SOIL TESTS IN URBAN PARKS: *ASSESSING THE IMPACTS OF DOG USE FINAL REPORT*

Submitted by:

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fieldwork design office


With the help of the LACF, we have scratched the surface of our understanding of dog impacts on park soils through novel soil testing.

What's In Here?

This research project has been made possible with research grant funding provided by the Landscape Architecture Canada Foundation.

Proponent Team

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Tyler Allen Bradt | Co-Project Lead

Principal Landscape Architect at Fieldwork Design Office Litd.

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With over 15 years of experience in Landscape Architecture, Urban Design, and Horticulture, Tyler brings a comprehensive approach to creating dynamic outdoor spaces rooted in culture and place. From urban parks and plazas to streetscapes, courtyards, and green roofs, Tyler has led projects from concept to construction. Throughout his career, Tyler has developed a deep understanding of the intersection between the anthropomorphic landscape, and ecology, ensuring that each project enhances the built environment while fostering a connection to nature and promoting biodiversity and ecosystem resilience.

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Katie is a landscape architect, project manager, and arborist with over a decade of experience practicing through the lens of urban ecology. Her work includes campus landscapes, parks, play spaces, streetscapes, planting design, arboriculture, and contract administration in both public and private sectors. Her practice emphasizes detail, aesthetics, and ecological processes, and is built on a foundation of hands-on expertise in horticulture and landscape construction, as well as work on numerous residential projects in the GTA and Dufferin County. Katie also pursues art projects through her collaborative venture D&S Projects, and has been exhibited at venues such as Jardins de Métis, Scotiabank Nuit Blanche, and the Gardiner Museum.

Michael Ormston-Holloway

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With over two decades of professional practice in landscape architecture, and a career before that in the biological and ecological sciences, Michael has a wealth of knowledge and experience with which he brings to his projects, and many technical perspectives with which to consider planning, design, and implementation toward more successful projects, and project outcomes. Michael currently defines his practice at the intersection of science and design, focusing strongly on landscape performance toward better tree and ecological strategies. Through this work, he has helped municipal, institutional, and private sector clients develop robust landscape design strategies centred on placemaking and public realm activation, environmental protection and enhancement, and the interpretation of natural processes and cultural patterns through thoughtful aesthetic and functional expression.

With special thanks to **Jack Legg** *at* **SGS Canada** *and* **Michael Lynch** *at* **Metagenom Bio** *for their expertise and support and to* **Matt Canaran** *at* **Friends of Allan Gardens** *and* **Heidi Weidelich** *at* **The City of Toronto** *for their cooperation. Special thanks to* **Michael Ormston-Holloway** *for helping us with letters of introduction.*

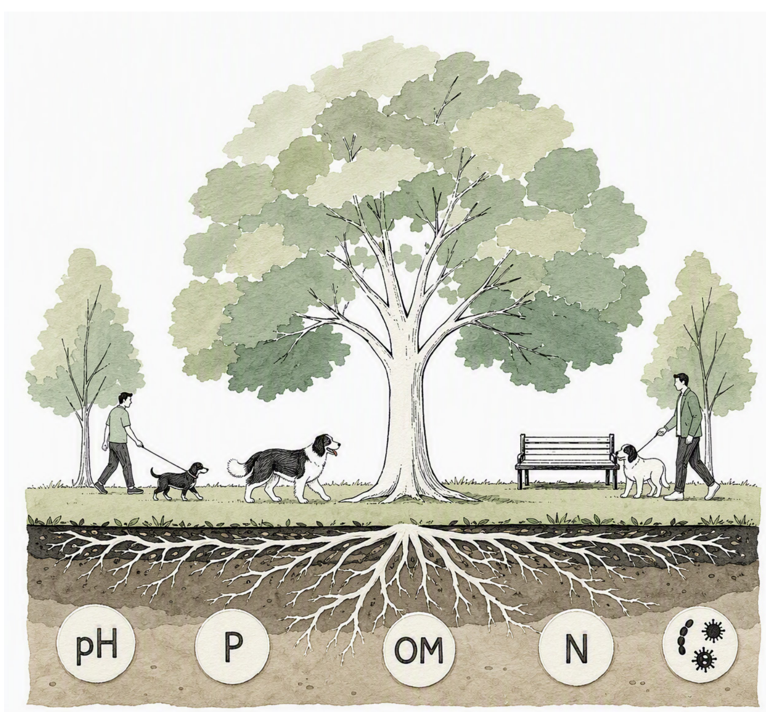
Introduction: Dogs and Urban Park Soils

Urban parks support a complex set of expectations that can be hard on the soil ecosystem. They must accommodate people, pets, programmed activities and citywide ecological goals, all within compact spaces where soils are under constant pressure and lack the time or intact systems needed to recover. Many Canadian cities are experiencing rising dog ownership and growing demand for dog-friendly spaces, placing increased pressure on park soils.

Although the effects of dog urine and feces are often considered surface level turf problems, the impacts extend much deeper. Soil health is fundamental to tree health, and a balanced soil ecosystem supports resilient green infrastructure that requires less maintenance and replacement over time. Although anyone can recognize dead spots in grass, dog inputs interact with soil chemistry, nutrient cycling and microbial processes in more complex ways that are still poorly understood in a Canadian context. This raises broader questions about the types of ecologies we are creating in urban parks and how their soils function under increasingly intensive use.

Supported by the Landscape Architecture Canada Foundation, our team conducted a study at Allan Gardens in Toronto to explore these relationships. Our initial goal was to develop a standard test to quantify the impacts of dogs on urban park soils and trees through a combination of laboratory chemical soil testing and field observations, building on conventional soil tests for nutrients such as nitrogen and phosphorus. As the project developed, our interest in how dog use might affect soil microbial communities led us to explore newer DNA-based microbial testing methods and their potential to complement traditional chemical soil testing. This expanded the study from asking whether dog impacts could be detected in soil chemistry to considering what different testing methods might tell us about how these soils are functioning.

The work is preliminary, but it led us to focus on nitrogen, a major component of dog urine and an essential plant nutrient that moves rapidly through the soil ecosystem. We became particularly interested in three questions: Does concentrated dog use produce detectable differences in soil nitrogen? How do those differences change over the growing season? And what can chemical and microbial tests each tell us about how these soils are functioning?



1 *GRAPHIC OF FACTORS CONTRIBUTING TO TREE HEALTH IN SOIL*

Existing Research

Our work builds on existing research that establishes dog activity can impact park soils through three interrelated mechanisms: physical impacts, like compaction and reduced infiltration; chemical loading, as urine and feces introduce nitrogen, and phosphorus and salts alter soil chemistry; and biological impacts such as microbial community shifts and the potential introduction of pathogens. Together, these processes can affect soil function and the capacity of urban soils to support vegetation.

We also drew on practical research undertaken by the City of Toronto and Toronto Metropolitan University within Allan Gardens and other city parks, as well as our own previous work in Allan Gardens for the Friends of Allan Gardens. This local work provides important context for baseline soil conditions and has helped us identify which questions about dog impacts remain underexplored.

Physical impacts

Previous work in the City of Toronto has already shown that intensive park use and dog areas need to be understood in relation to compaction and infiltration.

In 2015, City of Toronto Urban Forestry staff undertook a site-specific study to evaluate potential impacts of a dog off-leash area (OLA) on soils and trees at Baird Park. The Baird Park Off Leash Soil Study (Boven, 2015) compared bulk density, texture and nutrients inside and outside the OLA and assessed tree health over several years. Bulk density was above recommended ideal levels in parts of the park, but there was no statistically significant difference between measurements inside and outside the OLA. The study concluded that compaction was not attributable to the OLA alone and that further sampling would be needed to understand differences in soil nutrients.

