Informatics in the garden

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Love the soil
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Illustration by j.nardi
Project background

• NC SARE: Evaluation of soil quality and lead in Chicago community gardens

• CII: Using information technology to address soil quality in Chicago community gardens

ASAP
Agroecology and Sustainable Agriculture Program
Chicago community gardening paradise

http://neighbor-space.org/gardenmap.htm
Informatics Tools

• **Collaborative environments**
  – allow collaborators to define and organize their shared understanding of a research area

• **Text communication tools**
  – Face to face
  – Email
  – Forums
  – Wikis
  – RSS feeds (Current awareness)
  – Journals

• **Data management tools**
  – help reduce energy requirements to achieve information management goals
    • Concept mapping
    • Terminology and Definitions
    • Preservation standards

*B.Heidorn*
## Text Informatics Strengths

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fast Correction</th>
<th>Preservation</th>
<th>Ease of revision</th>
<th>Transparency</th>
<th>Peer Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face to face</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>E-mail</td>
<td>Excellent</td>
<td>Fair</td>
<td>Fair</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Forums</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Wiki</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Journals</td>
<td>Poor</td>
<td>Excellent</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

*B. Heidorn*
Informatics Objectives

• Data preservation
  – Long term data description
  – Provide archiving capabilities

• Access to ecological and environmental data
  – Promote data discovery, sharing & re-use
  – Maintain local autonomy for data management

• Analysis and Synthesis
  – Promote cross-cutting analysis by developing analytical tools
  – Address data heterogeneity issues

• Build an active informatics community
  – Enable more rapid IT advances through collaboration
  – Promote formal interactions among researchers and others
  – Break down barriers to data sharing
Transdisciplinarity is a principle of scientific research that describes the application of scientific approaches to problems that transcend the boundaries of conventional academic disciplines. Phenomena, such as the natural environment, energy, and health, are transdisciplinary.

Transdisciplinary research is distinguished by its goal, to understand the present world, which cannot be accomplished in the framework of disciplinary research.
Objectives CII

- provide educational resources to underserved communities regarding soil quality and environmental risk
- evaluate community use of informatics tools to enhance science literacy and access to resources.
- assess the needs and skill sets of different user audiences.
  - two audiences: educators (teachers, garden coordinators and master gardeners) and gardeners, students, the general public.
  - two delivery modes: in person educational programs, and individual users who will access content asynchronously.
Approach

• work with established organizations that are likely to use resources to educate themselves and others.

• key players include the nonprofit Openlands, numerous community gardens, master gardeners, extension and Chicago school teachers (eg: Paseo Barica).
Information cycle

- Share materials with COI
- Face to face settings
- COP on line
  - Shared materials
  - Resource repository
- Deliver and evaluate educational content
  - Support decision making
- Refine, revise, augment content
Unequal risk

• Pb poisoning has been reduced by 80% in the US to the current 2.2% level.

• A 2003 survey of 77 Chicago neighborhoods indicated 6% of children suffered from lead poisoning.

• 15% of urban children exhibit blood Pb levels above the “safe” level of 10 µg per deciliter and most are children of low socioeconomic-status minority groups.
Urban Pb and risk

- High blood-lead levels are often found where homes were built before the 1940s or where the site is downwind from some industries (e.g., lead smelters), and near busy streets.
- Lead can be deposited on floors, windowsills, eating and playing surfaces, or in the dirt outside the home.
- Areas adjacent to roads and in the drip lines of older housing often contain elevated levels.
- Exposure to high lead levels can cause a range of health problems and is associated with learning disabilities in young children.
- Kids under seven years of age are at the greatest risk of lead poisoning.

For more see http://www.childsdoc.org/spring2001/leadpoisoning.asp
http://urbanleadpoisoning.com/maps.html
Lead in Soils

• A little bit of lead is normal; about 10 to 50 parts per million worth of lead occurs naturally in soil. Up to 100 ppm is a safe level for children and pets to play in.

