Comparative Soil Analysis for Ecological Restoration: A Case Study at Kanaka Creek Regional Park

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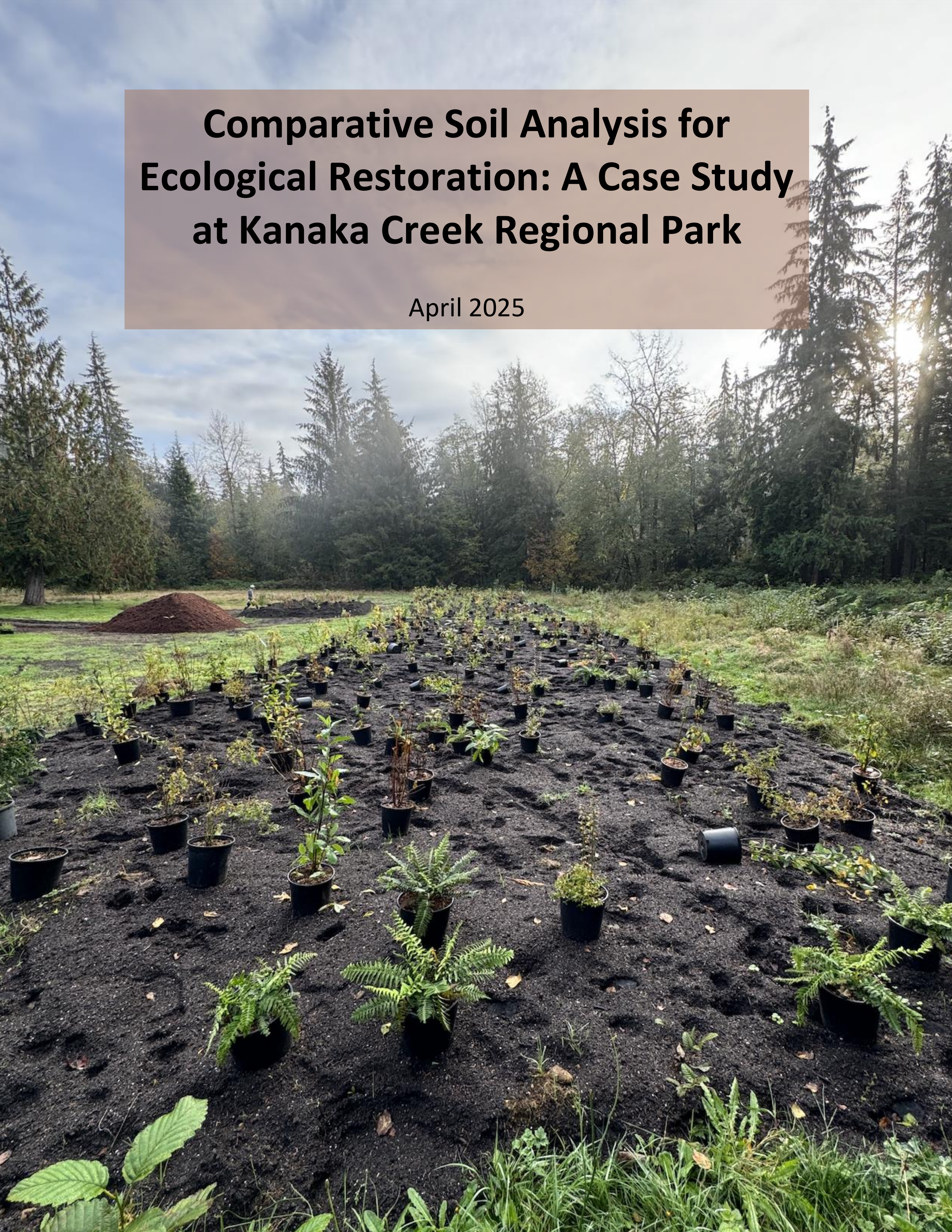

Comparative Soil Analysis for Ecological Restoration: A Case Study at Kanaka Creek Regional Park

A project focused on tracking native plant health and invasive species presence at a restoration site along Dewdney Trunk Road in Kanaka Creek Regional Park, Maple Ridge, British Columbia.

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Abstract
This study analyzes the performance of Metro Vancouver's Nutrifor landscaping soil compared with standard all-purpose garden soil in supporting native plant establishment and early restoration at Kanaka Creek Regional Park, Maple Ridge, British Columbia. In September 2024, 415 native plants representing 22 tree, shrub, and fern species were planted in two mirrored plots, one with Nutrifor landscaping soil and the other with an all-purpose garden soil. Seasonal monitoring in May, July, and October 2025 measured plant survival, growth (height and width), health scores, and invasive species presence, alongside soil nutrient and pH analyses.

Species-specific responses were observed. Nutrient-demanding, moisture-tolerant shrubs, including Red elderberry, Black twinberry and Salmonberry exhibited improved growth and health in Nutrifor, whereas acid-tolerant and upland species, such as Western red cedar, Sitka spruce, and Bigleaf maple, performed better in all-purpose soil. Overall survival exceeded 94% in both treatments, with modest advantages in Nutrifor for select species. However, Nutrifor plots also experienced higher invasive species pressure, and wildlife impacts such as deer browsing affected both soil treatments.

These findings emphasize the ecological trade-offs of biosolid use, highlighting the importance of species-soil matching, early invasive management, and adaptive monitoring for restoration success. Nutrifor landscaping soil supports fast-growing, nutrient-responsive plants and contributes to sustainable nutrient recycling under British Columbia's Organic Matter Recycling Regulation. Long-term monitoring is recommended to evaluate canopy development, nutrient cycling, and habitat provision for wildlife to fully assess ecosystem recovery.

Acknowledgments

This project was made possible through the support and collaboration of several individuals and teams.

I would like to extend my sincere gratitude to **Janice Jarvis**, Natural Resource Management Specialist, and **Roy Teo**, Natural Resource Management Technician with Metro Vancouver Regional Parks, for their guidance, expertise, and ongoing support throughout the planning and implementation of this project.

I am also grateful to the Kanaka Creek Operations team—**Jason Leroux**, **Ben Wharton**, and **Al Sutton**—for their efforts in site preparation and continued maintenance. Special appreciation is given to Park Patroller **Izaiah Vadasz** for his assistance in field monitoring and data collection.

Finally, I would like to thank Metro Vancouver's Utility Residuals Management Program for providing valuable information and assistance related to Nutrifor product usage.

Table of Contents

List of Figures and Tables

Introduction

1.1 Introduction to Nutrifor (Biosolids)

The use of biosolids in ecological restoration is becoming more common, as these nutrient-rich materials improve soil structure and provide essential elements for plant growth (Ministry of Environment and Climate Change Strategy, 2024). Biosolids are the organic material that is recovered from advanced wastewater treatment process. In British Columbia, biosolids production and land application are regulated under the *Organic Matter Recycling Regulation* (OMRR), which ensures biosolids meet strict quality and safety standards for beneficial use in land reclamation and composting (Ministry of Environment and Climate Change Strategy, 2024). These regulations ensure biosolids and biosolid products are used responsibly and in a manner that aligns with environmental protection goals. Under the OMRP, biosolids can be incorporated into a biosolids growing medium (BGM), which is produced by combining biosolids with carbon and mineral materials, including wood chips and sand.

Metro Vancouver's biosolids, marketed under the brand name Nutrifor, are produced under rigorous quality control procedures to ensure safety and consistency (Metro Vancouver, n.d.). During processing, the material undergoes high-temperature treatment and microbial decomposition to eliminate pathogens and reduce odours, resulting in a rich, earth-like product (Metro Vancouver, n.d.). In addition to these processing advantages, research on biosolids use in restoration shows that biosolids and biosolid blends can improve degraded soil conditions by increasing nutrient availability, enhancing soil ecosystem functions, and establishing dense, diverse vegetation cover (Basta, et al., 2016). Nutrifor provides essential nutrients, including nitrogen, phosphorus, and key micronutrients, along with organic matter that improves soil structure and supports healthy plant growth (Metro Vancouver, n.d.). These properties help enhance moisture retention, reduce erosion, and lower the need for synthetic fertilizers (Metro Vancouver, n.d.). By returning nutrients to the soil and supporting long-term soil health, Nutrifor landscaping soil provides a sustainable alternative to conventional fertilizers.

Soil quality is a key determinant of restoration success, influencing plant establishment, nutrient cycling, and overall ecosystem recovery (De Deyn & Kooistra, 2021). In Metro Vancouver, Nutrifor biosolids are primarily used in rangeland and reclamation projects, whereas Nutrifor landscaping soil is applied in urban and regional park settings**.** Both materials have been used successfully in a range of restoration projects (Bright & Healey, 2003; Whitehouse et al., 2022). However, additional performance data across varied site conditions would support informed decision-making in future restoration efforts.

