



Assessing Garden Crops as an Exposure Route for Soil Mercury

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South River Science Team
April 12, 2005

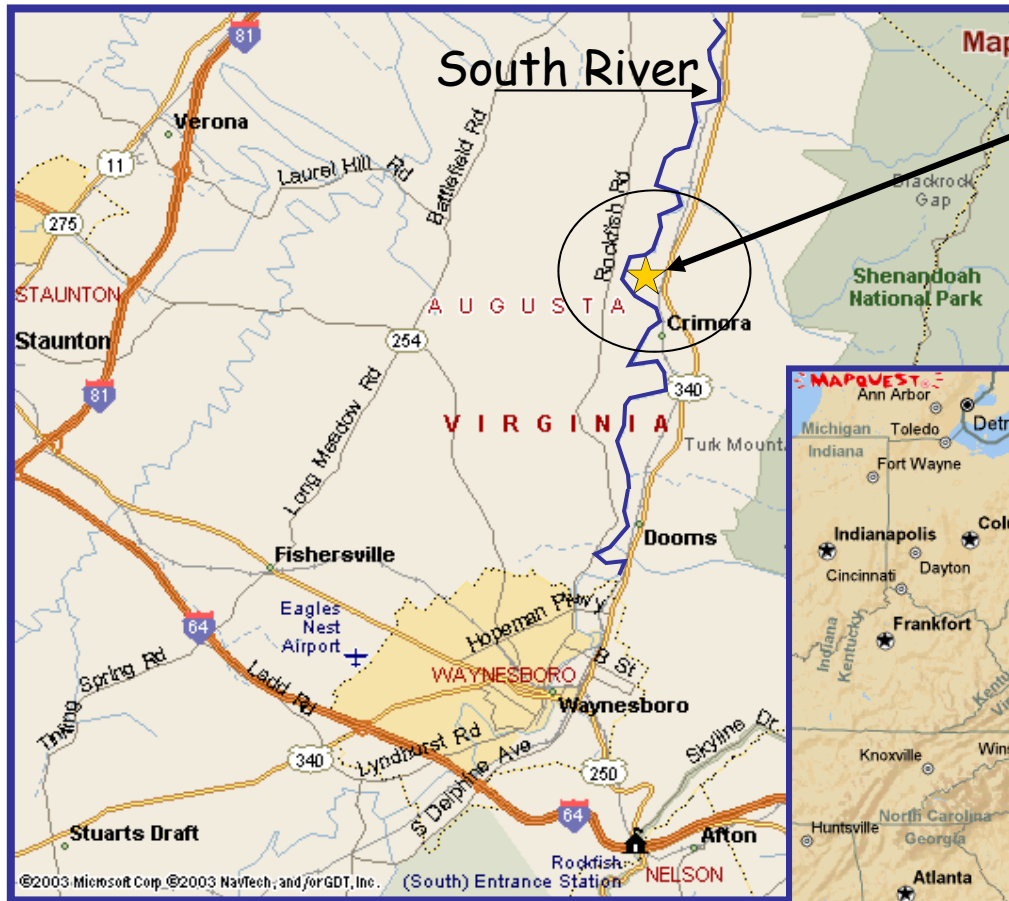


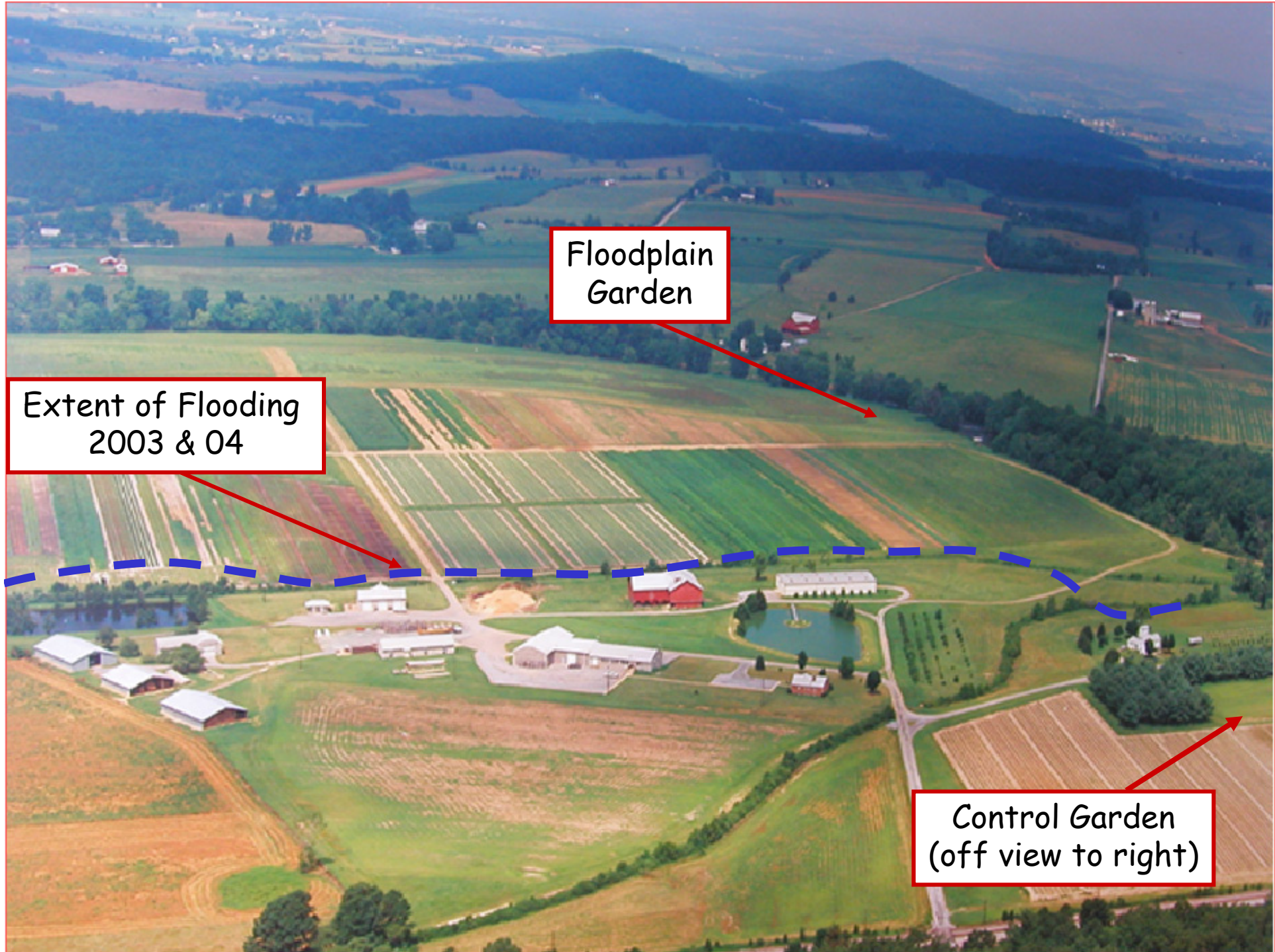
Vegetable Garden Study

Objective -

Determine if soil-Hg is taken-up by vegetables at concentrations sufficient to be a health risk

Augusta Forestry Center - Crimora, VA





Floodplain
Garden

Extent of Flooding
2003 & 04

Control Garden
(off view to right)