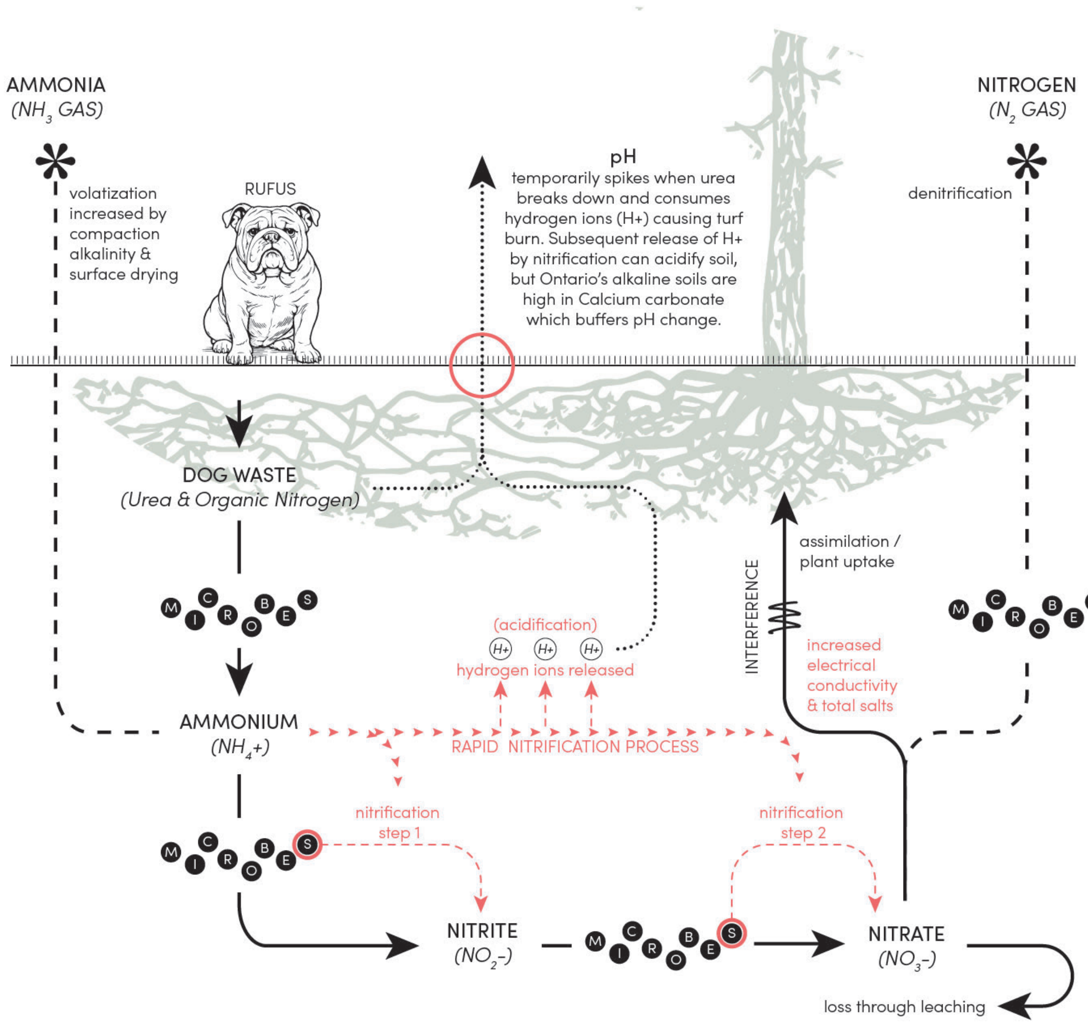
A 2009 master's thesis at what is now Toronto Metropolitan University focused specifically on Allan Gardens (Sabir, 2009). The study inventoried more than 300 trees and assessed soil conditions at 117 sampling locations, including within the newly created OLA. Soil analysis examined texture, compaction, bulk density and water permeability. Findings identified highly variable soil conditions across the park, with elevated compaction and bulk density and reduced infiltration in the dog park relative to broader site conditions. These physical constraints raised concerns about the rooting environment and water availability for park trees.

More broadly, urban soil research has long documented the effects of compaction and disturbance. Jim (1998) and Craul (1999) detailed how compaction reduces infiltration, root penetration, and gas exchange, creating difficult growing conditions for urban trees.

Chemical impacts

There is also existing peer-reviewed ecological research providing evidence of the chemical and biological impacts of dog urine. Allen, Setälä, and Kotze (2020) showed that soils adjacent to trees and posts along walking paths had significantly higher nitrate, ammonium, and total nitrogen concentrations, compared to soils further away. Stable isotope analysis provided further evidence that these nitrogen enrichments were associated with dog urine. The study concluded that dog urine likely represents a substantial portion of the urban nitrogen load, concentrated in localized hotspots. Particularly relevant to our study was the finding that nitrogen deposition was spatially concentrated around predictable marking locations rather than uniformly distributed across the parks studied.

There is also existing work estimating that dog inputs are substantial enough to be ecologically meaningful relative to other nutrient inputs. Using observations of dog activity combined with published estimates of nutrient excretion, De Frenne et al. (2022) estimated average inputs of approximately 11 kg N and 5 kg P per hectare per year across the peri-urban ecosystems they studied., which they liken to a type of patchy "fertilization".



2 *DOG WASTE AND THE NITROGEN CYCLE*

Understanding these inputs is complicated by the dynamic nature of nitrogen in soil. Although nitrogen is abundant in the atmosphere, most plants cannot use it until it has been converted into plant-available forms by soil microbes. In soil, nitrogen moves through a series of transformations, many of them driven by microorganisms. As organic matter decomposes, organic nitrogen can be converted into ammonium. Under warm, well-aerated conditions, microbes can then transform ammonium into nitrate through nitrification. Nitrate is readily available to plants but, because it moves easily with soil water, is also vulnerable to leaching or being lost to the atmosphere.

Dog urine introduces nitrogen primarily as urea, which is rapidly converted to ammonium and can subsequently be transformed into nitrate. Repeated urination can introduce concentrated pulses of nitrogen that move relatively quickly through the soil nitrogen cycle.

The difficulty of measuring this dynamic system was identified in the Baird Park study. Total nitrogen was slightly lower within the OLA than outside it, but Boven (2015) questioned the usefulness of total nitrogen as a stand-alone indicator and noted that biological processes as well as compaction, erosion and soil loss may have contributed to nitrogen loss, complicating interpretation. The study illustrates the broader methodological challenge that a single measurement of total nitrogen may reveal relatively little about the source, form or movement of nitrogen within an urban soil.

Biological impacts

The role of microorganisms in nitrogen cycling also raises the question of whether repeated urine inputs affect the biological community responsible for these and other soil processes.

Lee et al. (2019) examined the effects of canine urine on urban soil microbial communities in a controlled greenhouse experiment. Urine application significantly reduced total microbial biomass and microbial richness and increased water runoff. The authors suggest that these changes could affect nutrient cycling and soil water-holding capacity, demonstrating that the effects of urine may extend beyond visible vegetation damage to below-ground ecological processes.

Previous research pointed not only to gaps in understanding dog impacts, but also to limitations in how those impacts are measured. Nitrogen can be difficult to characterize through a single chemical measurement, while biological changes in soil may not be captured through conventional soil testing at all. At the same time, advances in DNA-based testing are making biological information increasingly available in other applied fields. These observations helped shape our interest in testing whether conventional soil chemistry and newer microbial sequencing methods could provide complementary information about urban park soils.

Fecal contamination and public-health issues

We also reviewed research on fecal contamination to investigate whether particular soil-borne organisms might function as an indicator of dog-related contamination, similar to the use of *E. coli* as an indicator of fecal contamination in water testing. Da Silva et al. (2021) investigated *Echinococcus multilocularis* in carnivore feces and soils and demonstrated that parasite eggs can persist in contaminated soil after the feces that carried them are no longer present. This illustrates both the potential for longer-term soil contamination and the difficulty of inferring soil conditions from visible fecal deposits alone. Research in Calgary examined the spatial distribution of uncollected dog feces in urban parks and found greater contamination in off-leash areas and near park entrances and parking areas (Mori et al., 2023).

