Influence of Stand Age, Micro-climate, and Litter Composition on the Decomposition of Ten Litter Types in White Spruce Plantation Forests in Nova Scotia, Canada

by

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Submitted in partial fulfilment of the requirements
for the degree of Master of Science

at

Dalhousie University
Halifax, Nova Scotia
June 2018

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The influence of stand age, micro-climate and litter composition on calculated decomposition rates of litter types was determined to gain information regarding soil nutrient supply in white spruce plantation forests in Nova Scotia, Canada. The decomposition rates of ten litter types were calculated using the litterbag method in 12 sites, with results ranging from 0.19-0.82 year^{-1}. Site quality was indicated to have less of an impact on decomposition rate than stand age. Principal component analysis determined decomposition rates are correlated to litter type and litter quality. PC1 (nutrient content) accounted for 46% of the variation in rates, while PC2 (chemical complexity) accounted for an additional 25%. Litter calcium, manganese, and nitrogen concentrations increased with time, while potassium and magnesium significantly decreased. Litter with low Klason lignin and low C:N ratios had faster decomposition rates, indicating that Klason lignin and C/N ratios are suitable predictors of rate.

LIST OF ABBREVIATIONS AND SYMBOLS USED

Al	Aluminum
B	Boron
Bb/Ra	Blackberry/Raspberry
Bf	Balsam fir
Br	Bracken
Bu	Bunchberry
C	Carbon
Ca	Calcium
Cu	Copper
$D_{b(LFH)}$	Bulk density of the surface organic horizon (LFH)
df	Dilution factor
Fe	Iron
FORECAST	Forestry and Environmental Change Assessment
Go	Goldenrod
Gr	Grasses
K	Potassium
k	Rate of decomposition ($year^{-1}$)
LB	Litterbag
LoI	Loss on Ignition
Mg	Magnesium
Mn	Manganese
N	Nitrogen
Na	Sodium
ODW_{sample}	Oven-dry weight of sample
OS	Ottawa Sand
P	Phosphorus
Rm	Red Maple
Sc	Schreber's moss
Wf	Wood fern
WS	White Spruce

Zn	Zinc
ε	Absorptivity value

ACKNOWLEDGEMENTS

This project would not have been possible without the help and support of all my family, friends, and colleagues. I would like to express many thanks to Dr. David Burton, my research supervisor, for providing me with this opportunity from which I have learned so much. I am particularly thankful for Dr. Burton's thoughtful guidance, much appreciated constructive criticism, and continuous support throughout my time at Dalhousie. I am also grateful to my committee members, Dr. Gordon Price and Dr. Peter Duinker, for their advice and direction. Thank you to Dr. Thomas Bouman for being an external examiner and providing many insightful comments.

This work could not have been possible without the financial support provided by the Natural Sciences and Engineering Research Council, Dr. Burton, and Dalhousie University, awarded through graduate scholarships and bursaries.

I wish to extend my gratitude to faculty, staff, and fellow students within the PFES Department for always providing a friendly work environment. A special thanks to Kevin Keys for your expertise in Nova Scotia's forests – I have learned so much about our province and forest ecosystems from days spent in the field with you. Thank you to Jenna Dooks and Billy-Rae Rattray who helped with field work. To my lab crew, especially Drucie Janes, Jay Woodworth, and Yu Zhang for helping me for countless hours in the lab throughout this project. Very special thanks to Anne Lelacheur for many answers and instrumental help, and guidance through my chemistry teaching assistantship.

The friendships I have made in Truro: Carolyn Mann, Jay Woodworth, Hannah Mawhinney, Rachel Rix and all other fellow students – thank you, your support and wisdom have been greatly appreciated. To my friends around the globe, thank you for believing in me, and supporting me with endless chats, hikes, and hangouts.

Finally, I would like to thank my parents, Natalie and Brian, my sister Jacqueline, and my brother-in-law TJ, for putting up with me through the ups and downs of this degree, providing endless encouragement and patience throughout my entire academic career. To my Nanny, for endless baking ideas, and love. And to my Grampy, for always watching over me, I know you would be so proud.

This journey could not have been possible without any of you; from the bottom of my heart, thank you.

CHAPTER 1: INTRODUCTION

1.1 Problem Statement

The decomposition of forest floor litter is a key process in forest ecosystems (Rahman et al., 2013; Keiser and Bradford, 2017). Litter fall is the largest source of nutrients and organic material inputs to the forest floor and the forest floor is the primary source of nutrients for growing vegetation. The three main factors that regulate litter decomposition are climate, microbial community, and litter quality (Zhang et al., 2008; Prakash et al., 2015; Keiser and Bradford, 2017). Climatic factors that are considered to have greatest impact on decomposition are temperature, precipitation, and evapotranspiration, and have a dominant effect on litter decomposition rates at a regional scale (Berg and McClaugherty, 2008; Zhang et al., 2008). At a local scale, litter quality is the main determinant of litter decomposition rates in forests (Berg and McClaugherty, 2008; Yang and Chen, 2009). Microorganisms, including bacteria and fungi, are the primary agents of litter decomposition, and in particular, are species capable of decomposing lignin and cellulose materials (Prakash et al., 2015).

White spruce (*Picea glauca*), a softwood tree species, is commonly used in plantation forests to produce pulpwood and other timber products. Spruce plantations are important in securing long-term conifer fibre supply for sawmills and pulp mills in Nova Scotia. This species of spruce is native to northern temperate climates in North America and is popular in the forest industry due to its ability to grow in diverse conditions, although it thrives best in moist, fertile locations (Stiell, 1976). White spruce is characterized by neatly organized needles and cigar-shaped cones. To maintain preferred species composition in plantation forests, forest management frequently requires the planting of tree seedlings (NSDNR, 2016). According to NSDNR, tree species chosen for planting are proportional to the species of primary forest products acquired (Lemieux et al., 2016). Thus, forest managers have considerable influence on the litter quality in the forest ecosystem as they control the tree species in regeneration plantings.

Developing sustainable management plans for the Nova Scotia forestry industry is important. Soil nutrient sustainability is a critical issue due to high rates of nutrient removal in timber harvests, acid rain, the acidic nature of Nova Scotia's soils, and other environmental factors. Assessing nutrient availability in the development of management plans for sustainable crop yields should consider multiple variables including the influence of climate, plantation age, site quality, and litter type. Assessing the decomposition rate of forest floor litter in white spruce plantations provides a baseline for quantifying nutrient supply for plant uptake. Determining long-term forest sustainability relies on an empirical understanding of nutrient cycling as a foundation for developing ecological/silvicultural-planning tools, such as the ecosystem-based model FORECAST (Forestry and Environmental Change Assessment; Welham et al., N.D.).

Integrating nutrient management practices into current forestry practices will allow for sustained productivity of plantation forests over multiple rotations (Morris, Kimmins, and Duckert, 1997). This study of litter decomposition will provide localized estimates of litter decomposition to the FORECAST model which incorporates ecosystem processes such as plant growth and carbon allocation, light, nutrient and moisture limitations, and competition for resources as a research tool in order to generate forest management plans (Kimmins et al., 1999; Welham et al., 2002). The goal of sustainable forest management is to produce forest ecosystems that are resilient to global stresses such as climate change, atmospheric pollution, and land use pressures. Sustainable management plans aim to balance economic, social, and ecological goals within the same process (NSDNR, 2012). Assessing nutrient supply rate is important in establishing the sustainability of a forest management plan, although it is not often considered across Canada.

To maintain long-term productivity, it has been hypothesized that most forest soils require supplementary fertilization (Cole, 1995). Whether this is true of plantation forests in Nova Scotia is being explored as part of an NSERC-funded program using the ecosystem-based model, FORECAST. The program examines whether nutrient depletion occurs throughout different stages of plantation forest development, providing insight on appropriate fertilization techniques and sustainable management practices. This project will fill an important knowledge gap relating to the role of litter quality and site condition in determining litter decomposition rates and soil nutrient supply in Nova Scotia.

1.2 Research Objectives and Hypotheses

The objectives of this study were to collect a comprehensive dataset to identify current ecological conditions in white spruce plantation forests in Nova Scotia, Canada. The dataset collected provides data to support the parameters to (1) determine the rate of decomposition and change in litter composition of ten litter types in white spruce plantation forests in Nova Scotia, (2) examine the influence of litter nutrient concentrations on decomposition rate, (3) examine the influence of plantation age and site quality on the rate of decomposition of different litter types, and (4) provide a dataset to support the parameterization of the litter decomposition in FORECAST for Nova Scotia conditions.

It was hypothesized that: i) higher lignin content, and higher C/N ratio values result in slower decomposition rates, ii) litter types with higher nutrient concentrations will decompose at faster rates, iii) the rate of decomposition will be more rapid in older plantations, and iv) litter quality will have a greater influence on decomposition rate than will site condition.

CHAPTER 2: LITERATURE REVIEW

2.1 Decomposition

Decomposition, a major process in all ecosystems, is controlled by both abiotic and biotic factors. Decomposition processes are responsible for nutrient cycling, aiding with soil and forest floor formation, and maintaining a diverse microbial community (Prescott and Grayston, 2013; Kohl et al., 2015). Decomposition is regulated by factors such as temperature and moisture, substrate quality in terms of chemical composition of plant litter, and microbial community composition (Swift et al., 1979; Cortez et al., 1996; Prescott 1996). The process of decomposition results in a transformation of litter under the influence of these interacting factors (Dai and Huang, 2006; Hilli et al., 2010).

2.2 Forest Floor Layers

Decomposition processes in forest ecosystems result in gradation of stages of decomposition in forest floor, represented by the L, F, and H layers. The top “L” layer refers to the litter layer, which is recently fallen plant litter. The intermediate “F” layer corresponds to the fermented material where fungi and other fauna are most active, and where the initial litter species decay occurs (Prescott and Grayston, 2013). The F layer is comprised of partially decomposed leaf and twig material. The bottom most “H” layer represents the stabilized, humic material – the recalcitrant organic material that remains following the decomposition process. Plant litter enters the decomposition subsystem as dead organic matter, otherwise known as detritus (Makita and Fujii, 2015). Microorganisms feed on this material to utilize the energy, carbon, and other nutrient sources for growth (Swift et al., 1979). Harvesting directly impacts the forest floor layers due to ground disturbance, leaving the LFH layers to be smaller and less distinguishable in younger sites as determined through bulk density measurements in different aged plantation forests.

This work focused on the decomposition of plant material and characteristics of the forest floor layers. The forest floor is the primary source of nutrients in forest ecosystems (Swift et al., 1979). It is understood that the mineral soil plays an important role in forest ecosystems. The effects of soil include both chemical and physical properties, such as the texture as it influences water and nutrient dynamics, pH, cation exchange capacity, and organic matter content (Berg and McClaugherty, 2008). These factors can influence the microbial composition, and the mobility of nutrients (Berg and McClaugherty, 2008).