Floodplain Garden - 2004

South River

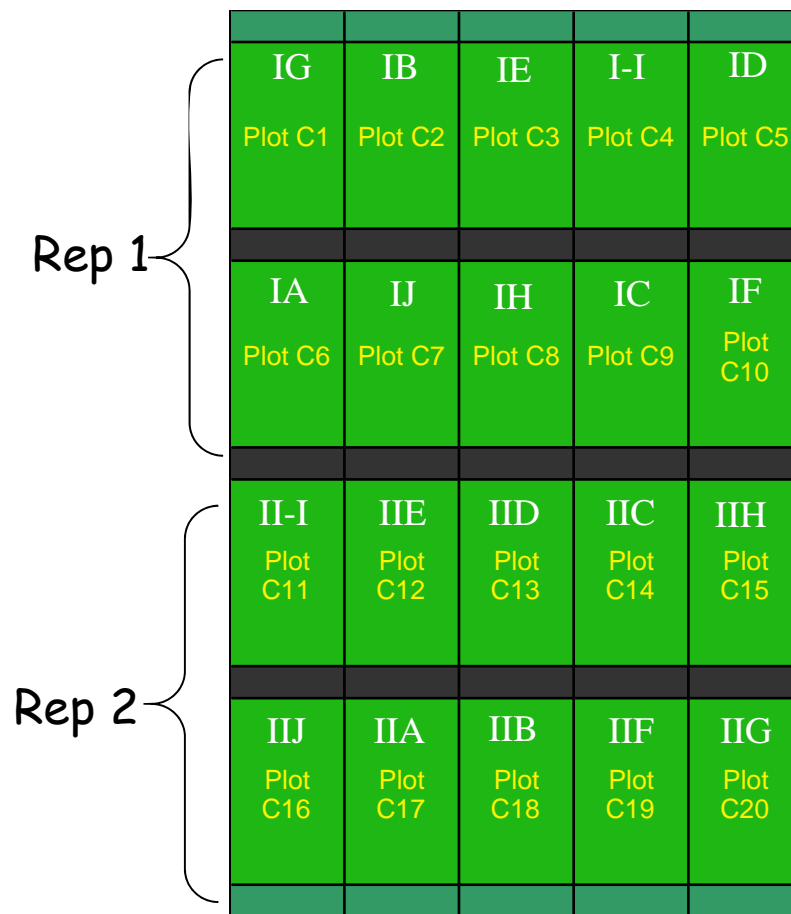
South River

| | | | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 1D 19.4 | 2B 35.1 | 2I 33.3 | 2E 44.6 | 2C 45.6 | 3D 55.8 | 3F 56.7 | 3H 48.1 | 4B 61.6 | 4E 67.9 |
| 1H 14.7 | 1I 18.3 | 1F 13.8 | 2A 20.3 | 2J 39.6 | 3G 56.3 | 4J 57.5 | 4A 58.8 | 4H 78.3 | 4I 57.9 |
| 1B 5.93 | 1E 4.22 | 1A 8.38 | 1C 9.58 | 2D 37.1 | 3E 45.6 | 3A 51.4 | 4D 62.6 | 4G 65.1 | 4C 61.4 |
| 1G 20.2 | 1J 19.7 | 2H 31.2 | 3J 48.3 | 4F 68.9 | 3B 56.2 | 3I 55.1 | 3C 54.6 | 2G 43.1 | 2F 32.9 |

- A Potato
- B Turnip & Beets
- C Pepper & Cauliflower
- D Cabbage
- E Onion
- F Squash
- G Radish & Carrot
- H Tomato
- I Spinach & Lettuce
- J Bush peas & Bush beans

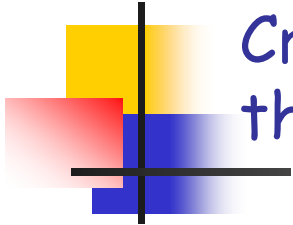
Sampled Nov 23, 2003
mg Hg/kg soil, dry weight basis

Control Garden - 2004



- A Potato
- B Turnip & Beets
- C Pepper & Cauliflower
- D Cabbage
- E Onion
- F Squash
- G Radish & Carrot
- H Tomato
- I Spinach & Lettuce
- J Bush peas & Bush beans

Plots in 2 x 10
Randomized
Complete Block
design with some
plots containing
two crops



Crops were planted much earlier in 2004 than in 2003

Root
Crops

| Crop list | Planted as: | Date 2003 | Date 2004 |
|-------------------|-------------------|-----------|-----------|
| Beet | Seed | ----- | 11-May |
| Radish | Seed | 30-Sept | 11-May |
| Carrot | Seed | 25-June | 11-May |
| Turnip | Seed | ----- | 11-May |
| Potato | Cut seed potatoes | ----- | 24-April |
| Red Onion | Onion sets | 25-June | 24-April |
| Scallions (onion) | Seed | ----- | 14-May |
| Lettuce | Seed | 30-Sept | 11-May |
| Spinach | Seed | 30-Sept | 11-May |
| Cabbage | Transplanted | 25-June | 24-April |
| Cauliflower | Transplanted | ----- | 11-May |
| Bush pea | Seed | ----- | 11-May |
| Bush bean | Seed | ----- | 11-May |
| Bell Pepper | Transplanted | 25-June | 11-May |
| Tomato | Transplanted | 25 -June | 11-May |
| Squash | Transplanted | 25-June | 11-May |
| Sweet corn | Seed | 25-June | ----- |

Sample Preparation

- Harvested and stored cold
- Washed, sliced, and diced
- Shipped to analytical lab for Hg analysis
 - Samples digested and Hg measured





