Urban Soils, Plant Growth, and Human Health.

Notes from a presentation by Dr. Wes Jarrell, Professor and Head Natural Resources and Environmental Science University of Illinois, Urbana-Champaign

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Garden of Springfield Community Garden
Photo by Grace Troccolo

As part of a mini-symposium on urban contaminated soils in February of 2005, Dr. Wes Jarrell of the University of Illinois presented the following information concerning plant, soil and human interactions.

PRESENTATION OUTLINE

1. Original soils of Chicago
2. Characteristics of urban soils
3. Heavy metal contamination
4. Organic pollutants
5. Plant response
6. Amendments
7. Compost
8. Container gardening
9. Soil testing
10. Recommendations

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1. Chicago's Past Soils

Chicago's history of glacial activity has left the region with, relatively, young soils. As the glaciers and related lakes retreated between 11,000 to 13,000 years ago, a fire-dependent plant community dominated the landscape. Glacial activity left stratified layers of sand, silt, and clay-rich sediments throughout the area. Wetland, prairie and pockets of woodland vegetation were found across what is now the city of Chicago.

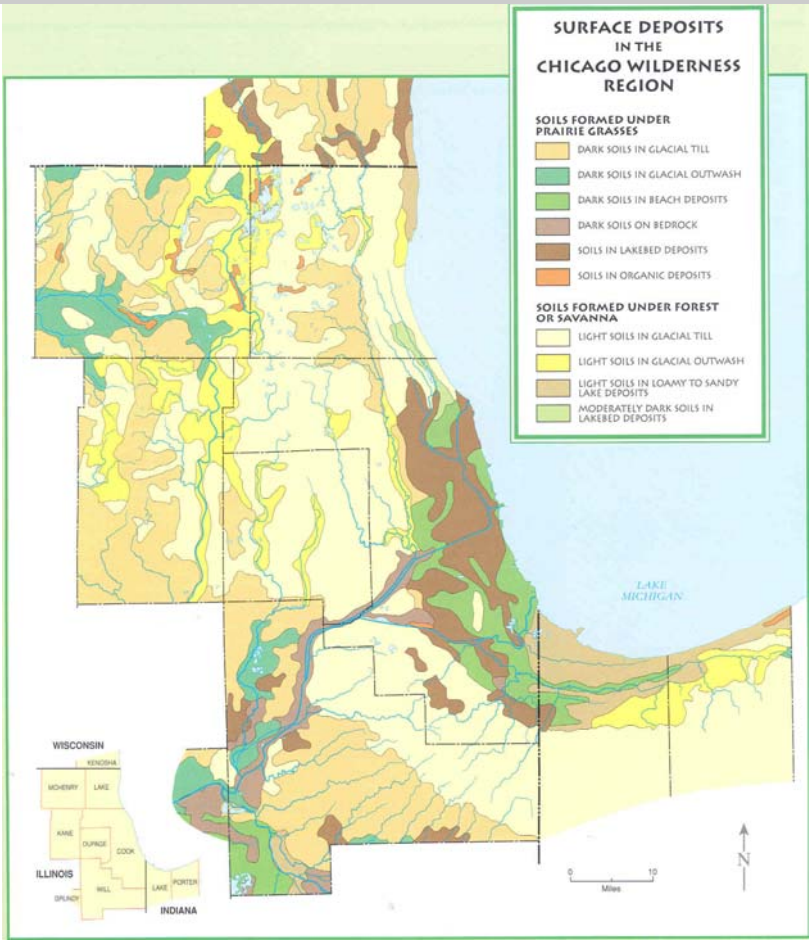


Image courtesy of Chicago Wilderness: An Atlas of Biodiversity

Human development has disturbed the native plant and soil communities increasingly over that last 300 years. The introduction of drainage tiles to dry agricultural land for cultivation had a profound affect on the Northeastern Illinois landscape. Much of the soil of Chicago is fill used to grade and fill in the region's wetlands. The Chicago fire of 1871 created tons of debris that was used to create new land along the lake front including what is now Grant Park. Additional land alteration was caused by dredging rivers and canals for navigation. Additional information on native soils and ecological restoration in the region can be found through Chicago Wilderness.