The decomposition of forest floor litter can be categorized into three phases that correspond to the loss of specific litter fractions, altering the rate at which the litter can decompose (Long-Term Intersite Decomposition Experiment Team (LIDET), 1995; Trofymow and CIDET Working Group, 1998; Berg et al., 2015). The first phase, lasting only a few months, referred to as the nutrient-controlled phase (Berg et al., 2015), has a rapid rate of decomposition due to the microbial consumption of the litter species, and by rapid weight loss through the leaching of soluble compounds (de Santo et al., 2009). The second phase, lasting up to a few years, consists of slower decomposition rates, and an increase in the loss of carbon from the cell walls. Generally, the first two phases do not result in a significant decrease in nutrient content, unless leaching out of the plant material occurs, but nutrient contents may increase due to the microbial community present, as they can immobilize external sources of nutrients (Trofymow et al., 1998).

Nutrient concentrations can also increase because of carbon loss from the organic material. The third phase of decomposition, which lasts for several decades, occurs when lignin and secondary, recalcitrant materials remain. Lignin, due to its complex structure, is difficult to decompose, thereby controlling the decomposition rate in the later phases of decomposition (Trofymow et al., 1998; Berg et al., 2015). Lignin is slowly decayed by bacterial and fungal species, and therefore contributes to a major fraction of the material that becomes humus as it decomposes (Rahman et al., 2013). In a decomposition study completed on Scots pine, it was estimated that an average of 15.3% of the litter became stabilized as non-decomposing organic material (Berg et al., 1999).

The main polymers in plant litter are cellulose, hemi-cellulose, and lignin. Cellulose is degraded by different species of bacteria and fungi which rely on extracellular enzymes to help degrade litter materials by attacking the cellulose polymer (Berg and McClaugherty, 2008). The degradation of hemicellulose requires several different hydrolytic enzymes to break down the molecule, which are more complex than those needed to hydrolyze cellulose (Berg and McClaugherty, 2008). The three main decomposers of lignin are white-rot, soft-rot, and brown-rot fungi. The white-rot is one of the most capable lignin degrader and is capable of completely mineralizing lignin to CO_2 and H_2O (Berg and McClaugherty, 2008).

Forest ecosystems carry much greater aboveground biomass in comparison to grassland ecosystems due to the available water as a result of higher rates of precipitation relative to evapotranspiration (Kohl et al., 2015). The composition of the litter input from above and belowground sources structures the ecosystem. Soil is a major part of the ecosystem structure, which results from the type of vegetation present, thus providing information regarding the soil organic matter formed through plant litter decomposition (Ge et al., 2013). The combination of soil properties forms a habitat for a variety of microorganisms that are key to decomposition processes. A change in the composition of aboveground plant communities can affect the structure, activity, and functions of the microbial community of the soil (Fanin and Bertand, 2016). As with plant succession, microbial communities in the soil adapt to the changing dominant plant species, adapting to the decomposition of available plant litter (Fanin and Bertand, 2016).

2.3 Nutrient Cycling

In terrestrial ecosystems, decomposition leads to the mineralization of essential elements – the conversion of a nutrient from an organic form to an inorganic, plant available form. Litter nutrient concentrations are important drivers for decomposition rates in early phases of decomposition. Initial decomposition dynamics are largely controlled by the release of soluble organic compounds (Keiser and Bradford, 2017). The chemical and physical makeup of different litter species provides insight to litter quality, as these factors influence decomposition rates. For example, plant litter types with higher lignin content and low nitrogen tend to decompose slower than litter with low lignin and high nitrogen content (Hendricks and Boring, 1992; Rahman et al., 2013).

Nutrient cycling within an ecosystem is primarily influenced by the chemical composition of the plant litter. Nutrient cycling starts with the uptake of nutrients by plant roots and the mycorrhizal fungi (Figure 1). This allows the allocation of nutrients throughout the plant to occur, permitting plant growth. Season patterns in plant growth cumulate in reabsorption of nutrients from senescing litter, followed by nutrient return to the forest floor through above- and below-ground litter deposition. Once the litter has returned to the forest floor, decomposition begins, allowing the microbial community to release the nutrients through the process of mineralization, turning the nutrients into a usable, inorganic form which allows them to be taken up by plants, where the process begins again (Barnes et al., 1998; Rahman et al., 2013).

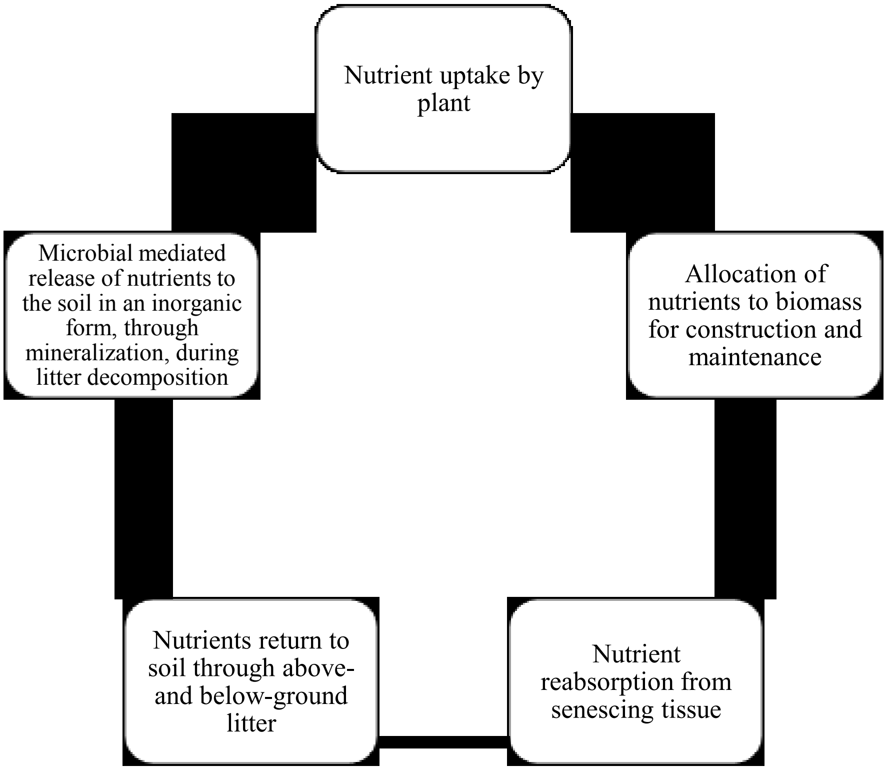


Figure 1. Nutrient cycling process adapted from Barnes et al. (1998).

Forest nutrient dynamics are of interest due to the reliance on forest litter decomposition to replenish nutrients transforming nutrients into usable forms for plant uptake (Cole, 1995). Forest floor litter is the major input of nutrients into forest soils (Ukonmaanaho et al., 2008; Yroz et al., 2011; Fanin and Bertand, 2016). Monitoring the amount and quality of litter fall and its rate of decomposition can provide information regarding nutrient cycling and nutrient availability in forest ecosystems (Ukonmaanaho et al., 2008).

The total annual litter production in plantation forests varies with stand age and type (Saarsalmi et al., 2007; Ukonmaanaho et al., 2008). In the study completed by Ukonmaanaho et al. (2008), the range of litter fall for all spruce plots was 651 to 4912 kg ha^{-1}, averaging 2986 kg ha^{-1}. This value compares well to the estimated long-term litter production in spruce stands of 2400 kg ha^{-1} yr^{-1} (Saarsalmi et al., 2007).

Nutrients are made unavailable for uptake, or are lost from an ecosystem, due to harvesting, leaching, immobilization by microorganisms, and sorption (Cole, 1995; Hynes and Germida, 2013). Nutrient uptake can be increased by the symbiosis between tree species and mycorrhizal fungi. Mycorrhizal fungi can account for up to 80% of a fungal community, and an estimated of 30% of the total biomass of microbes found in forest soils (Prescott and Grayston, 2013). The fungus acts as a bridge between the plant and the soil solution, providing an increase in surface area for the absorption of biologically available nutrients, promoting growth, productivity, and an increase in overall plant health (Behie and Bidochka, 2014).

Substrate quality is partly reflected in the carbon-to-nitrogen ratio (C/N) and influences the decomposition of forest floor litter. Higher decomposition rates are a result of an increase in available N (largely NH_4^+, and NO_3^-) (Paul, 2007), implying that nitrogen limits the activity of the decomposer organisms, indicative of a dominant control, over decomposition processes in early phases (Nave et al., 2009). Faster decomposition rates tend to be observed in litter types with smaller C/N ratios

(C/N<25:1) due to higher nitrogen content. This reflects not only the content of nitrogen but also the nature of the compounds comprising the litter. Metabolically active plant constituents, such as proteins, are rich in N. Complex, structural elements of plant tissues such as lignin have low N content (Swift et al., 1979). Decomposition rates are slower when substrate quality is lower, as seen in litter types with higher C/N ratios (C/N>25:1), as a result of both chemical complexity and nitrogen availability limiting biosynthesis and the growth of the decomposer community (Paul, 2007; Yang and Chen, 2009). This results in a decrease in decomposition rates over time as the more recalcitrant material persists. The C/N ratio of the litter also changes over time, which reflects the rate of decomposition (Swift et al., 1979).

Calcium (Ca), magnesium (Mg), potassium (K), and phosphorus (P) are readily studied in decomposition studies, as they are essential nutrients for life. Paul (2007) discusses how phosphorus is vital for life and has been noted as the dominant element controlling carbon (C) and nitrogen (N) immobilization in biological systems. Litter phosphorus and nitrogen concentrations are said to have a strong influence on initial litter decay (< 3 months), as higher concentrations of these elements are associated with faster decomposition rates, where lignin and C/N ratios determine later rates of decomposition (Aerts and de Caluwe, 1997; Ge et al., 2013; Rahman et al., 2013). Wang et al. (2008) concluded that C amounts were typically returned to the soil in the highest amounts, followed by N, and Ca, and the returns of P, K, and Mg to soil through decomposition processes were reported to be much smaller.

Berg et al. (1996) first detected a positive correlation between manganese (Mn) concentrations and litter decomposition rates (k). The positive relationship between Mn and k can be explained by the positive influence manganese has on lignin degradation (Trum et al., 2015). Manganese peroxidase (MnP) is an enzyme of the lignin degrading system that is secreted by white-rot fungi, which oxidizes Mn^{2+} to Mn^{3+} ions that are highly reactive and can oxidize phenolic units in the complex lignin structure (Perez and Jefferies, 1992; Trum et al., 2015). Manganese promotes lignin degradation by stabilizing lignin-degrading enzymes, which enhances enzyme production (Perez and Jefferies, 1992).

Soil microbial communities mediate the processes of nutrient cycling, organic matter decomposition – determining the distribution of nutrients within the ecosystem (Paul, 2007). Although climate, substrate quality, and the microbial community collectively drive the rate of decomposition, the microorganism community dominates at the local scale in the later stages of decomposition (Harmon et al., 2009; Keiser and Bradford, 2017). Keiser and Bradford (2017) discussed how climate is a structuring agent for microbial community function, and site-specific environmental factors could be an influential driver of later decomposition dynamics.

Microorganisms in soil are present in extremely high numbers, which can range up to 10^9 microbes per gram of soil, and the density of unique microbial genomes found in forest soils range from 10^3 to 10^7 species per gram of soil (Paul, 2007; Roesch et al., 2007; Levy-Booth et al., 2014). Forest soils are found to be more phylum-rich, and less species-rich compared to agricultural soils (Roesch et al., 2007; Levy-Booth et al., 2014). The microbial cycling of nutrients has a direct impact on the properties of forest soils, influencing tree growth, productivity, soil carbon sequestration and greenhouse gas emissions (Levy-Booth et al., 2014).

