USDA

United States Department of Agriculture

New Jersey

Natural Resources Conservation Service

pXRF in Technical Soil Services NJ & NYC

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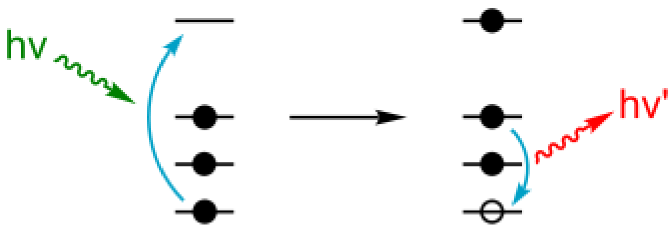
Natural Resources Conservation Service

nrcs.usda.gov/

X-ray fluorescence

Fluorescence - absorption of radiation of a specific energy results in the re-emission of radiation of a different energy (generally lower).



- X-ray photons knock out inner orbital electrons
- Outer orbital electrons move into vacancy
- Fluorescence emitted at element-specific wavelength

PXRF

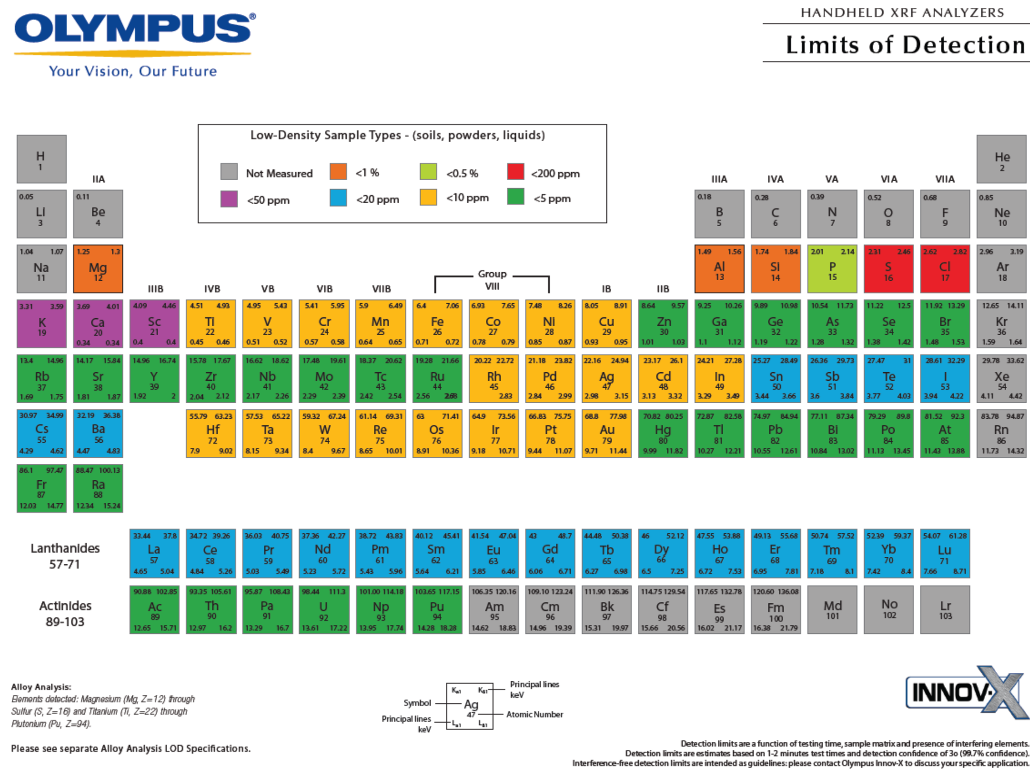
Portable X-ray fluorescence environmental analyzer

Innov-X (Olympus) Delta Standard model

- Good sensitivity
- Highly recommended
- Good customer service
- No software needed
    - Needed only with workstation

Innov-X Delta Standard Model

Element	Limit of Detection
Rb, Sr, Zr, Mo	1 ppm
As, Se, Br	1 to 3 ppm
Pb, Hg	2 to 4 ppm
Zn, Mn, Ga	3 to 5 ppm
Cu, Fe	5 to 7 ppm
Ag, Cd	6 to 8 ppm
Cr	5 to 10 ppm
Ti, V	7 to 15 ppm
Sn, Sb	12 to 15 ppm
Co, Ni, Ba	10 to 20 ppm
Ca	20 to 30 ppm
K	30 to 50 ppm
S	100 to 250 ppm
P	500 to 700 ppm