2. Characteristic's of Urban Soils

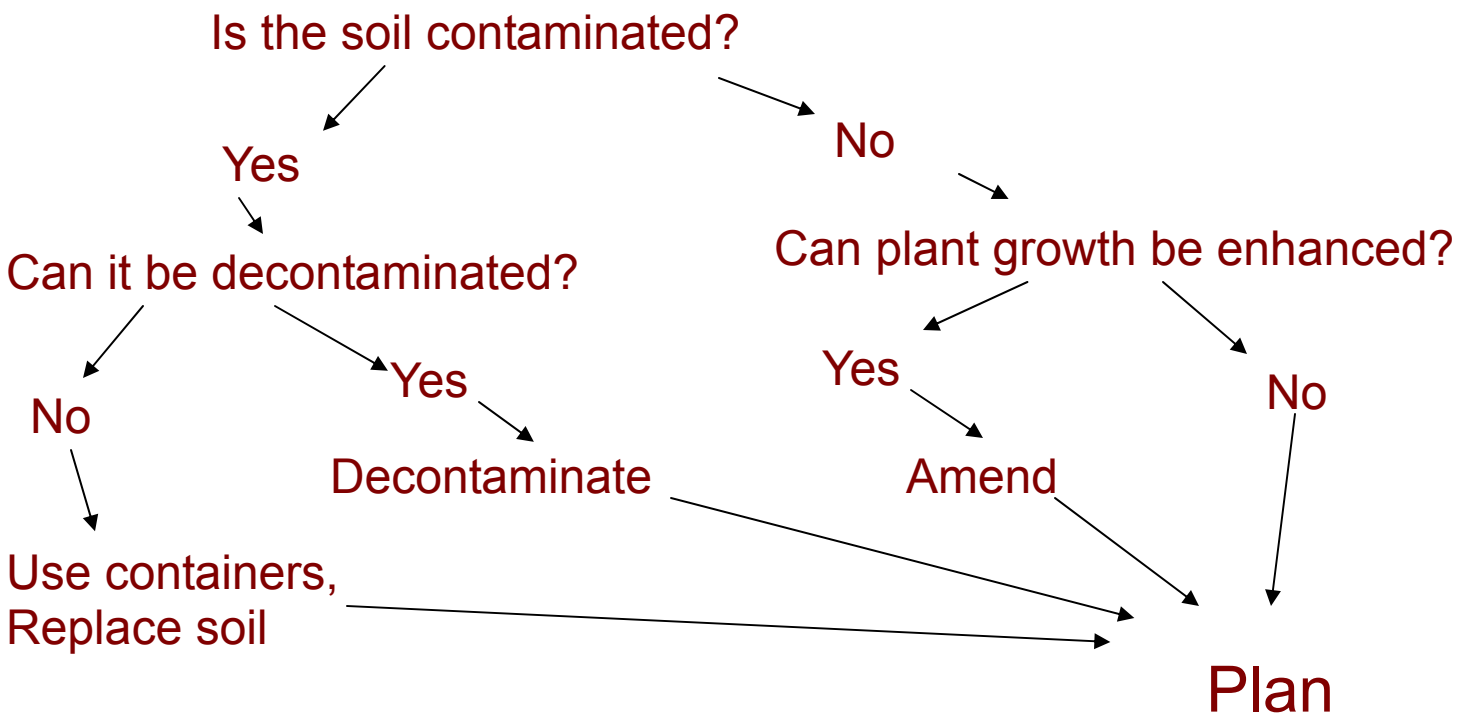
As previously mentioned, the soils of Chicago have been manipulated by geologic and human forces. There are few, if any, undeveloped parcels in the city limits.

Some characteristics of urban soils in general are:

- Highly disturbed
- Topsoil lost (planting in subsoils) or topsoil imported from somewhere else
- Heavily compacted
- Over-fertilized and elevated salinity levels
- Subject to flooding/ poor aeration
- Contaminants: metals and organic pollutants in particular

Decision Tree for Planning

Use this diagram to plan for your gardening project in urban soils.



