Soil Moisture Content and Soil C/N Ratios in Selected North Saanich Parks

Friends of North Saanich Parks

Sharon Hope and Tamara Bonsdorf

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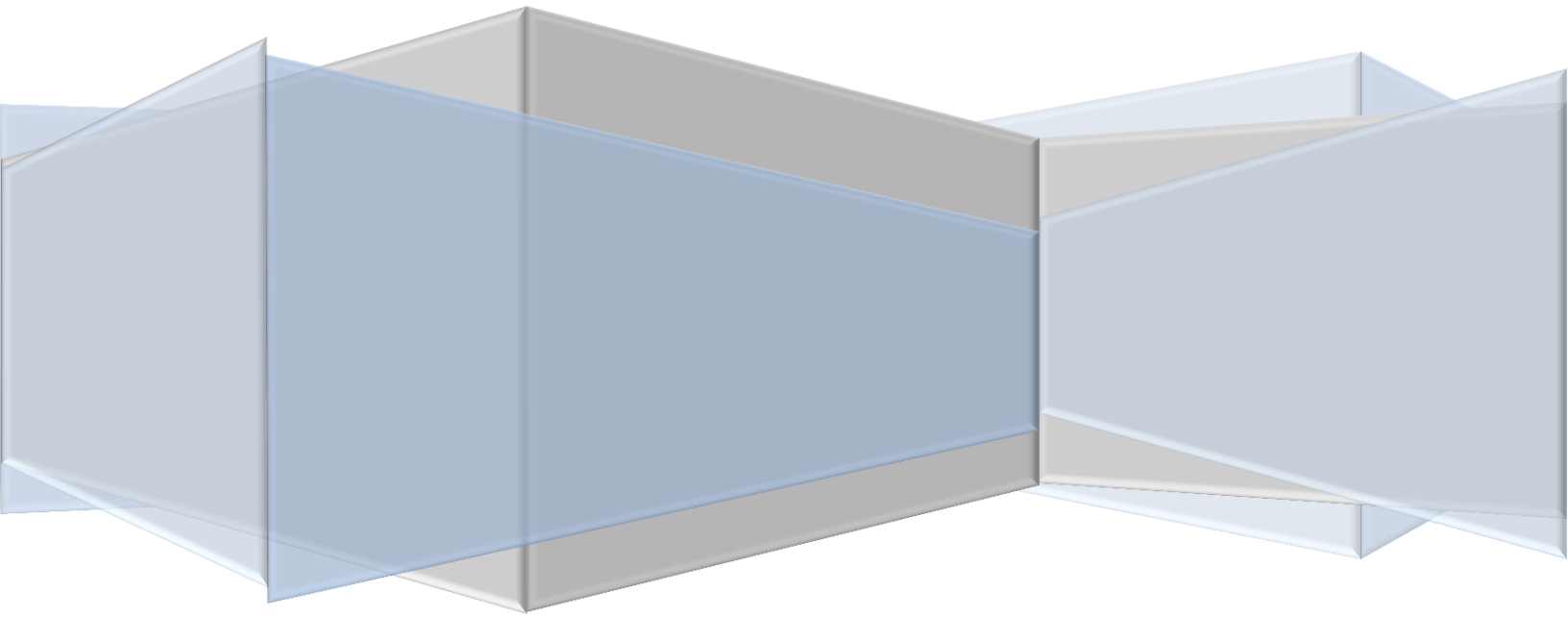

Introduction

The Friends of North Saanich Parks (FNSP) chose to investigate municipal park soil properties this year because much of the research information about Saanich Peninsula soils is linked to agricultural practices and perspectives. Furthermore, data was not preserved from the forest soil profiles taken on the Peninsula during the 1970s as a result of the Ministry of Forest's Biogeoclimatic Ecosystem Classification (BEC) Program. The goal of the FNSP soil studies in 2022, therefore, was to augment knowledge about North Saanich forested municipal parks and their ecosystems in order to increase the potential effectiveness of forest park management.

The first soil study this year submitted to the Mayor and Council described profile and horizon characteristics in eight parks and the second (this study) will report on a few soil profile water and chemical properties within the eight forested parks in which FNSP is working.