Prokaryotes and fungi are typically responsible for decomposition processes. Fungi play an important role in plant decomposition as they can decompose lignin and cellulose (Prakash et al., 2015). As litter decomposition progresses, the chemistry of the litter material is permanently altered, and the active microbial community changes to occupy the gradually decaying plant material (Prakash et al., 2015). The diversity of the microbial community is related to the quality and amount of forest floor litter to be decomposed (Ge et al., 2013). Prakash et al. (2015) concluded that a succession of fungi was observed during litter decomposition, as the fungal community niche adapted to the nutrient status and chemistry of the decomposing litter studied across multiple stages of decomposition.

2.4 Chronosequence Approaches and Litterbags

Chronosequence methods are based on a space-for-time substitution, assuming plantations proceed with similar ecosystem succession to reach mature plantations through three phases (i.e. early, middle, and late) (Walker et al., 2010; Neily et al., 2011). Sites of different ages are compared to represent each of the phases of decomposition. This type of approach allows for multiple analyses to be performed in a time-sensitive manner, while gathering information regarding plant succession and forest floor development (Walker et al., 2010). Using this type of method allows the opportunity to simultaneously determine the rate of decomposition for multiple age classes rather than relying on studies that would otherwise occur over decades. A major risk associated with chronosequence methods are the assumption that stand conditions will be consistent between different sites throughout the entirety of the harvest.

The method most commonly used in forest litter decomposition studies is the litterbag technique, first used by Bocock and Gilbert (1957). Litterbag methods have been widely used to measure the decomposition of litter of various species in a variety of ecosystems (Moore et al., 2005; de Santo et al., 2009; Wang, Ryan and Han, 2010; Loaiza-Usuga et al., 2013; Wu et al., 2013; Ramirez et al., 2014). These methods are generally used to investigate long-term (>2 years) decomposition studies (Prescott, 2005), although short-term studies frequently adopt this method (Zhang et al., 2008; Purahong et al., 2015). The Canadian Intersite Decomposition Team (CIDET) and The Long-term Intersite Decomposition Experiment Team (LIDET) in the United States have adopted the litterbag method as a standard method (LIDET, 1995; Trofymow et al., 1998).

Long-term studies are used to observe decomposition patterns over an extended period to examine the efficiency of the microbial community, and to provide information regarding nutrient cycling, where short-term studies examine initial litter decomposition trends (Trofymow et al., 1998; Prescott, 2005). The purpose of litterbag studies is to determine the rate of decomposition of litter species, in the context of local site conditions. This provides information that is useful in assessing nutrient cycling under realistic conditions and predicting future productivity, which can be obtained using mathematical modeling (Welham et al., 2002).

The litterbag methods adopted in this study closely resemble those developed in the LIDET and CIDET studies (LIDET, 1995; Trofymow et al., 1998). Both networks recommended using 20 cm x 20 cm litterbags, which adequately support 10 g to 15 g of air-dried litter material. These standardized protocols for the use of litterbags have been adopted in various decomposition studies (Moore et al., 1999; Moroni and Zhu, 2012;

Moore et al., 2017). Different mesh sizes and colours can be chosen depending on the size of the decomposing organisms and microorganisms of interest, and differences in UV radiation at different latitudes depending on site locations. The mesh size used in the studies completed by CIDET and Moore et al. (1999) was 0.25 mm x 0.50 mm, which provides a suitable reference for Canadian decomposition studies (Moore et al., 1999).

A challenge in litterbag techniques is determining the proper mesh size for the project. Decomposition occurs through the breakdown of plant materials, achieved through microbial activity, herbivores, and other organisms. Choosing a small mesh size (for example 0.25 mm x 0.50 mm) will exclude larger organisms from accessing the litter inside of the litterbag. Choosing a larger mesh size can be unfavourable, as smaller litter pieces cannot be contained, leading to an underestimation of decomposition by failing to include the influence of comminution, or overestimation because of the loss of undecomposed material. Other litterbag designs have been used to incorporate two different mesh sizes, allowing different sized decomposer organisms to access the litter (LIDET, 1995).

Litter decomposition can be measured by considering the litter of a single plant species or mixtures of species. Single species litterbags allow for the determination of the rate of decomposition for a given litter species under field conditions. This approach is often used to provide decomposition for models that are going to be applied to sites ranging in species composition such as FORECAST. The decomposition of the site-specific species combination is determined arithmetically. This approach does not assess the interaction of mixed species, where litter interactions may promote or hinder decomposition rates (Ge et al., 2013). The decomposition of pure litter types were used to determine decomposition rates (k, year^{-1}) for each litter type used in this study to provide decomposition data to be used in the FORECAST model.

The decomposition process can be quantified by a) monitoring the change in litter mass and b) monitoring changes in nutrient concentration over time. Rates of decomposition (k) are measured based on the mass loss of dried plant material placed in the litterbag during a period of deployment in the ecosystem. Litterbags allow for the reintroduction of plant material back into the ecosystem in a controlled manner.

CHAPTER 3: METHODS

3.1 Introduction

The decomposition of forest floor litter types in white spruce plantation forests in Nova Scotia, Canada, was monitored through a litterbag field study over 30-year chronosequence. Four chronosequences containing one site from each of three age classes of 1-6, 13-18, and 28-31 years were identified. Various site factors were monitored throughout this experiment including: weather information (air temperature, precipitation, soil temperature, and soil moisture), site quality (soil type, organic matter and nutrient content of the separated forest floor layers, pH), litter quality (C/N ratio, nutrient content, lignin content), duration of litterbag deployment, and stand age (years since planting). Although data have been obtained for all factors, this thesis focuses on calculating decomposition rates of different litter species in Nova Scotia's white spruce plantation forests, the influence of stand age and site quality on decomposition processes, and how litter quality influences decomposition rate over time, as determined through the duration of this project.

White spruce plantation forests managed by Northern Pulp Nova Scotia Corporation (Northern Pulp) were used in this experiment. Twelve sites were chosen, in the summer of 2015, based on plantation age (obtained from the company's planting history), and site quality (assessed by K. Keys, NSDNR). Four groups of three sites each were established with site quality classes of poor-medium, and medium-rich with a chronosequence of stand ages early, middle, and late ages within each group.

Ten plant litter types were selected based on prevalent plant species found throughout different sites. Litter was collected during August-November 2015. The litter types cover a wide range of plant types including coniferous needles, deciduous broadleaves, herbaceous species, forbs species, bryophytes, and graminoids. Ottawa sand (inert material used as a control), white spruce needles and twigs, and three other litter types were assigned to each site (Idol et al., 2002). The latter three litter types were assigned based on the likelihood of finding that species growing on the corresponding site quality class (e.g. bracken fern is more likely to be found on a poorer quality site) and incorporating the different types of litter species within each grouping.

A total of 1440 litterbags were deployed, using a randomized complete block design, to permit six sampling periods corresponding to spring 2016, summer 2016, fall 2016, and spring 2017, which are included in this study. Bags for additional samplings dates of spring 2018 and spring 2019 were also deployed. The assembled litterbags were deployed in fall 2015. Eight climate stations were installed then as well, with locations chosen based on sites and ages to ensure that most site locations were represented. After collection, litterbags were analyzed to identify the change in dry mass with time, and to determine changes in nutrient content of the litter, with a focus on calcium (Ca, mg g^{-1}), magnesium (Mg, mg g^{-1}), potassium (K, mg g^{-1}), phosphorus (P, mg g^{-1}), manganese (Mn, mg g^{-1}), carbon (C, %), nitrogen (N, %), C/N ratio values and Klason lignin (KL, %) content. Values obtained for aluminum (Al, mg g^{-1}), boron (B, mg g^{-1}), copper (Cu, mg g^{-1}), iron (Fe, mg g^{-1}), zinc (Zn, mg g^{-1}), sodium (Na, mg g^{-1}), sulphate (SO_4^{2-}, mg g^{-1}), and acid soluble lignin (ASL, %) will not be discussed here, but results can be found in

Appendix C. These values were not included in the analysis as other variables measured in this study were the primary focus.

3.2 Site Information and Characterization

A total of 21 candidate sites were assessed ranging in site quality from poor-medium to rich and in plantation age from 1 to 31 years. Site quality was determined based on plantation soil-type assessments and adjacent stand conditions. This information allowed for estimation of relative nutrient and moisture regime positions (ecosite unit) as described in the forest ecosystem classification (FEC) guide for Nova Scotia (Neily et al., 2013). Assessments were conducted by Kevin Keys, an expert in site classification and co-author of the FEC guide. From these 21 candidate sites, the best 12 were selected based on similarities in site characteristics and plantation age requirements.

Appendix A describes the characteristics for each site, including: plantation maps and aerial images, plot ID, year planted, the location and associated county within Nova Scotia, the exact UTM coordinates (Zone 20), elevation (above sea level), site quality, soil group, soil type, and percent canopy cover. The sites were all managed by Northern Pulp (Nova Scotia, Canada).

A compositional analysis was completed through forest floor sampling, where information for the litter (L) and the combined fermented (F) plus humic (H) layers were recorded. The information obtained on the two layers were: bulk density, organic matter content though loss on ignition, pH, calcium (Ca, mg g^{-1}), magnesium (Mg, mg g^{-1}), potassium (K, mg g^{-1}), phosphorus (P, mg g^{-1}), sulphate (SO_4^{2-}, mg g^{-1}), aluminum (Al, mg g^{-1}), copper (Cu, mg g^{-1}), iron (Fe, mg g^{-1}), manganese (Mn, mg g^{-1}), zinc (Zn, mg g^{-}

^{1}), carbon (C, mg g^{-1}), nitrogen (N, mg g^{-1}), and C/N ratio. The plantation maps for each site (Appendix A) were obtained using ArcMap and a plantation polygon layer supplied by Northern Pulp.

The twelve white spruce plantation stands were chosen for this study based on site quality characteristics, plantation age, and plantation type (Table 1). Sites were selected in summer 2015. Site quality was established based on ground vegetation present and soil profile characteristics (Prescott, 1996). Litter species used in this study were determined by identifying prevalent species found at the sites.

Table 1. Site number with corresponding plot ID, age, location, site quality (PM (poor medium), M (medium), MR (medrium rich), R (rich)), and UTM coordinates (Zone 20).