Radiation Safety

Maximum exposure

< 1uSv* (10^{-6}) at the trigger ~ < 2mSv annually to the hand (ICRP max to extremity = 50 mSv for gen. public)

100 uSv per dental X-ray

10 seconds exposure to beam = 550 mSv

*1 sievert = 100 rem = 5.5% chance of developing cancer

Calibration/QA

- Energy calibration check at least twice daily
- A blank (SiO_2) is run every 20 samples
- Calibration verification with reference standards is run at least once daily
  - NIST ref materials → high & med trace metal soils
  - Difference between pXRF measurements and the reference soils should $\leq$ 20%

Sources of error

- Non-homogenous sample
  - Sieve sample
  - Mortar & pestle (EPA method 6200)

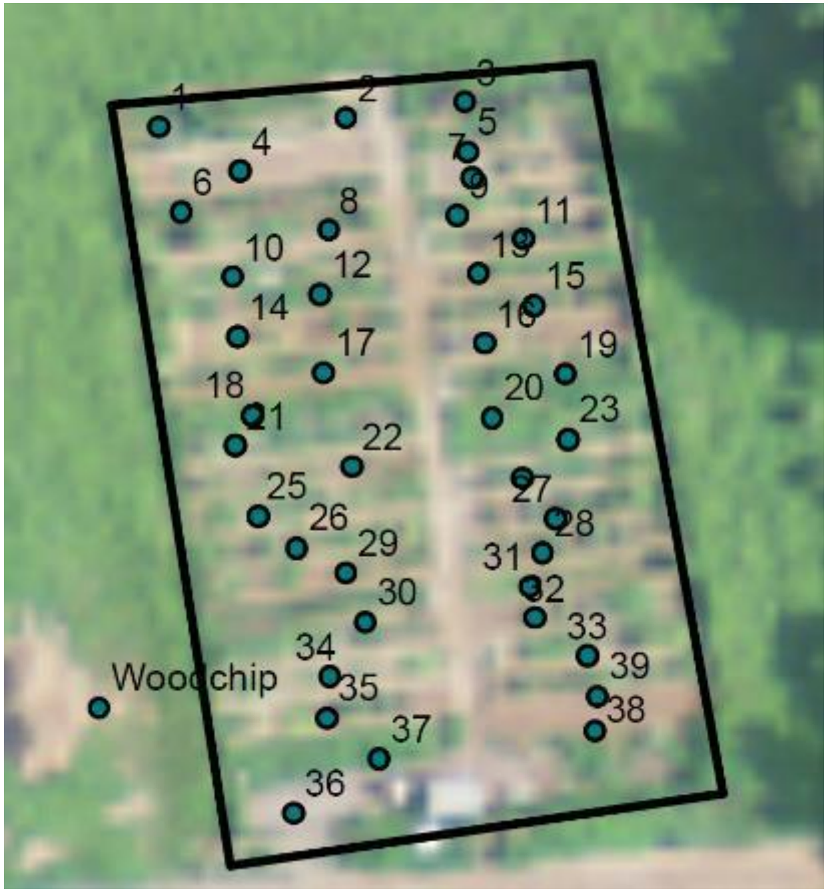
- Soil moisture - dilution effect
  - Air dry sample

Workstation

- Office setup
- Emissions contained in chamber
- Need additional software

Onsite screening method

- Grid pattern to cover area of interest
- Auger sample at 2 depths



Interpretation

- New York State Department of Environmental Conservation
    - Soil Cleanup Objectives - Residential Use
- NJDEP Soil Remediation Standards

	NJDEP Soil Remediation Standards	NYS DEC, Soil Cleanup Objectives
Chromium		36
Manganese	11000	2000
Cobalt	1600	
Nickel	1600	140
Copper	3100	270
Zinc	23000	2200
Arsenic	19	16
Selenium	390	36
Silver	390	36
Cadmium	78	2.5
Barium	16000	350
Lead	400	400

ppm

Recommendations

Soil Nutrient Analysis Laboratory

Soil Nutrient Analysis Laboratory, 6 Sherman Place, Unit 5102, Storrs, CT 06269-5102 • Phone: 860-486-4274
Fax: 860-486-4562 Location: Union Cottage, Depot Campus, Mansfield

Lead in Garden Soils

What is lead?