• Up to 400 ppm is still considered acceptable for adults growing vegetables. Any higher concentration than this can pose a danger to adults too.
Exposure in and around the garden

- Most lead is taken up by direct ingestion so contamination of unwashed produce is a greater risk than that posed by plant uptake.
- Fine particles sticking to food and hands identified as important source.
- Concentrations vary notably with depth and proximity to sources (roads, drip lines, buildings)
Ingestion of plant parts

Fig. 1. Distribution of lead as a function of grain size in soil from three urban backyard gardens. Bold lines represent the average bulk and <100 \mu m Pb concentration for all (n = 141) gardens tested, including the three gardens presented.

Clark et al. 2008
Soil materials vary

Fig. 2. Distribution of lead content (%) by soil grain size fraction in compost, three raised beds/excavation sites, and three urban backyard gardens. The dashed lines represent the average percent of lead in the <100μm size fraction for compost, raised beds, and gardens to illustrate the difference in the three soil media.
Lead bioavailability varies with minerals, pH

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Formula</th>
<th>Log Kps</th>
<th>Solubility (g per 100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoroapatite</td>
<td>Ca$_{10}$(PO$_4$)$_6$F$_2$</td>
<td>-55.9</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Hydroxyapatite</td>
<td>Ca$_{10}$(PO$_4$)$_6$(OH)$_2$</td>
<td>-110.2</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Carbonate apatite</td>
<td>Ca$_{10}$(PO$_4$)$_6$(CO$_3$)$_2$</td>
<td>-108.3</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Tricalcium phosphate</td>
<td>Ca$_3$(PO$_4$)$_2$</td>
<td>-24</td>
<td>0.02</td>
</tr>
<tr>
<td>Calcium monohydrogen phosphate</td>
<td>CaHPO$_4$.2H$_2$O</td>
<td>-6.6</td>
<td>0.14</td>
</tr>
<tr>
<td>Calcium dihydrogen phosphate</td>
<td>Ca(H$_2$PO$_4$)$_2$.H$_2$O</td>
<td>-1.14</td>
<td>18</td>
</tr>
<tr>
<td>Vivianite</td>
<td>Fe$_3$(PO$_4$)$_2$.8$H$_2$O</td>
<td>-36</td>
<td></td>
</tr>
<tr>
<td>Chloropyromorphite</td>
<td>Pb$_5$(PO$_4$)$_3$Cl</td>
<td>-18.69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pb$_5$(PO$_4$)$_3$Cl</td>
<td>-25.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pb$_5$(PO$_4$)$_3$Cl</td>
<td>-46.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pb$_5$(PO$_4$)$_3$Cl</td>
<td>-84.4</td>
<td></td>
</tr>
<tr>
<td>Hydroxypyromorphite</td>
<td>Pb$_5$(PO$_4$)$_3$OH</td>
<td>-4.14</td>
<td></td>
</tr>
</tbody>
</table>

Miretzky and Fernandez-Cirelli 2008
Recontamination by paint in dust

**Fig. 3.** Geochemical trace elements in compost, raised beds, and garden are plotted with titanium, a trace element associated with paint, on the x-axis to separate the population. The average value for the compost samples and the 90th percentile of garden soil samples are plotted with x- and y-error bars representing the standard deviation of the population. The dashed line represents a two-point linear regression between average compost and 90th percentile garden soil.
What is typically being done and associated issues

- Avoidance by importing soils and using raised beds is a recommended tactic.
- Measurement not common, in and around the garden is possible, depth, distribution of samples, and cost have all been issues.
- Most widely used Pb analysis methods are digests that estimate total, not bioavailable forms.
Dear Chicago Community Gardeners,

Please participate in a survey of Chicago Community Gardens. This survey is being distributed to garden coordinators in the Chicago Metropolitan area to help me with my Masters research being carried out at the University of Illinois in the Department of Natural Resources. You’re receiving this email because you have previously indicated interest in participating in a soil quality study about Chicago gardens. Thank you for your enthusiasm and interest thus far!

We are interested in learning more about the physical and cultural characteristics of gardens and seek to identify sites that vary in the likelihood that they contain lead. Please take the time to follow the link (url here) and complete the attached survey.