Crop samples all less than Method Detection Limit - MDL

2003

- Cabbage
- Pepper
- Small squash

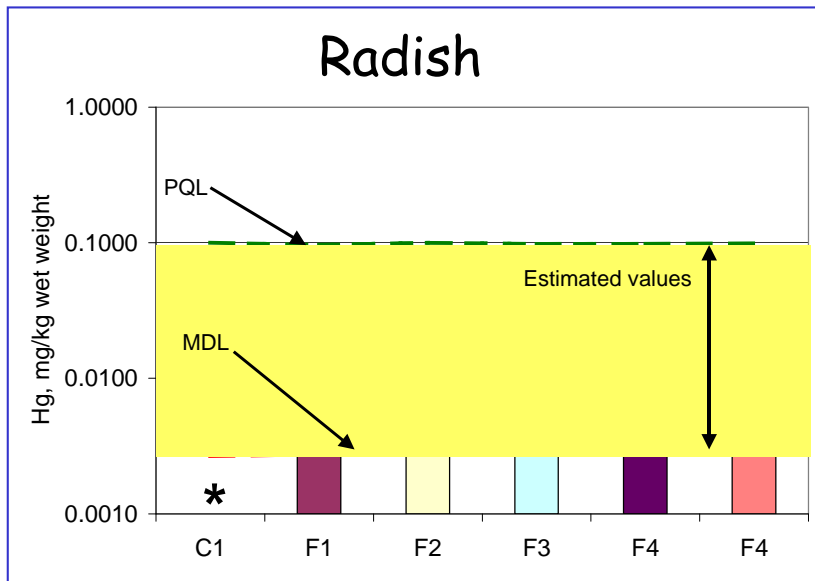
2004

- Bean
- Beet
- Pea
- Pepper
- Radish
- Red onion
- Potato

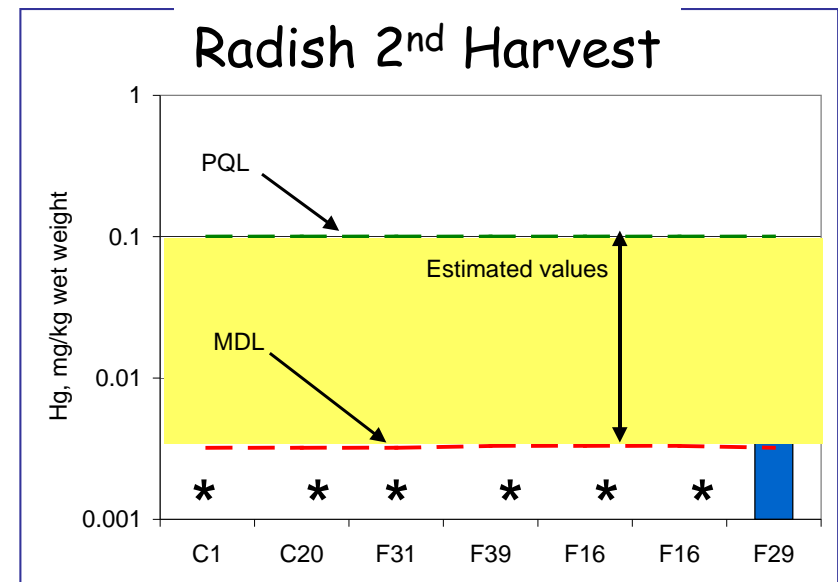
MDL < 0.003 mg Hg kg⁻¹ wet weight

Radish Crop Harvest

