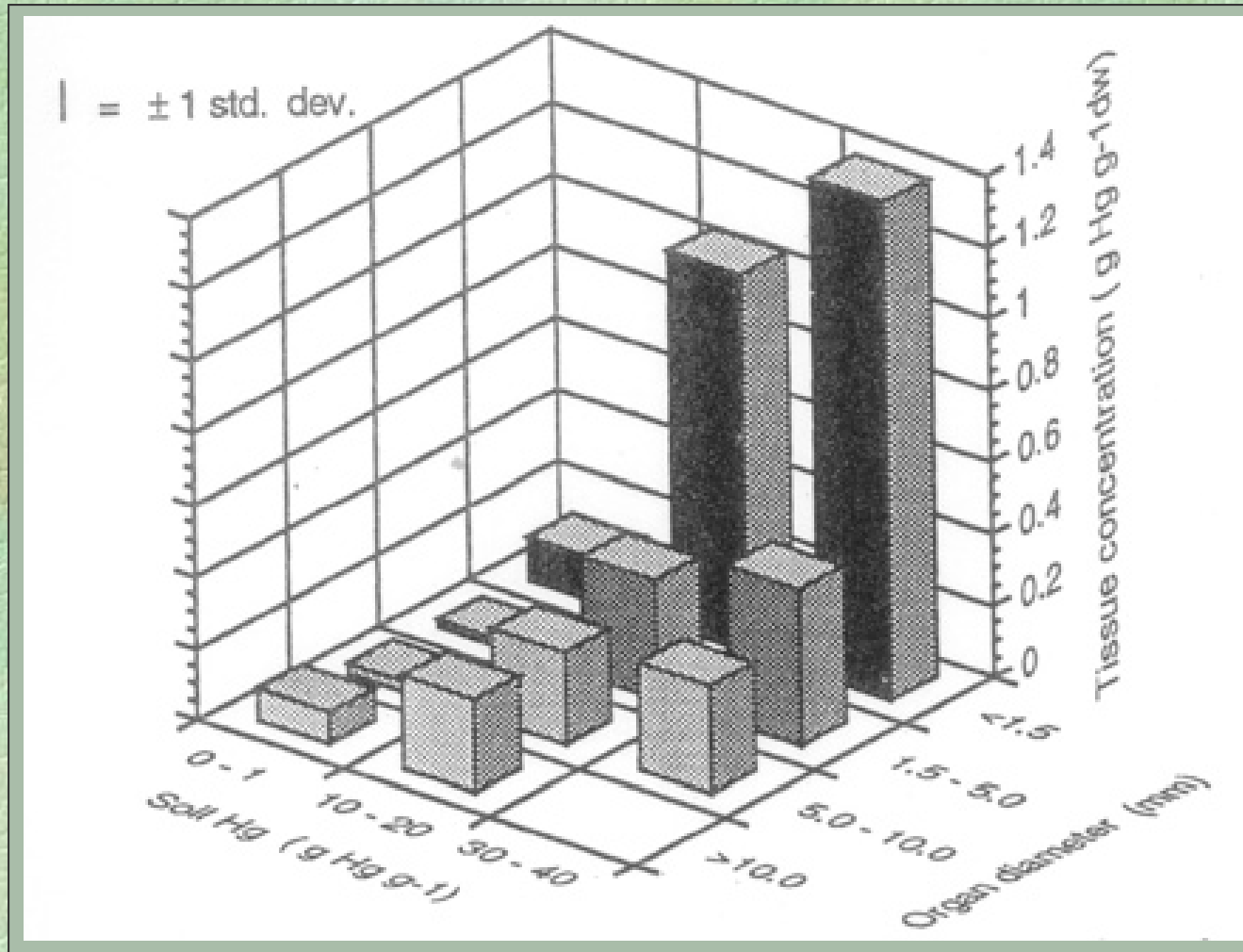
Analysis of milkweed plants demonstrated a similar inverse Hg concentration : root/rhizome size gradient

- In this case the data from soils with 10-20 and 30-40 $\mu\text{g Hg gdw}^{-1}$ are separated.
- There is a direct proportionality between soil Hg concentration and the association with fine root tissues.
- Small animals feeding on roots frequently use the smaller size organs. Other herbivores feed indiscriminately.