As part of this investigation, we consulted with veterinarian Dr. Wendy Webster about how parasites and pathogens are detected in veterinary medicine. Dr. Webster explained that some parasite eggs are large enough to be identified directly in fecal samples and would likely also be detectable in soil, while DNA-based testing is increasingly used to identify pathogens and parasites that may otherwise be difficult to detect (personal communication, March 5, 2025). We found that similar developments are occurring in environmental monitoring. PCR-based methods are now used in recreational-water monitoring to rapidly detect fecal indicator organisms, while molecular testing for cyanobacteria can identify particular organisms and genes associated with toxin production.

We ultimately did not identify an established method for using soil parasites or pathogens as a proxy for the chemical or ecological soil changes we were interested in measuring, and did not pursue this line of testing at Allan Gardens. However, the discussion introduced the example of other applied professions already incorporating DNA-based biological testing alongside more conventional diagnostic methods. As DNA-based soil testing becomes increasingly accessible, a similar approach could eventually provide landscape architects with information about soil conditions that cannot be captured through conventional chemical testing alone.

Implications for our project

Taken together, this research establishes that dog use can affect soils physically, chemically and biologically, while also revealing important gaps in how these impacts are identified. Physical impacts such as compaction have been studied locally, including at Allan Gardens, while chemical and microbial responses have largely been examined under controlled research conditions.

The existing research also helped us reconsider some of the practical limitations identified in earlier local studies. The Baird Park Off Leash Soil Study (Boven, 2015), undertaken by City of Toronto Urban Forestry staff, questioned the usefulness of total nitrogen as a stand-alone indicator because nitrogen is continually transformed, taken up and lost from the soil. Subsequent peer-reviewed research does not eliminate this challenge, but demonstrates practical ways of obtaining a more informative picture. Allen et al. (2020), for example, measured nitrate and ammonium separately alongside total nitrogen, allowing different forms of soil nitrogen to be compared between areas of concentrated dog activity and background conditions.

Importantly for our project, this type of testing is not limited to academic research. In consultation with Jack Legg at SGS Agricultural Labs in Guelph, we found that a similar suite of conventional soil analyses could be adapted for practitioner-led investigations using commercially available testing. Our 2025 laboratory cost for pH, electrical conductivity, total Kjeldahl nitrogen, nitrate and ammonium was approximately $79 per sample, with opportunities to further reduce costs in the future by undertaking some measurements, such as electrical conductivity, in the field. Notably SGS had also undertaken the laboratory analysis for the earlier Baird Park study. The difference was less about access to specialized laboratory technology than about which nitrogen measurements were selected and how the sampling program was designed.

Our consultation with Legg also expanded the project beyond conventional soil chemistry. While discussing the difficulty of interpreting nitrogen measurements, he suggested that commercially available microbial testing could provide another perspective on the biological processes occurring in the soil. This connected directly with research such as Lee et al. (2019), which demonstrated changes in soil microbial communities following canine urine application, but introduced an approach we had not initially considered accessible to practitioners. Based on this recommendation, we decided to investigate DNA-based microbial analysis alongside conventional chemical testing.

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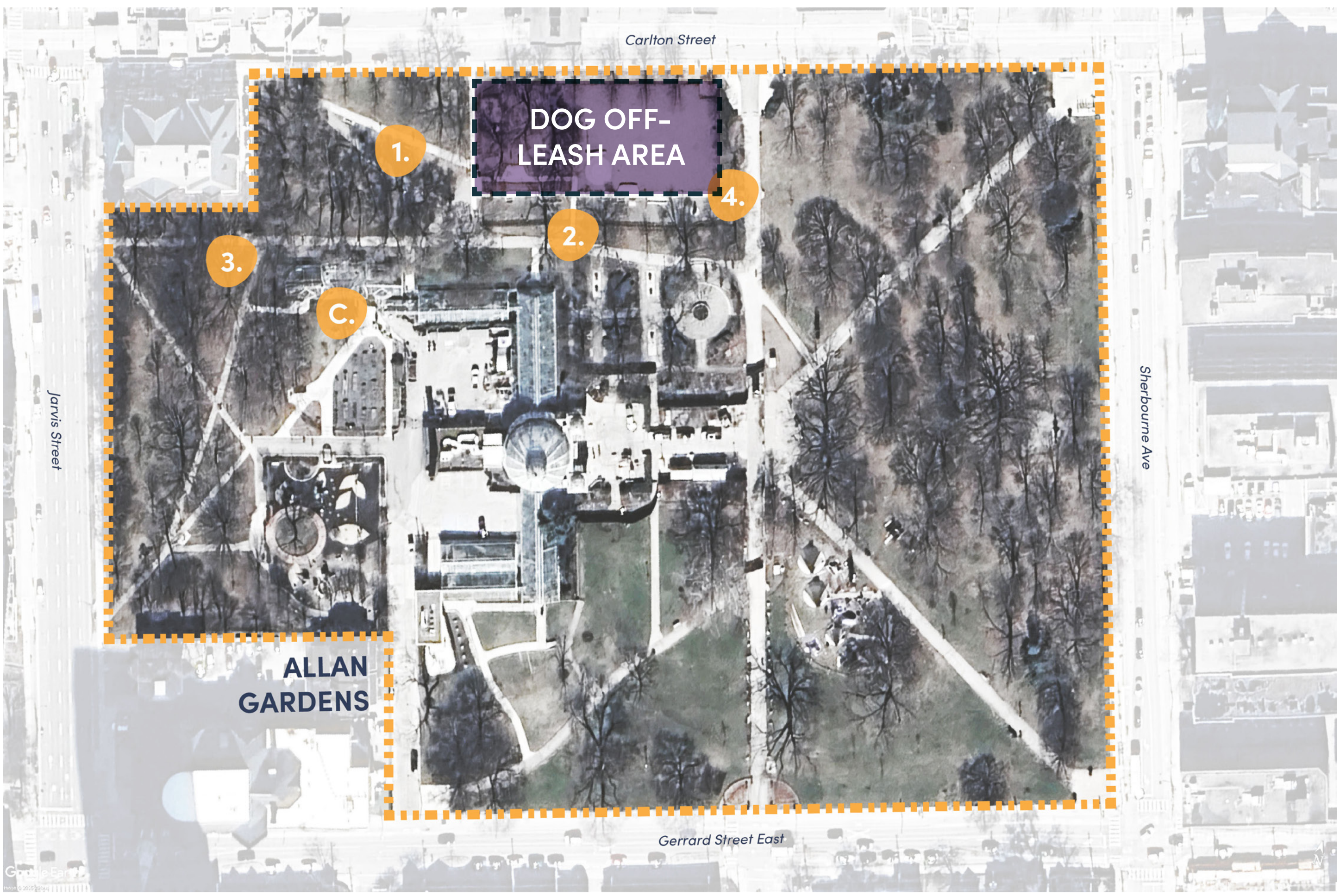
The Allan Gardens Study

Allan Gardens is one of Toronto's oldest and most heavily used parks, with mature trees, turf, gardens and a busy fenced off-leash area. Although Allan Gardens includes a busy fenced off-leash area, substantial dog activity also occurs throughout the broader park. This provided opportunities to investigate soils exposed to regular dog use, while a fenced children's garden where dogs are not permitted offered a nearby control.

Allan Gardens also offered an existing body of knowledge to build upon. Sabir's 2009 study had documented physical soil conditions throughout the park, while our previous work with the Friends of Allan Gardens provided familiarity with the site's trees, landscape conditions and patterns of use. Rather than repeating this earlier work on compaction and infiltration, we focused our investigation on the less understood chemical and biological dimensions of dog impacts.

Our initial grant proposal anticipated developing a relatively straightforward soil test for dog impacts. As the project developed, however, nitrogen emerged as a more complicated indicator than we initially anticipated. Because nitrogen can move rapidly between different chemical forms through microbially mediated processes, we became interested not only in how much nitrogen was present, but also in what the soil microbial community might reveal about how it was being processed.

As a result, we chose an exploratory approach that paired conventional chemical soil testing with DNA-based microbial sequencing. The intention was not only to compare dog-impacted and control soils, but also to evaluate what these different testing methods could contribute to understanding urban park soil function.



