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Analyzing Leaf Litter and Soil Health at the University of Pennsylvania

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Abstract:

Leaf litter has been shown to support soil ecology, although this relationship is poorly understood in urban environments. Currently, the University of Pennsylvania removes leaf litter from most of its landscapes to make way for lawn, mulch, or ground cover planting. To assess the ecological impacts of various landscape management practices at Penn, our team is monitoring the chemical and biological changes that occur in soil treatments across campus. After final data are collected, we hypothesize sites covered with leaf litter will demonstrate a notable ecological benefit. These findings will inform sustainable landscape practices, both at Penn and in other urban landscapes.

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INTRODUCTION

Decomposition of plant litter refers to the reduction of litter to its molecular constituents via physical and chemical processes. Leaf litter decomposition rate is dictated by various factors, including climate, leaf species and chemical characteristics of leaf litter, substrate quality, and soil microbiota [see 1-5]. Litter is first broken into smaller pieces by detritivores; the pieces are then chemically reduced into basic molecules by microorganisms [6]. Leaf litter decomposition is an essential component of carbon and nutrient cycling, acting as the primary source of nutrients to plants and microbes [7,8]. Therefore, leaf litter decomposition is a critical process for ecosystem function and the dispersal of ecosystem goods and services [9].

Many studies have examined leaf litter decomposition and nutrient cycling in natural ecosystems and agricultural settings. Fewer studies have been able to encapsulate complex urban biogeochemical processes. Human activity alters local climate and atmospheric deposition rates, reshapes plant and animal communities, and accumulates fertilizer and waste. Because of uneven biogeochemical properties in urban environments, traditional soil models cannot accurately predict urban nutrient cycling [10].

Leaf litter can provide an important habitat for invertebrates, supporting broader ecosystem health. Some native invertebrates require native host plants to grow and develop. Native leaf species might also provide a more enduring habitat for invertebrates because they decompose more slowly [11].

METHODS

Purpose: The purpose of this project is to conduct a pilot investigation assessing the ecological impacts of the different management plans recommended in the Penn Ecological Landscape Stewardship Plan: traditional mulching, in-situ whole leaf litter, and shredded composite litter. The study aims to inform future soil experiments and management practices on campus. The study will result in a collaborative article authored by the research team.

Spatial Design: Five areas of Interest (AOI) containing a total of fifteen plots are located around the University of Pennsylvania main campus representing a variety of habitats and management strategies (Figure 1). Sites were chosen based on the diversity of management strategies and campus facility permission.