Site Number	Plot ID[1]	Year Planted	Age[2] (year)	Location (within NS)	Northing[3]	Easting[3]	Site Quality[4]
1	14960	2014	1	Greenfield	5018021.8	495429.5	M
2	1370	2009	6	River Lake	5003458.5	513628.8	PM
3	3167	1999	16	Dickey Lake	5016881.7	515025.8	M
4	1111	1998	17	River Lake	5003191.9	514991.8	PM
5	4289	1986	29	Riversdale	5032780.0	497229.6	M
6	2457	1984	31	Loon Lake	5005993.4	520848.4	PM
7	14951	2014	1	Greenfield	5016433.6	494068.7	R
8	14509	2013	2	Riversdale	5017920.7	502651.3	MR
9	4883	2002	13	Polson	5040609.7	488582.8	MR
10	4305	1997	18	Camden	5014643.9	490246.1	MR
11	5171	1987	28	Mount Thom	5040915.6	499875.5	R
12	2783	1986	29	Dickey Lake	5013518.1	517356.2	R

[1] site number with the corresponding plot ID (based on Northern Pulp records)
[2] the stand age in 2015, location within Nova Scotia
[3] UTM coordinates (Zone 20)
[4] Site quality was established based on ground vegetation, and on the soil profile (Prescott, 1996)

The four chronosequences each included three age classes (young < 6 years; middle-aged 13-18 years; old 29-31 years) were situated on poor-medium (1-6) or medium-rich (7-12) quality sites. In each chronosequence similar litters types were monitored (Table 2).

3.2.1 Forest Floor Sampling

Forest floor sampling was completed in June 2016. The purpose of forest floor sampling was to gain a further understanding of the surface organic horizon (LFH) (Curran and Maynard, 2008). The analyses completed on the collected samples are: loss on ignition (LoI) to determine an estimate of organic matter content, pH, total carbon (C) and nitrogen (N), nutrient content, and bulk density.

Forest floor sampling included the collection of eight (20 x 20 cm) samples per site. Samples were collected from both the L and FH layers, providing a total of 16 samples per site. Eight locations were randomly selected and were assigned to a location on the transect line where a litterbag had been collected during spring 2016 sampling. Plot plans, data sheets (to record depth of the L, F, and H layers, and any additional notes), and collection bags (12 lb clear plastic bags) were organized and labelled before entering the field.

The procedure for forest floor sampling was: a 20 x 20 cm metal frame was placed on the surface of the forest floor and any greenery present (above-ground plant material such as grasses and live moss) was removed from the litter layer (Curran and Maynard, 2008). Cutters were used to cut along the inside of the metal frame. The litter layer (L) was collected first, separate from the foliar material (F) and humic material (H) layers.

Four depth measurements were taken on the inside, middle, of the frame, which provided values for the average depth of the litter layer. The F and H layer were collected together by peeling back until mineral soil was exposed, ensuring no mineral soil was included in the sample. Again, four measurements were taken on the middle of the inside of the frame. The F and H layer measurements were taken separately, unless difficult to distinguish between the two, then both layers were measured together. This process was completed eight times per site. The total number of samples collected was 192 (96 L, 96 FH). The samples were stored in a cooler with ice packs until returning to the lab.

Upon arrival to the lab, paper bags were weighed and labelled according to the sample bag ID. The samples were placed into the appropriate paper bags and weighed for initial mass using a scale to two decimal points (g). The samples were air dried, and were weighed periodically until a constant mass was obtained.

Once the forest floor samples were dried to constant weight, they were ground up using a forage grinder that includes a sieving process, to obtain a homogeneous consistency. This prepared the samples for further analysis.

3.2.2 Bulk Density

The bulk density calculated for the forest floor of each site considered the mass of each layer obtained separately (L separate from FH). Bulk density was obtained by using the final (dry) values of mass obtained for each field sample. The equations used in the calculation of bulk density ($D_{b(L,FH)}$) are:

$$V_{LFH} = 400cm^2 Dep_{L,FH}(cm)$$

$$D_{b(LFH)} = \frac{Wt_{(L,FH)}}{V_{L,FH}}$$

where $V_{L,FH}$ is the volume of the hole (cm^3), $Dep_{L,FH}$ the depth of the hole, $D_{b(L,FH)}$ the bulk density of the surface organic horizon, and $Wt_{L,FH}$ the dry weight of the surface organic material (L, FH) (Curran and Maynard, 2008).

3.2.3 Forest Floor pH

The pH of the forest floor samples was determined according to Hendershot et al. (2008) and Kalra and Maynard (1991). Each sample (1 g) was weighed into 125 mL French square bottles. The sample was then saturated using $CaCl_2$ (0.01 M) and left to stand for 1 hour. $CaCl_2$ (20 mL, 0.01 M) was added to the sample, and left to stir for 10 seconds once the material had absorbed the solution. The samples were left to stand for 30 minutes and stirred occasionally. The sample was then left to settle for 1 hour. The electrode was then immersed into the clear supernatant and the pH was recorded once the reading was constant.

3.2.4 Organic Matter Content (% LoI)

Loss on ignition (LoI) is a direct estimation of organic matter. Following the methods developed by Ball (1964) and Federer et al. (1993), 1 g of organic sample was weighed in a pre-weighed and numbered crucible. The samples were dried in an oven at 75 °C for 2 hours. The samples were then removed to a desiccator to cool, and the weight was recorded. The samples were then placed in a muffle furnace set at 550 °C for 4 hours. They were then removed to a desiccator to cool, and the final weight was recorded using a three-decimal-place scale (g). The calculation used to determine the organic matter content is based on the percent loss of weight:

$$Loss\ of\ weight = (Wt_{soil+crucible\ @\ 110℃}) - (Wt_{soil+crucible\ @\ 550℃})$$

$$LoI\ (\%) = \left(\frac{Loss\ of\ weight}{Wt_{soil\ @\ 110℃}}\right) \times \%$$

3.2.5 Compositional Determination

Acid digests and total nutrient analysis (Section 3.7), as well as total carbon and nitrogen (Section 3.9), were completed on the dried, ground forest floor layers (L, FH). The summarized data for each site are in Appendix A.

3.2.6 Weather Station Information

Weather stations were used to collect information on air temperature, precipitation, soil moisture, soil temperature, and soil electrical conductivity. Eight sites were chosen to be geographically representative of the 23 sites, as well as taking into consideration the different stand ages. The eight sites chosen were: 1, 2, 3, 6, 8, 9, 10, and 11. These cover the areas of Greenfield, Riversdale, Dickey Lake, Camden, Loon Lake, Mount Thom, River Lake, and Polson Mountain. The data loggers (EM50s; Decagon, Pullman, WA) were fitted with air temperature (ECT/RT), precipitation (CNRN-100 - site 1, 2, 3, and 6; and CNRN-50 - site 8, 9, 10, and 11), soil volumetric water content (EC-20) and combination moisture/temperature/electrical conductivity probes (5TE) at two soil depths (5 and 15 cm).

The weather station data for air temperature, soil temperature, and soil moisture for each site are represented as a daily average, while cumulative precipitation for each month is reported (Appendix A). Environment Canada's climate normal values (1980-2010) from weather stations located closest to each site were included in Appendix A for comparison.

Missing data are a result of technical and physical errors with the weather station; these could include, but are not limited to, dead batteries in the data logger, disruption due to animal activity, such as damage to instruments (e.g. wires damaged to rain gauge at Polson site), and obstruction to rain gauge, as some had litter fall or pieces of spruce cone lodged in the top.

3.2.7 Soil Type

Soil type was determined based on the Nova Scotia Soil Survey obtained online from the Canadian Soil Information Service (http://sis.agr.gc.ca/cansis/). The soil series obtained for each site provides information regarding the general soil attributes, including information regarding stoniness, rockiness, general soil characteristics, soil material, soil components (dominant and significant soils), drainage, and slope classes. The 12 sites are located within three counties in Nova Scotia: Colchester, Halifax, and Pictou County. The legend showing the descriptions for each county are presented in Appendix D.

3.2.8 Statistical Methods

For forest floor sampling, the L and FH layer data were collected and analyzed separately. The values for nutrient data, bulk density, pH, and LoI were expressed as mean (SD), and Tukey's comparison-of-means test was completed to determine if there was a significant difference between the L and FH layers. All statistics were performed in JMP 13.

3.3 Litterbag Design

Litterbag design and construction was adapted from CIDET (Trofymow et al., 1998) and LIDET (LIDET, 1995) protocols. Litterbags were made from a tan/black coloured pool-cover mesh material (BlocMesh99^{TM}, HPI M08-2785, Lumite style 6065400; Lowry's Pool Service Plus, Porters Lake, NS), with a mesh size of 0.25 x 0.5 mm. The mesh was cut into 20 x 42 cm pieces to create a 20 x 20 cm bag when assembled (Figure 2) (LIDET, 1995; Trofymow et al., 1998; Moore et al., 1999; Moroni and Zhu, 2012). Each bag was sewn together using a twin-needle, to form a triple stitch, using a Brother LX3850 sewing machine. Coats polyester-covered polyester multipurpose thread (black and tan) was used. Once sewn, a single hole-punch was used to create a hole in the top corner to allow attachment of an aluminum write-on tag (Universal Field Supplies; Mississauga, ON), using UV-Black zip-ties, and for the galvanized nail (4") used to secure the litterbag to the forest floor.

The bags were filled with 10 g (air-dried weight) of litter, except white spruce, where 15 g of air-dried litter (needles and twigs) was used. The litterbags were sealed with five stainless-steel staples, and tagged according to the contents, site number, and the bag series. The mass of the litterbag, staples, aluminum tag, litter, and assembled bag were recorded using Mettler PE 360 and Mettler PE 440 three decimal place balances (g).

Figure 2. Litterbags in the field.

Ottawa sand (OS) was used as an inert correction material (Idol et al., 2002). It was determined that less than 1% of mass was added or removed from the correction bag, allowing the assumption of negligible change of mass in the deployed litterbags. Litterbags clearly identified to have a significant mass loss containing Ottawa sand were a result of actual loss of material from the bag, not mass loss due to decomposition. This was detected by examining the litterbags that had significant mass lost that contained Ottawa sand to identify possible areas of leakage (litterbag seam holes, leakage through the folded and stapled part of the litterbag). Litterbags containing OS that had identified leakage were excluded from the percentage-change calculation. Leakage may have also occured with smaller pieces of litter material, although the size of the litter types is substantially higher than that of the OS.

3.4 Litter Collection and Preparation

Ten fresh litter types were collected late August-September 2015 based on prevalent plant species observed throughout multiple sites through a qualitative assessment. The litter types include: white spruce needles (*Picea glauca,* WS), balsam fir (*Abies balsamea,* Bf), red maple leaves (*Acer rubrum,* Rm), goldenrod leaves and stems (*Solidago spp.,* Go), Schreber's moss (*Pleurozium schreberi,* Sc), wood fern (*Aspidium intermedium,* Wf), bunchberry leaves (*Cornus canadensis,* Bu), bracken fern (*Pteridium aquilinum,* Br), blackberry/raspberry leaves and stems (*Rubus allegheniensis/ Rubus idaeus,* Bb/Ra), and grasses (common bent-grass, *Agrostis capillaris*, Gr). The litter types were assigned to each of three chronosequence age groups (1-6, 13-18, and 28-31 years) and site qualities (poor-medium, and medium-rich) based on where the plant litter types were observed during collection (Table 2). Litterbags containing only Ottawa sand (OS) were included as a means of measuring any corrections to the litterbags during field deployment (Idol et al., 2002).

Table 2. Litter types assigned to each group based on chronosequence.