3 *STUDY AREA TESTING LOCATIONS*

Methods

Given the shortcomings of measuring total nitrogen (N) identified by Baird and the example of the more comprehensive approach used by Allen, our consultation with SGS led us to measure nitrate, ammonium and total Kjeldahl nitrogen (TKN) at two points in the growing season, alongside microbial sequencing.

We developed an exploratory testing approach that paired conventional chemical soil testing with DNA-based microbial sequencing. The intention was to compare soils in areas of concentrated dog use with a nearby control, while also evaluating what the different testing methods could tell us about urban park soil function.

We identified four sampling sites in high-use dog zones and a control site within the fenced children's garden, where dogs are not permitted. Sampling locations were selected based on field observations of dog activity and landscape features likely to concentrate repeated use. Soil samples were collected in June and August to examine how conditions changed over the growing season.

Site Observations and Sample Selection

Before selecting sampling locations, we reviewed previous pedestrian observations, existing soil research and historic disturbance patterns within Allan Gardens. On April 23, 2025, we also conducted a structured field observation of dog activity, rotating between areas of the park at 15-minute intervals between 10:45 a.m. and 1:25 p.m., with a short break between observation periods.

During approximately two hours of observation, we recorded 92 dogs within the areas being monitored. Dog activity varied across the park, with more dogs observed near the off-leash area and fewer in the less-shaded southern portion. However, we did not observe the clear relationship between paths, marking targets and dog activity described by Allen et al. (2020). Dogs moved throughout the park and were observed urinating both near and away from paths. Mature trees and other potential marking locations are also widely distributed throughout Allan Gardens, making it difficult to identify open park areas substantially removed from potential dog inputs.

As a result, we selected four sampling locations where regular dog activity had been observed, including locations where dogs were directly observed urinating, rather than attempting to establish a distance-based gradient from paths or marking targets. The fenced children's garden, where dogs are not permitted, provided a more clearly differentiated control condition.

Chemical Soil Testing

Working with Jack Legg at SGS Agricultural Labs in Guelph, we developed a testing program that measured nitrate nitrogen, ammonium nitrogen and total Kjeldahl nitrogen (TKN), along with pH and total salts. Samples from all five locations were tested twice during the summer of 2025. Measuring multiple forms of nitrogen provided a more detailed snapshot of soil conditions than total nitrogen alone and allowed us to compare both differences between sampling locations and changes over the growing season.

Microbial Testing

Legg also recommended microbial testing as a way to investigate the biological processes underlying the chemical measurements. Based on this recommendation, we worked with Dr. Michael Lynch at Metagenom Bio in Waterloo to use DNA-based testing to examine bacterial and fungal communities in a subset of the samples. One active location and the control were tested in both June and August, with samples collected concurrently with those used for chemical analysis.

Microbial testing was considerably more expensive than conventional soil chemistry and limited the number of samples we could analyze. DNA extraction, fungal ITS sequencing and bacterial 16S analysis cost approximately

$225 per sample before tax in 2025, compared with approximately $79 per sample for our chemical testing suite. We decided to treat the microbial component as an exploratory comparison rather than attempting to replicate it across all five sampling locations.

Rather than measuring soil chemistry directly, the DNA-based analysis identifies microbial groups present in a sample and their relative abundance. Comparing community composition and diversity allowed us to look for biological patterns that might accompany differences identified through conventional chemical testing.

Study Scope

This was an exploratory case study rather than an experiment designed to establish statistical causation. The cost of conventional soil chemistry allowed us to test all five locations at two points in the growing season, while the higher cost of microbial analysis limited that portion of the study to one active location and the control. Sampling locations were intentionally selected based on our field observations of locations with substantial dog activity rather than randomly distributed across the park. The results are best understood as observed patterns that can help evaluate testing methods and identify questions for further research. We did not establish a quantitative gradient of dog use across the park, so the samples are comparisons between selected dog-exposed locations and a dog-excluded control, rather than as a measure of the relationship between the intensity of dog use and soil conditions.

4 *TEST SITE 1*

5 *TEST SITE 2*

6 *TEST SITE 3*

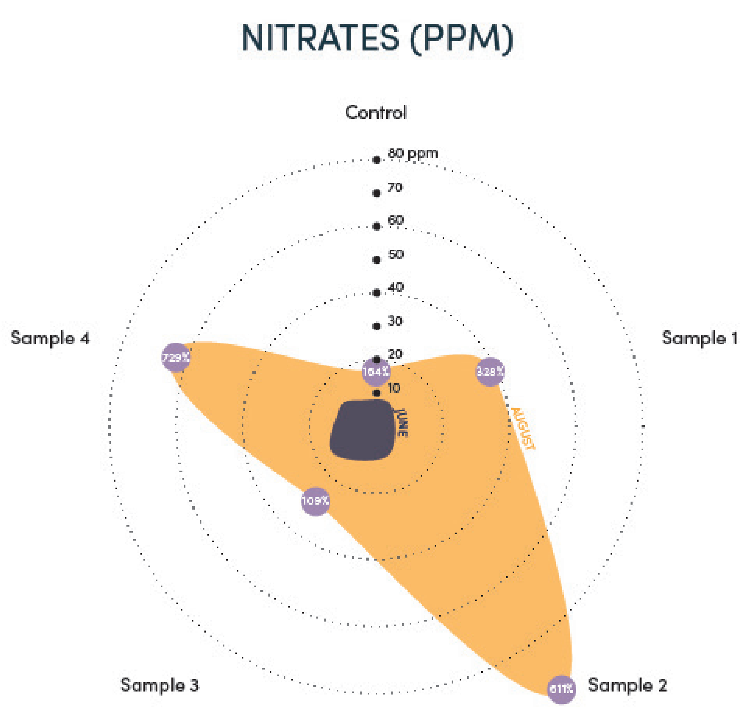
7 *TEST SITE 4*

8 *CONTROL SITE*

Key Results

Summary

- **Nitrate Hotspots:** Nitrate was higher at all four dog-exposed locations than in the fenced control during both sampling rounds and increased substantially over the growing season. One location near the dog park entrance increased by approximately 610%, compared with 62% in the control. Chronic nitrogen loading creates localized chemical imbalances that can affect root health and turf resilience.
- **Rapid Ammonium Conversion:** Ammonium remained comparatively low and changed little between June and August. Together with rising nitrate concentrations, this is consistent with fast microbial nitrification under summer conditions.
- **Salinity Shifts:** Total salts increased slightly in high-use areas compared to the control area which stayed the same. This is likely the result of urea breaking down into soluble ions in the soil which forms salts. This adds stress for fine roots, particularly in compacted soils.
- **Stable pH:** Despite heavy nitrogen inputs, pH remained stable, likely due to strong buffering from local geology and urban fill, highlighting the need for indicators beyond pH.
- **Microbial Shifts:** DNA sequencing revealed subtle declines in bacterial diversity and increased abundance of nitrogen-processing specialists in dog zones. These changes suggest emerging niche heterogeneity and possible long-term effects on soil resilience. The limited number of samples, however, prevents these patterns from being attributed specifically to dog activity.