Rohrer, 1987

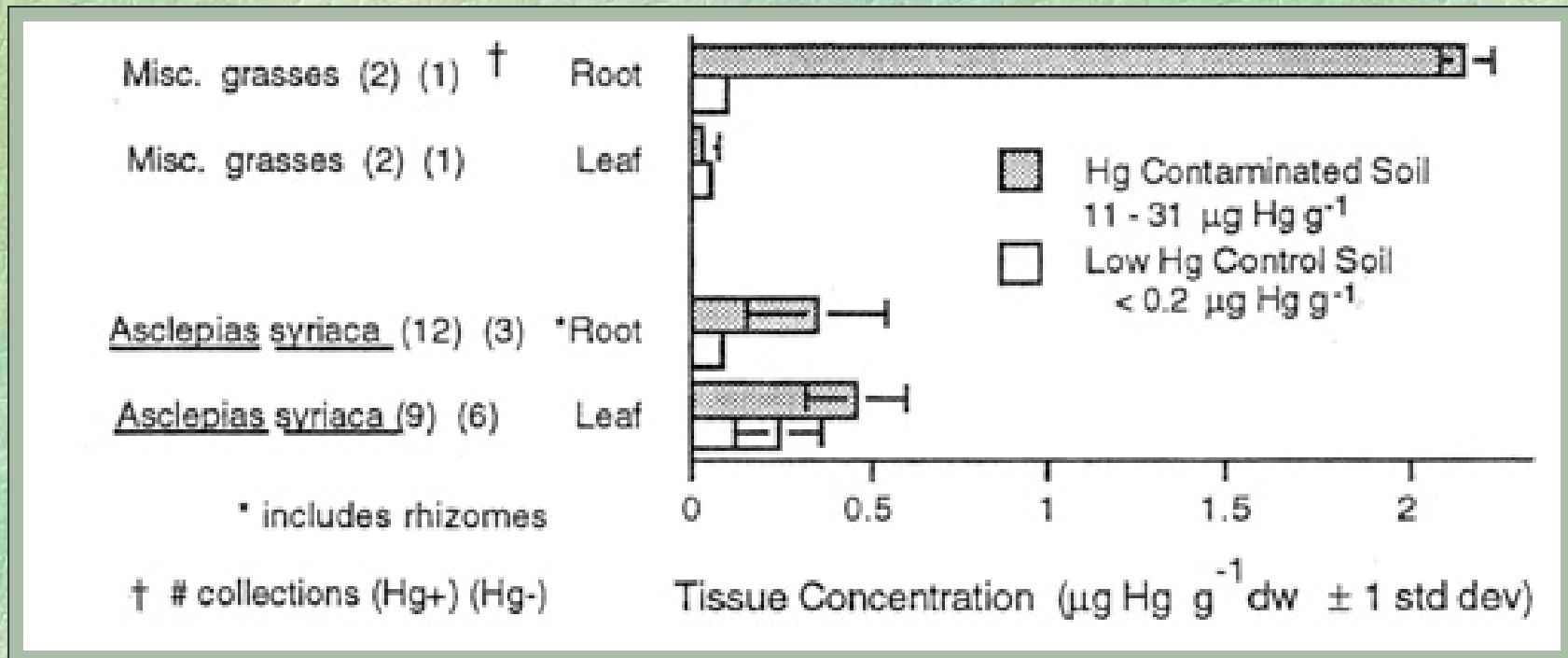


Another way of looking at the [Hg] in milkweed rhizomes and roots is presented here.



Cocking et al., 1995

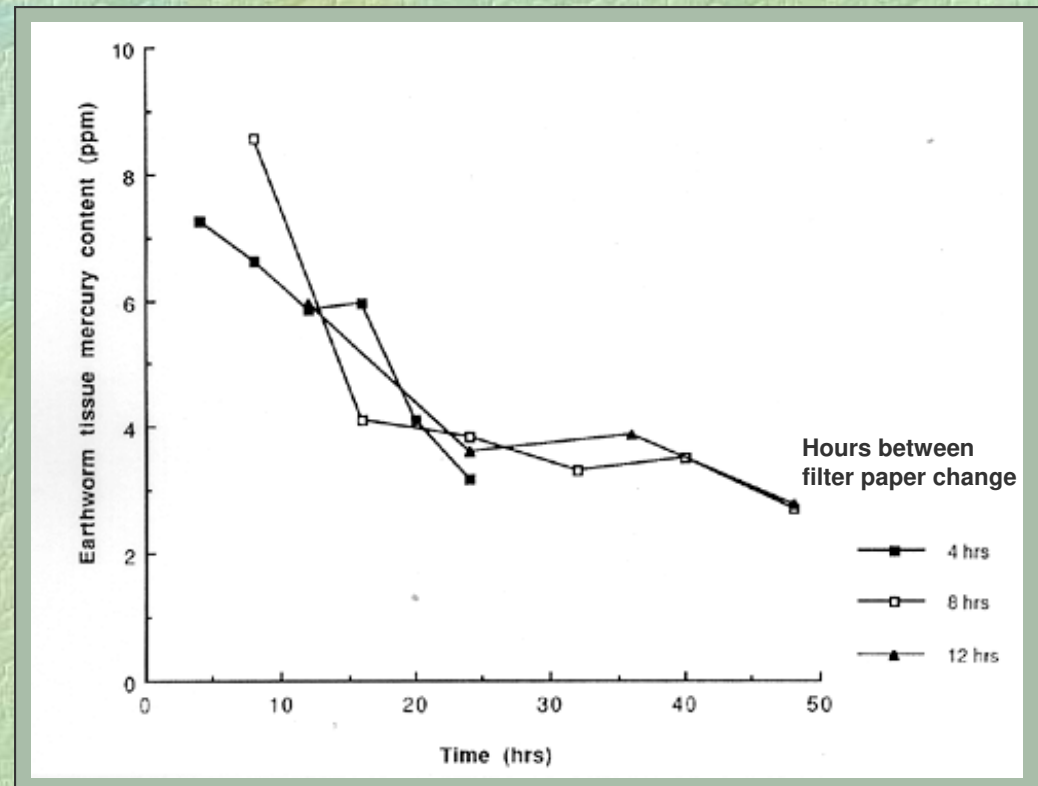
The inverse relationship of root size to associated Hg is further illustrated when fibrous grass root systems are compared with the underground tissues of milkweed, which has a tap root-like system.