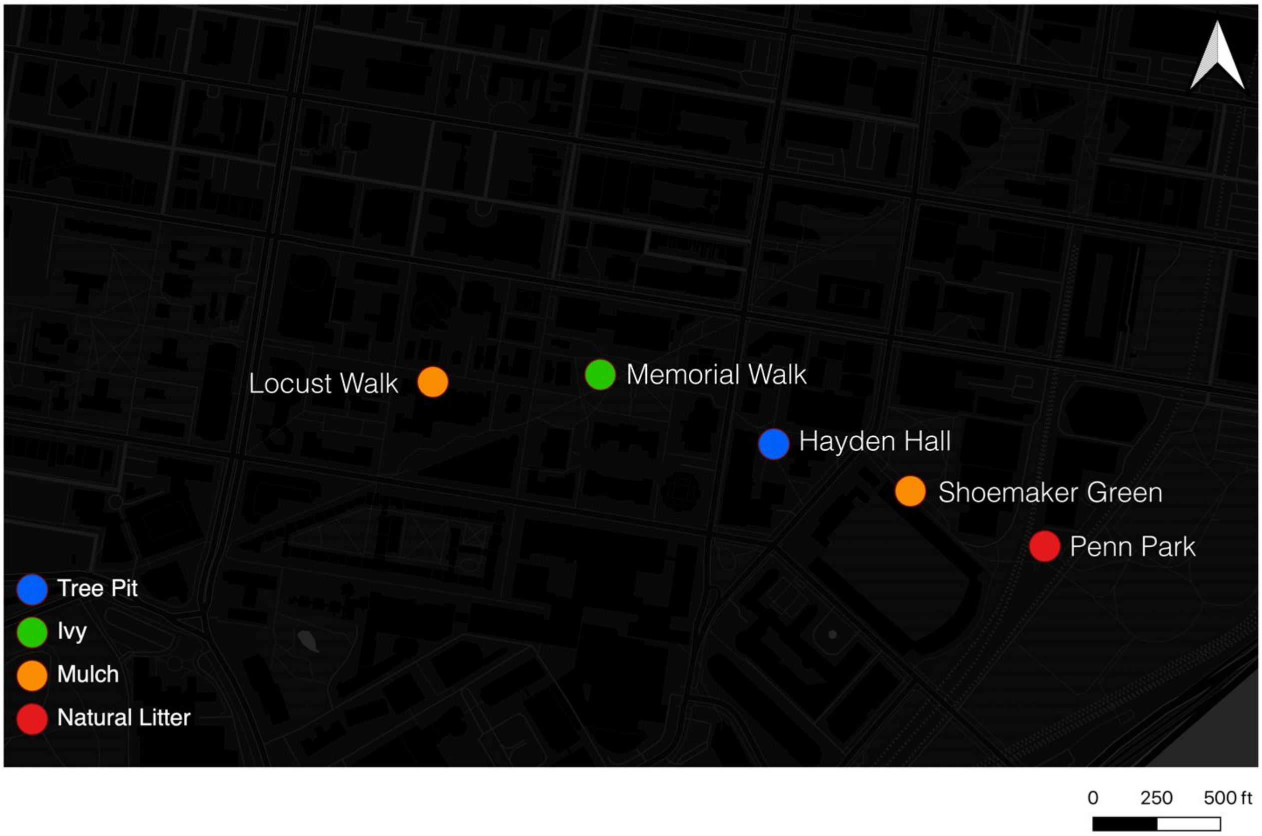

Figure 1 – Map of AOI across campus

Temporal Design:

1. September – Complete thorough literature review
2. October – Deploy leaf litter bags, soil probes, make plot observations
3. December – Retrieve and replace soil probes
4. April – Collect litter bags and replace soil probes. Process collected specimens. Produce final report for Penn Facilities and Real Estate Services.

Methodology:

Each AOI is demarcated with a rope or tape hanging on stakes. Each AOI contains an informational sign to prevent disturbance (Figure 2).

Figure 2 – Penn Park AOI

Three 1m^2 plots were set up within each AOI. Each plot was measured using a 1m^2 PVC quad. These three plots include a control plot (which represents existing management practices), a whole leaf treatment plot, and a shredded leaf treatment plot. The whole leaf treatment plot contains whole leaves collected from the AOI. Penn facilities were instructed not to remove these leaves as they usually would during winter management activities. The shredded leaf treatment plot contains mixed, partially decomposed shredded leaves provided by Penn facilities from across campus.

During plot preparation, each plot's location was recorded using a handheld GPS device. Then, environmental and soil conditions were recorded, including weather conditions, temperature, soil texture, soil moisture, and depth of existing litter. Existing vegetation in each AOI was mapped and identified. Next, leaf litter bags were placed in each treatment plot containing equal masses of leaves. Each shredded leaf treatment plot was filled with shredded leaves and contained two leaf litter bags filled with shredded leaves. Likewise, each whole leaf treatment plot was filled with whole leaf litter from the site and contained two leaf litter bags filled with whole leaves from the site. Figures 3, 4, and 5 demonstrate examples of the three different plots at one AOI (Shoemaker Green).

Figure 3 – Control plot with two pairs of soil probes and no leaf treatment. Photo includes temporary PVC quadrat.