Poor/Medium – Medium		Medium/Rich – Rich	
Sites 1, 3, 5	Sites 2, 4, 6	Sites 7, 9, 11	Sites 8, 10, 12
White spruce	White spruce	White spruce	White spruce
Ottawa sand	Ottawa sand	Ottawa sand	Ottawa sand
Schreber's moss	Goldenrod	Blackberry/raspberry	Grasses
Balsam fir	Red maple	Balsam fir	Red maple
Bracken fern	Blackberry/raspberry	Bunchberry	Wood fern

Litter types were prepared for the litterbags differently depending on the size of the litter used. For example, balsam fir branches were cut into roughly 5 cm pieces, red maple leaves may have been broken during bag assembly, bracken fern was broken up by hand separating into workable pieces (~10 cm), goldenrod was broken into ~10 cm pieces (the flower, stem, and leaves were all included), and blackberry/raspberry stems were cut into pieces (~5 cm), and the leaves were included as well.

Four subsamples (replicates) of each litter type were obtained during the preparation of the litterbags. The ten litter types, and empty assembled litterbags, were oven dried (55 °C) to constant weight (Ramierz et al., 2014). The dried litter material was ground using a coffee grinder, then roller-milled to obtain a homogeneous flour. Litter nutrient characterization analyses were completed on litter samples before deployment, and samples collected at each sampling time. The analyses quantified the concentrations of calcium (Ca, mg g^{-1}), magnesium (Mg, mg g^{-1}), potassium (K, mg g^{-1}), phosphorus (P, mg g^{-1}), manganese (Mn, mg g^{-1}), sodium (Na, mg g^{-1}), sulphate (SO_4^{2-}, mg g^{-1}), aluminum (Al mg g^{-1}), boron (B, mg g^{-1}), copper (Cu, mg g^{-1}), iron (Fe, mg g^{-1}), and zinc (Zn, mg g^{-1}) found in the litter tissue. Total nitrogen (N, %), and carbon (C, %), C/N ratio, and Klason lignin (KL, %) concentrations were also determined.

3.5 Preparation, Plot Layout and Field Placement of Litterbags

Plot plans were generated for each site by assigning litterbags numbered in sets of six (one for each sampling time) to each block. An online random-number generator was used to completely randomize the litterbags within each block. Litterbags were organized based on the plot plans before reaching the site, as this allowed for efficiency while deploying the litterbags. The litterbags were deployed between November 25, 2015 and December 4, 2015. Flagging tape was used to identify the point of entry from the road at each site. GPS points were recorded for each site: latitude, longitude, and UTM coordinates. Identification markers were placed, and painted, at the beginning of each row. At the beginning of each row, a 30-metre measuring tape was laid out, and the appropriate litterbags, according to the plot plans, were secured to the ground using galvanized nails (10 cm) every metre. Litterbags were placed on the forest floor, although visible rocks and logs were avoided.

3.6 Sampling and Analysis of Litterbags

The data considered in this project are based on four sampling periods (spring 2016, summer 2016, fall 2016, and spring 2017) (Table 3). Each sampling consisted of collecting a litterbag from each block for each type of litter (five litterbags per block, total of 20 per site for each sampling). Immediately following the collection of the litterbags, excess debris was removed from the exterior of the bag, although particulate matter may have been embedded in the pores, the initial weight was taken (using identical scales as used in initial weight of litterbags), and the litterbags were placed in an oven (55 °C) for 48 hours to stabilize the samples and prevent further microbial growth (LIDET, 1995; Trofymow et al., 1998; Ramirez et al., 2014). The dry weight of the litterbag was taken after 48 hours, and periodically until a constant mass was reached.

Table 3. Date of litterbag (LB) deployment and sampling for each site.

Sampling Period	Date	Site Number(s)
LB Deployment	November 25, 2015	2, 4, 6
LB Deployment	November 27, 2015	1, 7
LB Deployment	November 30, 2015	9, 11
LB Deployment	December 1, 2015	3, 8, 12
LB Deployment	December 4, 2015	5, 10
Spring 2016	April 29, 2016	5
Spring 2016	May 3, 2016	2, 3, 4, 6, 8, 9, 11, 12

Sampling Period	Date	Site Number(s)
Spring 2016	May 4, 2016	1, 7, 10
Summer 2016	August 29, 2016	1, 5, 7, 9, 10, 11
Summer 2016	August 30, 2016	2, 3, 4, 6, 8, 12
Fall 2016	November 24, 2016	1, 5, 7, 9, 10, 11
Fall 2016	November 25, 2016	2, 3, 4, 6, 8, 12
Spring 2017	May 2, 2017	2, 3, 4, 6, 8, 12
Spring 2017	May 3, 2017	1, 5, 7, 9, 10, 11

To start the analysis of the litter, the litter was first removed from the litterbag. The tissue samples were then ground using a coffee grinder, then further ground using a roller mill to a homogeneous flour. Generally, the litter was intact when removed from the litterbags, but in cases where decomposition was more extensive, the inside of the litterbag was scraped with a spatula to remove adhering particles of organic matter.

3.7 Acid Digests/Nutrient Analysis

Acid digests were completed on the dried, ground litter samples on each sample collected over the four sampling periods. Acid digests were completed using a microwave (MARS 6) acid digestion procedure for plant tissue. The method involved adding 0.5 g of plant material and 10 mL HNO_3 to a reaction vessel, which underwent a digestion at temperature 200 °C for 10 minutes at 800 psi at 900-1050 W (CEM Corporation, 2016). Once the pressure was released from the reaction vessel, 15 mL of deionized water was added to the vessel. The sample was then filtered using Whatman 5 filter paper, and the filtrate was diluted to 50 mL, inverted 25 times to ensure uniformity throughout the solution (Figure 3). A blank sample containing only nitric acid was included in every run to account for any contamination within a set. Nutrient concentrations were determined using an ICP-OES at the Department of Agriculture, Harlow Institute, Truro NS. The limits of detection for the ICP-OES used in the laboratory are as follows: 0.20 µg/mL (Ca), 0.20 µg/mL (Mg), 1.50 µg/mL (K), 0.10 µg/mL (P), 1.50 µg/mL (Na), 0.50 µg/mL (sulphate), 0.50 µg/mL (Al), 0.10 µg/mL (B), 0.05 µg/mL (Cu), 0.05 µg/mL (Fe), 0.10 µg/mL (Mn), and 0.02 µg/mL (Zn).

Figure 3. Filtering system used for acid digests (left), and a completed set of diluted samples (right).

3.8 Lignin Determination

Acid-insoluble lignin (Klason lignin) was determined using the protocol described by Rowell (2012). Ground tissue sample (200 mg) was weighed out into 120 mL French square glass bottles. Sulphuric acid (2 mL, 72% w/w H_2SO_4) was added to the glass bottles, and the material was mixed using a glass-rod. The bottles were then incubated in a water bath (30 °C) for 1 hour. Distilled water (56 mL) was then added, resulting in a 4% solution for the secondary hydrolysis. The samples were then covered with aluminum foil, and autoclaved at 121°C, 12 psi, for 1 hour. The samples were then removed from the autoclave, and filtered while still warm with suction, using Gooch crucibles, and Whatman™ glass microfibre filters (21 mm, 24 mm) (filters were rinsed into crucibles, dried, and weighed prior to use). The samples were then washed with hot water (3 x 5 mL) and dried overnight at 105 °C in an oven. After the crucibles were removed from the oven and placed in a desiccator for 1 hour to cool, the final weights of the samples were obtained (Figure 4).

Klason lignin was then calculated based on the initial and final weights of the sample (Gomes et al., 2011; Rowell, 2012). The equation used to determine the Klason lignin (KL) content was:

$$\%KL = \left(\frac{ODW_{sample}}{initial\ weight_{sample}}\right) \times 100\%$$

where ODW_{sample} is the final oven dry weight of the sample.

Figure 4. Lignin filtrate (acid-soluble lignin fraction) (left), and dried acid-insoluble fraction (Klason lignin) (right).

The filtrate was collected (Figure 4, L) and analyzed on a Cary UV-Spectrometer at 205 nm and 110 $lg^{-1}cm^{-1}$ to obtain the amount of acid-soluble lignin in the sample (Aldaeus et al., 2011; Rabemanolontsoa, Ayada and Saka, 2011; Lourenco et al., 2013). The equation used to calculate the acid-soluble lignin (ASL) fraction was:

$$\%ASL = \left(\frac{UV_{abs} \times Volume_{Filtrate} \times df}{\varepsilon \times ODW_{sample} \times Pathlength}\right) \times 100$$

where UV_{abs} is the UV-Vis absorbance for the sample at 205 nm, $Volume_{filtrate}$ is the total volume of filtrate, ε is the absorptivity value for lignin at wavelength 205 nm, df is the dilution factor, ODW_{sample} is the final oven-dry weight of the sample, and pathlength is the pathlength of UV-VIS cell in cm (1 cm) (Sluiter et al., 2012).

3.9 Total Carbon and Nitrogen

Total carbon and nitrogen (TCN) were analyzed for all samples using an Elementar (varioMAX CN; Plant500 method) by combustion of 0.30-0.50 g of dry, ground litter material. The results from TCN are reported as carbon (%), nitrogen (%), and C/N ratio throughout this study.

3.10 Statistical Analysis

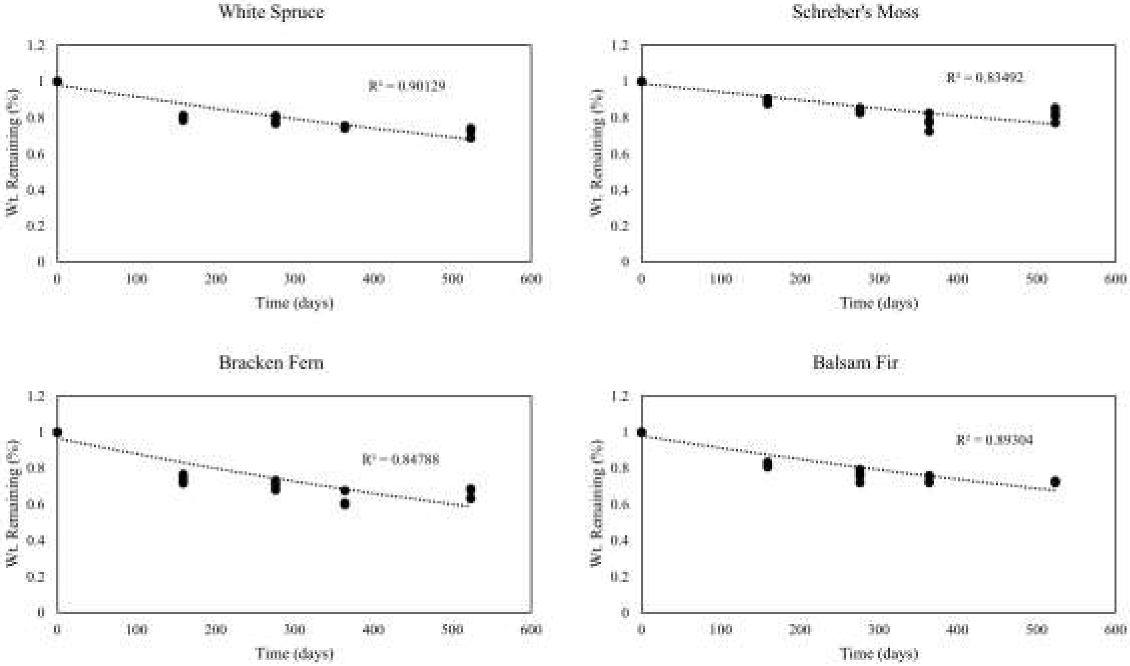
All statistics were completed using the program JMP 13.