This study was initiated to assess the ecological suitability of Metro Vancouver's Nutrifor landscaping soil in a local restoration context, providing evidence to guide use in native plant habitat restoration projects. Specifically, it evaluates plant growth and health in biosolids growing medium to determine potential benefits and risks. Previous studies on municipal biosolids growing medium have shown improvements in nutrient availability and support for native plant growth but also highlight potential risks such as contaminant introduction or increased susceptibility to invasive species (Waterhouse et al., 2014). Monitoring plant performance in this trial provides practical insight into soil management and informs decisions for future restoration initiatives.

1.2 Park Location and Site Description

Kanaka Creek Regional Park (Figure 1) is a 400-hectare protected area in Maple Ridge, located on the unceded traditional territories of the Katzie, Kwantlen, Matsqui, Musqueam, Semiahmoo, and Tsleil-Waututh First Nations. Managed by Metro Vancouver Regional Parks, Kanaka Creek Regional Park stretches 12 km along the creek and encompasses two biogeoclimatic subzones, the Coastal Western Hemlock Very Dry Maritime (CWHdm) and, in the western section, the Coastal Western Hemlock Xeric Maritime 1 (CWHxm1). These zones reflect the mild climate, high precipitation, and productive mixed-forest ecosystems characteristic of the lower Fraser Valley (City of Maple Ridge, 2025; Meidinger & Pojar, 1991). Geological diversity along the creek has resulted in fourteen distinct soil classes, transitioning from the headwaters to the junction, where the creek flows into the Fraser River (Metro Vancouver, 2004). The lower reaches are dominated by clay-rich floodplain deposits with poor drainage and high-water tables, leading to rapid surface runoff and increased erosion during storm events (Kanaka Education & Environmental Partnership Society, 2025). Upstream, steep slopes with thin soils over conglomerate and sandstone create unstable banks and hydrologic sensitivity, while gravel-based channels provide critical salmonid spawning habitat, highlighting the importance of protecting soil and watershed health (Metro Vancouver, 2004; Kanaka Education & Environmental Partnership Society, 2025).

The restoration area is located in the eastern part of Kanaka Creek Regional Park, south of Dewdney Trunk Road, where the landscape transitions into a typical Douglas-fir coastal forest. This section was selected for the study as it required restoration and could be feasibly rehabilitated and monitored over a one-year period, building on ongoing restoration efforts and providing a suitable setting to evaluate the effects of using a biosolids based soil product on native plant growth. Here, moist and nutrient-rich clay soils are highly susceptible to compaction and seasonal flooding, directly influencing native plant establishment and vegetation development (Metro Vancouver, 2004). The site falls within the Western Red

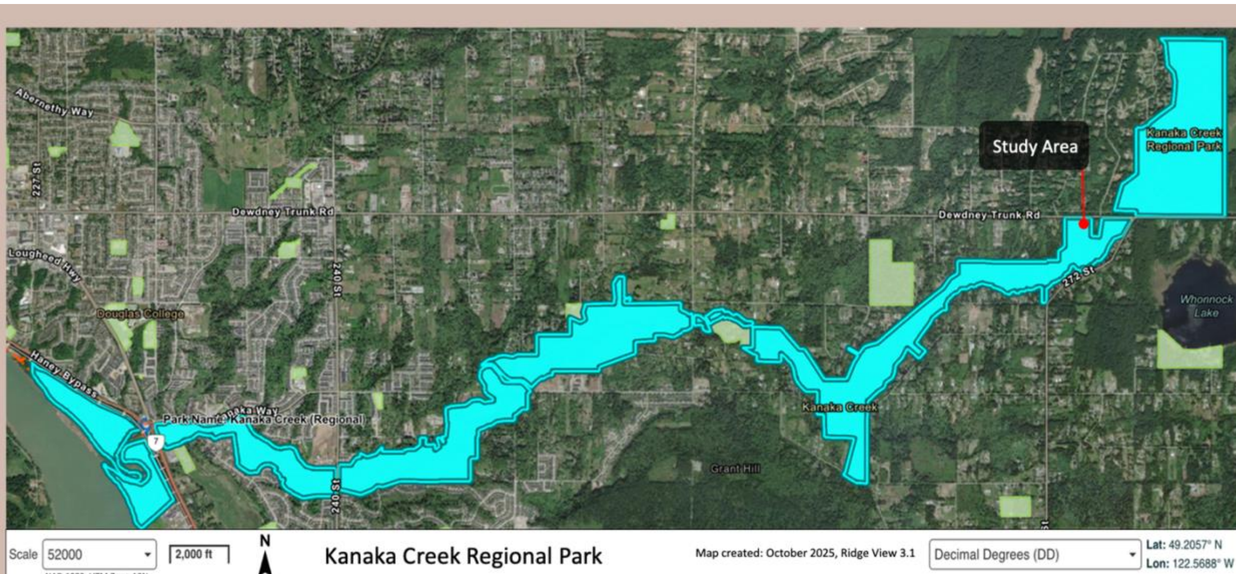

Figure 1: Kanaka Creek Park Map

Kanaka Creek forms part of the broader Metro Vancouver Regional Parks system, located in Maple Ridge, BC. The map illustrates the full park boundary, encompassing the creek corridor from its upper watershed to its confluence with the Fraser River. Areas highlighted in blue represent lands managed and operated by Metro Vancouver.

Cedar/Three-leaved Foamflower Dry Maritime site series (site series 07), dominated by Western red cedar (Thuja plicata) and other coniferous species, with a dense understory that can include Three-leaved foamflower (Tiarella trifoliata) and other shade-tolerant plants (Pojar & Andrew, 2004).

Historical logging, urban expansion, and decades of residential use have significantly altered the site's hydrology and soil structure (City of Maple Ridge, 2024). As a former private property, the area contains layers of backfill, sand, and mixed imported materials used to level the ground and support past structures. These disturbances have reduced infiltration capacity, increased erosion risk in unstable sections, and created an irregular and unpredictable soil profile (Metro Vancouver, 2004). The raised soil beds provided a practical and low-impact alternative for establishing experimental plots. Two soil treatments were used, Metro Vancouver's Nutrifor landscaping soil (containing < 10% of biosolids by dry weight) and a standard all-purpose garden soil. These controlled plots create a consistent testing environment for assessing soil amendment performance under challenging, highly disturbed site conditions.

1.3 Project Objectives

The primary goal of this study is to evaluate the effectiveness of Metro Vancouver's Nutrifor landscaping soil in supporting native plant growth compared with standard all-purpose garden soil. This assessment focuses on plant health, survival, and growth, providing insight into the potential benefits and limitations of using fabricated soils containing biosolids in small-scale, site-specific restoration projects.

This study was conducted at Kanaka Creek Regional Park because this section required restoration and offered a feasible setting for monitoring, building on ongoing restoration efforts. The restoration area was previously disturbed, and the soils and hydrology create challenges for plant establishment, making it an ideal site for testing the performance of different soil products. Native plant species were selected based on their ecological suitability, functional role in the ecosystem, and ability to support restoration objectives. Tree species such as Douglas-fir (*Psedotsuga menziesii*), Western red cedar, and Bigleaf maple (*Acer macrophyllum*) were chosen to provide long-term canopy structure, soil stabilization, and habitat for wildlife. Shrub species, including Salmonberry (*Rubus spectabilis*) and Red elderberry (*Sambucus racemosa*), were selected to enhance understory complexity, provide food and cover for birds and small mammals, and reduce erosion along slopes and the creek buffer. Ferns and groundcover species, like Sword fern (*Polystichum munitum*), were included to improve soil moisture retention, prevent invasive species establishment, and promote overall vegetation diversity. Collectively, these species were intended to recreate a resilient and ecologically functional riparian corridor that strengthens habitat connectivity along Kanaka Creek. Based on these objectives, it was hypothesized that:

H1. Native plant species will exhibit stronger growth and higher survival in the Nutrifor landscaping soil as compared to standard garden soil, reflecting the benefits of increased nutrient availability.

H2. Nutrifor landscaping soil will support greater invasive species and weed presence, indicating a potential trade-off between nutrient enrichment and weed proliferation.

These hypotheses are designed to capture both the benefits and potential drawbacks of biosolids growing medium, generating evidence to guide future restoration planning, species selection, and soil management decisions. This project responds to a broader need identified in discussions with Metro Vancouver, where substantial resources are typically invested in the initial implementation of restoration work, while follow-up monitoring and adaptive management often receive limited attention due to budget constraints, time pressures, and shifting priorities. By incorporating structured post-planting monitoring, this study contributes to addressing that gap and provides information that can help support more effective long-term restoration outcomes.