2003



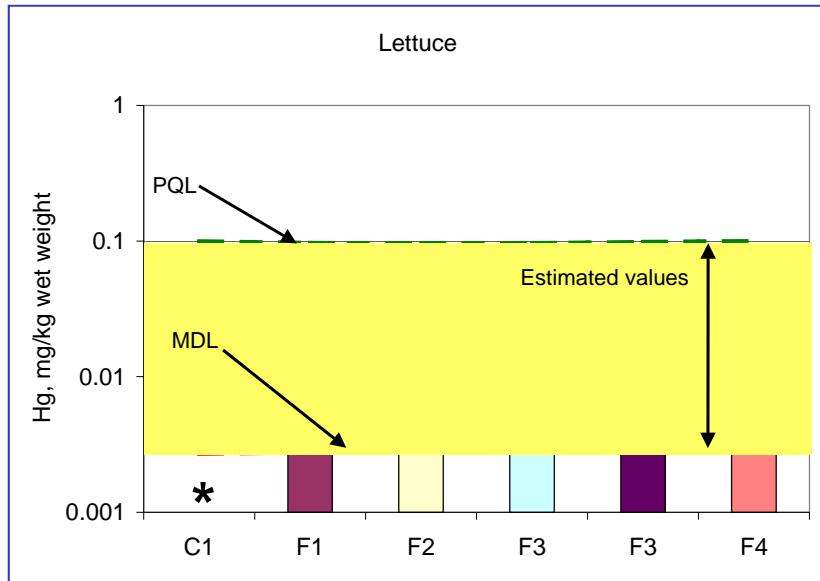
2004



* = less than the MDL

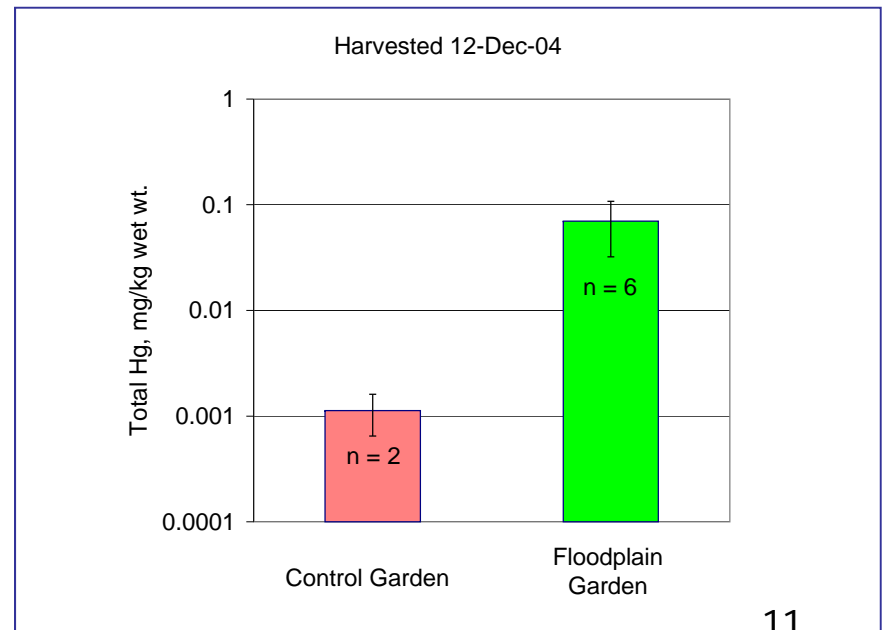
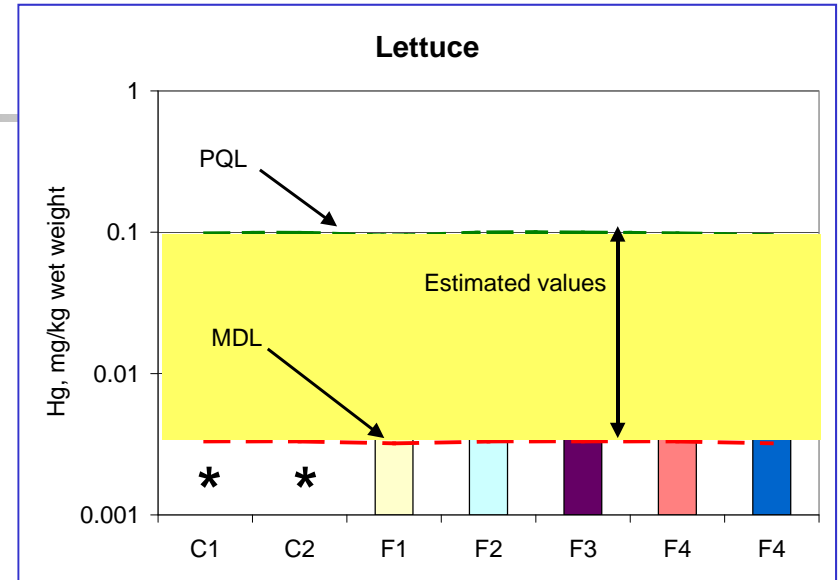
Crop Harvest: Lettuce

2003



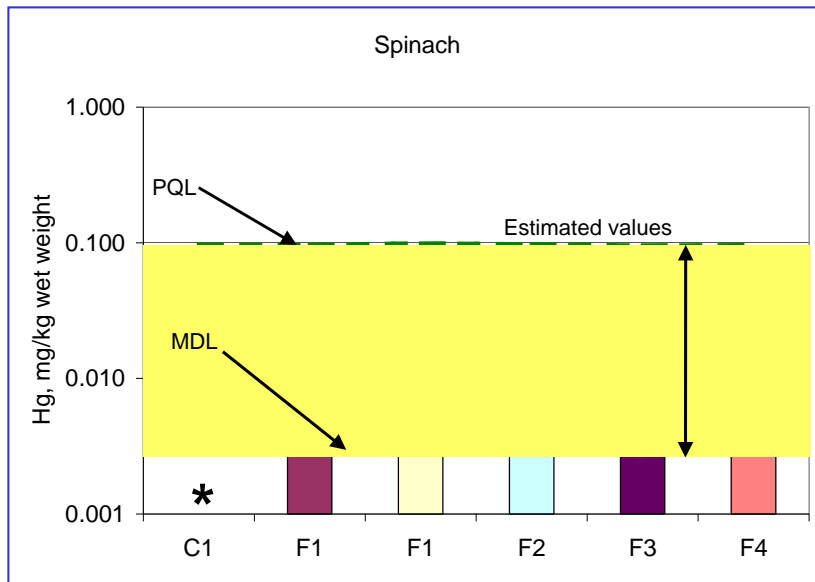
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2004



