Soil Health

Winthrop Square Park Project: Using Cornell University's Comprehensive Assessment of Soil Health in an Urban Environment

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Introduction

Soil health has recently captured the attention of farmers in the U.S. and internationally, yet there are many applications that expand beyond the field of agriculture. The green urban landscape has great potential for improving soil quality. In city parks and greenways, compaction from both human and machine activity, and the mixing of topsoil and subsoil during routine park maintenance can affect soil functions such as plant growth, water infiltration, and the support of biological life. Although soil degradation is visible in many parks, a systematic approach to characterize soil health has only recently been applied to urban landscapes.

Fig.1. 1852 McIntyre map of Boston showing the Training Field in relation to City Square and the Bunker Hill monument. By this time the Training Field site was becoming more park-like. Photo taken from the Cultural Landscape Plan for Winthrop Square Park.

Cornell University's Comprehensive Assessment of Soil Health (CASH) provides an assessment of soil health relative to important soil physical, chemical and biological processes. In both rural and urban settings, chemical indicators such as pH and macro/micro nutrients are often at optimal levels due to lime and fertilizer applications, yet the soil itself can still be physically and biologically degraded. CASH provides a full picture of what's going on below the surface. It outlines the interconnected processes causing constraints, which in turn empowers land managers to make informed decisions about soil amelioration and future maintenance.

By promoting urban soil health, cities can create positive environmental outcomes such as flood protection, groundwater recharge, and sequestration of dust and carbon, while providing a more comfortable urban climate through healthy plants. Recently, CASH was evaluated as a tool for a renovation project in Boston, Massachusetts, which is a notable example of the application of the test for soil health management in city parks.

Case Study: Winthrop Square Park

Pocket parks (or mini parks) play an important role in city life, whether it's sitting on a park bench, strolling through a bit of green in an urban jungle, or the neighborhood kids playing a game of kickball. These small parks, sometimes no larger than ¼ acre, provide a safe and inviting environment for community members. They support the overall ecology of the surrounding environment, landscape and heritage, and empower local residents to make decisions that affect their community. Boston has hundreds of these outdoor parks all over the city, and one of the oldest and most beloved is Charlestown's Winthrop Square Park.

Fig.2. Aerial view of the park and the six unique sampled areas

The park, also known as the "Training Field", is a .89 acre green space with a 400 year history. It was a training ground for colonial militia in the 1640's, was witness to the Battle of Bunker Hill in 1775, served multiple functions as a civic space throughout the centuries, and most recently became a hotspot for Charlestown residents and a stop along the Freedom Trail. Although this space is deeply significant to the community and the city itself, it has been many years since restorations took place. Along with other much needed rehabilitation work, it faced drainage and erosion problems, and the overall soil health was lacking in many areas.

The park renovation project developed out of a cultural landscape report, prepared by Kyle Zick, Landscape Architect, and Shary Page Berg, Landscape Preservationist, in partnership with two local community groups, the Charlestown Preservation Society and the Friends of the Training Field. The Boston Parks and Recreation Department led the way and a park renovation proposal was approved by the City, along with $690,000 from its Capital Budget.

Site Analysis

Sherzi & Company LLC was part of the consulting team brought in to address the drainage and soil health issues at the site. Owner Chuck Sherzi had extensively used the CASH approach in previous projects, and recommended to employ this holistic approach to address the concerns facing the park. The complete diagnostic report included data analysis and interpretations from the Cornell Soil Health lab, site observations, and a detailed summaries of suggested recommendations and appropriate construction materials. Since the site is naturally divided into six unique areas and each had a specific set of challenges (foot traffic, grade elevation, water flow, etc.), separate soil samples were collected from each area (Figure 2).

The Comprehensive Assessment of Soil Health

The CASH approach emphasizes the integration of soil biological, physical, and chemical measurements. These include soil texture, available water capacity, soil penetration resistance (compaction), wet aggregate stability, organic matter content, soil proteins, respiration, active carbon, and macro- and micro-nutrient content (see soilhealth.cals.cornell.edu/ for more details). The results are synthesized into a comprehensive soil health report with indicator scores, constraint identification, and management suggestions. The report can be used by consultants and managers as a baseline assessment and to guide soil amelioration and future management.

Winthrop Square Soil Health Results

The entire site showed soil health concerns, with overall quality scores of low to medium. Specifically, the CASH reports (Figure 3) showed:
Physical Indicators

- **Aggregate stability** (indicating soil resistance to disintegration from rainfall) and **available water capacity** (indicating the soil's ability to store water) scored high

on all six assessments, possibly a result of minimal soil disturbance at the site over the years.

- **Surface** (0 – 6 inches) and **subsurface** (6 – 18 inches) **hardness** (indicating compaction that limits root growth, water transmission and plant access to nutrients and water) scored mostly low and medium throughout the site.

Biological Indicators

- The indicators generally scored medium or low, suggesting marginal soil biological activity. Although several areas tested within range for total **organic matter**, **active carbon** was constrained at four sites, indicating a lack of biologically available food and energy within the organic matter.
- All six areas scored medium in the **root health** rating, most likely due to compaction.

Chemical Indicators

- **pH** and **minor elements** scored low or medium in five of the six areas.
- **Heavy metals** in all areas were found to be within the allowable concentrations for garden soil and were therefore not a concern for this project.