Figure 4 – Whole leaf treatment plot with two pairs of soil probes and two leaf litter bags filled with whole leaf litter collected on site. Photo includes temporary PVC quadrat.

Figure 5 – Shredded leaf treatment plot with two pairs of soil probes and two leaf litter bags filled with shredded leaf litter collected off-site.

Two pairs of Plant Root Simulator (PRS) resin probes were placed in each plot. Each pair of PRS soil probes were placed adjacent to one another directly underneath leaf litter bags in the uppermost 15 cm of soil. One pair of probes includes one anion probe and one cation probe. Soil probe details can be found in Appendix I. Each litter bag and each probe were labelled with a unique laminated tag (Figure 6). Photographs were taken of each AOI.

Figure 6 – Leaf litter bag with laminated tag. Photograph by Eric Sucar / University of Pennsylvania

Analysis

When results are collected, the leaf litter mass from each litter bag will be recorded. Macroinvertebrates will be collected from the samples using a Tullgren funnel. Then, the leaves will be dried, and their dry masses will be recorded. Samples will be air-dried or oven-dried depending on necessity. Then, leaves will be ground to the required laboratory specifications and sent to the Penn State Soil Testing lab for composition analysis.

The soil probes capture the supply rates of essential compounds such as NO_3^-, $H_2PO_4^-$, SO_4^{2-}, NH_4^+, K^+, Ca^{2+}, Mg^{2+} and will be sent to the manufacturer for analysis.

RESULTS

Due to the seasonality of the project, results will be collected following the presentation of this report. Results and conclusions will be included in the final version of this report which will be prepared for University of Pennsylvania Facilities and Real Estate Services.

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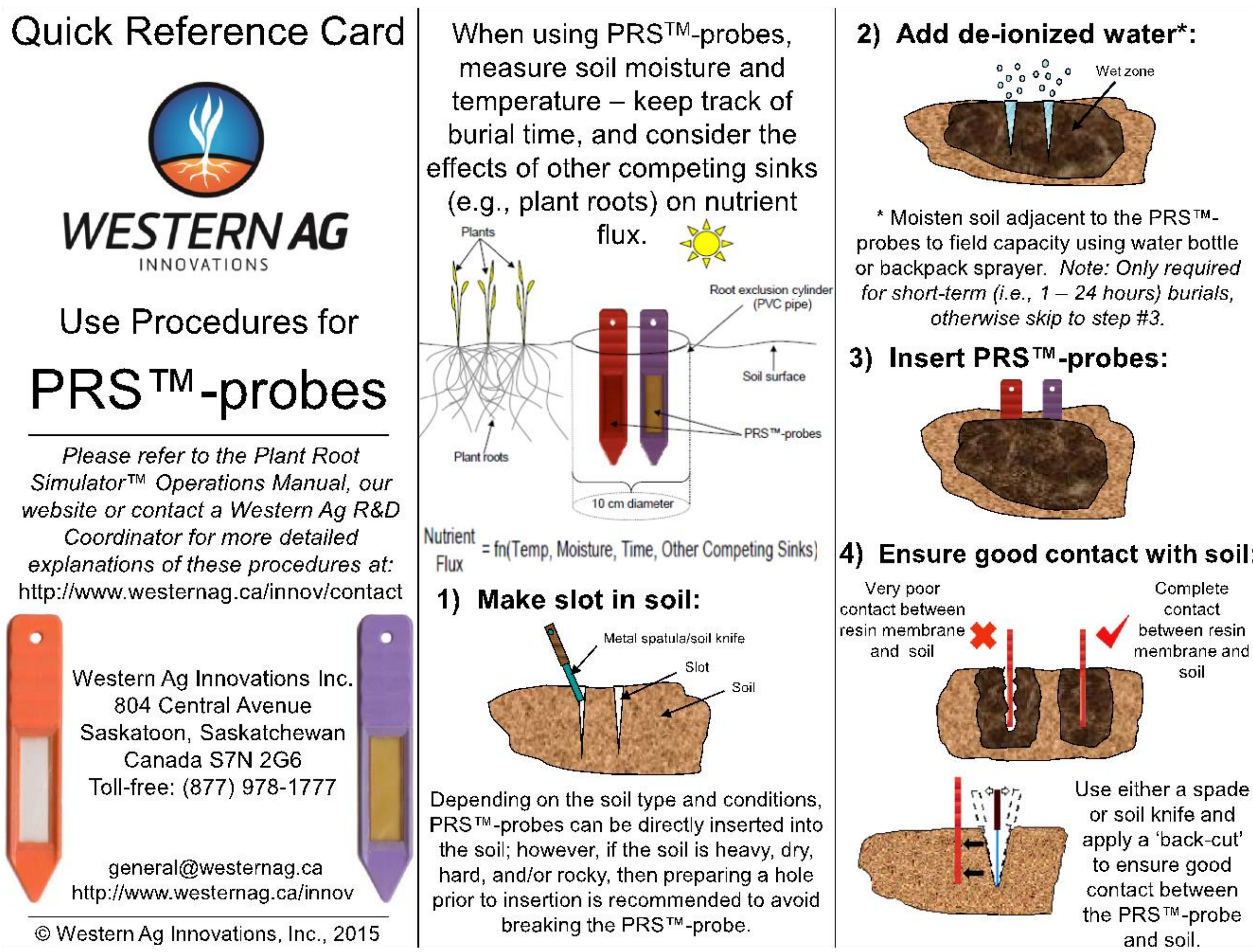
APPENDIX I.