Where is lead and what are considered to be normal background levels?

How did soils become contaminated with lead?

Who is affected by lead?

How does lead affect children and adults?

Lead Contaminated Soil: Minimizing Health Risks

Fact Sheet FS336

Cooperative Extension

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Joseph Heckman, Ph.D., Extension Specialist in Soil Fertility
Stephanie Murphy, Ph.D., Director, Soil Testing Laboratory

Lead in Our Environment

Lead is a naturally occurring element found in soils at low concentrations. Elevated levels of lead are usually due to contamination. Living systems have no known biological use for lead, and exposure to elevated concentrations of lead can cause human health problems.

Gardening or playing where soils are contaminated with lead can result in toxicity in humans. Lead can be transferred from the soil when inhaled as soil dust or when directly ingested. While few persons deliberately eat soil, young children, especially toddlers, are at the greatest risk for accidentally ingesting soil and dust, since they have heightened hand-to-mouth activity. The United States Center for Disease Control and Prevention (CDC) has indicated that lead poisoning is one of the most common, but also preventable, childhood environmental health issues facing our country today. New Jersey law requires physicians to screen all children for elevated blood lead levels.

Specific Health Concerns

Children are more sensitive than adults to lead exposure since their brains and bodies are quickly developing, and can absorb and retain high percentages of lead. Extremely high levels of lead in the blood (80 µg/dL) are rare in this country but can cause coma and death. The consequences of moderate levels of exposure to ingested lead (10 to 40 µg/dL) include neurological damage, lowered IQ, learning disabilities, decreased stature and may be associated with delinquency.

One problem with moderate lead poisoning (10 to 40 µg/dL blood lead) is that the symptoms are not unique to lead exposure and can be mistaken for other illnesses. Children with blood lead levels in this range may develop deficiencies in speech and language processing, attention and classroom performance.

The Centers for Disease Control and Prevention has recognized "that a blood lead of 10 µg/dL did not define a threshold for harmful effect", which means that even blood lead levels less than 10 µg/dL may cause adverse health effects. New Jersey state law requires physicians to screen children between the ages of 12 and 24 months for blood lead levels. Blood levels greater than 20 µg/dL lead to notification of health and human services personnel. Chelation therapy is recommended for blood lead levels greater than 45 µg/dL.

Children are not the only ones affected. Lead exposure can cause similar neurological health problems for adults. Fetuses are also at risk, because lead can be transferred from the mother. Nursing mothers can deliver lead through breast milk.

Pollution Sources

Some soils were polluted long ago by lead. Leaded gasoline contained tetraethyl lead as an antiknock agent for many years; this was volatilized in engines and emitted from tail-pipes. Lead was deposited along streets and highways until lead use in gasoline was prohibited in the United States, in 1986. Lead from automobile emissions is estimated to have

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Healthy Soils, Healthy Communities

Metals in Urban Garden Soils

Metals are naturally present in rock, soil, and other materials. They are also used in manufactured (*anthropogenic*) materials, and human activity can increase the levels of metals in soil. Urban soils often have higher levels of metals than rural soils because they have been affected more by human activity. Gardening in urban soils may increase your exposure to metals if you swallow or breathe in soil particles or eat food raised in or on the soil.

What metals can be found in urban gardens?

The table on this page lists several metals commonly found in urban garden soils, along with guidance values developed to protect human health, and ranges of "background" levels typically found in rural and urban soils in New York State (NYS) and New York City (NYC).

The following pages provide some basic information for gardeners about each of these metals: where they come from (both natural and anthropogenic sources), how they behave in soil, considerations for human and plant health, and what gardeners can do to help reduce exposure to metals in garden soils.

What levels of metals are acceptable in garden soils?

There are no standards protective of public health specifically for metals in garden soils in NYS, but there are guidance values developed for other purposes that gardeners can consider. The guidance values in the table on this page are residential soil cleanup objectives developed by the NYS Department of Environmental Conservation and the NYS Department of Health for the NYS environmental remediation programs (see References, p. 9). These values were developed to consider residential exposures, including gardening. However, they assume that you live on the property with the soil, and that you are exposed in some ways every day and over a lifetime. Exposure to metals in soils for an urban gardener may be less than this.