1.4 Project Timeline

The idea for this project began in August 2024, with preliminary plans established to collaborate with the Metro Vancouver Natural Resource Management (NRM) team. In September, the first meeting with was held, overviewing the 2024 fall planting schedule and choosing restoration work, which would be carried out in October. Once project details were finalized, a proposal was submitted to the RNS Director for approval prior to any data collection. After approval, data was collected over three seasonal periods: May, June, and October. The final phase focused on data analysis, report writing, and preparing the report for submission, which was completed on December 1, 2025 (Figure 2).

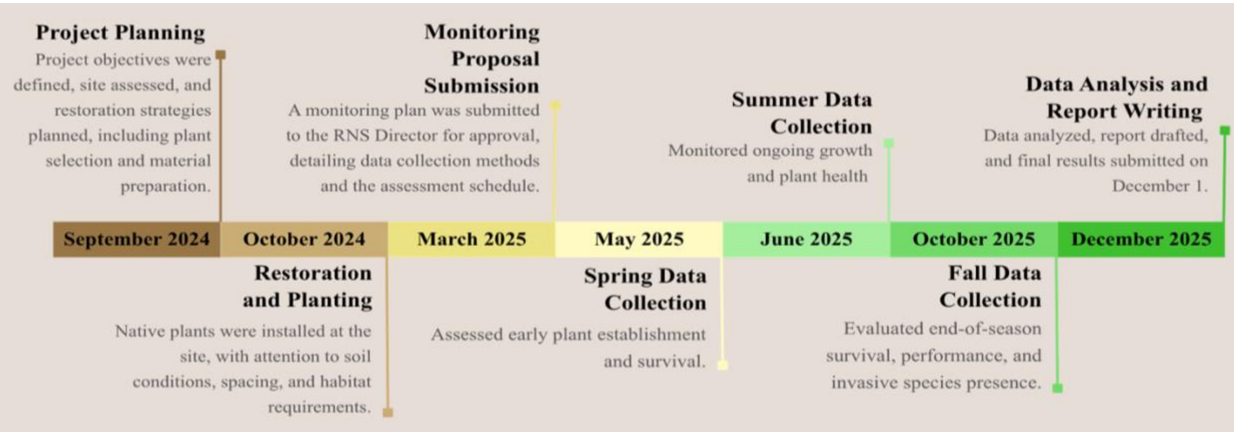

Figure 2: Project Timeline
This timeline illustrates the five main stages of the restoration project, including data collection over three seasons. This project begins with the initial planning and planting (Sept 2024–Oct 2024) to ongoing monitoring, assessment of plant survival, and finalizes with the submission of the report (Dec 2025).

Methods

2.1 Restoration Preparation

In September 2024, collaboration began with Metro Vancouver's NRM team, including NRM Specialist Janice Jarvis and NRM Technician Roy Teo, to identify a suitable restoration project for a one-year assessment and monitoring period focused on plant health and growth. The concept of completing a site restoration first, followed by creating a monitoring plan to evaluate soil performance and determine if adaptive management was needed, began to take shape. Although Nutrifor landscaping soil had already been used in Metro Vancouver's East Area projects with reported success, observations had been primarily qualitative. This deficiency of quantitative data provided the rationale for the present study to formally compare Nutrifor with a standard garden soil and assess any significant differences in native plant performance over time.

In the previous year, Janice and Roy, along with volunteers, completed a planting in the southern portion of the selected site surrounding a constructed pond, with the long-term goal of establishing a dense vegetated buffer between Dewdney Trunk Road and Kanaka Creek. Since acquiring the property, Metro Vancouver has taken responsibility for the restoration, transitioning it from a former private residence to a rehabilitated natural area (Figure 3). The existing pond, originally constructed with a poured concrete liner by the previous landowner, was partially deconstructed during Metro Vancouver's initial site take-over and demolition of former buildings. The concrete liner was removed, leaving only a concrete rim, and the pond bottom has since transitioned to natural substrate. The restored pond now retains water year-round and provides habitat for a variety of aquatic species. The initial restoration planting further enhanced the ecological value of the site by improving habitat quality and supports the species that rely on the pond as a resource.

Figure 3: Planting Area
This ariel view shows the planting area, which was once a private residence, with a pond. This photo is Google imagery from 2018.

Figure 4: Plot 1 and 2
This image shows the boundaries of plot 1 and 2 for restoration activities, including building up the soil with additional material and planting native species.

Building on last year's restoration, this year's planting, forming the foundation of the current project and monitoring effort, consists of two large plots situated directly in front of the previous year's restoration area (Figure 4). The new plots are designed to strengthen the existing buffer, expand native vegetation cover, restore degraded habitat, and support wildlife movement by forming a connected corridor. The two plots, separated by a narrow divide, are similar in size, slope, and environmental conditions. Following a site visit, it was decided to mirror the planting layout across the plots, ensuring identical species placement on both sides. This mirrored design enables a direct comparison of plant performance and the effects of the biosolids growing medium against the locally sourced garden soil.

A total of 415 native plants, approximately 207 per plot, were ordered for the restoration. These plants, representing 22 locally sourced tree, shrub, and fern species, were supplied by NATS Nursery. The restoration included a diverse mix of species intended to enhance structural complexity and ecological function. Key tree species included Bigleaf Maple, Sitka Spruce (*Picea sitchensis*), Douglas Fir (*Psedotsuga menziesii*), Western Red Cedar, and Vine Maple (*Acer circinatum*), alongside a variety of shrubs, ferns, and willow species to support habitat diversity. A complete list of all species planted is provided in Appendix A.

2.2 Plot Design

A high-density planting design was chosen to maximize the likelihood of project success. The NRM team developed a plot layout and procured the plant material, planning for each species to be spaced approximately 0.5 meters apart (Figure 5). This approach was informed by observations from previous plantings in the area and guided by the principles of the Miyawaki method, which emphasizes dense, mixed-species plantings to accelerate canopy development and ecological succession (Webber, 2022). The high-density layout was intended to enhance early competition with invasive species and promote rapid establishment of the site.

Figure 5: Plant Layout
This image shows Plot 2, with the Nutrifor soil bed and 22 different native species arranged for planting.

Previous restoration efforts at Kanaka Creek with lower planting densities showed that invasive species, particularly Himalayan blackberry (Rubus armeniacus), can quickly dominate. To counter this, the current design positions most native plants closely together to encourage rapid growth and faster canopy closure. Shrub species were generally planted in groups of three or five, while trees were spaced individually to accommodate their larger growth requirements. By integrating key principles of the Miyawaki method, the layout aims to develop a multi-layered forest structure, enhance ecological resilience, and limit the spread of invasives (Webber, 2022). Once the design was finalized, the plants were arranged on site to facilitate installation before volunteers arrived.

2.3 Planting

In October 2024, Kanaka Creek operations staff completed site preparation and received the soil deliveries. A tractor was used to form the raised planting beds and separate the two soil types, ensuring the beds were at least 30 cm deep and kept rough and loose to promote healthy root growth. Hand tools such as shovels, buckets, and gloves were also used during the restoration work. Student volunteers from a nearby school assisted with planting the native species, gaining hands-on experience in ecological restoration. Before beginning, the NRM team provided the student volunteers with background information on the significance of restoration efforts and Metro Vancouver’s role in rehabilitating regional park ecosystems. The planting process took roughly five hours to complete.

After planting was completed, students applied Douglas-fir mulch (approximately 1-inch particle size) around the base of each plant. The mulch, sourced from Meadows Landscape Supplies Ltd., was used to retain soil moisture, suppress weed growth, and improve plant survival over winter, supporting stronger establishment in spring. A final inspection was completed by the NRM team to ensure that all plants were correctly installed and that the mulch was properly placed, covering the soil surface but not the plant stems, to prevent rot and promote healthy growth.

2.4 Soil Analysis

Understanding the soil's source, properties, and nutrient levels was essential for interpreting the vegetation performance patterns observed in the field. To obtain accurate soil test results, the supplier first had to be confirmed. In coordination with Metro Vancouver's Utility Residuals Management Program, a detailed data sheet for the Nutrifor landscaping soil blend was requested. The dataset outlines particle size distribution, organic matter content, C/N ratio, total nitrogen, available phosphorus and potassium, pH, salinity (EC), and other quality indicators. These parameters provide the context needed to assess how nutrient availability and soil conditions may contribute to performance differences between the biosolids growing medium and the standard garden soil. Images of the soil products used are shown in Appendix D.

2.5 Monitoring Protocol

Monitoring was scheduled to track plant growth, survival, and the presence of invasive species. Data was collected over multiple sessions to allow the plants to establish and for weeds and grasses to emerge, providing insight into early site dynamics and restoration progress. Monitoring occurred at three key intervals including spring (May), summer (July), and late fall (October), to capture seasonal observations in plant performance and overall site development. Each monitoring session required three to four field days to collect data from all 415 plants, followed by an additional day for data entry, verification, and quality assurance using Excel. A combination of quantitative and qualitative metrics was used to assess plant performance. Plant height and width (in centimeters) was measured to evaluate growth trends and vigor across the two soil treatments, while survival was recorded using a simple alive/dead status to determine establishment success.