Cocking et al., 1995

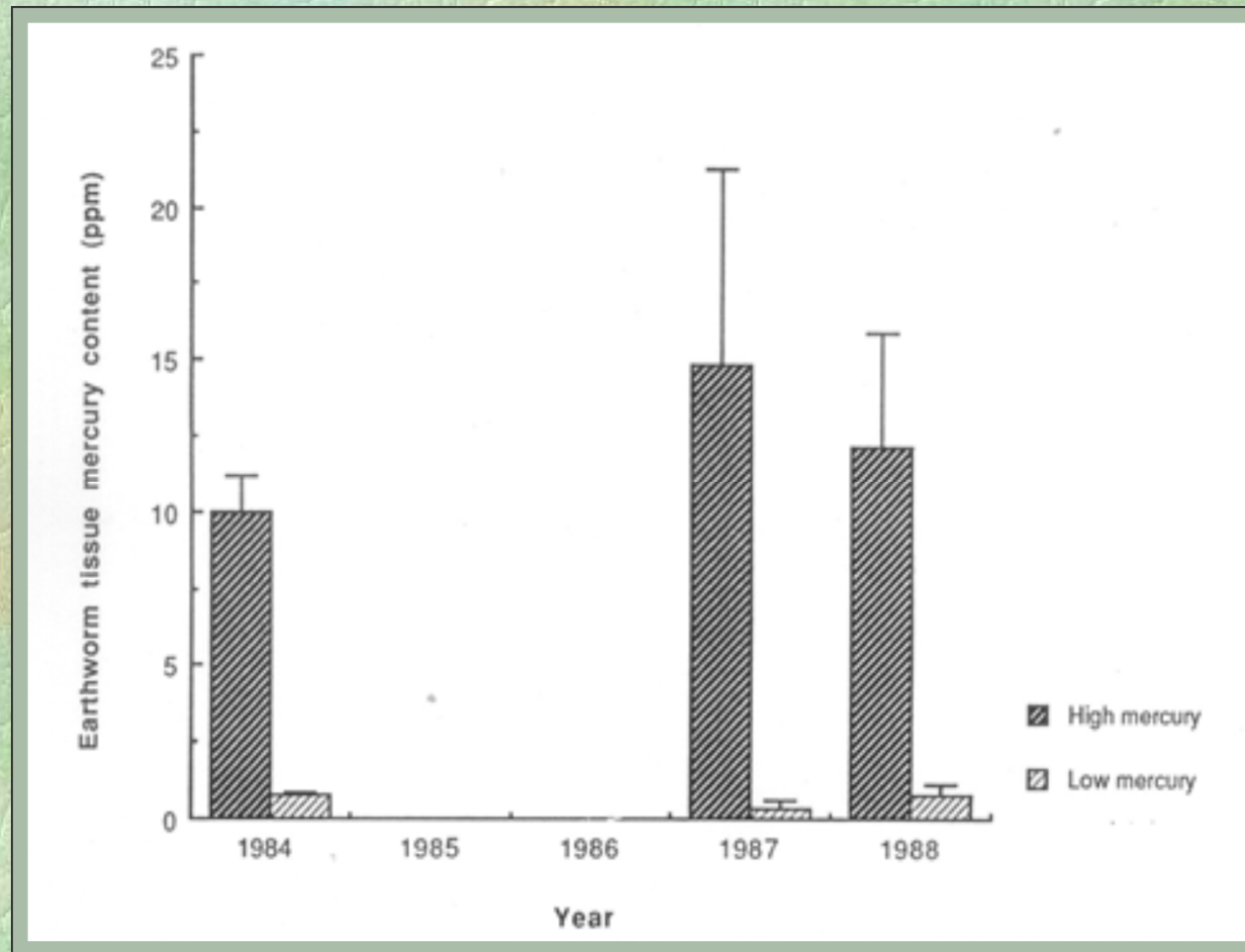
Earthworms were chosen as a primary indicator of biological Hg accumulation in soils. They ingest, process and digest detritus (organic debris)

- ❧ Earthworms collected from the field were placed on moist filter paper to allow them to void gut contents.
- ❧ Individuals grown in the lab in $21 \mu\text{g Hg gdw}^{-1}$ soil reach equilibrium tissue [Hg] after 1-2 weeks.
- ❧ Voiding of equilibrated earthworms indicated that the residual Hg in gut contents was cleared in 24 hr.
- ❧ Frequent changing of filter paper had little effect.
- ❧ Voided earthworms were freeze dried, acid washed, hot acid digested and analyzed.



King, 1989 unpublished data

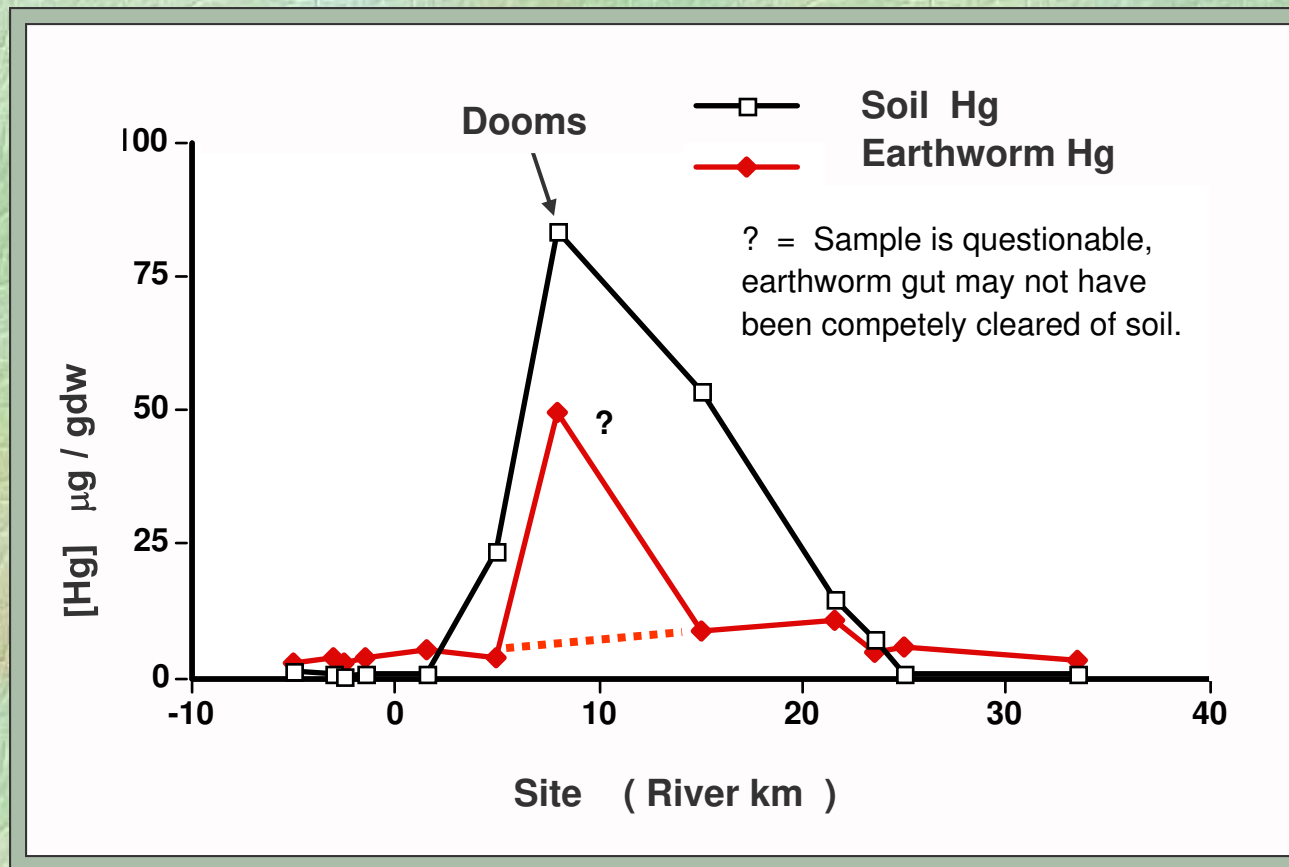
Hg Concentration in soil and earthworms within Old field site at Hopeman Parkway. ($\mu\text{g Hg gdw}^{-1}$)