CORNELL SOIL HEALTH TEST REPORT

Name of Farmer: Chuck Sherzi, Jr.	Sample ID: k1060
Location: One Cottage Rd., Andover, MA, 01814	Agent: 0
Field/Treatment: Sample-Area #5 Winthrop Square, Charlestown	Agent's Email: 0
Tillage: 0	Given Soil Texture: 0
Crops Grown: 0	Date Sampled: 6/20/2013

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	70.9	97	
	Available Water Capacity (m/m)	0.21	88	
	Surface Hardness (psi)	452	0	rooting, water transmission
	Subsurface Hardness (psi)	505	2	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	4.1	73	
	Active Carbon (ppm) [Permanganate Oxidizable]	456	33	
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	1.0	0	N Supply Capacity
	Root Health Rating (1-9)	5.0	50	
CHEMICAL	pH (see Nutrient Analysis Report)	4.7	0	Toxicity, Nutrient Availability (for crop specific guide, see CNAL report)
	Extractable Phosphorus (see Nutrient Analysis Report)	18.4	100	
	Extractable Potassium (see Nutrient Analysis Report)	62.1	72	
	Minor Elements (see Nutrient Analysis Report)		11	More than one minor- or/and micro-nutrient deficiencient or excessive
	OVERALL QUALITY SCORE (OUT OF 100):		43.9	Low

Soil Textural Class:==> sandy loam

SAND (%): 60.3 SILT (%): 31.9 CLAY (%): 7.8

Fig.3. Summary page from the Area 5 Soil Health report.

Example of Detailed Problem Spot: Area #5 (Figure 3)

Area 5 was the second largest of the areas assessed, experiencing a high amount of foot traffic and patchy consistency throughout. It had the lowest soil health score, with the major constraints being surface and subsurface compaction. While the organic matter scored high, other biological indicators were relatively low. The sandy loam texture could be a factor in the loss of nutrients through leaching, and the low nutrient base cations Mg++ and Ca++ could be associated with a low pH. A layered approach was proposed for Area 5 and all other areas assessed.

Recommendations and Implementations

Results of the assessment highlighted soil compaction as the major underlying constraint common to all six of the Winthrop Square areas. Issues with the physical structure of soil eventually leads to negative impacts of both biological and chemical components. Compacted soils have decreased pore space that can limit infiltration, increase runoff and erosion potential, and allow for anaerobic conditions that are unfavorable for beneficial microbial communities. They can also limit plant access to nutrients and water. Given these results, recommendations for the site were focused on decompaction measures followed by incorporation of organic amendments to improve nutrient cycling, pH, and the overall biological health of the soil. Sherzi also recommended amending the sandy loam soil with biochar and a green manure to break up the surface hardness, aid in nutrient retention and further prevent runoff and erosion.

Soil Decompaction Techniques

A multi-tiered approach was used to addressing soil compaction. Due to the natural slope at the site, any remediation effort had to be careful not to destabilize the existing upper soil profile. The project was done in phases where Areas 1, 2, 3 and 4 were done together as they do not impact the daily flow of foot traffic in the park. Areas 5 and 6 were addressed separately as they are the two largest spaces and have the most foot traffic (Figure 2). The compaction issues were addressed using the following tools/techniques:

- **Air Spading**: Useful for tree root collar work and excising of girdling roots. The specialized tool uses compressed air to dislodge, breakup, and aerate compacted soil. Soil amendments are then added and "stirred" into the existing soil using the air tool.

Fig.4. Air spade used to aerate and break up soil at Winthrop Square Park.

- **Vertical Composting**: Utilizes air tools to open up holes in the soil along a predetermined grid pattern in turf areas. Soil amendments are then added to these holes and graded over. The compaction layer is slowly broken up by the microbes as the holes begin to coalesce, reducing compaction and improving the overall soil health.

Fig.5. Example of vertical composting.

- **Radial Trenching**: much like the root collar technique, this approach works on a pattern of trenches, radiating from the trunk of the tree, either dug by hand, by machine or by air tool. Soil amendments are then added to help stimulate fibrous roots of the tree.

Fig.6. Radial trenching pattern around tree at Winthrop Square.

In addition to the physical decompaction work, incorporating organic matter, both dry and liquid, was critical for maintaining balanced soil biological communities. Dry and liquid soil amendments used in conjunction with the de-compaction work: compost, calcitic lime, bio-char, fish hydrolysate.

Maintenance Recommendations

Potential long term management solutions for the park include top dressing with compost, adding fertilizer, limestone for pH, and fungal foods, grass mowing at 3.5-4" height, and keeping pedestrian foot traffic on walkways. An irrigation system was installed along with moisture sensors to determine proper watering amounts.

Project Progress

The Winthrop Park Project is scheduled for completion in summer 2016, including attention to the hardscape –new concrete, relining the 'Freedom Trail', fencing, etc. CASH, with its site-specific soil health analysis and holistic management approach, proved to be effective for soil testing in the urban environment. Using this method, a cherished piece of green-scape for the Charlestown community set an example for how cities can approach future soil health monitoring in city parks.

For more information about CASH, please visit soilhealth.cals.cornell.edu. For more information about the project contact Chuck Sherzi Jr. at csherzi@comcast.net.