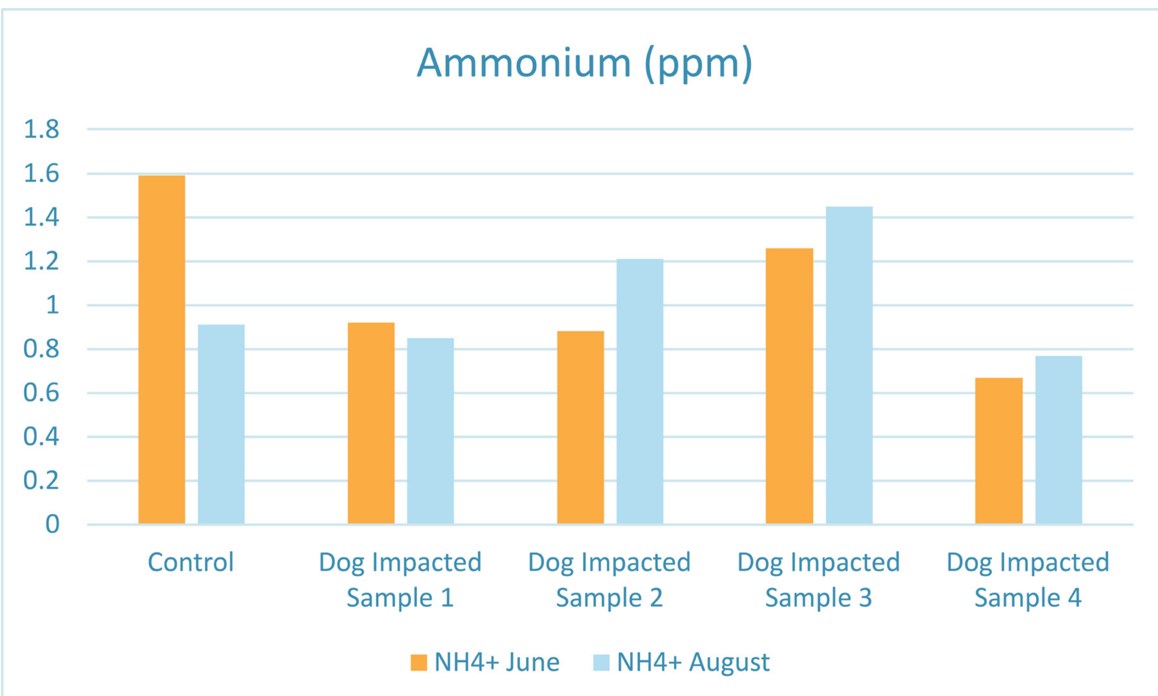


9 *GRAPHIC VISUALIZATION OF NITRATE HOTSPOTS*

Nitrogen Hotspots and Soil Chemistry

Nitrate nitrogen provided the clearest distinction between the dog-exposed locations and the fenced control. Concentrations were higher at all four active locations during both sampling rounds and increased substantially between June and August. In particular, the sample location near the main dog park entrance increased by 610% between sampling intervals. This aligns with other studies which have found high levels of soil nitrogen near dog activity zones (Allen et al., 2020).

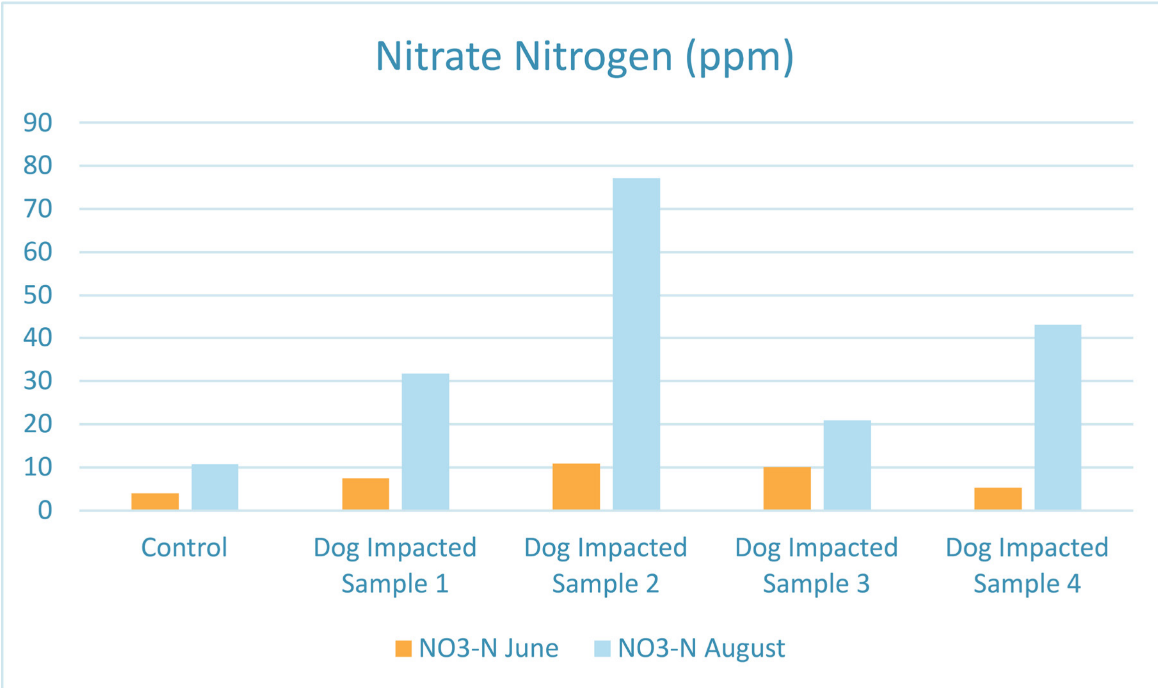
By comparison, ammonium levels were relatively stable across all sites, changing by less than 1 ppm between June and August. This suggests that nitrification, the microbial conversion of ammonium to nitrate, was rapid and that dog-related nitrogen inputs were accumulating later in the cycle rather than in ammonium form. Under warm summer conditions, ammonium commonly converts quickly to nitrate. The control sample, however, began with higher ammonium levels in June and declined by August, likely reflecting uptake of nitrogen from soil organic matter or leaf litter over the season. In the dog-impacted samples, ammonium increased slightly over the same period, suggesting continued inputs from the breakdown of dog waste through the growing season.



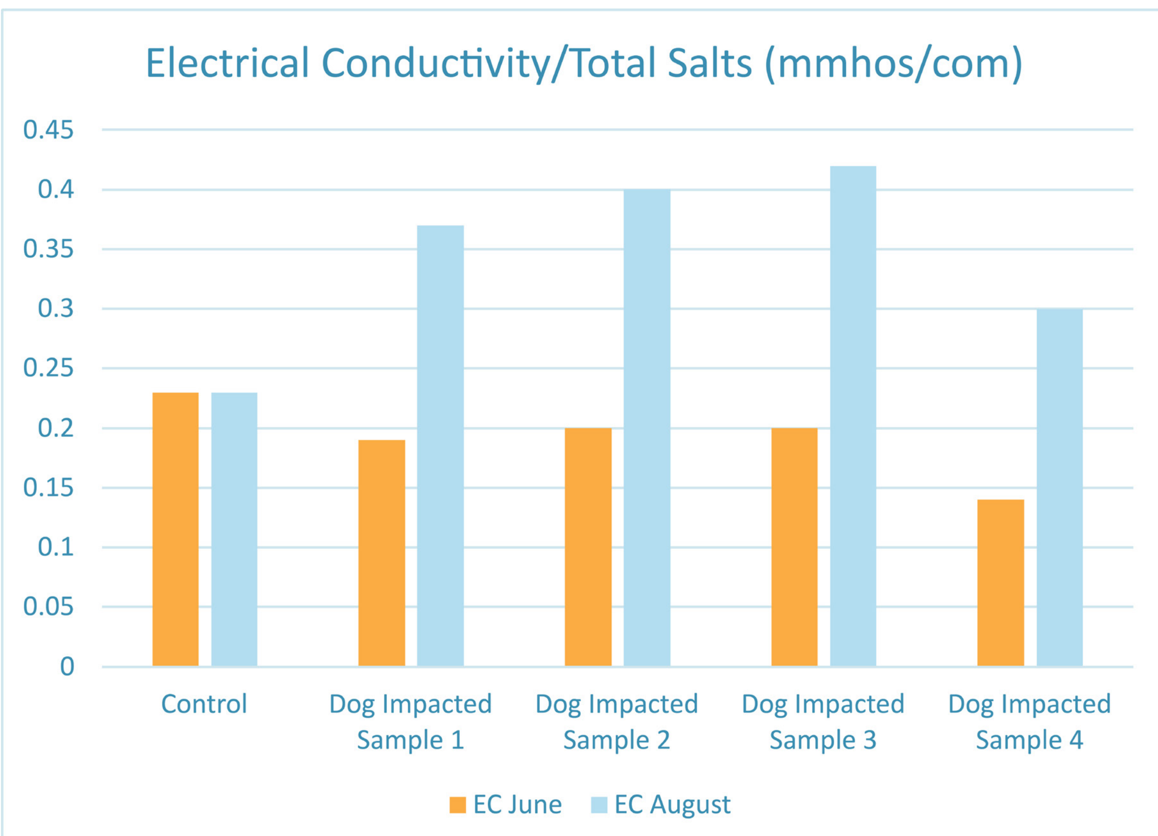
10 *AMMONIUM TESTING RESULTS*

The contrast between relatively stable ammonium and rapidly changing nitrate illustrates why measuring multiple forms of nitrogen provided a more informative picture than total nitrogen alone

As expected, total salts increased in dog-impacted areas. This reflects the overall concentration of dissolved ions in the soil, like K^+, Na^+, Ca^{2+}, Mg^{2+}, Cl^-, as well as nitrogen compounds. Although increases were moderate, elevated salts can contribute to stress in fine roots and limit nutrient uptake, particularly in compacted soils.