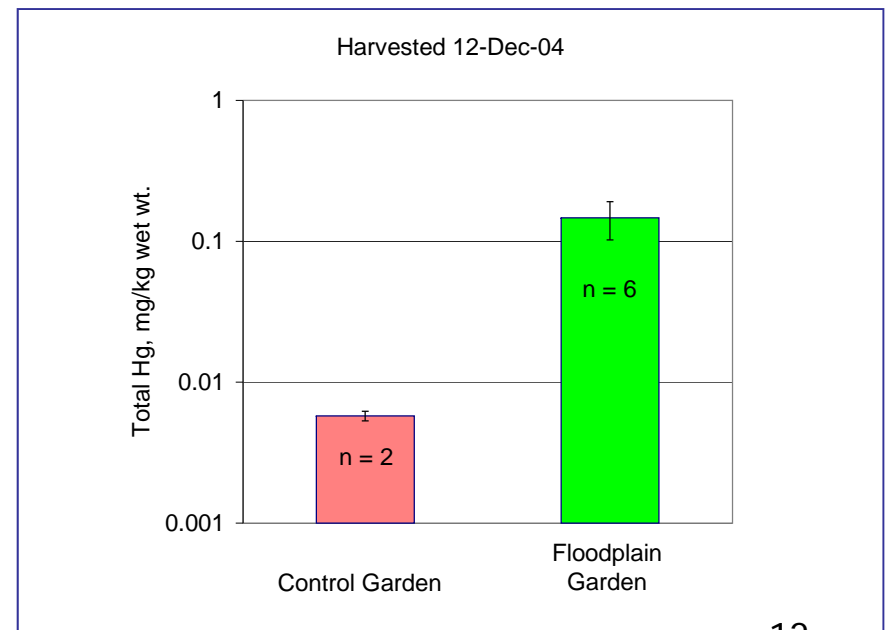
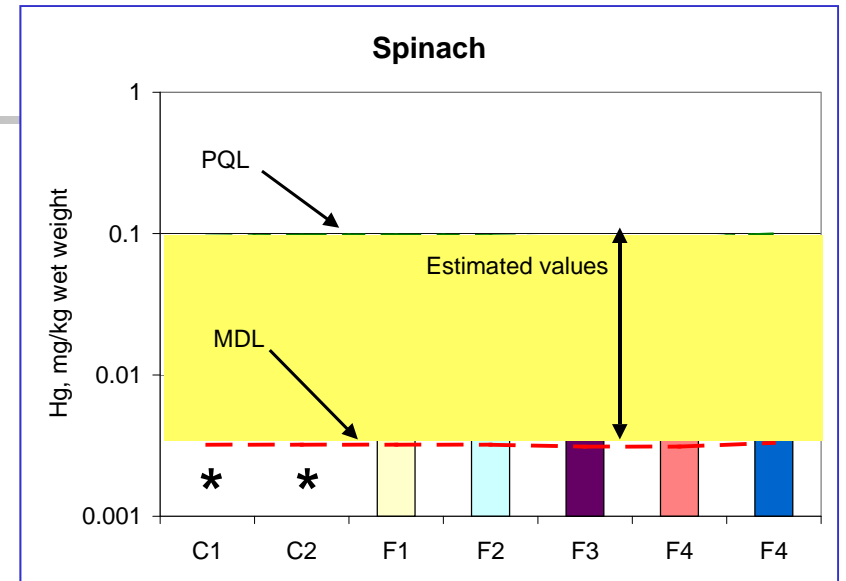
Crop Harvest: Spinach