3.10.1 Rate of Decomposition

The rate of decomposition (k, year^{-1}) was calculated as the change in dry mass over time in litterbags deployed under field conditions. The rate was calculated using the mass of the four replicate litterbags for each litter type on each site, at each sampling (change of mass with time). Replicates consisted of one of four blocks located on the site, over a period of four samplings. The decomposition rate was calculated based on fitting the normalized mass remaining (x_t/x_0) over time (t; years) to a first-order decay function to determine the decomposition rate (k; year^{-1})

$$\frac{x_t}{x_0} = e^{-kt}$$

The mass remaining was normalized to the original mass contained in the litterbag to allow comparison between litter types. Figure 5 provides an example of the fit to the first-order decay function for each litter type at site 1, using four replicates of mass at each of the four sampling dates. The normalized litter mass at time=0 is 1.0 by definition as was included in the first-order fit. Fitted models for each litter type for each site can be seen in Appendix B. The normality and homogeneity of variances was verified for the ANOVA results by analyzing a normal quantile plot and using an O'Brien test (p>0.05) in JMP, respectively.


White Spruce

Schreber's Moss

Bracken Fern

Balsam Fir

Figure 5. Fitted decay model for the four litter types found at site 1. Each litter type uses the proportion of mass remaining (n=4) for each sampling period to determine the rate of decomposition.

3.10.2 Determining the Effect of Litter Type and Site on Decomposition Rate

One-way analysis of variance was used to examine the decomposition rate as influenced by litter type. This analysis used the decomposition rate determined on each litter type, at each sampling location. This analysis assesses whether litter type influenced decomposition rate across sites that contained similar litter types. Bracken fern, bunchberry, goldenrod, grasses, Schreber's moss, and wood fern were observed on three sites each, blackberry/raspberry, balsam fir, and red maple were used as litter types at six sites, while white spruce was monitored across all 12 sites.

When the analysis of variance (ANOVA) results showed a significant difference between litter type for decomposition rate within a site, Tukey's multiple comparison of means was used to distinguish which litter types were significantly different from one another ($p<0.05$).

Litterbags were distributed in a randomized complete block design at each site. An ANOVA was used to determine if a blocking effect was observed. It was determined that no significant blocking effect was observed ($p>0.05$) at any site.

3.10.3 Examining Litter Composition

Analysis of variance was used to determine the differences in concentration of various chemical and physical components between each litter type. Instrumental error occurred for the determination of TCN for one of the bracken fern samples that were completed on litter samples before the deployment of the litterbags. Due to the error, the values obtained for this sample were omitted.

3.10.4 Determining the Effect of Litter Composition Over Time

An analysis of variance (ANOVA) was used to determine whether there were significant differences in litter composition for each sampling period. Tukey's multiple comparison of means was used to determine if litter types significantly differed between one another regarding their nutrient content. This was completed for the mean value of each litter type, as well as per site. When examining differences within a site, each sampling period was used as a means of observing concentration change across all time periods.

3.10.5 Determining the Effect of Litter Composition on Decomposition Rate

A Principal Components Analysis (PCA) was used to reduce the dimensionality of the dataset to allow for an easier interpretation of the effect of compositional variables on decomposition rate. The PCA results visually demonstrate the influence of litter content values of calcium, magnesium, potassium, phosphorus, and manganese concentrations, as well as nitrogen, carbon, and Klason lignin content, and C/N ratios on the decomposition rates (k) obtained for this study.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Litter Characterization

Litter subsamples (n=4) were obtained and analyzed for each litter type when preparing the litterbags. As seen below in Table 4, the mean ($\overline{x}$) value and the residual mean square error (RMSE) for each litter type is summarized using a pooled estimate of error variance for each parameter. Tukey's multiple comparison of means ($p<0.05$) was used to determine which litter types had significantly different concentrations from one another, and the results are denoted as means followed by different letters indicating a significant difference between litter types.

Table 4. Litter characterization mean data. Tukey's multiple comparison of means are denoted as letters ($P<0.05$).

Litter Type	KL (%)	N (%)	C (%)	C/N	Ca (mg/g)	Mg (mg/g)	K (mg/g)	P (mg/g)	Mn (mg/g)
Bb/Ra	29 f	2.0 b	46 e	23 f	6.2 c	2.5 c	7.3 c	1.3 c	2.7 a
Bf	47 a	1.2 d	51 a	44 b	6.3 b	0.6 gh	3.6 e	0.9 d	1.4 b
Br	45 b	2.5 a	46 f	23 f	3.3 d	1.8 e	12.9 a	1.5 b	0.7 ef
Bu	25 g	1.3 d	43 i	33 e	17.0 a	3.7 b	5.9 d	1.0 d	0.4 g
Go	33 e	1.6 c	47 d	30 e	6.1 b	2.2 d	12.5 a	1.4 b	1.0 cd
Gr	29 f	0.8 e	46 f	60 a	0.5 f	0.3 i	1.1 f	0.4 g	0.5 f
Rm	29 f	1.3 d	48 c	37 d	5.2 c	1.5 f	3.8 e	0.8 e	1.0 c
Sc	36 d	0.7 e	45 g	62 a	2.0 e	0.8 g	3.5 e	0.6 f	0.4 g
Wf	37 d	1.7 c	44 h	25 f	3.0 d	4.1 a	11.2 b	2.1 a	1.5 b
WS	42 c	1.2 d	50 b	41 c	2.4 e	0.5 hi	0.9 f	1.0 d	0.8 de
RMSE	1	0.1	0.1	3	0.5	0.2	0.6	0.09	0.1

Prob>F: <0.0001* for all ANOVA

4.2 Litter Mass

4.2.1 Decomposition rates as influenced by litter type

Litter type had a significant effect ($p<0.05$) on decomposition rate (Table 5). Litter types that showed the most rapid decomposition rates were blackberry/raspberry, and bunchberry, while Schreber's moss, grasses, white spruce, and balsam fir exhibited the slowest rates.

Table 5. Mean decomposition rate, k, and mean mass remaining (5), with standard error (SE) for ten litter types. Letters represent results of Tukey's multiple comparison of means ($p<0.05$).

Litter Type	Decomposition Rate (k, year^{-1})		Mass Remaining (%)	
	Mean	SE	Mean	SE
Blackberry/Raspberry	0.82a	0.05	36.2	0.02
Bunchberry	0.75a	0.02	38.4	0.01
Goldenrod	0.52b	0.02	54.8	0.02
Red maple	0.50b	0.01	53.4	0.01
Wood fern	0.43b	0.01	59.9	0.02
Bracken fern	0.41bc	0.03	60.0	0.03
Balsam fir	0.31cd	0.01	67.7	0.01
White spruce	0.28de	0.01	70.1	0.01
Grasses	0.27de	0.01	72.4	0.01
Schreber's moss	0.19e	0.01	80.6	0.01

Litter quality is an important determination of decomposition rate. The chemical and physical composition of the litter material is directly related to the rate of decomposition. Klason lignin content accounted for 40% of the variation in decomposition rate (Figure 6). Higher lignin content corresponds to slower decomposition rates (k, year^{-1}). Litter types with lower lignin content (blackberry/raspberry, and bunchberry) had the most rapid rates of decomposition, while litter types with high lignin content (Schreber's moss, grasses, white spruce, and balsam fir) decomposed at a lower rate. The data obtained in this study verifies the relationship between decomposition rate and Klason lignin content for different litter types.

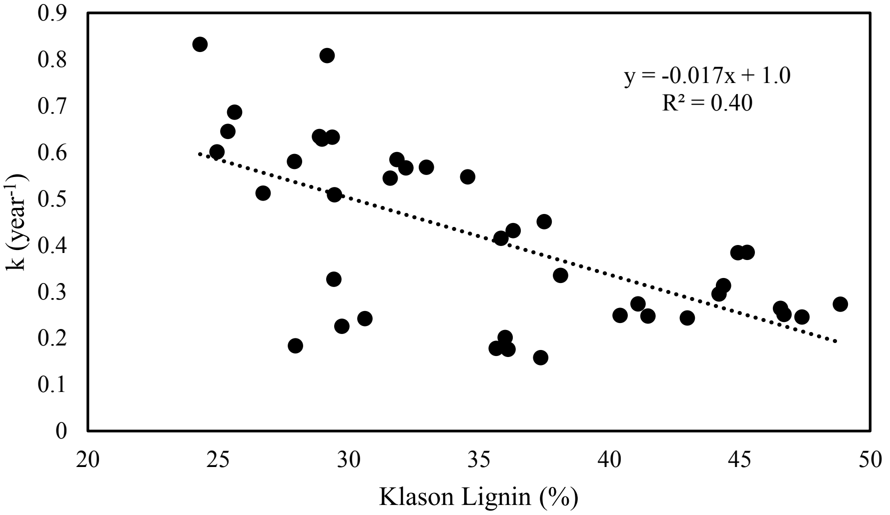


Figure 6. Decomposition rate vs. Klason lignin content with a linear fit.

Another indicator of litter quality used throughout this study was the C/N ratio, which ranged from 22.6 to 62 for bracken fern and Schreber's moss, respectively (Table 4). There was a significant negative correlation between C/N ratio and decomposition rate accounting for 40% of the variation in decomposition rate (Figure 7). There was no correlation between Klason lignin and C/N ratio values (R^2=0.00026).

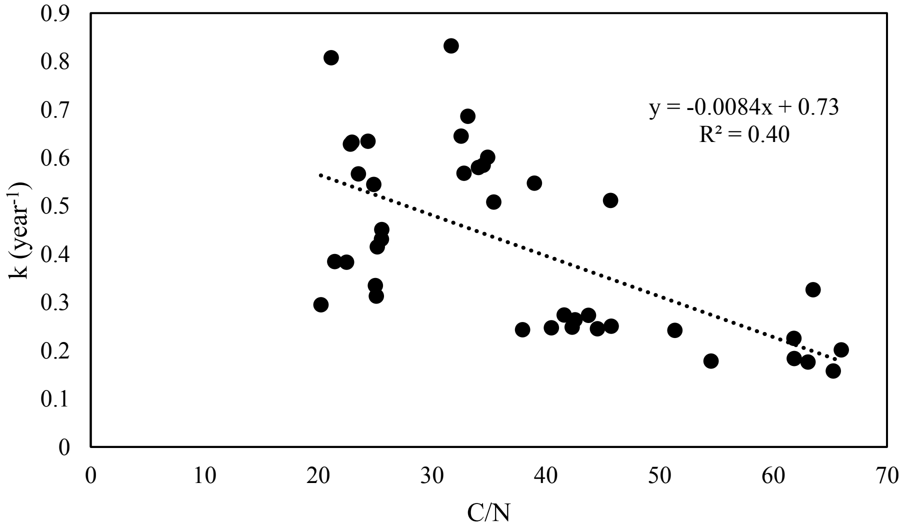


Figure 7. Decomposition rate, k ($year^{-1}$), vs C/N ratio with a linear fir.