Laura Witzling (NRES masters student) and Michelle Wander (Associate Professor of Soil Fertility/Ecology)
Speakers felt it premature to share the data on this slide

*community and school garden survey of soils adjacent to gardens*
## Gardens

<table>
<thead>
<tr>
<th>Purpose</th>
<th># People</th>
<th>#Grocery bags</th>
<th>Soil brought in?</th>
<th>Contained beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>market, pantry, edu.</td>
<td>50-100</td>
<td>50-100</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>edu. &amp; personal use</td>
<td>21-50</td>
<td>50-100</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>educational, flowers</td>
<td>21-50</td>
<td>0-10</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>market, educational</td>
<td>21-50</td>
<td>21-50</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>recreation</td>
<td>1-10</td>
<td>0-10</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>educational</td>
<td>1-10</td>
<td>0-10</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>food for market</td>
<td>1-10</td>
<td>0-10</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>recreation</td>
<td>50-100</td>
<td>50-100</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>educational</td>
<td>50-100</td>
<td>21-50</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>for personal use</td>
<td>1-10</td>
<td>0-10</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>
Anticipated questions

- Does avoidance tactic work?
- What is a practical strategy for testing?
- How do I evaluate toxicity?
- What are remediation methods?
SARE project

10 gardens

4 questions

• Soil grown vs imported soil
• Paths vs gardens
• EPA Pb test vs Mehlich III
• Is Pb present bioavailable, if so what are likely routes of uptake
Garden piece

• Take 4 samples per garden or plot within beds 0-30 cm depth, multiple plots sampled in larger gardens
• Take 3 samples in paths or play areas where kids playing may be exposed
• Carry out chemical and biological analyses of soil quality and lead
Soil assays

• Physical status, Habitat
  – Bulk density, porosity, texture

• Chemical status
  – pH, plant available P, K, MIII: base cations, metals (Pb, Cu, Zn, Fe)

• Biotic status
  – Mineralizable N, particulate organic matter, nematode bioassay, plant bioassays
Speakers felt it was premature to share the data on this slide.
Speakers felt it was premature to share the data on this slide.
Availability is reduced with increasing soil pH
Speakers felt it was premature to share data on this slide

EPA 3050b (ppm)

MIII Pb (ppm)
Bioassays have the last word

- Nematodes (*c. elegans*) added to soils from paths and gardens
- Lettuce grown in garden soils
- Lettuce ‘dusted’ with lead contaminated soils
eLearning piece

- Use a CMS to develop and host content
- Conduct face-to-face trainings
- Conduct online trainings
- Carry out surveys to assess knowledge and learning preferences of groups who have or have not participated in trainings
USQI Online

• For the COI
  – Urban gardener chat space
  – Resources for Urban Gardeners
  – About the project
  – Events

• For the COP
  – Educational content
    • Experience soils
    • Interpreting tests and managing risk
Lead in Soils

- Sources
- When to worry
- Testing
- Management
Fact sheets and hands on needs

- Urban soil quality fact sheet (test card?)
- Urban soil quality basics
  - Lead
  - Nutrients
  - Metals
  - Car fluids
  - Clay soils
  - Compaction
  - Signs of life
- Buying or building good soils
- Interpreting soil tests
- Remediation lead- best practices for Pb (pictures)
face to face

• Hands on: experience soil
  – Labfest
  – City Wilds
  – Westchester Master gardeners… coming up

• Interpreting tests
  – El Coqui Community Garden
  – North park village meeting
1. How important is learning about soil quality to you? Circle one number:

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Very important</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Not important at all</td>
</tr>
</tbody>
</table>

2. Name or describe one attribute of soil that helps determine soil quality:

- No response=color
- Nutrients
- Moisture
- Organic matter
- Texture
- PH
- Organic matter
- Fertility
- Color
- Structure
- History
- Worms
- Plants
3. Name or describe one test that helps determine soil quality:
   No response>>pH>water=texture=plants
   No response>pH>organic matter=color>clay=soil test=ease of digging