Table 1: Health Scores
Scores were assigned based on visual assessment of plant vigor, foliage condition, and overall health.

Score	Description
5.0	Excellent vigor: full canopy, no visible stress or damage.
4.5	Strong vigor: >90% healthy foliage with minimal imperfections.
4.0	Good health: minor discoloration or <10% foliage stress.
3.5	Moderate vigor: early signs of stress or partial leaf yellowing.
3.0	Fair health: 25–50% of foliage showing stress symptoms.
2.5	Reduced vigor: clear decline or localized dieback.
2.0	Poor condition: >50% foliage yellowed or damaged.
1.5	Severe decline: limited green tissue or extensive dieback.
1.0	Near death: minimal living tissue remaining.
0.5	Critical condition: plant mostly dead.
0.0	Dead or removed from plot.

Plant health in the experimental plots was evaluated using a five-point scale with 0.5-point increments (Table 1). This scale was developed by Metro Vancouver Parks for internal use and was adopted for this project as a tailored assessment tool, drawing on standard restoration monitoring practices in British Columbia (Douglas, 2003). A rating of 5 indicated robust, healthy growth with no visible stress, while a score of 0 denoted a dead or removed plant. Plants with symptoms such as discoloration, wilting, pest damage, yellowing, or root issues received progressively lower scores, with intermediate values capturing gradations from minor cosmetic stress (score 4) to severe decline (score 1). Mean health scores were calculated for each species and averaged across monitoring sessions. All analyses were conducted in R and summarized using graphical outputs in RStudio. Appendix B summarizes the metadata included in the Excel dataset.

Growth was measured as the change in plant height and width from the initial monitoring session (Session 1) to the final session (Session 3), spanning approximately five months. Data was collected from the 415 plants across both soil treatments, with species-level sample sizes ranging from 1 to 37 individuals per soil type. Growth calculations were performed only for plants with complete measurements in both Sessions 1 and 3.

2.6 Site Observations and Invasive Species Recording

Photographs were taken of individual plants and the overall plots during each monitoring session to maintain consistency in documenting site conditions and allow comparisons across the three data collection periods. The photos served as a visual reference to support monitoring, allowing comparisons between plots and helped guide assessments of plant growth, survival, and overall site changes. In addition to this, invasive species were recorded by identifying and documenting all weeds and invasive plants observed around the planted natives. Photographs, field notes, and annotated maps were used to track the distribution of invasives, with species identifications supported using mobile apps such as *iNaturalist* and *Seek*. Observations of the surrounding area helped determine whether invasives had naturally encroached or were introduced by soil transport or storage. Together, this combination of photo records and field data provided a reliable visual and quantitative record of vegetation growth, invasive species presence, and overall site conditions over time. A handover package for Metro Vancouver, detailing how to replicate data visualizations and the annotated R code used in this study, is provided in Appendix C.

Results

3.1 Soil Properties and Nutrient Analysis

NutriGrow, a third-party contractor, manufactures Nutrifor landscaping soil for Metro Vancouver. A specification sheet and independent laboratory analysis was obtained, confirming that NutriGrow's Planter Blend was the specific material applied at the site. NutriGrow produces a variety of soil and compost products tailored to specific applications (NutriGrow, 2025). The material used at the Kanaka Creek restoration site is composed of premium aged bark, Class A organics (biosolids), and clean, free-draining river sand (NutriGrow, 2025). This blend is specifically marketed as suitable for riparian planting zones, where it supports drainage and provides structural stability (NutriGrow, 2025). Metro Vancouver Regional Parks received the Nutrifor material at no cost; only shipping expenses were incurred for the project.

Table 2 highlights the chemical breakdown of the soil. Physical testing was conducted by Pacific Soils Analysis Inc. (PSAI) and Element Laboratories, with results evaluated against the

Canadian Landscape Standard (CLS 2P) guidelines for planting media. The October 2025 analysis revealed a predominantly sandy, well-draining texture, consisting of 77.4% sand, 6.9% fines (<2 mm), 2.7% organic material, and the remainder as gravel larger than 4 mm. Total organic matter was 13%, supporting water retention and microbial activity essential for root development and early plant establishment. Key nutrient parameters met or exceeded CLS 2P requirements, the carbon-to-nitrogen (C:N) ratio was 21:1, providing balanced nutrient release without immobilization. Total nitrogen was 0.27%, sufficient for initial growth and available potassium measured 120 ppm, within the recommended range (NutriGrow, 2025).

Table 2: Chemical Break-Down

The Nutri-planter soil blend from October 2025 is mostly sand (77%) with some fines (7%) and organic matter (13%), plus balanced nutrients like nitrogen (0.27%), high phosphorus (440 ppm), and high potassium (120 ppm). It fully meets Canadian landscape standards, with a neutral pH (7.8) and low salinity (2.0 dS/m).

Soil Blend	Soil Properties				Nutrients and Quality Parameters					
Nutri-planter October 2025	>4 mm fraction (organics + gravel)	Sands	Fines	Organic matter	C/N ratio	Total nitrogen	Avail. Phosphorus	Avail. Potassium	pH	Salinity (EC)
	%	%	%	%	ratio	%	ppm	ppm		dS/m
Nutri-planter levels	**2.7**	**77.4**	**6.9**	**13**	**21:1**	**0.27**	**440**	**120**	**7.8**	**2.0**
Compliance with Canadian Landscape Standard	✓	✓	✓	✓	✓	✓	High	✓	High	✓
	2P	2P	2P	2P	2P	2P	2P	2P	2P	2P
2P Standards	<5	40 to 80	<35	10 to 20	<40:1	0.2-0.6	20 to 250	50 to 1000	4.5 – 6.5	<3

In comparison, the standard all-purpose garden soil was obtained from Bradley's Albion 1 Stop Landscape and Renovation Center in Maple Ridge, B.C. This product represents a commercial blend, generally consisting of loam, compost, and sand to provide balanced drainage and fertility. According to the supplier's website, the premium garden blend is priced at $45 per yard and is composted for a minimum of one year, incorporating mushroom manure and sand (One Stop Landscape Supplies, 2025).

While specific lab analyses was not available for this batch, standard all-purpose garden soils generally have a slightly acidic to neutral pH of 5.5–6.5, moderate organic matter (5–10%), and lower nutrient levels, such as nitrogen at 0.1–0.2%, phosphorus at 10–20 ppm, and potassium at 50–100 ppm, compared to biosolids growing medium products like Nutrifor (Oka, Thomas, & Lavkulich, 2014). This composition reflects the characteristics of general-purpose soils used in landscaping, providing sufficient, but not excessive, fertility, which can help minimize nutrient leaching and reduce the risk of promoting invasive species in sensitive riparian areas (Oka, Thomas, & Lavkulich, 2014). The composition of the native site soil was not assessed, as all planting occurred in the raised soil beds.

3.2 Health Score Assessment

Plant performance differed by soil type, with ten species achieving higher mean health scores in Nutrifor, eleven species performing better in all-purpose soil, and one species showing equivalent performance across both soils (Figure 6). Red elderberry exhibited one of the strongest positive responses, averaging 4.92 in Nutrifor versus 4.44 in all-purpose soil. Red-flowering currant (*Ribes sanguineum*) also performed slightly better in Nutrifor, averaging 4.94 compared to 4.83 in all-purpose soil. Nootka rose (*Rosa nutkana*) averaged 3.57 in Nutrifor and 3.00 in all-purpose soil, while Thimbleberry (*Rubus parviflorus*) averaged 3.22 in Nutrifor versus 2.88 in all-purpose soil. Sitka spruce and Sitka willow (*Salix sitchensis*) had identical Nutrifor scores of 4.83, with slightly lower all-purpose soil scores of 4.67 and 4.42, respectively. Other species showing modest increases in Nutrifor included Salmonberry, Black twinberry (*Lonicera involucrata*), and Red-osier dogwood (*Cornus stolonifera*), with differences of 0.16–0.23 points.