Note the tissues were freeze dried. Therefore, assuming 90% H_2O , in animal tissues, earthworms living in contaminated soil contained from 1 - 1.5 $\mu\text{g Hg / g}$ fresh weight

King, 1989

Floodplain Earthworm [Hg] South River ($\mu\text{g Hg gdw}^{-1}$)

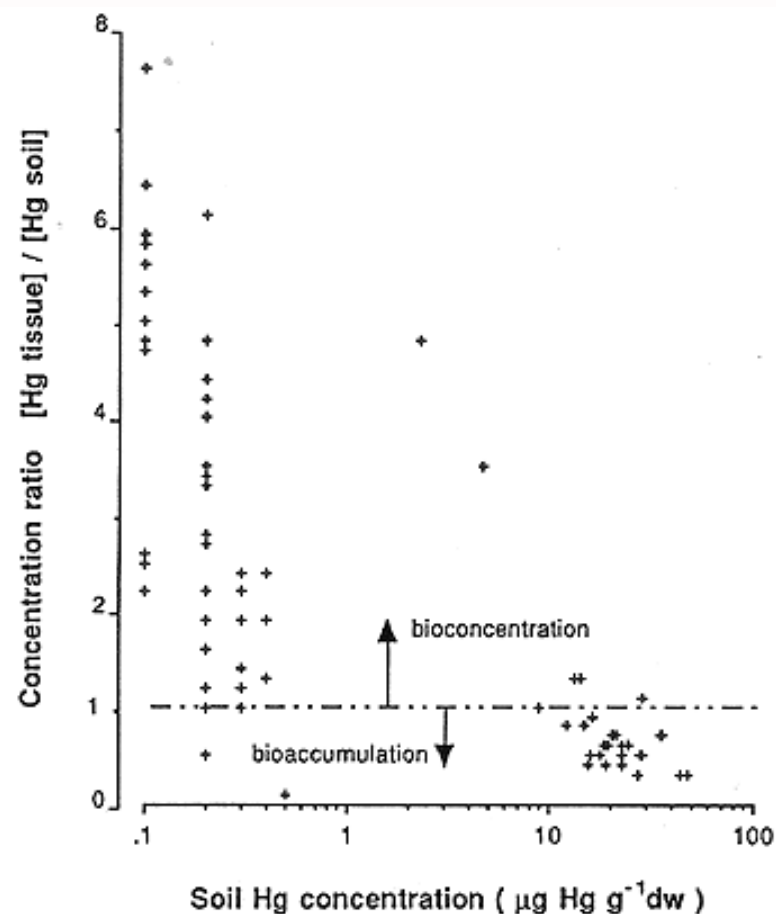
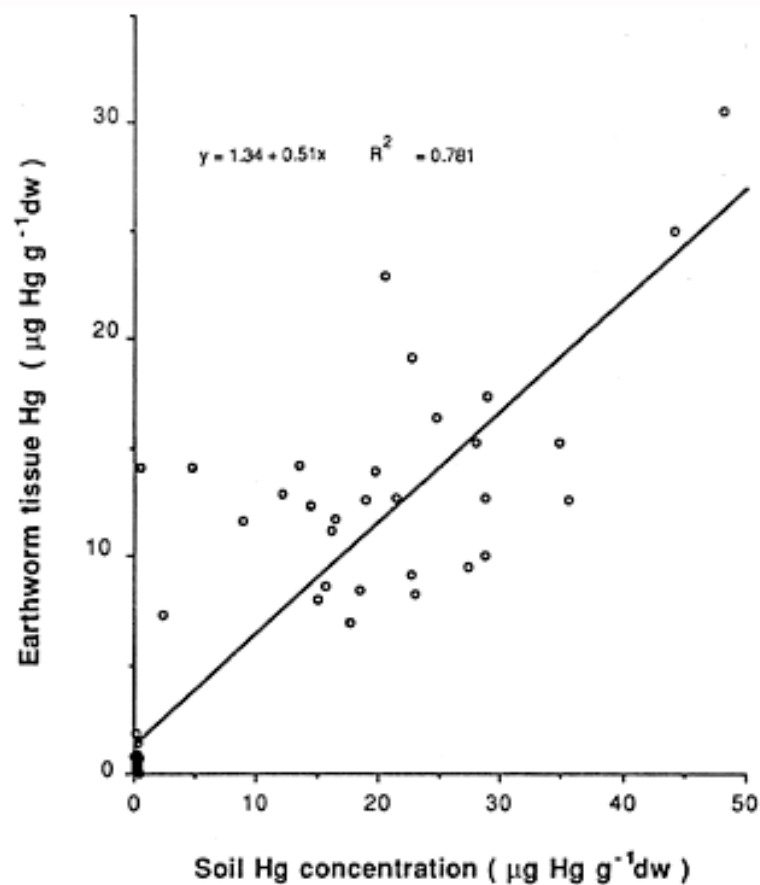


Jakes and Cocking, 1998 unpublished study

Floodplain Earthworm [Hg] is directly correlated with soil [Hg]

Biological concentration occurs only at low [Hg]