4. Where do you primarily use the Internet? Check one.
   Home 20 24
   Library 2 3
   Never use it 1
   Somewhere else (please list): 1 school 4 work

5. What is your favorite way to learn something new? Check one.
   Hands-on activities 14 21
   Watching a demonstration 2 4
   Listening to a lecture 2 2
   Reading something (not on the Internet) 3 1
   Using the Internet 2 2
   Other (please list): 1
6. Would these be useful to you? Check ALL that apply.
A website about urban soil quality                       9  18
An online space to communicate with other gardeners     7  16
More information about environmental risks and urban gardens 15  25
No response                                                2

7. What is your age? Check one.
25-                                                        0  4
25-35                                                      6  3
35-49                                                      13  8
50-64                                                      2  8
65+                                                        5

9. About how much time have you spent at our booth before filling out the survey:
Less than five                                             8  11
About 10 minutes                                           13  18
More than 20                                               0  1
face to face w/community of practice

- Include some use of internet on site
- Survey before and after completion of educational unit
- Will we recruit to carry out subsequent units on line (with and without previous contact)
- Will we host materials for them to use on site and track use/development
Interpreting garden test results

*Report for garden X*

<table>
<thead>
<tr>
<th>Soil property</th>
<th>Garden result</th>
<th>range for study</th>
<th>Target values</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.3</td>
<td>6.3-8.6</td>
<td>6.5-7.0</td>
</tr>
<tr>
<td>Bulk Density</td>
<td>1.2</td>
<td>0.8-1.6</td>
<td>Between 1 and 1.3; Tend to be higher in sandy soils</td>
</tr>
<tr>
<td>Organic matter</td>
<td>9.6%</td>
<td>0.5-91</td>
<td>&gt;2%</td>
</tr>
<tr>
<td>Plant available P</td>
<td>861 ppm</td>
<td>6-12190</td>
<td>Between 40 and 50</td>
</tr>
<tr>
<td>EPA 3054b Pb</td>
<td>24</td>
<td>15-888</td>
<td>&lt;400</td>
</tr>
<tr>
<td>MIII: Pb</td>
<td>8.3</td>
<td>4.7-456</td>
<td>Has not been established, we estimate about 200</td>
</tr>
</tbody>
</table>

Comments:
Science Literacy and Action

Andrew (Chick) Ahlgren, Project 2061 at AAAS;
http://www.eurekalert.org/multimedia/pub/3631.php
Recommendations for urban gardeners

- Survey the property to determine the potential lead hazards, extent of the contamination and location of high-risk areas.
- Plan to locate fruit and vegetable gardens away from buildings, especially if peeling paint is evident and sites where sludge with heavy metals was applied.
- Analyze lead concentration in soil samples from areas where vegetable gardens exist or are planned.
- Do not grow food crops in a soil that is contaminated to levels greater than 400 ppm.
- Instead, use either containers or construct raised beds, with a semi-permeable barrier between the clean and contaminated soil.
- Where container or raised bed gardening is not possible, fruiting crops should be grown.
- Root vegetables, leafy greens and herbs should not be planted in contaminated soils.
- Test new topsoil before using it and annually retest the garden soil to monitor for recontamination.
- Do not use plants grown in contaminated soils for compost.
- Use mulch or a weed tarp in garden beds to reduce the potential for aerial soil dust deposition or soil splash up on crops.
- Maintain soil pH above 6.5 by liming when necessary.
- Remove outer leaves of leafy crops, peel all root crops, and thoroughly wash the remaining produce in water containing vinegar (1 percent) or soap (0.5 percent).
Summary

• Chicago’s urban gardeners want and need more information about soils and environmental risk
• We have the tools and knowledge to fulfill this need
• An ‘informatics repository’ could help satisfy this need
• Development of low cost, locally vetted testing strategies and data bases can make a positive impact- if there are resources available to do this
• Access to the web does not seem to be a barrier
• Learning preferences point to need for hands on or interactive educational tools
• Tapping and training educators will be a key component