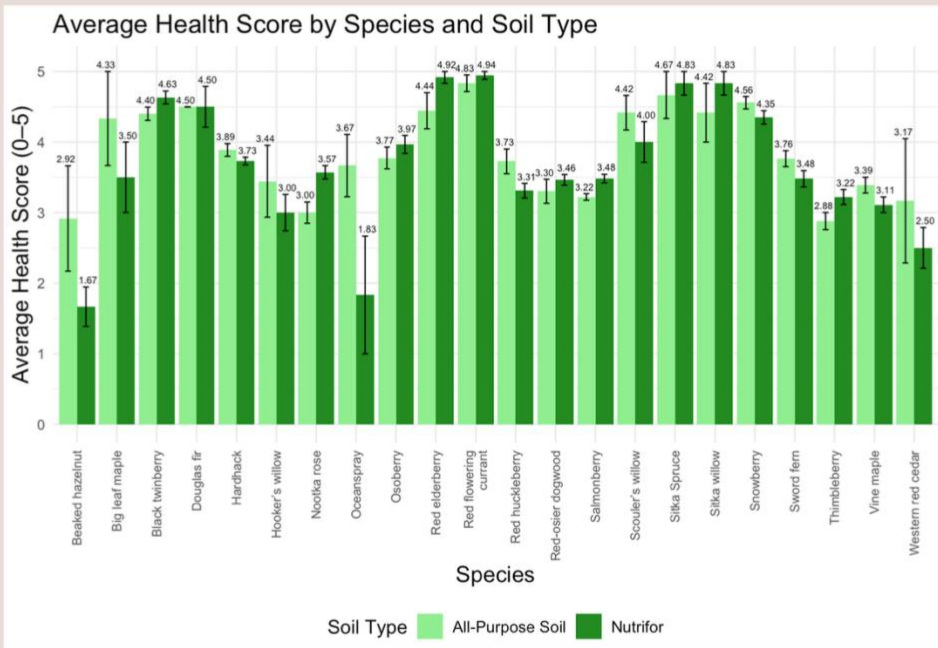

Figure 6: Comparing Health Scores

All the species planted in Plot 1 and 2 are noted along the bottom line. This graph is to compare average health scores of all species to better understand the impact soil type has on plant health. Most species scored similarly, except for Beaked hazelnut, Oceanspray, Big leaf maple, and Western red cedar which have the largest variances. Standard error of the mean is represented by the thin black lines above each bar.

Oceanspray (*Holodiscus discolor*) exhibited the largest negative response to Nutrifor, averaging 1.83 in Nutrifor compared to 3.67 in all-purpose soil. Beaked hazelnut (*Corylus cornuta*) also performed substantially better in all-purpose soil, averaging 2.92 versus 1.67 in Nutrifor. Western red cedar averaged 3.17 in all-purpose soil and 2.50 in Nutrifor, while Red huckleberry (*Vaccinium parvifolium*) showed a similar pattern, scoring 3.73 in all-purpose soil versus 3.31 in Nutrifor. Sword fern averaged 3.76 in all-purpose soil and 3.48 in Nutrifor, and Vine maple averaged 3.39 in all-purpose soil versus 3.11 in Nutrifor. Hooker's willow (*Salix hookeriana*) also performed better in all-purpose soil, averaging 3.44 compared to 3.00 in Nutrifor. Hardhack (Spiraea douglasii), Bigleaf maple, Scouler's willow (*Salix scouleriana*), and Snowberry (*Symphoricarpos albus*) all had moderately higher scores in all-purpose soil. Douglas-fir was the only species that showed no difference between soils, averaging 4.50 in both Nutrifor and all-purpose soil. This indicates that, at least during the 2025 growing season, soil amendment did not influence Douglas-fir health in either direction.

Temporal trends in plant health across the three monitoring sessions revealed consistent patterns among the 22 species, with some variation by soil type (Figure 7). Most species began with scores of 4.0–5.0 and experienced declines by the final session, generally more pronounced in all-purpose soil than in Nutrifor. Standard errors (SEM) were small overall, though larger variability occurred in some cases, such as Osoberry (*Oemleria cerasiformis*) in Nutrifor.

Several species showed notable declines, including Beaked hazelnut, Bigleaf maple, Black twinberry, Douglas fir, Hardhack, Hooker's willow, Nootka rose, Oceanspray, Red elderberry, Red huckleberry, Red-osier dogwood, Scouler's willow, Sitka spruce, Sitka willow, Snowberry, Sword fern, Thimbleberry, and Vine maple. Salmonberry declined more in all-purpose soil than Nutrifor, and Thimbleberry also decreased more in all-purpose soil. In contrast, Red-flowering currant remained stable across both soils. Western red cedar improved in all-purpose soil but stayed steady in Nutrifor. Osoberry in Nutrifor experienced a mid-season dip before partial recovery, while in all-purpose soil it declined steadily over time.

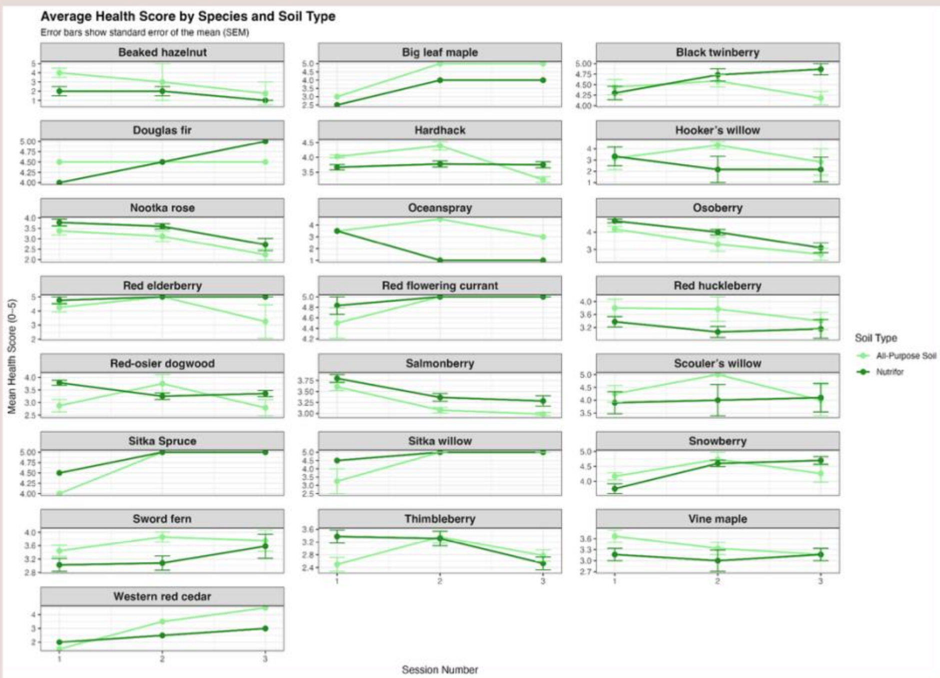

Figure 7: Comparing Health Scores Over Time

This set of graphs compares health score trends for each species across the two soil types using species-specific line charts with SEM error bars. Most plants performed better in All-Purpose Soil, while only a small group showed equal or stronger scores in Nutrifor. Species responses varied across sessions, with some improving through time and others declining by Session 3.

3.3 Growth Assessment

Across all species, average growth was nearly equivalent between the two soil treatments (Figure 8). Plants in all-purpose soil exhibited mean increases of 14.51 cm in height and 15.86 cm in width, while those in Nutrifor showed comparable mean increases of 14.52 cm in height and 14.44 cm in width. Black twinberry, Bigleaf maple, Hooker's willow, Oceanspray, Red flowering currant, and Red huckleberry exhibited greater mean height growth in all-purpose soil compared to Nutrifor, with differences ranging from approximately 9 cm (Black twinberry) to 113 cm (Bigleaf maple). Similarly, width growth for these species was generally higher in all-purpose soil, except for Bigleaf maple where the difference was pronounced but based on limited samples. Conversely, species like Hardhack, Osoberry, Red elderberry, Sitka Spruce, and Snowberry showed superior height growth in Nutrifor, with gains up to 79 cm higher (Red elderberry) than in all-purpose soil. Width growth followed similar trends for these species, though Osoberry experienced a net width decline in all-purpose soil (-18.75 cm) versus a slight gain in Nutrifor (0.48 cm).

Other species displayed minimal differences or mixed results. For example, Douglas fir had identical height growth (23 cm) in both soils but better width growth in all-purpose soil. Salmonberry, Sword fern, and Scouler's willow showed comparable height growth across soils, with slight advantages in all-Purpose for width in some cases. Species like Beaked hazelnut, Nootka rose, Red-osier dogwood, Thimbleberry, and Vine maple experienced net declines or modest gains in both soils, with no clear superiority; however, declines were often less severe in Nutrifor (Beaked hazelnut height decline of -8 cm in Nutrifor vs. -14.5 cm in All-purpose soil).