Substrate quality of the litter has previously been shown to relate to the decomposition rate, generally, the lower the quality (higher C/N ratio), the slower the decomposition rate (Moore et al., 1999). The low quality of litter typically signifies higher lignin content, and lower nutrient concentrations. Litter decomposes at various rates due to the leaching of readily available nutrients in early stages of decomposition. This change in composition and mass permanently alters the plant material, leaving an increasing amount of recalcitrant material remaining, which is more difficult to degrade (Purahong et al., 2016).

4.1.2 Effect of Site Quality and Stand age on Decomposition Rate for Each Litter Type

The effect of site quality and stand age on decomposition rates were examined in this project. This was completed to determine if there was any significant difference in decomposition rates for each individual litter types in sites of different quality or age. The experiment was designed to allow an assessment of stand age by using the chronosequence method, and therefore calculating decomposition rates for different litter types in different aged plantation forests. Site quality was assessed based on soil type and adjacent stand conditions. White spruce, balsam fir, red maple, and blackberry/raspberry litters were used in assessment of the influence of site quality in two chronosequences of different qualities (poor-medium, and medium-rich). White spruce litter was placed in four chronosequences, representing different qualities (poor-medium, and medium-rich). Site quality and age interactions were represented in the experimental design by using similar litter types on different quality chronosequence.

Stand age had a significant impact on decomposition rates for four of the ten litter types: blackberry/raspberry, balsam fir, red maple, and white spruce. The range of mean decomposition rates were 0.51 – 1.06 year^{-1}, 0.26 – 0.36 year^{-1}, 0.42 – 0.55 year^{-1}, 0.24 – 0.37 year^{-1} for blackberry/raspberry, balsam fir, red maple, and white spruce, respectively. There was no significant impact of site on the decomposition rates of bracken fern, bunchberry, goldenrod, grasses, Schreber's moss, and wood fern. Site quality did not have a significant impact on litter decomposition rates.

The six litter types that did not show a significant site effect were bracken fern, bunchberry, goldenrod, grasses, Schreber's moss, and wood fern (Table 6). Correlation indicated that 23% or less of the variation in decomposition rate was explained by stand age (Table 6).

Table 6. The average decomposition rate (k) for each litter type and the percentage of variation in decomposition rate accounted for by stand age.

Litter Type	Decomposition Rate (k) (year^{-1})	SE	R^2
Blackberry/Raspberry	0.82	(0.05)	0.66
Balsam Fir	0.31	(0.01)	0.67
Bracken Fern	0.41	(0.03)	0.021
Bunchberry	0.75	(0.02)	0.20
Goldenrod	0.52	(0.02)	0.12
Grasses	0.27	(0.01)	0.23
Red Maple	0.50	(0.01)	0.15
Schreber's moss	0.19	(0.01)	0.081
White Spruce	0.28	(0.01)	0.66
Wood fern	0.43	(0.01)	0.0037

BLACKBERRY/RASPBERRY (RUBUS ALLEGHENIENSIS/ RUBUS IDAEUS)

There was a significant ($p<0.05$) effect of stand age on the decomposition rates of blackberry/raspberry litter (Table 7). Younger sites (2, 4 and 7) exhibited slower rates of decomposition than did older sites (6, 9 and 11). Decomposition was not influenced by the quality of site. Sites of low quality (2-6) were not different from those of high quality (7-11). Site 7, a young site (planted in 2014), may have had a reduced decomposition rate due to the lack of litter cover on the forest floor, resulting from the mechanical disturbance during harvest.

Table 7. Decomposition rate and standard error of blackberry/raspberry filled litterbags. Letters represent Tukey's multiple comparison of means for each decomposition rate. Sites with different letters are significantly different from other sites ($p<0.05$).

Site	Stand age (Years)	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
2	6	PM	0.68b	(0.04)	0.93
4	17	PM	0.724b	(0.009)	0.92
6	31	PM	1.02a	(0.05)	0.94
7	1	R	0.51b	(0.05)	0.89
9	13	MR	0.95a	(0.06)	0.94
11	28	R	1.06a	(0.06)	0.87

Correlation also demonstrates the effects of stand age on decomposition rate, showing a 1.6% increase in decomposition rate per year independent of site quality class for blackberry/raspberry litter (Figure 8). Stand age accounted for 66% of the variability in decomposition rate (R^2=0.66) in blackberry/raspberry litterbags.

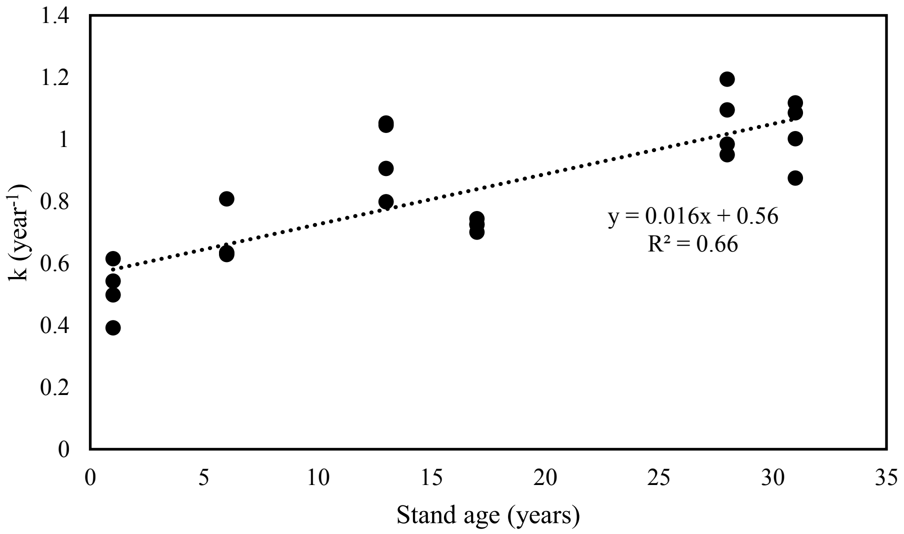


Figure 8. Effect of stand age on decomposition rate (k, year^{-1}) for blackberry/raspberry across all six sites measured.

Site quality had less impact on decomposition than did stand age for the decomposition of blackberry/raspberry litter in this study. Stand age has a clear impact on decomposition (Figure 9) accounting for over 70% of the variation in decomposition rate. The relationship with age was only slightly impacted by differences in site quality. Decomposition rate increased to a slightly lesser degree in lower quality sites (Sites 2, 4, 6) than in higher quality sites (Sites 7, 9, 11). The R^2 values obtained showing the correlation between stand age and decomposition rate, k, indicate that stand age accounts for 74% and 73% of the variability for the poor-medium quality chronosequence and medium-rich quality chronosequence, respectively.

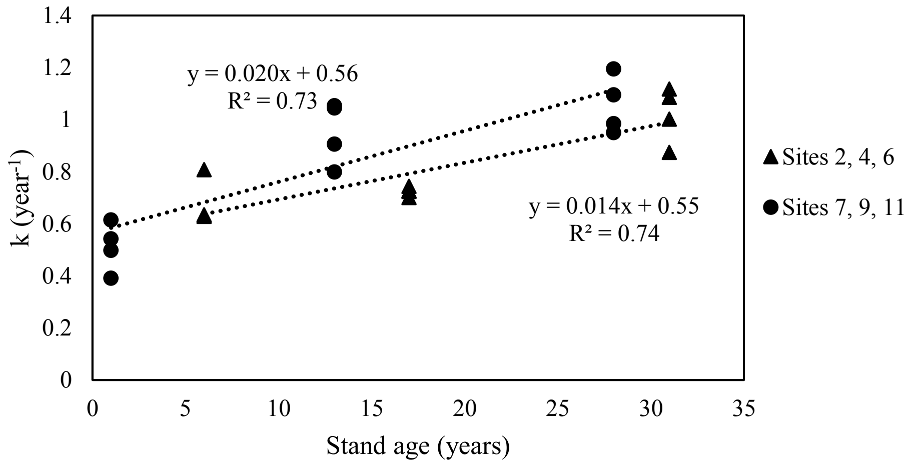


Figure 9. The effect of stand age on decomposition rate for blackberry/raspberry plant litter. Each linear relationship indicates a different site quality.

BALSAM FIR (ABIES BALSAMEA)

There were significant differences between sites for the decomposition of balsam fir (Table 8). In general, as stand age increased, the decomposition rates increased slightly. Decomposition was not influenced by the quality of the site. Sites of low quality (1-5) were not different from those of high quality (7-11).

Table 8. Mean decomposition rate (k) and standard error of balsam fir. Letters represent the results of Tukey's multiple comparison of means for the decomposition rate associated with each site. Sites that are significantly different from each other were statistically determined ($p<0.05$).

Site	Stand age	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
1	1	M	0.26b	(0.006)	0.89
3	16	M	0.31ab	(0.01)	0.91
5	29	M	0.36a	(0.02)	0.95
7	1	R	0.26b	(0.0008)	0.92
9	13	MR	0.34a	(0.02)	0.92
11	28	R	0.35a	(0.02)	0.91

Balsam fir, as a conifer, has slower decomposition rates than blackberry/raspberry, bunchberry, goldenrod, red maple, wood fern, and bracken fern due to the chemical and physical nature of the litter material, as the needles contain high lignin contents (Hatcher, 1990). The chemical and physical nature of balsam fir needles prevents microorganisms from accessing the needle and prevents the leaching of nutrients and water loss. High lignin levels in conifer needles have been shown to have a negative effect on decomposition rate (Berg et al., 1981).

Balsam fir showed a significant difference in decomposition rates, k, between sites. Site quality had relatively little impact on decomposition rates as can be seen in similarity in decomposition rates for each age class (Figure 10). This is a significant observation as other variables influence decomposition greater than site quality alone. Stand age accounts for 67% of the variability in decomposition rate across the six sites balsam fir was monitored.

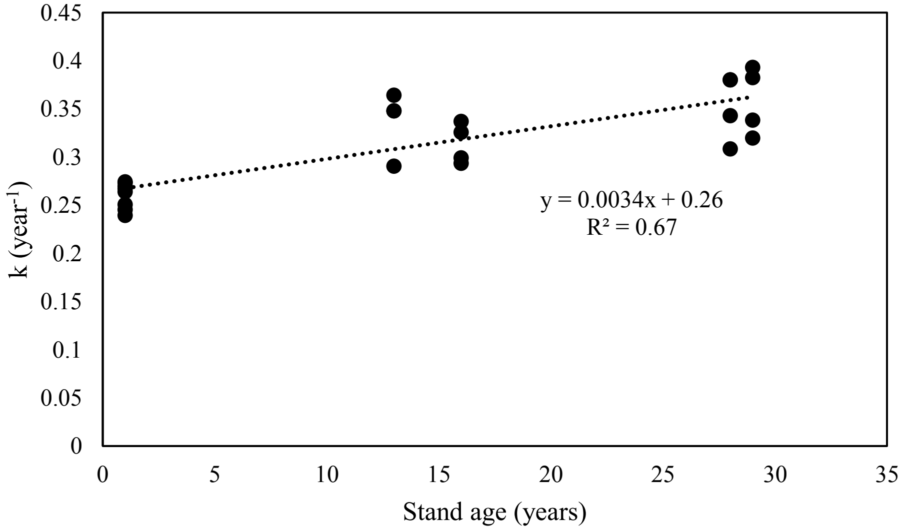


Figure 10. Effect of stand age on decomposition rate (k, year^{-1}) for balsam fir.