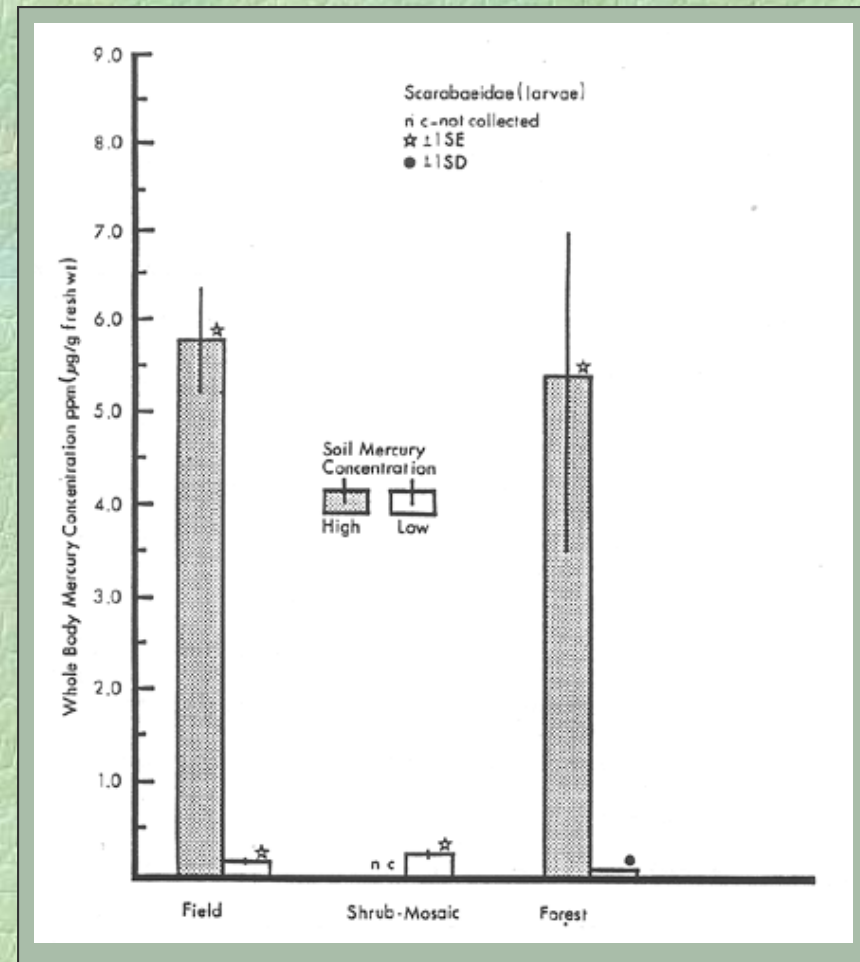
($\mu\text{g Hg gdw}^{-1}$)



King, 1989; Cocking, et. al. 1994

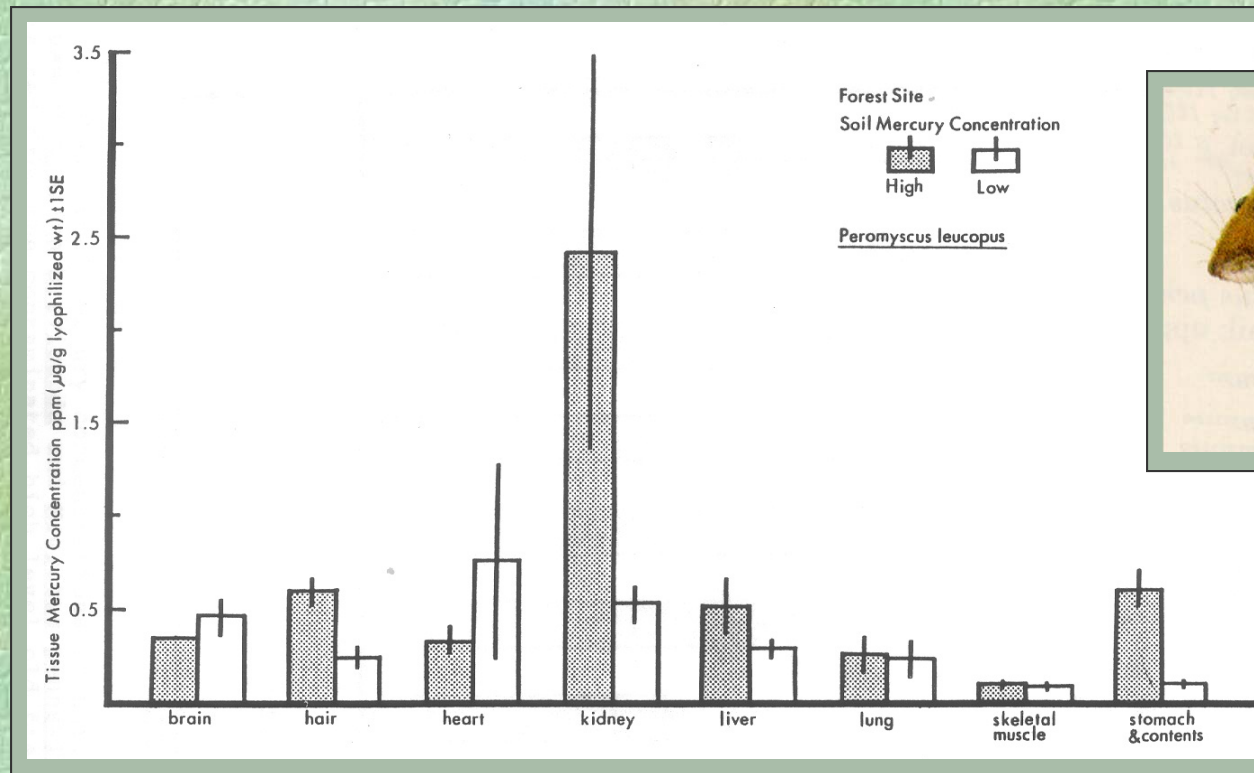
Other detritivores, such as beetle larvae, also accumulate Hg in both forest and old-fields.

- Most likely, the detritus food web is central to the movement of Hg into floodplain ecosystems
- Hg associated with soil organic particles is consumed regardless of whether it is internal or external.