2003

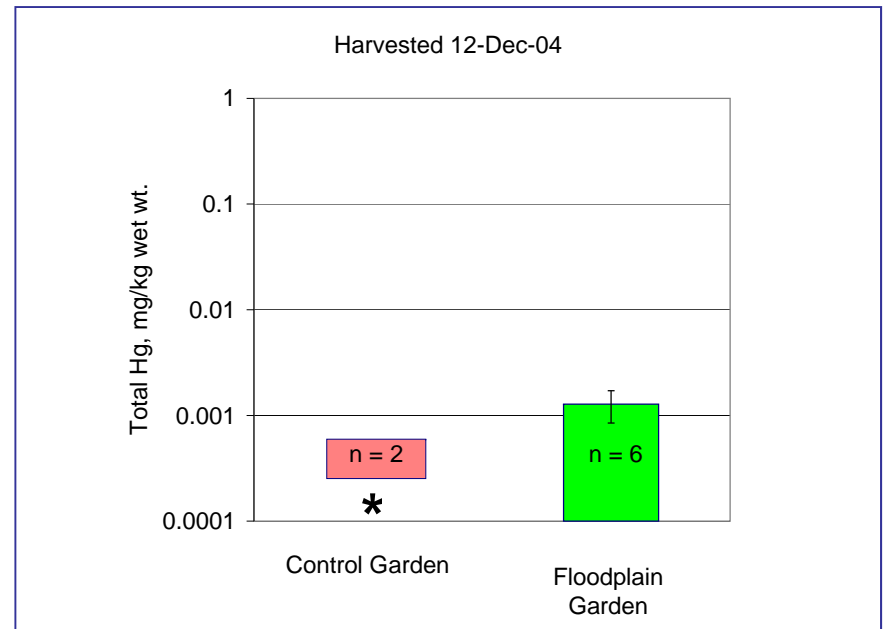
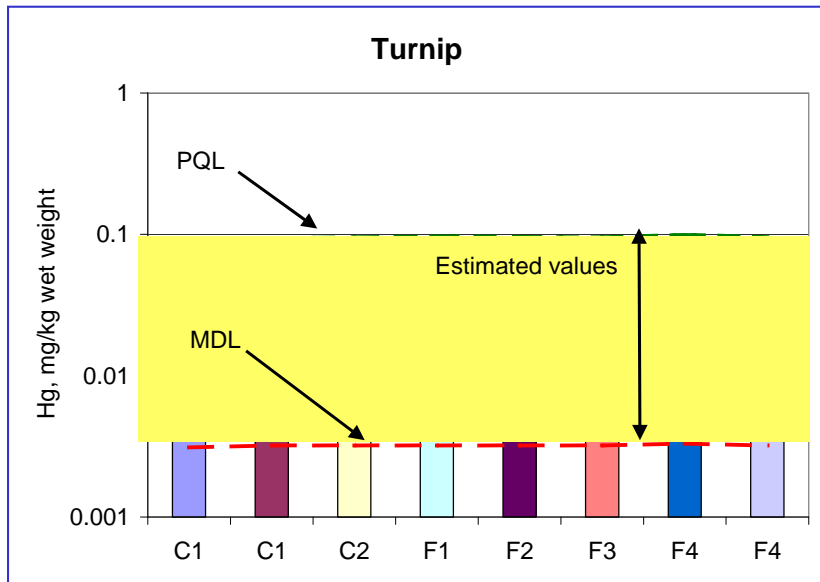


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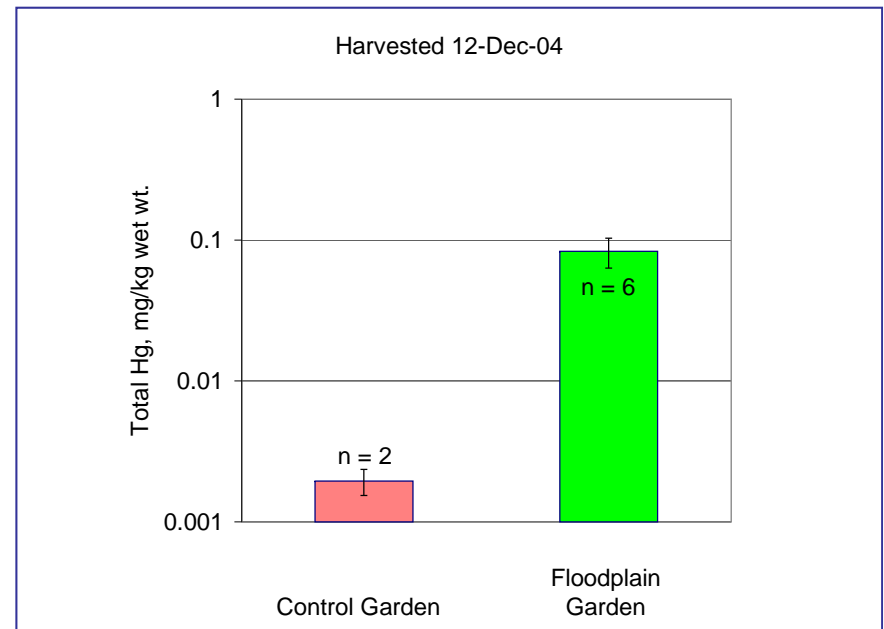
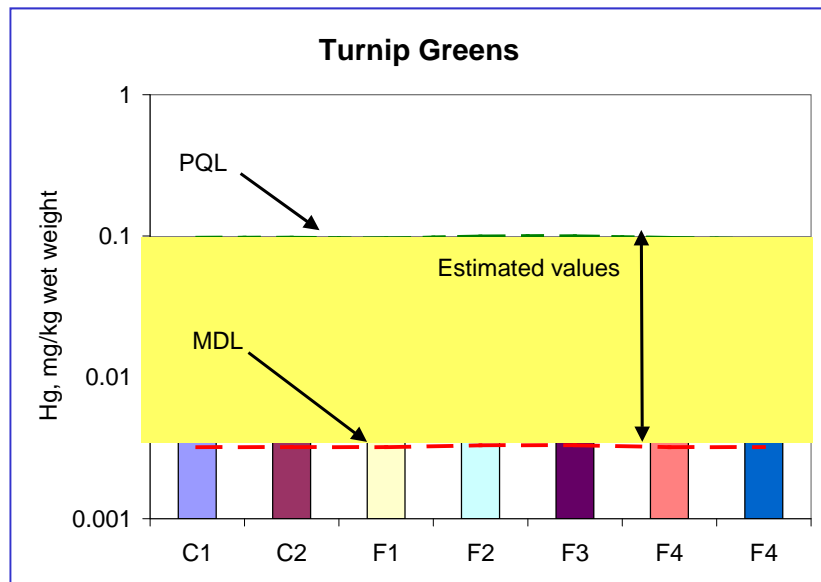
2004