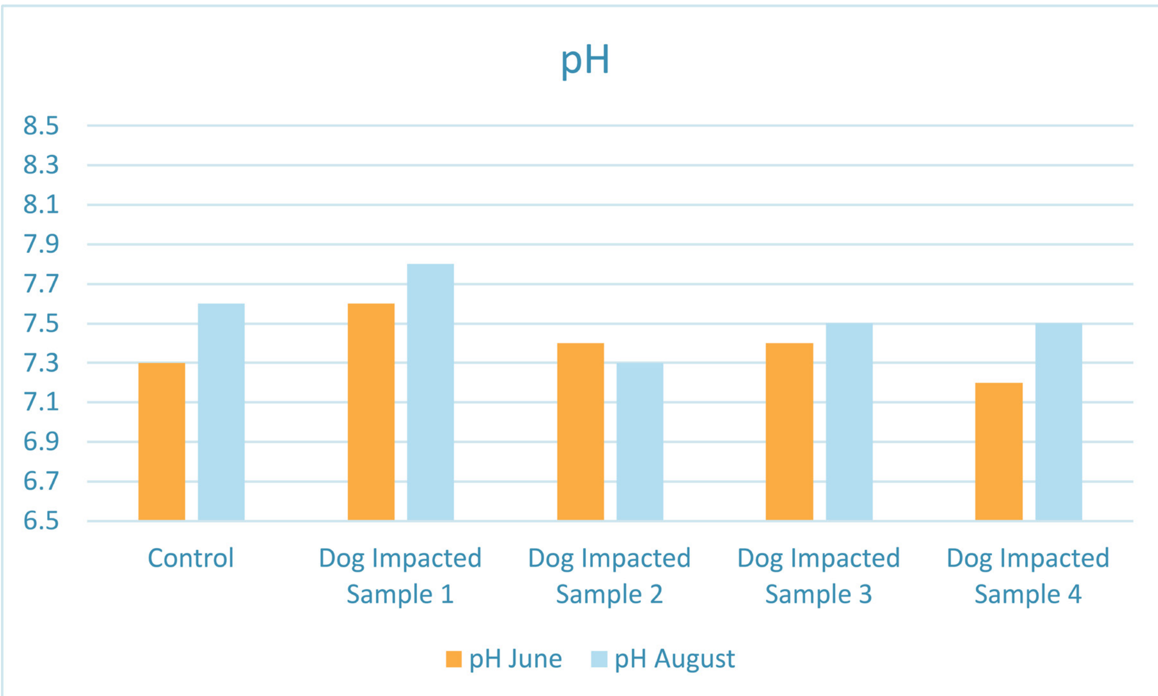


11 *NITRATE NITROGEN TESTING RESULTS*



12 *ELECTRICAL CONDUCTIVITY/TOTAL SALTS TESTING RESULTS*

We found no significant change in pH, despite reports from other regions that dog urine can cause soil acidification. This is likely due to the slightly alkaline conditions of the Allan Gardens soils, which are characteristic of Southern Ontario. Most soils in the area have strong buffering capacity due to calcium carbonate derived from the limestone bedrock, which helps neutralize pH changes. This effect can be further enhanced in areas with urban fill containing concrete aggregate. As a result, pH alone may not be a reliable indicator of dog-related soil stress in this context.



13 *pH TESTING RESULTS*

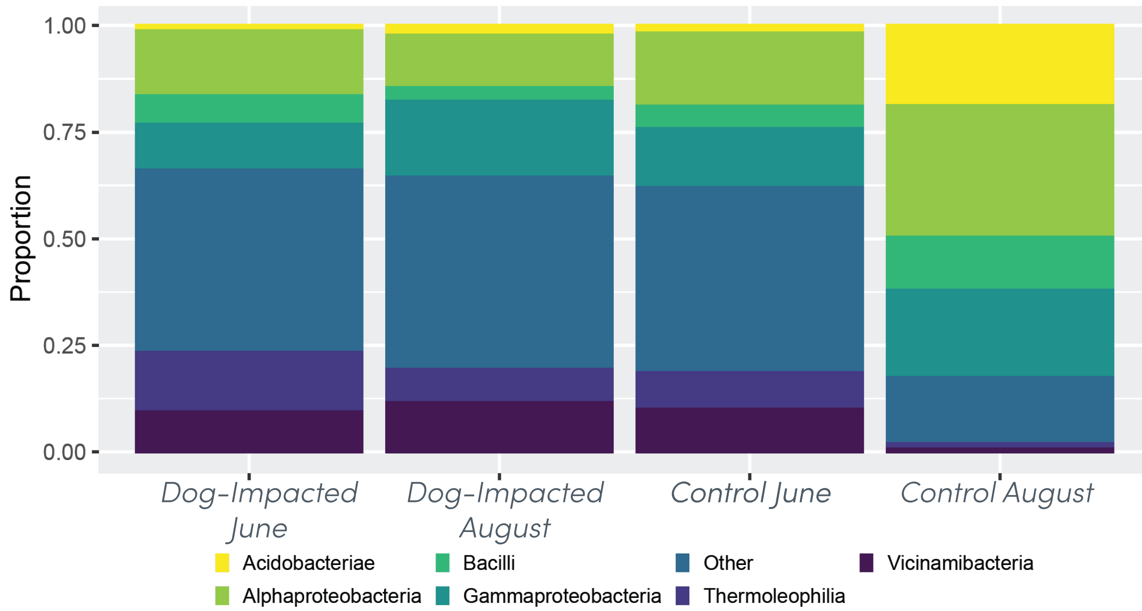
Soil Biology: Niche Heterogeneity and Emerging Specialists

The microbial analysis offered early insight into how soil biology responds to chronic dog activity. Dog impacted soils showed slightly lower bacterial diversity in late summer and subtle shifts in the abundance of groups involved in nitrogen transformations.

These differences may reflect growing niche heterogeneity (the variation in ecological roles and species interactions within an ecosystem). Urban park soils already contain many distinct microhabitats shaped by compaction, root density, moisture, and park activities and management. Dog waste creates additional patches of high nitrogen availability. Within these patches, microbial communities may shift toward bacteria that specialize in urea breakdown or rapid nitrification.

Future research could identify which microbial functional groups are responding most strongly and whether they influence root health or nutrient availability.

The technique also sequenced all the bacteria in the soil samples, and identified that there is relatively low diversity of bacterial species present in both the dog-impacted and control sites (~1000), which suggests a microbial community more similar to one from a managed agricultural field than a more complex forest soil system, which might have 2000-4000 bacterial species.



14 BACTERIAL COMMUNITY COMPOSITION AT THE DOG-EXPOSED AND FENCED CONTROL SITES, JUNE AND AUGUST 2025. DNA SEQUENCING IDENTIFIED DIFFERENCES IN THE RELATIVE ABUNDANCE OF MAJOR BACTERIAL GROUPS BETWEEN LOCATIONS AND SAMPLING DATES. DATA: METAGENOM BIO LIFE SCIENCES.

Fungi

Sequencing identified changes in fungal community composition between samples, but we did not observe a consistent difference in richness or diversity between the dog-exposed and control sites or a clear seasonal response. Based on consultation with Michael Lynch at Metagenom Bio, the fungal communities were broadly characteristic of highly disturbed, high-traffic soils rather than the richer fungal relationships that might be expected in less disturbed ecosystems. Fungal communities also tend to respond more slowly to environmental change than bacterial communities, making them potentially less sensitive to the short-term changes we were investigating over a single growing season.