3. Heavy metal pollutants and their sources

Arsenic: pesticides, coal and petroleum wastes, mine tailings, wall board, copper arsenate wood preservative

Cadmium: electroplating, paint residues, plastics and batteries

Chromium: stainless steel, chrome-plated products, paints, fire brick

Copper: mine tailing, copper dust, fly ash, fertilizers, copper arsenate wood preservative

Lead: batteries, wet and dry air deposition, steel mill residues

Mercury: pesticides, catalyst, dentist offices

Nickel: wet and dry air deposition, electroplating, batteries

Zinc: galvanized metals (wires, roofing), brass and rubber products

Contaminant Mobility in Soil

♦High: Nitrate, chloride, sulfate

♦Intermediate: Calcium, magnesium, sodium, ammonium: rapid attach and release

♦Low: Phosphate (arsenate)

♦Very low: Metals: held tightly or precipitated as oxide (e.g., rust)

Clays and organic matter are highly active

Metals held strongly by organic matter

Arsenic acts like phosphate

4. Organic pollutants and their sources

Organic pollutants are biodegradable and may break down in the soil or through phytoremediation.

Pesticides: insecticides, herbicides – organic chlorinated, long residual

Polychlorinated biphenyls (PCBs): transformers

Fuel and motor oils (may contain metals as well): shade tree mechanics, leaking above or under ground fuel tanks

Objective: Healthy Plants in Healthy Soils

-No toxic components
-Optimum growth for food production

Organic materials decontamination practices

1. Degrade: High rates of "active" organic matter/ compost, to accelerate degradation

2. Inactivate: Activated charcoal- strongly binds pesticide molecules

3. Remove and replace soil

If herbicide contamination, may be able to grow non-sensitive species or decompose herbicide.

5. Plant response to contaminants

Pollutant behavior in plant

1. Rejected by root:

Certain heavy metals, many organics don't pass membrane into root cells readily

2. Tied up in root:

Cadmium, zinc, copper, lead

3. Remains in leaf if transported:

Arsenic, zinc, copper, cadmium

4. Transported to fruit:

<u>very few contaminants</u>

Turtle Park Community Garden
Photo by Joan Romero

6. Amendments for plant growth

Role of pH

Metals generally more soluble and available under acidic (low pH: 4-5) conditions

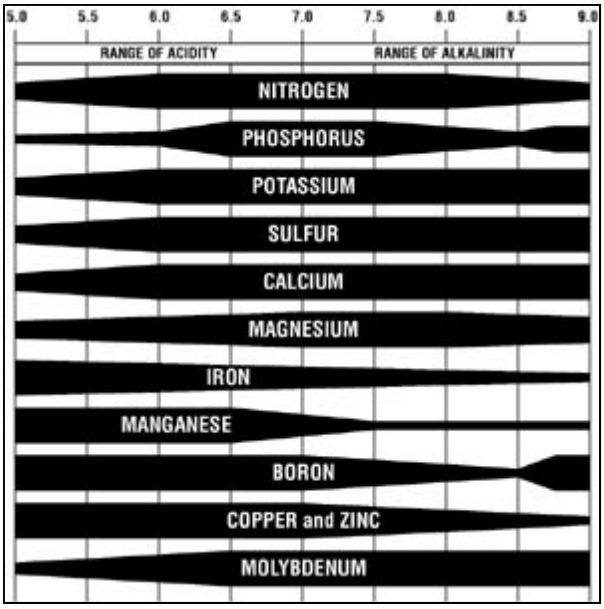
Phosphorus most available near mid-pH (6.5—7.5) range

Plants needing high iron do better under acidic conditions

Raise pH: Limestone – with or without magnesium

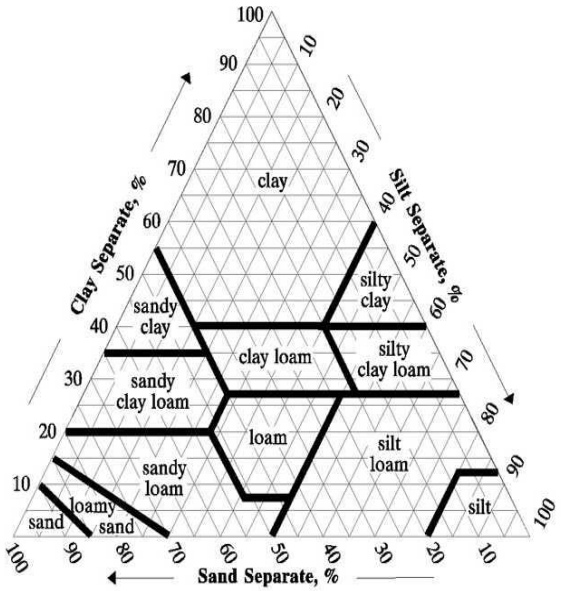
Lower pH: Elemental sulfur, ammonium fertilizers, peat moss (many composts neutral)