Hayes, 1986 MS thesis

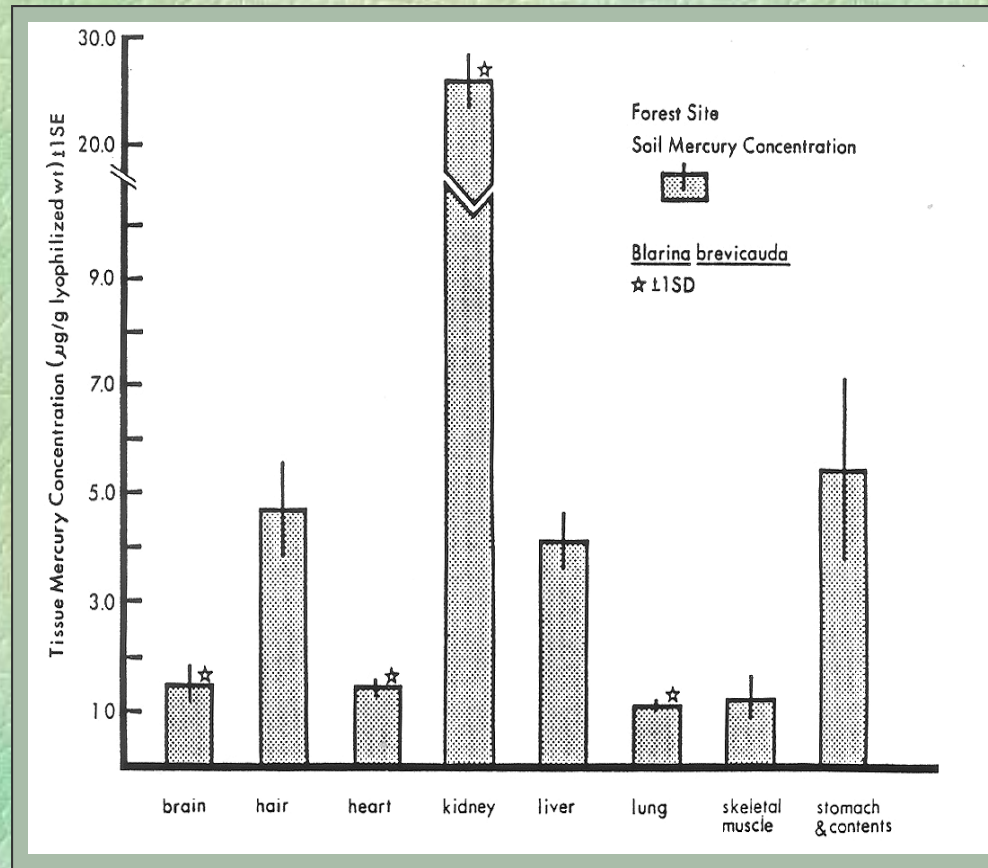
White-footed mice (*Peromyscus leucopus*), were collected from High and Low soil Hg forest sites.



- Feed on seeds, nuts and insects. None of these had extremely high [Hg].
- Not much difference in [Tissue Hg], except high level in kidney
- Note the tissues were lyophilized, therefore assuming 90% H₂O, the kidneys in these mice contained about 2.5 μg Hg / gram fresh weight
- Muscle tissues had almost undetectable [Hg] at both sites.

Hayes, 1986 MS thesis

Short tailed shrew (*Blarina brevicauda*) in High soil Hg forest sites.

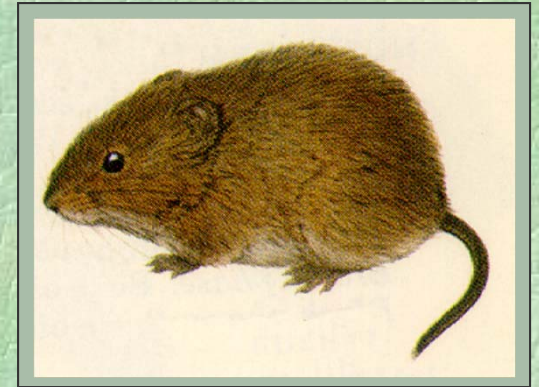


Hayes, 1986 MS thesis

- Feeds on insects, earthworms, snails, and other invertebrates.
- Significant differences in [Tissue Hg] between tissue types.
- Note the tissues were lyophilized, therefore assuming 90% H₂O, kidneys in these shrews contained about 20-30 μg Hg / gram fresh weight
- Muscle, brain and lung tissues contained much lower amounts of Hg.

The meadow vole (*Microtus pennsylvanicus*), was only collected from High soil Hg old-field site.

The only internal tissue which contained traces of Hg was muscle, and that was at what was considered to be the minimum detection limit, $0.1 \mu\text{g Hg gdw}^{-1}$