For the purposes of this study, bacterial communities emerged as the more promising focus for further investigation. Fungal analysis may be more informative in landscapes where fungal relationships are themselves an important component of ecosystem function, such as forested park soils, or in longer-term studies examining ecological recovery and soil development.

From Community Sequencing to Potential Indicators

Although the small sample set limits the conclusions that can be drawn from individual organisms, the microbial analysis demonstrated the amount of biological information that can be generated from a soil sample. Amplicon sequencing identified more than 1,100 bacterial and fungal sequence variants across the four samples and allowed differences in community composition, richness and diversity to be compared between locations and over time.

A larger study with replicated active and control locations could begin to determine whether particular organisms or combinations of organisms consistently correspond with nitrogen enrichment, dog exposure or relatively stable soil conditions. This could include formal indicator-species analysis and analysis of relationships between microbial composition and measured environmental variables. The immediate next step might not be to identify a particular bacteria species as an indicator, but to determine whether the patterns observed in this pilot study can be replicated.

If reliable biological indicators were eventually identified, a longer-term possibility would be to move from broad community sequencing toward more targeted molecular testing. Rather than sequencing the entire bacterial community each time, a PCR or qPCR assay could potentially test for specific organisms or genetic markers associated with particular soil conditions. Such a tool would require substantial validation by experts, but could ultimately be simpler and less expensive to deploy than the broad sequencing used in this study.

Field Observations: Compaction and Ammonia Odors

Beyond laboratory results, field observations revealed conditions that help explain some of the soil chemistry. High use areas displayed compacted soil, surface crusting and degraded or absent turf, which is consistent with previous soil studies done within the park (Sabir, 2009). Compaction limits infiltration and reduces pore space, which affects nitrogen cycling by altering oxygen availability.

We also noted an ammonia-like smell at several sampling locations. While this observation cannot confirm ammonia volatilization, it raised an additional question about whether some nitrogen may be lost to the atmosphere under warm, alkaline surface conditions. Volatilization converts ammonium to ammonia gas that is lost to the atmosphere. It is more likely in compacted or alkaline soils that are drying at the surface. The combination of localized nitrogen loading and compacted soil structure can lead to nitrogen loss before plants or microbes can use it, and may contribute to turf decline near tree bases or along dog routes. These conditions point to a mismatch between patterns of use and the soil processes needed to support healthy park vegetation long-term.

These interactions between physical soil structure and nitrogen dynamics are important. Future studies incorporating compaction measurements, infiltration testing and direct measurements of ammonia volatilization could help clarify how physical soil conditions interact with nitrogen cycling in intensively used park areas.

Impact of Funding

Funding from the Landscape Architecture Canada Foundation allowed us to approach this project as an investigation rather than a conventional consulting assignment. It supported field observations, repeated laboratory testing and, importantly, consultation with laboratory specialists who helped shape the research as it developed.

Our initial proposal anticipated developing a relatively straightforward chemical soil test for dog impacts. Conversations with Jack Legg at SGS Agricultural Labs helped us refine this approach by testing multiple forms of nitrogen rather than relying on total nitrogen alone. These discussions also introduced us to commercially available DNA-based microbial testing, an approach we had not initially considered accessible to landscape architecture practitioners. Funding allowed us to add this exploratory component and work with Michael Lynch at Metagenom Bio to better understand both its potential and its current limitations.

The project demonstrated that meaningful practitioner-led soil research does not necessarily require specialized academic facilities. Conventional testing for nitrate, ammonium and other soil characteristics was relatively inexpensive and readily available through a commercial laboratory. Broader microbial sequencing was considerably more costly and limited the number of samples we could analyze, but provided a first opportunity for us to explore biological information that conventional soil chemistry cannot capture.

Perhaps most importantly, the funding allowed the original research question to evolve. Rather than producing a single standard test for dog impacts, the project identified which measurements appear most promising, where current testing methods have limitations, and what would be required to develop a more robust approach. The work has provided a foundation for further research into practical indicators of urban soil function, including the potential for more targeted and affordable microbial testing in the future.

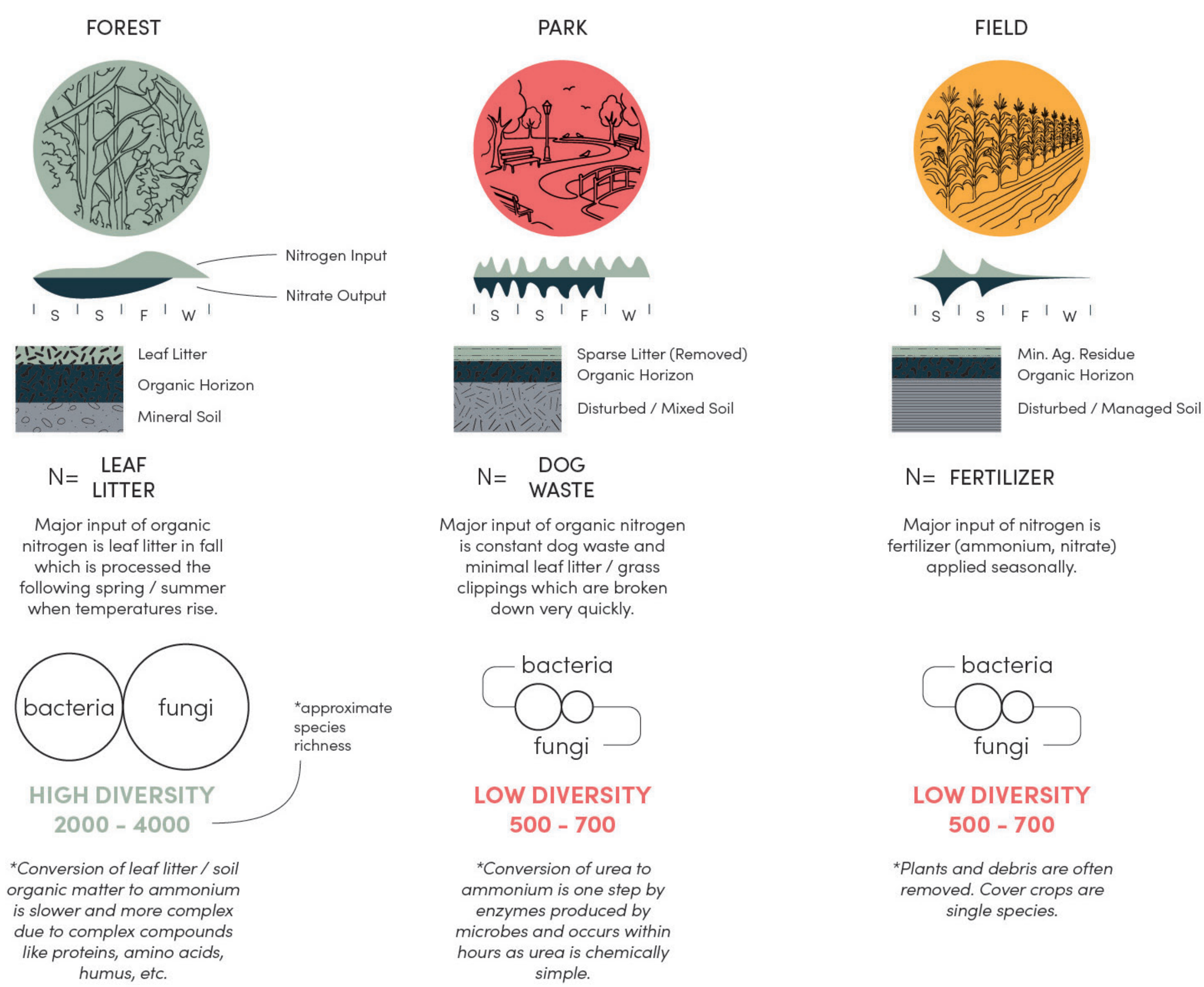
The research has also supported knowledge-sharing within the profession, including publication of the findings in Ground magazine, and has provided a basis for continued discussion with laboratories, researchers and other potential collaborators.