Turnip Harvest 2004



Turnip Greens 2004





Summary - Garden Soils

- Floodplain garden, 2003
 - Soil mercury from 4.2 to 78 mg Hg·kg⁻¹ dry weight in the surface 15 cm
- Control garden, 2003
 - Total soil mercury from 0.16 mg Hg·kg⁻¹ to less than the LOQ (<0.12 mg Hg·kg⁻¹ dry wt)



Path Forward

- Collect floodplain and control garden soils and analyze for total mercury
- As many as 3 publications planned
 - Collection and analysis of soil samples
 - Crop data
 - Crop evaluation



Acknowledgements

- Barry Wolstenholme
- Dick Jensen
- Annette Guiseppi-Elie
- Mike Liberati
- John Greene
- Sharon Nordstrom
- Allison Kelley
- Susie Temple
- Folks at the Augusta Forestry Center
 - Larry Estes
 - Thomas Frazier



Crop Study Evaluation (Guisseppi-Elie)

General Approach:

- Calculate Potential Average Daily Dose, ADD_{POT}
- Compare to the Reference Dose RfD,
 - Safe level over a lifetime of exposure
- Ratio of ADD_{POT} to RfD = Hazard Quotient
- $HQ < 1$, exposure not expected to cause harm



Crop Study Evaluation (cont)

Simplified ADD_{POT} Calculation

$$ADD_{POT} = C \times IR$$

| | | | | |
|-------|-------------|---|---|--|
| Where | | | | |
| | ADD_{pot} | = | $\frac{mg \text{ Constituent}}{Kg \text{ Body Weight} - day}$ | |
| | | | | |
| | C | = | $\frac{mg \text{ constituent}}{kg \text{ vegetable}}$ | |
| | | | | |
| | IR | = | $\frac{Kg \text{ Vegetable}}{Kg \text{ Body Weight} - day}$ | |
| | | | | |

Conservative Assumptions:

- 100% Methylmercury in vegetables
 - Reference Dose (RfD) = 1E-4 mg/kg-day
- 100% bioavailable
- Use maximum detected concentration or $\frac{1}{2}$ method detection limit, if not detected



Crop Study Evaluation (Cont.)

- Ingestion Rate from USEPA Exposure Factors Handbook, Homegrown produced
 - Individual Crops (19)
 - Total vegetables (153 floodplain and 74 control garden measurements):
 - all,
 - exposed, protected, root,
 - dark green, deep yellow, other
 - Central tendency estimate
 - 50% (or mean) of homegrown > 90% of general population
 - High end estimate
 - 90% of homegrown > 98% of general population



Crop Study Evaluation (Cont.)

- Results for seasonally adjusted IR for all (geometric mean) vegetables for the South
 - Seasonal to account for potential long-term exposure
 - All to account for potential cumulative effect
 - Geometric mean to account for variation in concentration
 - South to account for regional effects
- HQ = 0.06 for 50%
- HQ = 0.39 for 90%



Crop Study Evaluation (Cont.)

Workgroup agrees that no additional crop plantings are warranted