Availability of nutrients at various pH



Role of Nutrients

- Nitrogen is usually the most limiting factor to plant health
- Phosphorus and potassium secondly
- Calcium, magnesium are important minerals
- Trace elements may or may not be available



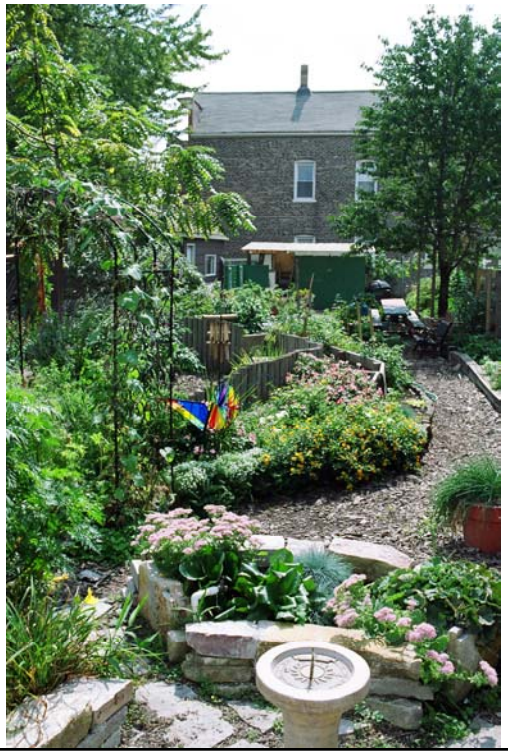
Soil texture is the relative quantities of sand, silt and clay. These are the basic United States Department of Agriculture (USDA) soil textural classes. Loam contains similar amounts of sand, silt and clay.

Role of organic matter

- Improves physical structure, bigger and more pores
- Retains many nutrients in available form
- Tightly binds metals, especially at high pH
- Source of nutrients to plants
- Food source for beneficial organisms, inhibiting many pathogens (not all)

7. Compost is a tool and a concern!

- Original ingredients: What goes in?
- Analysis: When is compost ready?
- Stability: Compost must be mature or it will rob nutrients
- Salinity: High salinity may damage plants
- pH: Amend compost as needed to attain near 7.0 pH
- Source of nutrients?: What nutrients are available in compost?
- Weight: Should be light and add sufficient organic material
- Color: Dark brown, never black (sign of anaerobic activity)



Xochiquetzal Community Garden
Photo by Joan Romero

8. What to consider with containers

Container Gardening is a popular solution to sites that have overwhelming or unanswerable issues with contamination.

Positives

- No leaching losses of nutrients, salts
- Efficient water use
- Lower volume of potting mix
- No connection of roots to field soil

Negatives

- Potential salt build-up
- Special container, special potting mix
- Can be too wet for some species

Subirrigated containers Bottom-up watering

- Potting soil: stable, holds nutrients, neutral pH, renewable, low salt
- Weight: easy to move, yet will not fall over
- Ratio of rooting/container volume to leaf area: smaller ratio, more frequent watering and fertilization
- Container color and heating of roots
- Drainage and root growth through holes into soil

9. Soil tests

Soil Tests are fundamental to knowing what is happening in your soil. This is a brief outline on how to test your site.

1. Mix soil and solution, filter out solution

2. Measure chemicals in solution

3. Compare to research: plant growth vs. soil test under controlled conditions

Other methods:

Soil Food Web

Bioassay (see sidebar)

Bioassay - radishes

- Obtain "standard" or "reference" (R) soil, excellent growth properties
- Place reference and test soil (T) in shallow containers
- Four treatments: R soil alone, T soil alone, R + liquid fertilizer, T + liquid fertilizer
- Use duplicates of each treatment
- Plant 10 radish seeds in each container
- Water and observe growth for 20 days

10. Recommendations

- Standards for soil testing
- Arrange with lab for custom tests (for urban agriculture's issues)
- Develop appropriate recommendations for urban gardeners
- Provide case study examples of restoration success
- Develop containers and container management as appropriate
- Longer, hands-on workshop on soils and remediation