Drought occurrence has been monitored on the Saanich Peninsula for decades because of the area's rich agricultural history. In recent years, however, drought periods appear to be more intense, of greater duration and more frequent. In 1998 Canada experienced its second warmest winter and warmest spring, summer and fall on record. The 1998 temperatures were an average of 2.4 degrees warmer than normal and it was likely the warmest year of the century. This resulted in the costliest fire season on record for the century. Daust (n.d.) stated "All seasons have warmed, but winter has warmed the most. As a result of warming, seasons are changing. The frost-free period has lengthened by 21 days over the last half of the last century."

During the 21st century, changes in temperature and moisture patterns and subsequent ecosystem impacts continued. In the summer of 2003 it was abnormally hot and dry which resulted in over 2,500 wildfire starts mostly in the Interior of the province. The interface fires destroyed over 334 homes and many businesses, and forced the evacuation of over 45,000 people. The total cost of the 2003 firestorm was estimated at $700 million (Johnson et. al. 2006). Only last year, Braela Quan (2021) described the effect of drought on salmon fry in the Tsolum River on Vancouver Island.

As Tamara mentioned in Bonsdorf and Hope (2022), in 2021 Greater Victoria had the driest spring on record and suffered extreme summer temperatures that caused a drought rating of 4 out of 5 beginning in early July. By September 1st 2022 the government had declared that Greater Victoria including the Peninsula had entered a summer seasonal drought level 3 (https://www2.gov.bc.ca › drought-flooding-dikes-dams).

Temperature and precipitation, soil physical and chemical properties, available nutrients and available soil water for plant growth form a complex synergy. Jungen (1985) stated that locations with Brunisolic soils (which are found on the Saanich Peninsula) are traditionally characterized by warm dry summers with high moisture deficits. In addition to the impact of weather conditions on the environment, water available for plant growth is also a function of site factors such slope position, rooting depth, soil texture and coarse fragment content (Spittlehouse and Stewart 2003).

The FNSP first soil report confirmed that all the sampled soil pits in the eight forested parks belonged to the Brunisolic Order, as described by Day et al. (1959). Brunisolic soils typically have thin litter layers as well as various A horizons with humus (Ah) and usually a B horizon with little development (Bm). In the parks we sampled, some of the lower horizons at pits located near sea level, had mottling, typical of imperfectly drained conditions. In North Saanich, the Brunisolic soils appear to be of two basic types: fairly low lying imperfectly drained soils mainly derived from marine clays such as found in Denham Till and Lillian Hoffar and scattered moderately well-drained soils with siltier loams or sandier textures such as those of Quarry, Gulf View and RO Bull.

With respect to the second portion of this FNSP study, the C/N ratios, the term C/N is defined as the mass of carbon to the mass of nitrogen in any particular soil profile. Soil microorganisms which control the decomposition of carbon rich materials like litter have a C/N ratio near 8:1. They must acquire enough carbon and nitrogen from the environment in which they live to maintain that ratio of carbon and nitrogen in their bodies. As a result, microbes require a diet with a C/N ratio near 24:1, with 16 parts of carbon used for energy and eight parts for maintenance (nrcseprd331820.pdf usda.gov). If the ratio is high for carbon rich logs or litter such as 60: 1 microbes utilize any nitrogen in their environment for their own requirements. This retention is known as nitrogen immobilization and when nitrogen is immobilized there is no excess available for plants. Consequently the composition of the litter or decayed wood, microbial nutrient and water requirements and the environment largely govern the potential for nitrogen to be available for plants.

While defining the focus for the second soil project in 2022, I decided to explore soil moisture content values over the summer months in conjunction with some soil bulk density measures designed to produce volumetric moisture values. Given that nitrogen is a major nutrient important for plant life, knowing when it could be inaccessible to plants is important. Scientists have described lower decomposition rates with low moisture contents (Moore 1986). Prescott (2003) found litter decomposition more influenced by moisture than temperature. To provide additional information, I arranged for analyses of total soil carbon and total soil nitrogen by horizon at a few sites to see if they appeared to be within a normal range for Peninsula Brunisolic soils. I also explored what additional information could be learned from the soil profile C/N ratios.