15 SAMPLING

Implications for Landscape Architecture

Urban park soils are something we create, both intentionally and unintentionally as landscape practitioners. They do not function exactly like forest soils or agricultural soils. They are their own thing – landscapes of long-lived trees and perennial vegetation dependent on complex soil processes, while the landscape is also subject to regular disturbance, biomass removal and concentrated external inputs. Dog waste adds another recurring nutrient source that is spatially uneven and biologically active. An undercurrent of this work is the question of what kind of soil ecology we are creating in heavily used urban parks.

The comparison below is intended as a conceptual model rather than a strict ecological classification. Forest soils typically receive substantial organic inputs through litter and support complex relationships among roots, fungi and bacteria. Agricultural soils receive managed nutrient inputs and are routinely disturbed. Intensively used park soils share characteristics of both, but operate under their own combination of disturbance, vegetation, maintenance and nutrient inputs. Landscape architecture frequently looks to natural ecosystems for models of how designed landscapes might support greater biodiversity and ecosystem services. Developing accessible ways to evaluate how constructed soil systems actually function can help us test these assumptions rather than relying on the model alone. Agricultural and sports-turf management routinely use soil testing and active management because soil conditions are directly connected to crop or surface performance. Comparable monitoring is less common in urban parks, where problems may not become apparent until vegetation decline or surface failure is already visible.



16 *NITROGEN CYCLING AND REFERENCE ECOLOGIES – IS A PARK MORE LIKE A FIELD OR A FOREST?*

Toronto has already developed a substantial body of practice-based knowledge about the pressures dogs place on urban park landscapes. Sabir's 2009 study at Allan Gardens documented compaction and reduced infiltration in the off-leash area, while the City's 2015 Baird Park study investigated soil structure, nutrients, tree condition and maintenance within and outside an OLA. More recently, Toronto's Dogs Off-Leash Strategy has translated accumulated experience and broader consultation into citywide guidance for locating, designing, maintaining and upgrading OLAs, with particular attention to surfacing, drainage, existing trees and vegetation, and ongoing maintenance.

Our study suggests that soil chemistry and biology provide an additional layer to this existing understanding. At Allan Gardens, nitrate distinguished dog-exposed soils from the fenced control much more clearly than pH or total nitrogen alone, while concentrations changed substantially between June and August. Field observations also showed that dog activity was not confined to the designated OLA. Dogs moved and urinated throughout the broader park, making it difficult to identify genuinely low-exposure areas except where dogs were physically excluded.

For landscape architects and park managers, this suggests that dog-related soil pressures should be considered as part of the broader soil system rather than solely as a question of worn turf within designated OLAs. Trees, circulation routes, entrances, shade and other landscape features can influence where dogs spend time, while compaction, drainage and soil chemistry influence how those inputs are processed. In intensively used parks, these conditions overlap

Relatively inexpensive soil testing could provide a practical way to better understand these conditions. Our study found that commercially available testing for nitrate, ammonium, total Kjeldahl nitrogen, pH and electrical conductivity can be incorporated into a practitioner-led assessment without specialized research facilities. Used alongside established measures such as compaction and infiltration, repeated testing could help identify whether nutrient accumulation is occurring, where it is concentrated and whether conditions are changing over time.

For practitioners, however, identifying a chemical difference is only part of the question. Ultimately, we need to understand whether these soil conditions correspond with observable changes in vegetation health and performance. Our short-term study was not designed to establish this relationship. A useful next step would be to pair repeated soil measurements with indicators such as turf cover and recovery, tree growth and foliar condition, allowing chemical and physical soil conditions to be evaluated against the vegetation they are intended to support.

This information could then support more site-specific decisions about soil rehabilitation, mulching, tree protection, surfacing, drainage, circulation and maintenance. Rather than assuming that one construction detail or management regime is appropriate for every park or OLA, soil monitoring offers a way to evaluate how individual parks are actually functioning and whether interventions are working.

Next Steps

Expanding Soil Monitoring

An immediate next step could be to test the chemical approach developed through this project across a larger and more representative sample of Toronto parks. A monitoring program could compare dog impacted soils across parks and OLAs of different sizes, ages, surfacing types and intensities of use, using repeated measurements of nitrate, ammonium and other soil indicators alongside compaction and infiltration testing. It would be important to pair these measurements with simple observations of vegetation performance, decline or recovery to begin to address the question of whether the chemical differences associated with dog-exposed soils translate into meaningful effects on the health or performance of park vegetation. Existing City studies at Allan Gardens and Baird Park provide valuable baseline information that could be built upon rather than starting again.

Repeated testing would also allow the City to evaluate management and design interventions already contemplated through the Dogs Off-Leash Strategy. Comparing soil conditions before and after changes to surfacing, drainage, tree protection, circulation or maintenance could begin to establish which approaches are most effective under Toronto conditions.

Research Opportunity: Biological Indicators

A second, more ambitious research direction would investigate whether microbial communities can provide reliable biological indicators of soil condition. Our pilot sequencing identified substantial differences in bacterial community composition between samples and over the growing season, but the limited sample size does not allow us to determine which differences are consistently associated with dog activity, nitrogen enrichment or other environmental conditions.

Addressing this question would require a substantially larger, replicated sampling program and expertise in experimental design, microbial ecology and statistical analysis. For this reason, we see this work as best suited to a partnership between practitioners, a municipality or park organization, and an academic research team rather than as another small independent study.

With sufficient replication, a future study could identify bacterial taxa or functional groups that consistently correspond with nutrient-enriched, disturbed or comparatively stable soils. If reliable indicators emerged, there may eventually be an opportunity to move from broad and relatively expensive community sequencing toward targeted PCR or qPCR tests for particular biological markers. The longer-term goal would be a practical biological soil-health tool that could complement conventional chemical and physical soil assessment.

Allan Gardens would remain a particularly useful site for this work. Previous research has documented its trees and physical soil conditions, this study adds chemical and preliminary microbial data, and the park continues to experience substantial and changing patterns of use. Continued monitoring could begin to create a long-term record connecting park use, soil structure, chemistry, biology and management within the same landscape.

Learning from Other Managed Landscapes

High-use park soils are generally managed less intensively than agricultural soils or sports fields, even though they can experience similarly concentrated pressures from compaction, nutrient inputs and vegetation wear. These fields have developed management practices such as aeration, topdressing, soil amendment, drainage management, nutrient monitoring and scheduled recovery periods to maintain productive soils under repeated disturbance. While these approaches cannot be transferred directly to public parks, there may be opportunities to adapt selected practices to heavily used dog areas.

Future work could examine which techniques are appropriate for urban parks, particularly where mature trees, public access and ecological objectives require different outcomes than either crop production or sports turf. Soil monitoring could then provide a way to evaluate whether these interventions actually improve soil conditions and vegetation performance.

Conclusion

Urban parks are living systems under unusually concentrated pressure. Dog use is only one part of that pressure, but our study suggests that its effects extend below visible turf wear into the chemical and biological processes that support park vegetation. At Allan Gardens, relatively accessible soil testing revealed patterns that would not have been apparent from pH, total nitrogen or visual assessment alone, while exploratory microbial sequencing opened new questions about how biological indicators might eventually contribute to soil assessment.

The broader question raised by this work is not how much dog use an urban park can accommodate, but what kind of soil ecology that use, as well as design and maintenance, is producing over time. Parks are neither forests nor agricultural fields, and they should not necessarily be expected to function like either. Understanding their particular ecological condition may help landscape architects and park managers make more informed decisions about how these landscapes are designed, maintained and renewed.

This work builds on more than fifteen years of soil investigation and evolving off-leash-area practice in Toronto. The next opportunity is not simply to conduct more testing, but to connect soil conditions with design, management and vegetation performance, and understand how different park conditions perform over time, determine whether measurable soil differences translate into effects on trees and turf, evaluate whether interventions improve those conditions, and develop practical tools that allow landscape architects and park managers to respond accordingly.

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