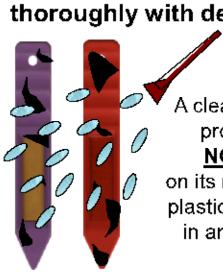
5) Leave PRS™-probes in soil for pre-determined length of time:

See PRS™ Operations Manual or our website for differences between short-term *vs.* long-term burials.

Short-term burials can be applied in lab incubations or in high nutrient supply ecosystems.


Long-term burials are useful in more tightly cycled, natural ecosystems.

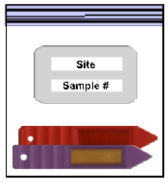

6) Remove from soil and wash thoroughly with de-ionized H_2O:



A clean PRS™-probe has **NO SOIL** on its membrane, plastic handle, or in any cracks.

See our website for examples of 'clean' *vs.* 'dirty' PRS™-probes.

7) Place in zipseal bag:



- Shake off excess water from PRS™-probes before placing in bag.
- Combine the anion and cation PRS™-probes that are analyzed as one sample.

Label samples consecutive (e.g., 1 - 60)

8) Re-wash PRS™-probes in lab if NOT COMPLETELY CLEAN.

There should be NO SOIL in the bag or on the PRS™-probe.

Transfer to a clean bag if necessary.

9) PRS™-probes storage:

- Keep in a cool, moist state prior to use (refrigerate where possible).
- Keep away from fertilizers or other concentrated chemicals.
- Do not expose to direct sunlight or extreme heat for extended periods.

10) Send PRS™-probes back to Western Ag for analysis:

Please return the PRS™-probes in the styrofoam-lined box provided, along with a couple of ice packs (do not include frozen water bottles).

11) PRS™-probe shipment *:

Fill out a ***shipping form*** and include inside the box. If necessary, also include three copies of the ***commercial invoices*** indicating that the **Goods RETURNING AND ORIGINATED IN CANADA; Code 066** and include with the other shipping documents (e.g., address) outside the box.

Note: documents are sent with PRS™-probes and are available on our website.

***Ground shipping across Canadian border can require a customs broker.**

Scientific papers in which PRS™-probe data have been published can be found on our website:

http://www.westernag.ca/innov/papers/

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