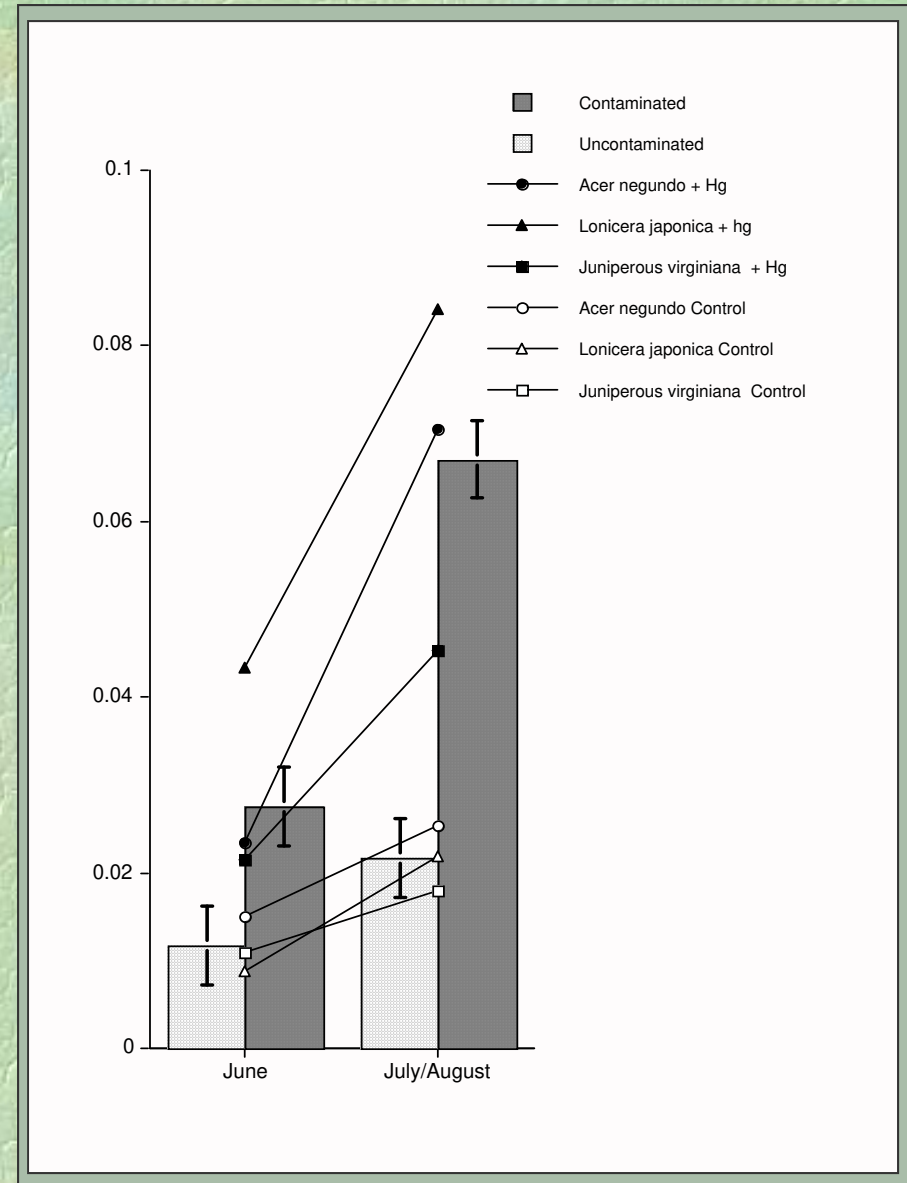
- Voles feed on grasses, sedges, seeds, grain, bark and probably some insects.
- Animal tissue (assumed to be muscle from cattle and poultry) samples were “found to be negative” by G. B. Estes, D.V.M., State Veterinarian, in 1981.
- Because these agricultural species are basically herbivorous and low muscle tissue [Hg] was found in wild species, this is consistent with our data.
- However, questions about the safety of organ meats (e.g. liver & kidney) of chickens and cattle may not have been completely resolved.

Hayes, 1986 MS thesis

Seasonal Leaf [Hg] Concentration Change ($\mu\text{g Hg gdw}^{-1}$)

- Leaves collected in July/August contained more Hg than from June
- Most likely due to dust deposition
- Note a significant increase at 'control' site

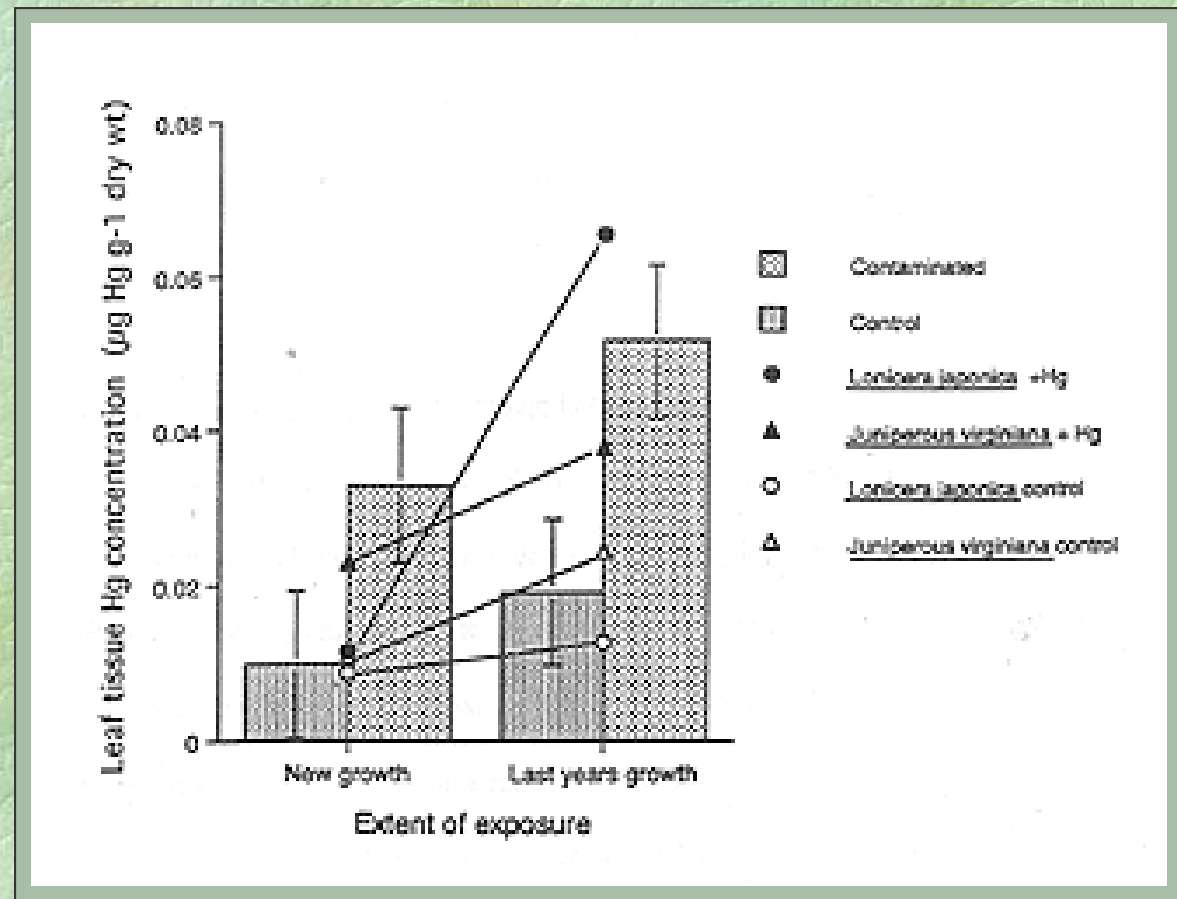
Pendleton, 1999 unpublished study



The Hg content of current years leaf tissue of shrubs was compared to that of two year old leaves.