Methods

To assess the moisture contents in the forested park soils, samples were taken from each major horizon within the profiles for Quarry, Gulf View, Lillian Hoffar, Nymph Point, Denham Till, RO Bull, Green and Prentice Pond Parks respectively. Location of the soil pits can be found in Bonsdorf and Hope 2022. Gravimetric moisture was chosen because FNSP required a simple inexpensive index of change in moisture content over time and I could convert some of these measures to volumetric moisture content through the use of the soil bulk density. Tamara and I collected samples at the beginning of May and at the end of August 2022. The samples were weighed and then dried at 70 C for 48 hours. We used two facilities: the Provincial Government Dept. of Natural Resources analytical laboratory facilities at North Road Victoria BC and the Restoration of Natural Systems Laboratory under the Program Director Nancy Shackleford at the University of Victoria.

Calculations of gravimetric soil moisture followed standard practice. Litter and fermented layer moisture contents were calculated as original weight–dry weight/original weight times 100. This was done to account for moisture within the plant tissue itself. Mineral soil moisture was calculated as original weight-dry weight/dry weight times 100.

Bulk density was sampled from each horizon of the three soil profiles found in Gulf View, Nymph Point and Denham Till Park respectively. The samples were weighed and dried at 70C for 48 hours and computed by the Dept. of Natural Resources analytical laboratory facilities. Volumetric moisture values were found by multiplying the gravimetric moisture content times the soil bulk density. No effort was made to infer these findings to broader land units such as hectares because of the small sample size compared to the meso-terrain variation existing over several hectares of park at each site.

As part of the final step in this project the Ministry of Environmental analytical laboratory on North Road in Victoria assessed the total carbon and total nitrogen from an additional set of air dried and sieved soil samples. These samples were collected in May. Samples were only taken from the three soil profiles in Gulf View, Nymph Pint and Denham Till Parks. C/N ratios were derived from the total carbon and total nitrogen data. The carbon-nitrogen analysis was undertaken to give some idea of the relative productivity and potential available nitrogen of the forested soils. These chemical results, like the moisture contents, should not be regarded as a comprehensive assessment because of the small sample size and lack of replication within the parks and over time.

Results and Discussion: Soil Moisture Content

The term field capacity refers to values of approximately 30%-42% volumetric moisture in soils depending on the amount of sand, clay and silt in the soil texture. At field capacity water is easily available to vegetation (Powers 1922). The volumetric moisture contents that we sampled in May for the sandy loam soil profile of Gulf View Park, for example, were above field capacity for the texture; Denham Till and Nymph Point Parks however with more clay in their mineral horizons were at less than field capacity according to their texture (Table 1). This finding might indicate that the amount of water in many park mineral soils with some clay content, although accessible for plant use in May, might have begun the summer season at somewhat less than optimum levels. All moisture contents for the LF layers for the three sites were low in May.

The term permanent wilting point refers to the moisture point in mineral soils where water in inaccessible to plants and plants wilt (Powers 1922). According to prior studies, the accepted permanent wilting point is reached at between 15-20% volumetric moisture content for clayish soils and 5-10% for sandier soils. Gulf View soils, according to hand texturing conducted during the profile descriptions, do not have high clay contents. This profile had values at the wilting point range by the end of August (Table 1). According to the volumetric moisture content values for the Nymph Point and Denham Till sites, the permanent wilting point range had also been reached by the last week in August within the mineral soils for these sites (Table 1).

I gave attention to the soil profile for Denham Till Park because the Douglas fir forest canopy is currently showing distress. The C layer in Denham Till has some cementation and mottling indicating imperfectly drained moisture conditions (Bonsdorf and Hope 2022). The C horizon had a higher bulk density than the other mineral soil C horizons that we sampled. The C layer only had a gravimetric

moisture content of 26% in May or 32% if the figure is expressed volumetrically. In August, the B horizon at Denham Till had only 7 percent volumetric moisture content which was certainly well below the wilting point of 15-20 percent for more clayish soils.