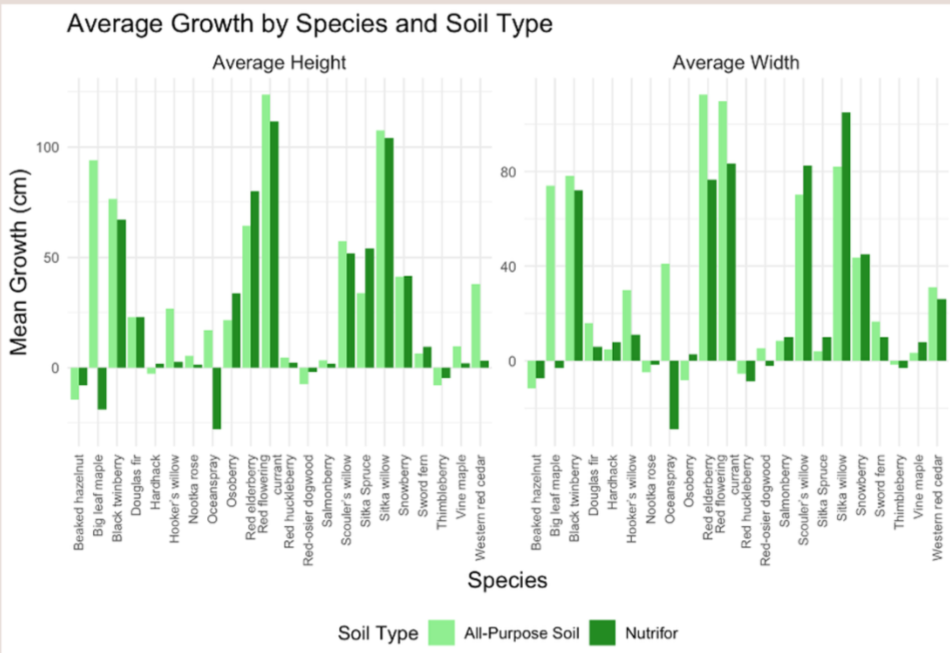

Figure 8: Comparing Growth

The figure includes two graphs illustrating mean height and width growth for each species planted in the two soil types. Several species showed greater growth in All-Purpose Soil, while others performed better in Nutrifor. A few species exhibited minimal or negative growth, likely due to dieback or transplant stress. Together, the graphs highlight the range of growth responses observed across species.

3.4 Plant Survival

Plant survival was assessed at the final observation (Session 3, October 2025) based on the "Alive/Dead" status recorded for each plant (Figure 9). Overall survival rates were high in both soil types, with 94.9% (196 out of 207 plants) surviving in all-purpose soil and 96.3% (198 out of 206 plants) in Nutrifor. Mortality was observed in only 9 species with no species experiencing complete loss in either soil.

Osoberry exhibited superior survival in Nutrifor (95.2%, 17/18 alive) relative to all-purpose soil (85.0%, 15/18 alive), corresponding to a 10.2% differential. Red elderberry achieved 100% survival (2/2 alive) in Nutrifor versus 75.0% (3/4 alive) in all-purpose soil, a 25% disparity. Hooker's willow demonstrated 100% survival (3/3 alive) in all-purpose soil but only 66.7% (2/3 alive) in Nutrifor, while Sword fern survival was higher in all-purpose soil (94.4%, 17/18 alive) than Nutrifor (88.9%, 16/18 alive), yielding a 5.5% difference. For species with limited mortality, survival metrics were comparable or marginally elevated in Nutrifor, including Nootka rose (all-purpose: 82.4%, 14/17 alive; Nutrifor: 87.5%, 14/16 alive), Red huckleberry (93.3%, 14/15 alive vs. 93.8%, 15/16 alive), Red-osier dogwood (91.7%, 11/12 alive vs. 100%, 14/14 alive), Snowberry (95.2%, 20/21 alive vs. 100%, 20/20 alive), and Thimbleberry (100%, 18/18 alive vs. 93.8%, 15/16 alive). The remaining 13 species, encompassing larger cohorts such as Salmonberry (33 in all-purpose, 37 in Nutrifor) and Black twinberry (17 and 15), maintained

100% survival across both substrates.

Figure 9: Plant Survival

This bar graph shows the survival of each plant species across both soil types, with the red portion of each bar indicating the percentage of dead plants. Most species maintained 100% survival over the five-month monitoring period, with only a few cases of mortality. Survival is shown as a percentage to account for the different numbers of individuals planted for each species. The graph highlights that both soil types supported high survival rates.

3.5 Invasive Species

Field-based visual assessments indicated clear differences in invasive species abundance, competitive vegetation, and herbivory between soil treatments (Figure 10). The Nutrifor plot experienced greater frequency and intensity of invasive and weedy plant encroachment than the all-purpose soil plot. Persistent and dense overgrowth by opportunistic species was observed across monitoring sessions, most commonly Black nightshade (*Solanum nigrum*), Horseweed (*Erigeron canadensis*), Smooth hawk's-beard (*Crepis capillaris*), Creeping buttercup (*Ranunculus repens*), Spotted lady's thumb (*Persicaria maculosa*), Oxeye daisy (*Leucanthemum vulgare*), Common selfheal (*Prunella vulgaris*), Alsike clover (*Trifolium hybridum*), Purple foxglove (*Digitalis purpurea*), Creeping thistle (*Cirsium arvense*), Broad-leaved dock (*Rumex obtusifolius*), Large-leaved avens (*Geum macrophyllum*), Watercress (*Nasturtium officinale*), Pearly everlasting (*Anaphalis margaritacea*), Large-leaved lupine (*Lupinus polyphyllus*), and Saltwater false willow (*Baccharis halimifolia*). Black nightshade and Red alder (*Alnus rubra*) seedlings were the dominant competitors, frequently overtopping or fully covering planted seedlings. Associated impacts included leaf browning, wilting, reduced vertical growth, and, in several cases, partial or complete mortality. Invasive biomass was consistently highest in the central portion of the Nutrifor plot. Himalayan blackberry and Reed canarygrass (*Phalaris arundinacea*) occurred in both treatments but were more extensive and competitive in Nutrifor.

The all-purpose soil plot exhibited moderate weed presence, with lower overall density and competitive pressure. Higher weed cover was concentrated along the eastern edge, where densities approached those observed in the Nutrifor plot. Common species included Creeping buttercup, Horseweed, Large-leaved lupine, Alsike clover, Ribwort plantain (*Plantago lanceolata*), Broad-leaved dock, Creeping thistle, Common selfheal, Purple foxglove, Osoberry and Red alder. Although competitive vegetation was present, overtopping and complete shading of planted seedlings occurred less frequently, and unobstructed microsites were more common in the central and western areas of the plot.

Herbivory was widespread across both soil treatments, primarily attributed to deer but potentially including bear and vole activity. Observed impacts included chewed tips, stripped leaders, rubbed stems, snapped shoots, and occasional complete removal of apical growth. Top dieback with basal resprouting was frequently documented, indicating repeated browse pressure. Several seedlings were fully defoliated or dead, while others retained green cambial tissue or produced new shoots following damage.

Figure 10: Plant Growth
This image shows Plot 1, the All-Purpose soil bed, where tall grasses dominate the base, with weeds and invasive species growing in the spaces between.

Discussion

The Nutrifor landscaping soil provided suitable texture, salinity, and nutrient conditions for native plant establishment at the Kanaka Creek restoration site, while the all-purpose soil served as a stable baseline for comparison. The results demonstrate that soil properties meaningfully influence plant performance, highlighting the importance of careful planning and species selection in restoration projects. Overall, survival, growth, and health were strong across both soils, though species-specific responses indicate that data-driven decisions remain critical to restoration success. The collected data generally support the study hypotheses. Hypothesis 1, predicting stronger growth and higher survival in Nutrifor landscaping soil, was partially confirmed: moisture-responsive, nutrient-demanding shrubs benefited most, whereas many upland or nutrient-sensitive species performed better in all-purpose soil. Hypothesis 2, anticipating increased invasive species in Nutrifor landscaping soil, was confirmed, emphasizing the ecological trade-offs associated with nutrient enrichment.

The effects of soil amendments were species-specific rather than uniform. In the nutrient-rich Nutrifor landscaping soil (pH 7.8), moisture-tolerant shrubs and early successional species showed higher health scores, likely reflecting increased organic matter and nutrient availability, with similar benefits observed in species with moderate nutrient demands. By comparison, the all-purpose soil favored species adapted to lower-nutrient conditions. Hardhack, Bigleaf maple, Scouler's willow, and Snowberry performed well, while Beaked hazelnut, Hooker's willow, Red huckleberry, Thimbleberry, Western red cedar, and Sitka spruce achieved higher health scores, suggesting that the more balanced, slightly acidic soil better matched the requirements of acid-tolerant or drainage-sensitive species without risking nutrient overload. To contextualize these results, under CWH site conditions a comparable soil would be expected to exhibit loamy textures, moderate to high forest-floor organic matter, slightly acidic pH (4–5), and relatively low nutrient availability, particularly nitrogen and phosphorus (Sajedi et al., 2012). Relative to this baseline, Nutrifor is sandier, contains higher organic matter (13%), has a higher pH, and elevated nutrient levels, especially nitrogen and potassium, supporting rapid early establishment (NutriGrow, 2025). By comparison, standard all-purpose garden soil more closely aligns with CWH forest soils, with slightly acidic pH, moderate organic matter, and lower nutrient levels that promote slower, sustained growth consistent with native species adaptations.