Because these species are shrubs or small trees, internal translocation is probably insignificant.

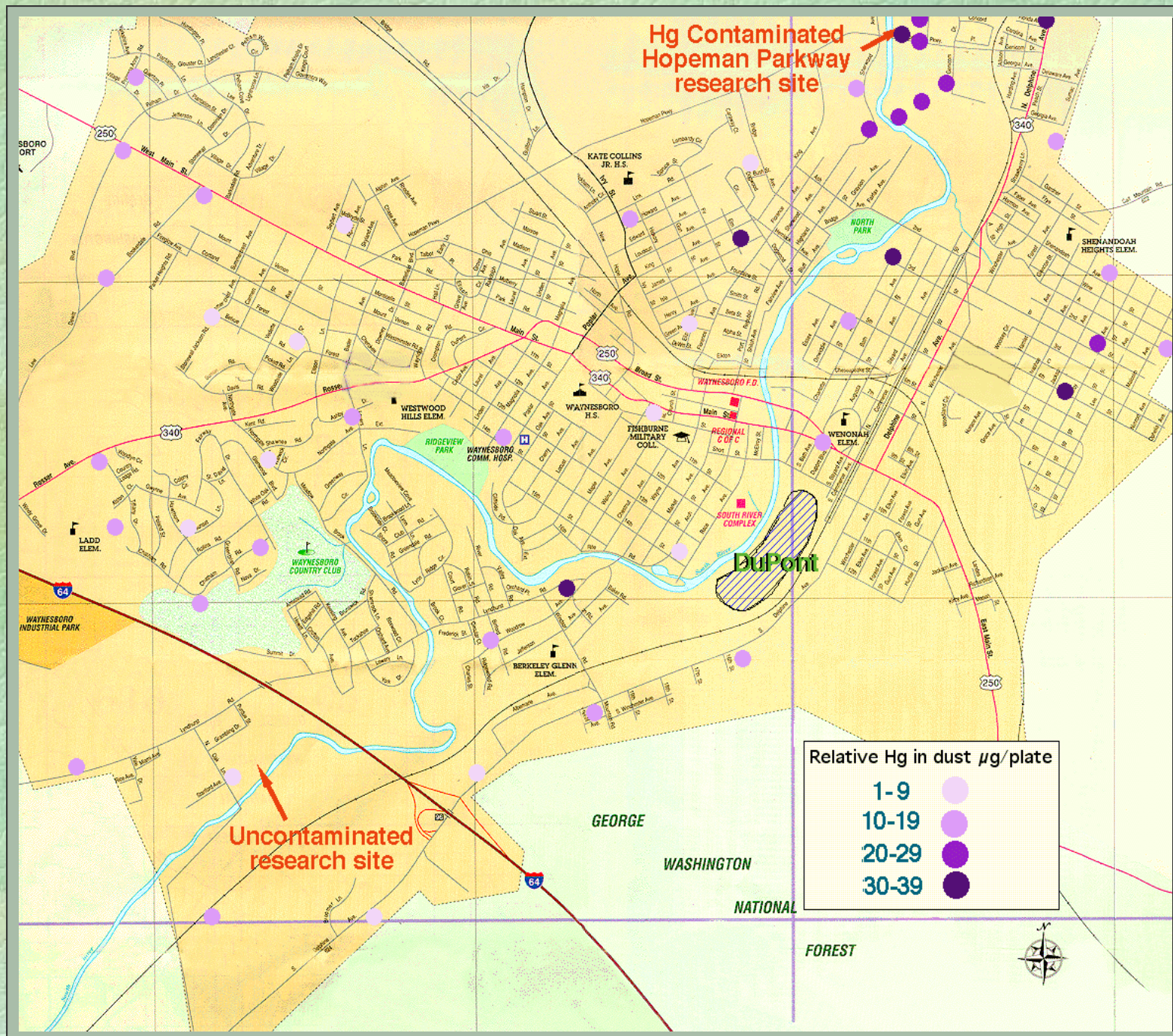
This implies an accumulation of Hg containing dust at both the contaminated and control site.



Pendleton, 1999 unpublished study

A preliminary study of dust deposition in the Waynesboro vicinity was initiated two years ago.

- **Plastic petri plates were poured with a diluted solution of “Tanglefoot” insect trap adhesive .**
- **Over a hundred of these plates were attached to telephone poles, or other relatively permanent objects, at various locations within the area.**
- **Vandalism was high, as might be expected, but fifty locations provided data.**
- **After six months the plates were collected and analyzed for total Hg in digested residue.**
- **Some of the Hg could be from insects or fine organic debris, but most is likely to be from accumulated dust.**



Future study questions....

- **Many of these studies were ‘preliminary’ in nature and resources have limited the ability to repeat experiments and expand on results.**
- **More extensive basic evaluation of Hg contamination in various terrestrial system compartments is needed.**
- **The actual Hg content and extent of the dust cloud over the Waynesboro should be determined. It is not likely to be sufficient to create a health hazard; however, without quantitative data this is an unknown.**
- **The downstream earthworm data indicate that floodplain ecosystems along the first 40 km are important for study. Earthworms would be a good monitor of the extent of soil/ecosystem contamination.**
- **While the primary biological contamination is undoubtedly aquatic and within the river, the flood plain should not be ignored. Associated wetlands and swales are potential sites for microbial Hg methylation and the creation of more biologically hazardous toxins.**

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