Metals commonly found in urban garden soils: Guidance values and background levels [a]

Metal	Level in soil (parts per million [ppm]) Guidance Value Protective of Public Health	NYS Rural Background Level	NYC Urban Background Level
Arsenic	16	< 0.2 - 12	4.1 - 26
Barium	350	4 - 170	46 - 200
Cadmium	2.5	< 0.05 - 2.4	0.27 - 1.0
Chromium	36	1 - 20	15 - 53
Copper [b]	270	2 - 32	23 - 110
Lead	400	3 - 72	48 - 690
Mercury	0.81	0.01 – 0.20	0.14 – 1.9
Nickel [b]	140	0 - 25	10 - 43
Zinc [b]	2200	10 - 140	64 - 380

[a] References, page 9

[b] Can be toxic to plants at levels below guidance values protective of public health

The guidance values also generally assume that metals are in one of the most toxic and available chemical forms, which is not always the case with metals in garden soil. Metals can be present in soil in different chemical forms. The behavior of metals in the environment, tendency to be taken up by plants, toxicity to plants and potential for health effects of human exposure to those metals depend on their chemical form. For example, some forms of metals can readily dissolve in water (soluble) and therefore can enter plants or the human body more easily than forms that cannot easily dissolve (insoluble). Human and plant toxicity depend upon the amount of metal that enters the body or plant.

Should I be concerned about exposure to metals in my garden soil?

Certain metals are essential in small amounts in the diet for good health, but eating or drinking large amounts of them can cause health effects. Other metals can cause health effects even in small amounts. Lead can pose a particular health concern, especially for young children. The likelihood that health effects will occur depends

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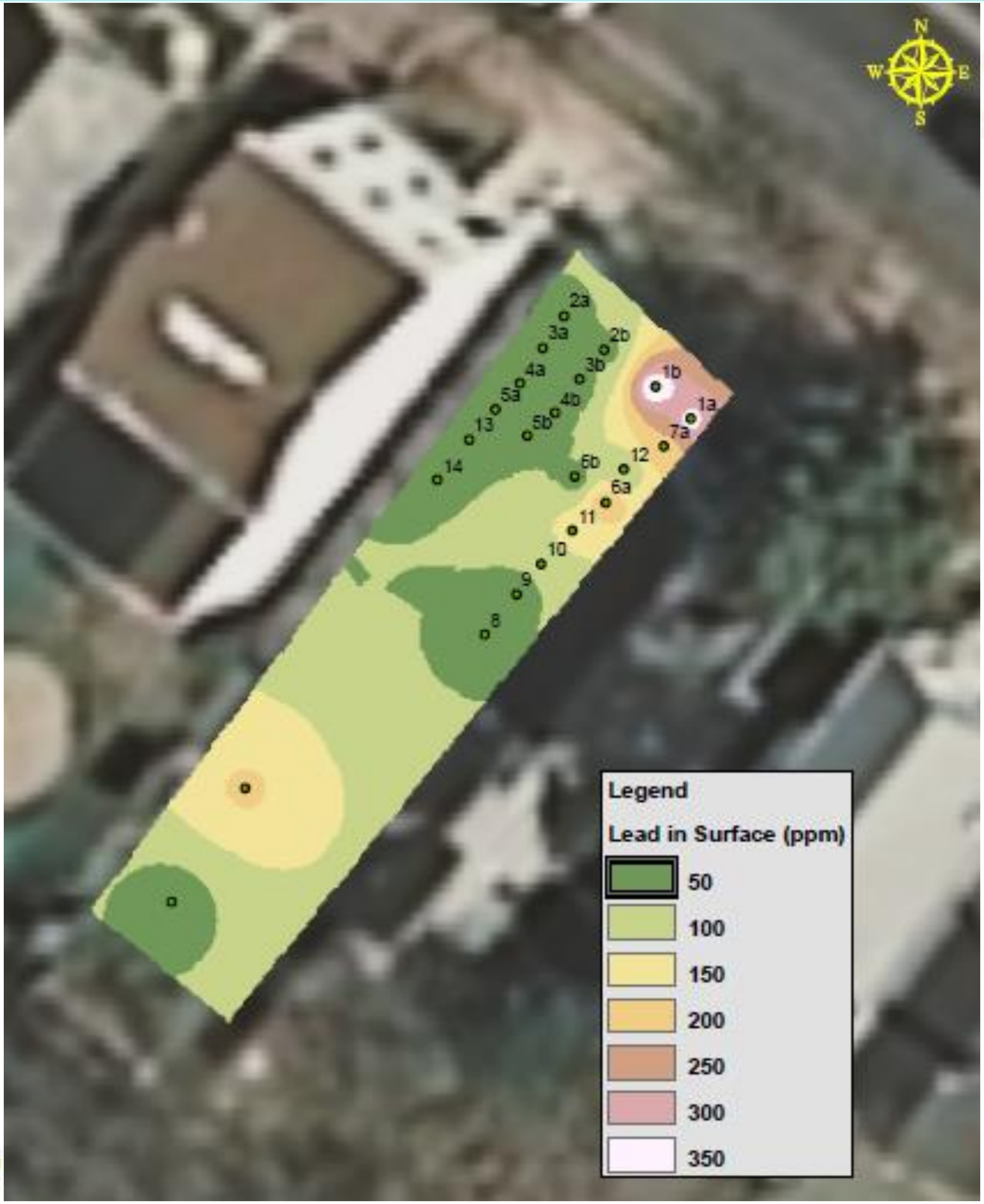
New York State Department of Health
Cornell University College of Agriculture and Life Sciences Department of Crop and Soil Sciences
Cornell University Cooperative Extension New York City