If one examines the August soil gravimetric moisture percentages for the other five parks, a trend can be seen toward low moisture contents probably below the wilting point volumetrically in many of the soil pits within the park sites we sampled (Table1). Some of the 8 parks had all their sampled mineral soil horizons likely at the permanent wilting point at the end of August. However it must be pointed out, further sampling and replication will be necessary to achieve a complete set of volumetric moisture content values for the soil horizons we sampled.

Results and Discussion: Total Carbon, Total Nitrogen and C/N Ratios

Litter decomposition, the main source of nutrients entering local North Saanich soils may take about 3-4 years to reach completion due in part to the influence of the CDFmm's Mediterranean climate. Since Tamara and I sampled the soils in May on southern Vancouver Island where winters are moist and mild, that process was likely underway from the fall of 2021.

In terms of tree species, Prescott (2006) described a study where litter samples from several conifers were assessed and she found that there was greater N mineralization in Douglas fir litter than redcedar. The dominant tree species in the CDFmm North Saanich park sites near seven out of nine soil pits was Douglas fir. One exception was Denham Till where a few Garry oak were close to the soil pit and there was some moss ground cover in addition to Douglas fir needle litter. The May L F C/N ratios for the three sites were, Gulf View 37, Nymph Point 43 and Denham Till 57 respectively. The total nitrogen level in the sampled litter at Denham Till was somewhat lower than the other two sites which had almost the same values (Table 1).

The C/N ratios for the mineral soils and their accompanying soil Great Group Associations are presented in Table 1 for the three sampled parks. I decided to use the B horizons to the end of the rooting depth in order to compare the figures among the parks. Gulf View (Association Beddis-C/N B horizon=15), Nymph Point (Association Saanichton- C/N average for the B horizon=16) and Denham Till (Association Fairbridge B horizon=16). These figures are virtually identical and indicate potential available nitrogen for plant uptake in the B horizons for the three sites.

Day et al. (1959) probably represents the closest study with comparable data to this 2022 study. The same Great Group Associations can be used to examine sites within North Saanich's CDFmm subzone and the three parks sampled. For example, in the 1959 study, an average soil C/N value of 19.5 was found for the Fairbridge Association B horizons (at depths of 1-19cm). These soils are similar to those classified in Denham Till Park. The authors also recorded the C/N ratios for Saanichton mineral soil

B horizons like those found in Nymph Point Park. Here the authors found horizons with an average C/N of 16. That figure is identical to our value. C/N values for Beddis mineral soils and litter layers were not found in the literature.

The Ah horizons in the three parks that we sampled in May had average C/N ratios of 20. This figure represents an almost ideal balance of microbial uptake of nitrogen for maintenance (immobilization) and nitrogen release (mineralization). Most tree and shrub fine roots in our soil pits were found in the Ah and upper B horizons; their placement would effectively capture potential available soil moisture and nitrogen. FNSP's first soil study found earthworms in all soil pit Ah and upper B horizons; earthworms are often considered a positive contributor to decomposition (Gonzales et al. 2003).

Based on the soil Great Group Associations for some of the other North Saanich parks (Bonsdorf and Hope 2022) and using the C/N ratios from Day et al., the 1959 study found the average B horizon ratios were as follows: Cowichan Association - C/N of 15 (the same Great Group as Lillian Hoffar Park) and Qualicum Association- C/N for the B horizon of 16.5 (the same Great Group as Prentice Pond Park). Such ratios would indicate potential available nitrogen for plants.

Those Great Group Association C/N values we obtained for Brunisolic soils in the three North Saanich Parks B horizons, therefore, seem to be compatible with those values reported in Day et. al. (1959). The authors considered these soils generally fertile for agriculture and FNSP increment cores for Nymph Point and Gulf View Parks have shown good growth for conifers.

In May of 2022 the mineral soil C/N ratios and the potential available nitrogen described here might have benefited plants but without available water during August, nitrogen uptake by plants would probably be very small to nil by the end of summer and into September. The study which Kevin Brown is undertaking will explore conifer needle nutrients and metals under these summer conditions.