Growth patterns from Session 1 to Session 3, measured by plant height and width, revealed distinct species responses to soil treatments. Nutrifor promoted faster early growth in nutrient-responsive species, producing slightly greater increases in width, while height gains were generally similar across soils. In contrast, all-purpose soil supported steadier, more gradual growth in species such as Bigleaf maple, illustrating how soil characteristics influence both the timing and magnitude of development. Plant survival was slightly higher in Nutrifor for nutrient-responsive species, though some individuals may have been obscured by dense grasses, outcompeted, or affected by wildlife, so results should be interpreted with caution. Wildlife impacts were more frequently observed in Nutrifor plots, but plants in these nutrient-rich soils often recovered more effectively. Additionally, park maintenance and the flow of a small surface-water channel through the all-purpose soil plot influenced outcomes, benefiting nearby moisture-sensitive species.

Observations indicated that Nutrifor plots were more susceptible to invasive species and heavier weed growth, while all-purpose plots experienced moderate competition. Notably, Black nightshade was not observed in surrounding areas, suggesting it was introduced through the Nutrifor landscaping soil. Despite these pressures, many plants in both soils thrived, showing strong vertical growth, dense foliage, and minimal interference in areas with lower weed density and adequate light. These results highlight a key trade-off, Nutrifor enhances nutrient availability but increases vulnerability to invasives, potentially offsetting early growth advantages. From a cost and management perspective, Nutrifor offers notable benefits, as Metro Vancouver Parks received the material at no cost aside from shipping, whereas all-purpose soil incurs both purchase and shipping expenses. However, higher nutrient availability in Nutrifor may require additional management, including mulching, targeted weed removal, and adaptive interventions.

Recommendations

Based on the findings, the following recommendations are proposed to guide future restoration efforts. Restoration planning should prioritize matching soil amendments to species functional traits. Nutrifor offers advantages for nutrient-demanding, moisture-responsive shrubs where rapid early establishment is a priority, while all-purpose soil supports acid-tolerant or slow-growing species by reducing nutrient stress and promoting long-term stability under CWH conditions.

Where biosolids growing medium are used, active management is essential. Early planting and sustained weed control, including mulching and targeted invasive removal, should be incorporated into project planning, along with preventative measures such as covered storage of biosolids to limit weed introduction. Vulnerable plantings should be protected during early establishment using stucco mesh plant guards. Nutrifor offers cost advantages but may require increased monitoring to address invasive pressure or uneven establishment. Regular assessment of plant performance and site conditions will support timely interventions, such as selective replanting or supplemental mulching, ensuring resilient, long-term restoration outcomes across mixed soil treatments.

Conclusion

This demonstration study evaluated Metro Vancouver's Nutrifor landscaping soil relative to standard all-purpose soil for supporting native plant establishment at the Kanaka Creek Regional Park restoration site. Monitoring 415 plants across 22 locally sourced native species over three seasonal periods in 2025 revealed clear species-specific responses, highlighting the importance of soil properties, nutrient availability, and site conditions in shaping restoration outcomes. Nutrifor enhanced early growth and vigor in nutrient-demanding, moisture-tolerant shrubs such as Black twinberry, Red elderberry, and Salmonberry, while acid-tolerant and upland species performed better in all-purpose soil, partially supporting Hypothesis 1.

Soil analyses confirmed that Nutrifor provided elevated nutrient levels and higher pH, benefiting certain shrubs but limiting performance in acid-preferring species. These gains were accompanied by increased invasive pressure, including Black nightshade, Horseweed, and Reed canarygrass, confirming Hypothesis 2. Site-specific factors such as herbivory, residual grasses, and localized water features further influenced plant performance. Despite these differences, survival exceeded 94% across both soil treatments, demonstrating that successful restoration can be achieved under multiple soil regimes when species–soil compatibility is considered.

Overall, the results highlight the value of biosolids growing medium as a sustainable restoration tool when applied selectively. Biosolids can accelerate early establishment and reduce reliance on synthetic fertilizers, but their use should be paired with targeted species selection and active management. Nutrient-demanding shrubs and early successional species are well suited to biosolids growing medium, while acid-tolerant conifers and upland shrubs perform more reliably in all-purpose soil. Proactive invasive species control, herbivory protection, and ongoing monitoring remain essential for long-term success. Although limited to one year and study plots were not replicated, this study provides practical guidance for restoration in the Coastal Western Hemlock zone and reinforces the importance of integrating soil amendments, species selection, and adaptive management to support resilient ecosystem recovery.

Works Cited

Basta, N., Busalacchi, D., Hundal, L., Kumar, K., Dick, R., Lanno, R., . . . Granato, T. (2016). Restoring Ecosystem Function in Degraded Urban Soil Using Biosolids, Biosolids Blend, and Compost. *ournal of Environmental Quality*, 74-83.

Bright, D., & Healey, N. (2003). Contaminant risks from biosolids land application: Contemporary organic contaminant levels in digested sewage sludge from five treatment plants in Greater Vancouver, British Columbia. *Environmental Pollution*, 39-49.

Brown, S., Ippolito, J., Hundal, L., & Basta, N. (2020). Municipal biosolids — A resource for sustainable communities. *Current Opinion in Environmental Science & Health, Volume 14*, 56-52.

City of Maple Ridge. (2024, June). *Urban Forest Management Plan*. Retrieved from https://www.mapleridge.ca/media/file/finalufms240723v15with-appendicesreducedfinalpdf-0

City of Maple Ridge. (2025). *Kanaka Creek Regional Park*. Retrieved November 2025, from City of Maple Ridge: https://www.mapleridge.ca/parks-recreation/recreation-facilities/kanaka-creek-regional-park?utm_source=chatgpt.com

De Deyn, G. B., & Kooistra, L. (2021). The role of soils in habitat creation, maintenance and restoration. *Philosophical Transactions of the Royal Society B, 376(1834)*.

Douglas, T. (2003). *Ecological Restoration Guidelines for British Columbia.* Victoria, BC: Ministry of Water, Land and Air Protection.

Government of British Columbia. (n.d.). *Biosolids in BC*. Retrieved March 2025, from Government of British Columbia: https://www2.gov.bc.ca/gov/content/environment/waste-management/food-and-organic-waste/regulations-guidelines/biosolids-in-bc

Kanaka Education & Environmental Partnership Society. (2025). *Kanaka Watershed*. Retrieved November 2025, from Kanaka Education & Environmental Partnership Society: https://keeps.org/kanaka-watershed/

Meidinger, D., & Pojar, J. (1991). *Ecosystems of British Columbia.* B.C: Ministry of Forests.

Metro Vancouver. (2004). *Kanaka Creek Regional Park Management Plan.* Vancouver, BC: Metro Vancouver.

Metro Vancouver. (n.d.). *Nutrifor 101*. Retrieved March 2025, from Metro Vancouver: https://metrovancouver.org/services/liquid-waste/biosolids/about/what-is-nutrifor

Metro Vancouver. (n.d.). *Nutrifor (BioSolids)*. Retrieved from Metro Vancouver: https://metrovancouver.org/services/liquid-waste/biosolids

Metro Vancouver. (n.d.). *Nutrifor 101*. Retrieved from Metro Vancouver: https://metrovancouver.org/services/liquid-waste/biosolids/about/what-is-nutrifor

Ministry of Environment and Climate Change Strategy. (2024, August 21). *Biosolids in B.C*. Retrieved from Province of British Columbia: https://www2.gov.bc.ca/gov/content/environment/waste-management/food-and-organic-waste/regulations-guidelines/biosolids-in-bc

Nats Nursey. (2024, October 11). *Native Plants Start Here Specialized Growers & Wholesalers*. Retrieved from Nats Nursey: https://natsnursery.com/

Newman, R., Krzic, M., & Wallace, B. (2014). Differing Effects of Biosolids on Native Plants in Grasslands of Southern British Columbia. *Journal of Environmental Quality*, 1672-1678.

NutriGrow. (2025). *Soils*. Retrieved November 2025, from NutriGrow: https://nutrigrow.ca/products/soils/

Oka, G., Thomas, L., & Lavkulich, L. (2014). Soil assessment for urban agriculture: a Vancouver case study. *Journal of soil science and plant nutrition*, 657-669.

One Stop Landscape Suppplies. (2025). *Landscape Supplies*. Retrieved November 2025, from One Stop Landscape Suppplies: https://onestoplandscapesupplies.com/materials

Pojar, J., & Andrew, M. (2004). *Plants of Costal British Columbia: Including Washington, Oregon and Alaska.* Lone Pine Publishing.