New Brunswick, NJ
Community Garden - raised beds



Pb content 200 - 400ppm in some raised beds

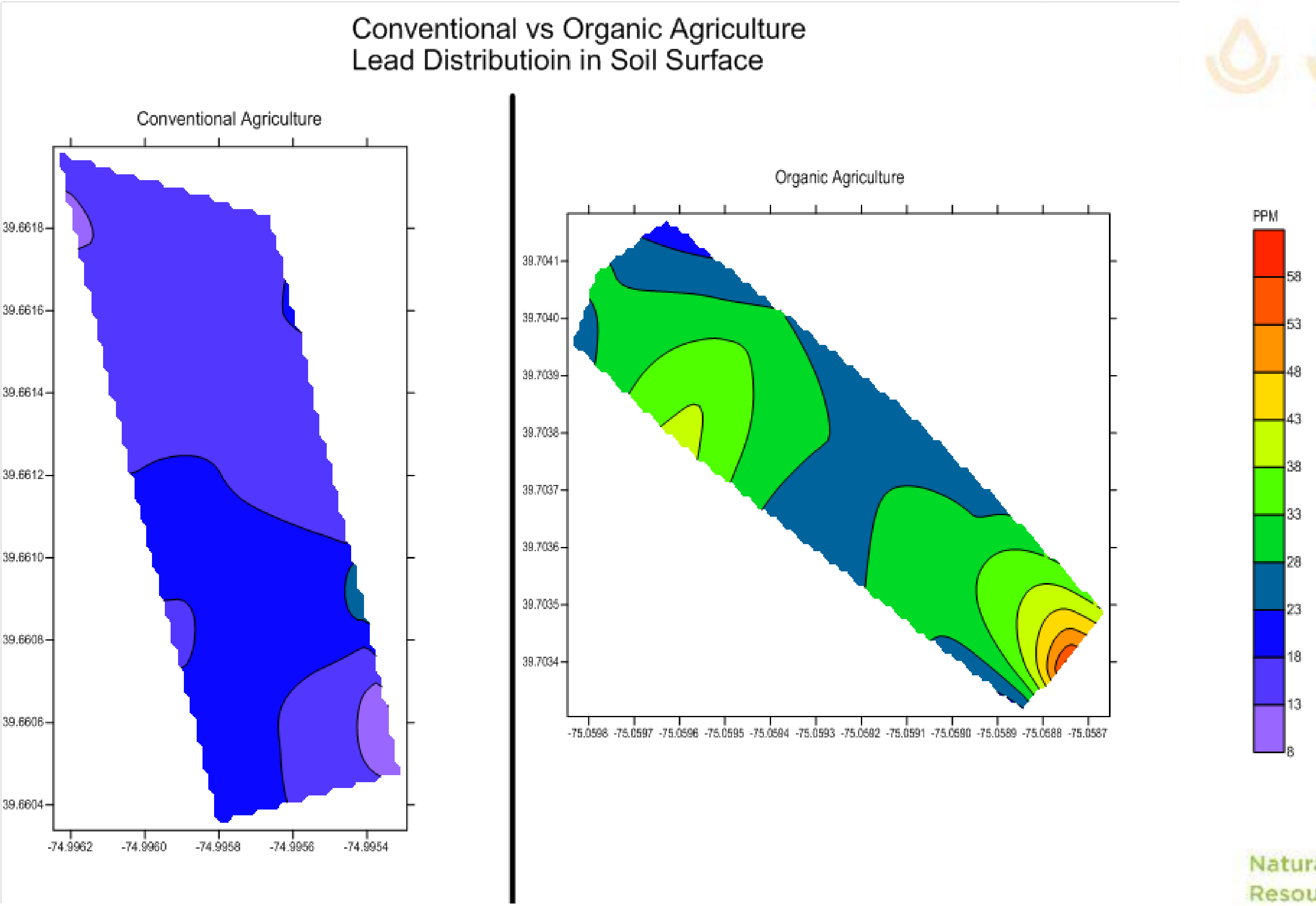
Elevated Pb content associated with construction dust/debris