Summary

Although this study requires expanded sampling to present more accurate information for all eight parks, the results do show low soil moisture content percentages in August. The majority of the figures are likely to be below the volumetric permanent wilting point as described for each soil texture type. Very low prolonged soil moisture levels have been known to limit tree growth, render trees and shrubs susceptible to disease and can even cause death of vegetation. Douglas fir may suffer reduced productivity over the long term from climate change (Spittlehouse 2013). In late spring, the C/N ratios about 20 or slightly less indicate that in mineral soils, nitrogen is likely to be available for plant uptake. However nitrogen uptake may be limited by very low soil moisture content in late summer. Spittlehouse and Stewart (2003) presented a table of suggested adaptive practices in forestry in response to climate change. A similar action would be useful to undertake for stands in North Saanich growing on public lands. The trends toward low soil moisture content levels at the end of August indicate that future planting of indigenous shrubs or trees in North Saanich parks for example, could be limited to those that are the most drought-tolerant and those most adapted to the individual site in question. The findings of this report are also relevant to the North Saanich Tree Protection Bylaw. Finally, the Douglas fir stands in Denham Till Park that are showing signs of considerable distress should be investigated further as a priority to better determine the precise causes of the stands' decline.

Table 1 Moisture content, soil texture, bulk density and C/N ratios by soil horizon for eight North Saanich Parks.

Park	Soil Horizon	May Moisture Content %	August Moisture Content %	Bulk Density	Volumetric Moisture Content May	Volumetric Moisture Content August	Soil Texture (Bonsdorf and Hope 2022)	Total Carbon %	Total Nitrogen %	C/N Ratios
Quarry	LF	41	8							
	Ah	46	11				Sandy loam			
	Bm	18	7				Sandy loam			
	C	13	6				Loamy sand			
Quarry (small profile)	LF	46	16							
	Ah	46	25				Loam			
Bedrock below the Bm	Bm	18	5				Silty loam			
Gulf View	LF	43	10	.11	.047	.011		36.33	.988	37
	Ah	46	6	1.07	.482	.063*	Sandy loam	5.28	.262	20
	Bm	23	5	1.21	.278	.054*	Sandy loam	1.22	.0836	15
	C	19	4	1.18	.225*	.051*	Sandy clay loam	1.21	.07	17
Lillian Hoffar	LF	56	10							
	Ah	55	10				Silty loam			
	Bg	41	11				Silty clay loam			
	Cg	18	10				Silty clay loam			
Nymph Point	LF	60	14	.13	.078	.018		42.7	.993	43
	Ah	32	8	.75	.240*	.059*	Silty clay loam	6.89	.319	22
	Bg	19	5	1.24	.232*	.065*	Silty clay	1.96	.095	21
	BCg	19	4	1.14	.217*	.048*	Silty clay	1.12	.0674	17
Denham Till	LF	56	1	.06	.033	.007		42.5	.734	58
	Ah	29	8	.91	.245*	.069*	Silty clay	3.31	.158	21

							loam			
	Bgj	25	7	1.03	.277*	.071*	Silty clay loam	2.21	.122	18
	Cg	26	15	1.42	.365*	.212*	Silty clay loam	.548	.0533	10
RO Bull	LFH	62	11							
	Ah	44	10				Loam			
	Bm_1	14	5				Sandy loam			
	Bm_2	10	6				Sandy loam			
Green Park Lower	LF	63	10							
	Ah	34	7				Loamy sand			
	Bm	13	4				Loamy sand			
	BC	22	6				Loamy sand			
Green Park Upper	LF	59	11							
	Ah	34	9				Loam			
	Bm	32	9				Loam			
	BC	20	6				Silty loam			
Prentic e Pond	LF	62	13							
	Ah	45	10				Loam			
	Bm	24	6				Loamy sand			
	C	15	5				Loamy sand			

*Asterisks indicate horizons with: 1) May figures that are at or below field capacity based on volumetric moisture contents for the respective soil texture 2) August figures that are at or below permanent wilting point based on volumetric moisture contents and the soil texture.

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These tins were used for measuring soil moisture content and bulk density at Nymph Point Park. The leaves shown on the tins are reflections from the Arbutus tree above.

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