Sajedi, T., Prescott, C., Seely, B., & Lavkulich, L. (2012). Relationships among soil moisture, aeration and plant communities in natural and harvested coniferous forests in coastal British Columbia, Canada. *Journal of Ecology*, 605-618.

U.S. Environmental Protection Agency. (n.d.). *Using Biosolids for Reclamation/Remediation of Disturbed Soils*. Retrieved from https://www.epa.gov/sites/default/files/2015-05/documents/biosolidswhitepaper-uwash.pdf

Waterhouse, B. R., Boyer, S., Adair, K., & Wratten, S. (2014). Using municipal biosolids in ecological restoration: What is good for plants and soil may not be good for endemic earthworms. *Ecological Engineering 70(5)*, 414-421.

Webber, D. (2022, May 23). *The Miyawaki method for creating forests*. Retrieved April 2025, from Creating Tomorrow’s Forests: https://www.creatingtomorrowsforests.co.uk/blog/the-miyawaki-method-for-creating-forests

Appendix A:

Table 3 - Plant Order
This table outlines the plant orders for the all-purpose soil plot (Plot 1) and the Nutrifor plot (Plot 2). Native species were chosen to support ecological restoration by re-vegetating the previously cut section of the property. A range of pot sizes were ordered based on nursery availability.

Tree/Shrub Species	***Plot 1***	***Plot 2***	***Total***	***Size***
Bigleaf maple (Acer macrophyllum)	1	1	2	#5 pot
Sitka Spruce (Picea sitchensis)	1	1	2	#5 pot
Douglas fir (Psedotsuga menziesii)	1	1	2	#5 pot
Western red cedar (Thuja plicata)	1	1	2	#5 pot
Vine maple (Acer circinatum)	3	3	6	#5 pot
Beaked hazelnut (Corylus cornuta)	1	1	2	#2 pot
Red elderberry (Sambucus racemosa)	2	2	4	#2 pot
Red-osier dogwood (Cornus stolonifera)	12	12	24	#2 pot
Oceanspray (Holodiscus discolor)	1	1	2	#2 pot
Black twinberry (Lonicera involucrata)	15	15	30	#2 pot
Osoberry (Oemleria cerasiformis)	18	18	36	#2 pot
Sword fern (Polystichum munitum)	15	15	30	#2 pot
Red flowering currant (Ribes sanguineum)	3	3	6	#2 pot
Nootka rose (Rosa nutkana)	18	18	36	#2 pot
Thimbleberry (Rubus parviflorus)	18	18	36	#2 pot
Salmonberry (Rubus spectabilis)	33	37	70	#2 pot
Hooker's willow (Salix hookeriana)	3	3	6	#1 pot
Scouler's willow (Salix scouleriana)	3	3	6	#1 pot
Sitka willow (Salix sitchensis)	3	3	6	#1 pot
Hardhack (Spiraea douglasii)	18	18	36	#2 pot
Snowberry (Symphorcarpos albus)	24	23	47	#2 pot
Red huckleberry (Vaccinium parvifolium)	12	12	24	#1 pot

Appendix B:

Table 4 - Dataset Metadata Table

This table describes all columns in the plant monitoring dataset, including their format, units, and notes for interpretation. It details identifiers (session and plant), experimental conditions (soil type, species), observation dates, survival and growth metrics (height, width, health score), and additional notes on environmental factors or disturbances.

Column Name	Description	Units / Format	Notes
Session_Number	Monitoring session identifier	Integer (1–3)	Indicates observation round
Plant_ID	Unique identifier for each plant	Text (e.g., NF-001, RS-001)	Constant for each plant across sessions
Soil_Type	Soil type used	Text (Nutrifor / All-Purpose Soil)	Mirrors experimental plots
Species	Scientific name with common name	Text (e.g., Sword fern (Polystichum munitum))	22 native species observed
Date_Observed	Monitoring date	MM-DD-YYYY (parsed to YYYY-MM-DD in cleaning)	Per survey event
Alive_Dead	Survival status	Text (Alive / Dead)	Converted to binary (1/0) in analysis
Height_cm	Height from base to tallest stem	Centimetres (integer)	Key growth metric
Width_cm	Width at widest point	Centimetres (integer)	Additional growth metric
Health_Score	0–5 health scale	Numeric (0–5, 0.5 increments)	5 = very healthy; 0 = dead
Notes	Additional observations	Text	Includes wildlife disturbance, invasives (e.g., black nightshade), competition, chewing

Appendix C: Handover Package for Metro Vancouver

This package provides a streamlined resource for the plant-soil study. Metro Vancouver will be able to use this as a resource to help in replicating the monitoring process or apply it to other restoration sites. It includes notes on cleaning datasets, a monitoring protocol, key statistical summaries, and an example of a concise annotated R script.

Cleaning Data:

The dataset comprises **1,245 rows** (3 monitoring sessions × 415 plants). A sample of the cleaned data:

- Session 1, NF-001, Nutrifor, Sword fern (Polystichum munitum), 2025-05-22, 1, 37, 55, 3
- Session 2, NF-001, Nutrifor, Sword fern (Polystichum munitum), 2025-07-25, 1, 53, 47, 3

Monitoring Protocol:

A monitoring plan should be established to track plant growth throughout the growing season (March–October). Ideally, observations should occur every **4–6 weeks**, depending on feasibility. If possible, include one additional observation during late fall or winter.

Required Tools: Tape measure, notebook, camera.

Per Plant Observations:

- Record survival (alive/dead)
- Assess health on a 0–5 scale
- Measure height and width (cm)
- Note any relevant observations (e.g., invasive species, damage)

Photos: Take one photo per soil plot and capture any notable issues.

Data Management: Enter all observations into an Excel or CSV file.

Quality Control: Check data for errors and, if possible, have the same observer consistently record measurements to reduce variability.

Key Stats:

- Survival: 96% Nutrifor, 95% All-Purpose (similar).
- Avg Health: 3.5 both soils.
- Avg Growth: Height +5 cm Nutrifor, +4 cm All-Purpose; Width +10 cm both.
- ANOVA: No big differences between soils ($p > 0.05$ for health/growth).

Example R Script for Data Visualization

```
# ==========================
# Plant Health Analysis Script
# ==========================
# ---- Load libraries ----
library(readxl)   # to read Excel files
library(dplyr)    # for data manipulation
library(ggplot2)  # for plotting
# ---- Load & clean data ----
data <- read_excel("ER390_Data.xlsx", sheet = "Field_Data") %>%
  mutate(
    Species = gsub("\\s\\(.*\\)", "", trimws(Species)),  # remove parentheses and extra spaces
    Soil_Type = trimws(Soil_Type)                         # remove extra spaces
  )
# ---- Summarize data ----
summary_data <- data %>%
  group_by(Session_Number, Species, Soil_Type) %>%
  summarise(
    mean_health = mean(Health_Score, na.rm = TRUE),      # average health score
    sem = sd(Health_Score, na.rm = TRUE) / sqrt(n()),  # standard error
    .groups = "drop"
  )
# ---- Create plot ----
plot <- ggplot(summary_data, aes(
  x = Session_Number,
  y = mean_health,
  color = Soil_Type,
  group = Soil_Type
)) +
  geom_line(size = 0.9) +
  geom_point(size = 2.3) +
  geom_errorbar(aes(
    ymin = mean_health - sem,
    ymax = mean_health + sem
  ), width = 0.15) +
  facet_wrap(~ Species, scales = "free_y", ncol = 3) +
  scale_x_continuous(breaks = c(1, 2, 3)) +
  scale_color_manual(values = c(
    "All-Purpose Soil" = "lightgreen",
```

```
    "Nutrifor" = "forestgreen"
  )) +
  labs(
    title = "Average Health Score by Species and Soil Type",
    subtitle = "Error bars show standard error of the mean (SEM)",
    x = "Session Number",
    y = "Mean Health Score (0–5)",
    color = "Soil Type"
  ) +
  theme_bw() +
  theme(
    strip.text = element_text(size = 12, face = "bold"),
    plot.title = element_text(size = 14, face = "bold"),
    plot.subtitle = element_text(size = 10),
    legend.text = element_text(size = 9),
    panel.spacing = unit(1, "lines")
  )
# ---- Display plot in RStudio ----
print(plot)
# ---- Save plot as PNG ----
ggsave("Health_Score_FacetPlot.png", plot, width = 14, height = 10, dpi = 300)
```

Appendix D:

Figure 11 - Soil Comparison

This figure provides a close-up view of the soil and mulch used at the Kanaka Creek restoration site. Nutrifor with finer, sandier material, the all-purpose soil with larger woody components, and the Douglas-fir mulch identifiable by the brighter coloration.