Camden, NJ
Community Garden – in ground

- Pb content 400 to 939 ppm
- 6-12” depth

High Pb associated with artifactual fill

Gloucester County, NJ
Municipal Leaves Additions & Soil Trace Metal Contents



Conventional
8 to 28 ppm Pb

Organic w/leaves
18 to 58 ppm Pb

St Mary's Church, Harlem
Community Garden - raised beds

Paterson, NJ
Community Garden – In ground

Far Rockaway, NY

Bronx, NY

Newark, NJ

Clifton, NJ

Other Applications

- **Soil Survey**
  - Serpentine soils
  - Artifacts and trace metals
- **Research Projects**
  - Urbanization & adaptation in white-footed mice

    Stephen Harris, CUNY PhD candidate

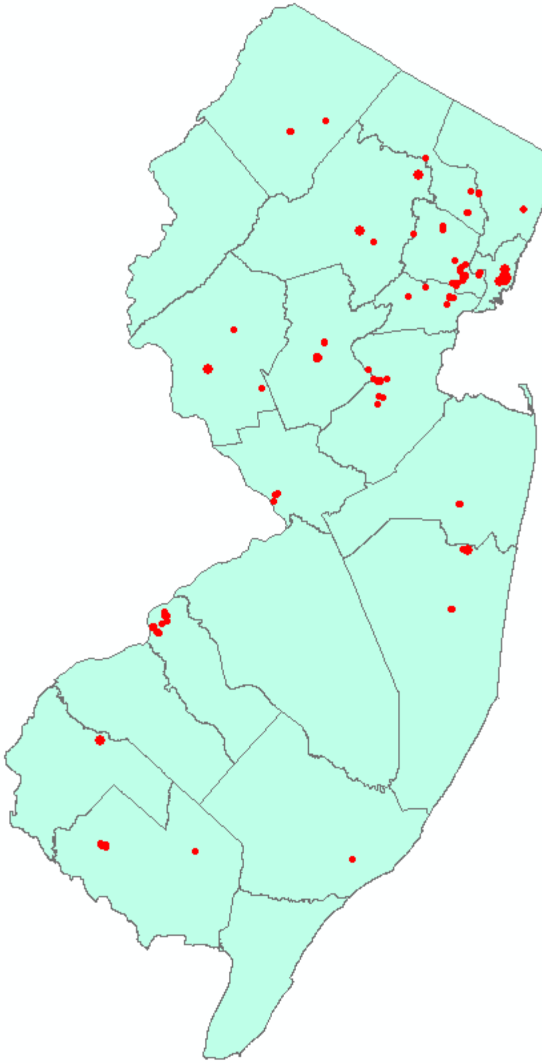
    Evolution Right Under Our Noses, NY Times, 7/25/11
  - Evaluation of some NYC Parks restoration efforts

    Lea Johnson, Rutgers PhD candidate
  - Trace Metal Content and Electro Magnetic Inductance (Magnetic Properties) of Some Pennsylvania Soils

    Jim Doolittle, Research Soil Scientist, USDA-NRCS

Totals and locations

Community gardens	114
Sampling points	3716
Points exceeding Pb	8.3%
Points exceeding As	7.7%



pXRF

- Not cheap ~$30,000
- Easy to operate & maintain
- Applications
  - environmental quality & health (community gardens)
  - soil survey & characterization
  - soils-based research
- Ideal for assessing spatial variability

Conclusions

- Health & safety issue that we can address
- More thorough, affordable vs lab testing
- Provide services to underserved customer base unfamiliar with our agency
- Rewarding service

Contact information

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