Similar to the decomposition of blackberry/raspberry, when the stand ages were categorized into poor-medium and medium-rich site qualities, there is insignificant differences between the two quality classes. For sites 1, 3, and 5, age accounted for 79% of the variability with decomposition rate for balsam fir, while sites 7, 9, and 11 only accounted for 59% (Figure 11).

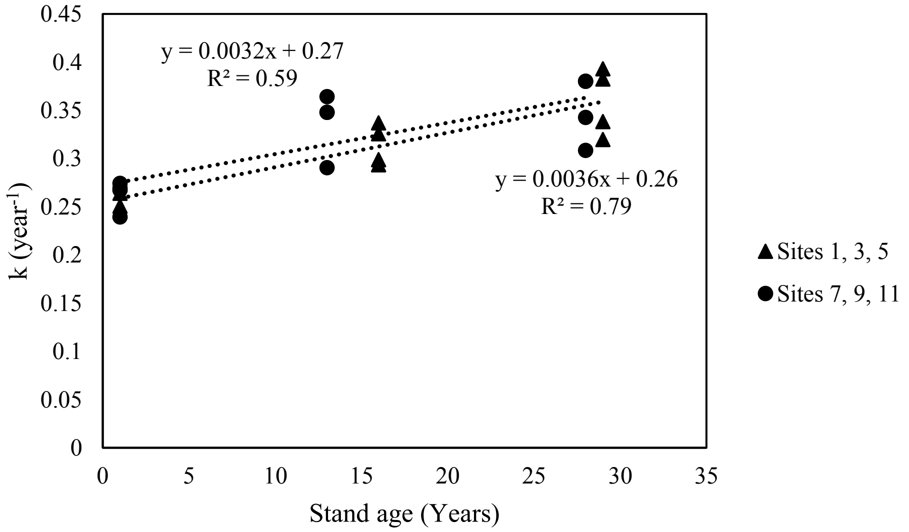


Figure 11. The effect of stand age on decomposition rate, k, shown for both chronosequence used to monitor the decomposition of balsam fir litter.

BRACKEN FERN (PTERIDIUM AQUILINUM)

Bracken fern decomposition was monitored in only three medium quality sites (1, 3 and 5) as this litter material was not found in higher quality sites. Decomposition rates of bracken fern were not significantly different between the three sites (Table 9), suggesting that plantation age is not a good predictor of decomposition rate for this litter type. The lack of difference in decomposition rate across the chronosequence could indicate that the biological community is less able to adapt with time to the decomposition of this litter type.

Table 9. Mean decomposition rate and standard error of bracken fern. Letters indicate significantly different rates per site ($p<0.05$) through a Tukey's comparison of means.

Site	Stand age	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
1	1	M	0.34a	(0.02)	0.85
3	16	M	0.51a	(0.07)	0.88
5	29	M	0.38a	(0.02)	0.91

BUNCHBERRY (CORNUS CANADENSIS)

There was no significant ($p>0.05$) difference in bunchberry decomposition rates between sites (Table 10).

Table 10. Mean decomposition rate and standard error of bunchberry. Letters indicate significantly different ($p<0.05$) sites as determined through Tukey's comparison of means.

Site	Stand age	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
7	1	R	0.69a	(0.05)	0.96
9	13	MR	0.77a	(0.02)	0.95
11	28	R	0.78a	(0.04)	0.94

The lack of significance between stand age for the decomposition rate of some plant materials has been observed by Prescott et al. (2004). In their study, the decomposition of forest floor material, deciduous and coniferous litter was determined in clear-cut and forest ecosystems, using both pure and mixed litterbags. They concluded that the decomposition of different litter types was either slower or relatively the same in clear-cut ecosystems compared to mature forests. This is observed in the decomposition of bunchberry of this study, as the youngest site after harvest had numerically the slowest decomposition rate compared to the older plantations, although the difference in rates was not significant.

GOLDENROD (SOLIDAGO SPP.)

There was no significant ($p>0.05$) difference between rates of decomposition for goldenrod among sites (Table 11). This indicates that stand age did not have an impact on the decomposition rate of goldenrod litter.

Table 11. Mean decomposition rate and standard error of goldenrod. Letters indicate significantly different ($p<0.05$) sites based on Tukey's comparison of means.

Site	Stand age	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
2	6	PM	0.56a	(0.006)	0.92
4	17	PM	0.49a	(0.02)	0.82
6	31	PM	0.50a	(0.05)	0.79

GRASSES (AGROSTIS CAPILLARIS)

There was no significant ($p>0.05$) difference between decomposition rate of grasses among sites (Table 12).

Table 12. Mean decomposition rate and standard error for grasses. Letters indicate significantly different ($p<0.05$) sites based on Tukey's comparison of means.

Site	Stand age	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
8	2	MR	0.24a	(0.03)	0.89
10	18	MR	0.27a	(0.007)	0.90
12	29	R	0.29a	(0.02)	0.92

When analyzing the decomposition rate for grasses at site 8, it is estimated that 79% of the mass will be remaining after the first year, as calculated by the decay function. After two years, it is calculated that 62% of the mass will remain, if the litter continues to decompose at the same rate for this time period. The slower decomposition rate for grasses is consistent with the higher C/N ratio (60) of this litter and its relatively low nitrogen content, 0.77%. The high C/N ratio and low nitrogen content (%) are characteristic to slower decomposition rates.

RED MAPLE (ACER RUBRUM)

The rate of decomposition of red maple foliage was significantly ($p<0.05$) influenced by the interaction between stand age and site quality (Table 13). In higher quality sites (8, 10 and 12), decomposition rate increased with stand age. In lower quality sites (2, 4, and 6) there was no influence of stand age on decomposition rate of red maple litter.

Table 13. Mean rate of decomposition and standard error of red maple. Letters indicate significantly different ($p<0.05$) sites based on Tukey's comparison of means.

Site	Stand age (years)	Site Quality	Decomposition rate (k) (year^{-1})	SE	R^2
2	6	PM	0.55a	(0.02)	0.88
4	17	PM	0.48ab	(0.02)	0.84
6	31	PM	0.53ab	(0.04)	0.91
8	2	MR	0.42b	(0.02)	0.79
10	18	MR	0.49ab	(0.02)	0.89
12	29	R	0.54a	(0.03)	0.92

The decomposition rate for site 2 is much higher than would be expected, as rates tend to increase with stand age (Figure 12). Site 8 is the only site that shows a significant difference in decomposition rate compared to sites 2 and 12. This indicates that other factors other than stand age is influencing decomposition rate. The relationship between stand age and decomposition rate across the six sites used to monitor red maple litter shows that stand age only accounted for 15% of the variation of decomposition rate (Figure 13).

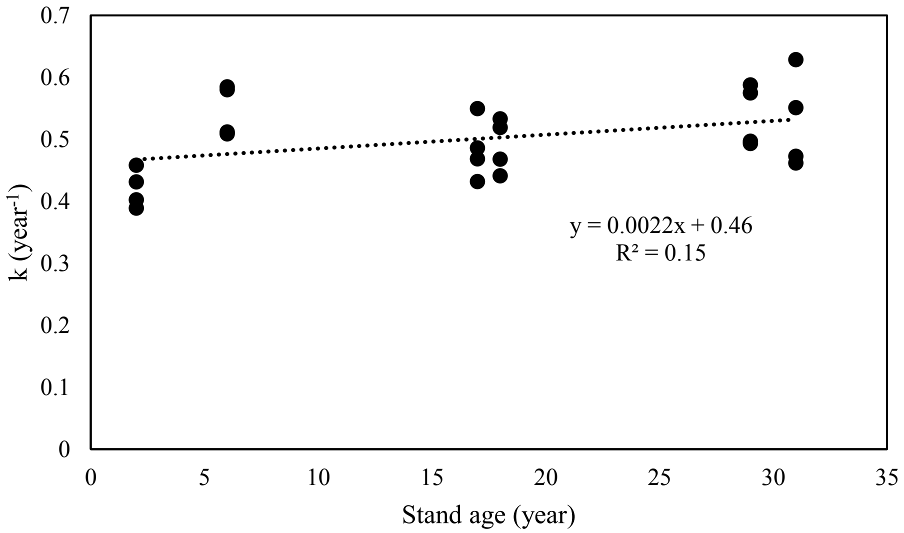


Figure 12. The effect of stand age on decomposition rate (k) for red maple across the six sites used.

When looking at the relationship between stand age and decomposition rate for the two chronosequences, there was little change in rate between sites 2, 4, and 6 (R^2=0.0094) (Figure 13). This indicates that stand age or quality has hardly any effect on decomposition rate for red maple. No relationship was detected between the sites 2, 4, and 6 as indicated through linear regression (Figure 13). The rates for sites 8, 10, and 12 show an increase with increasing age. For this chronosequence, the stand age accounted for 64% of the variation in the rates obtained.

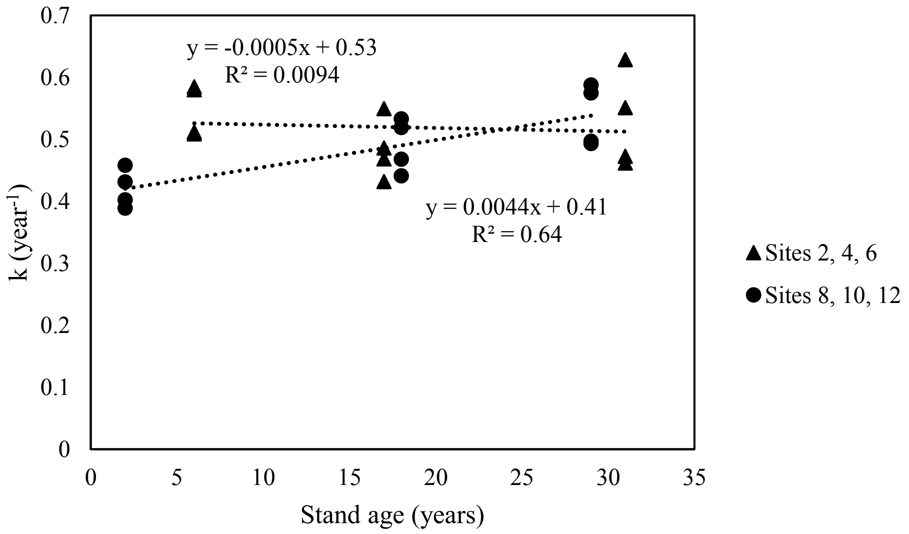


Figure 13. Relationship of stand age on decomposition rate for two chronosequence of red maple litter.

SCHREBER'S MOSS (PLEUROZIUM SCHREBERI)

Schreber's moss was monitored for decomposition through weight loss at sites 1, 3 and 5. Mean rates of decomposition for each site were not significantly different ($p>0.05$) from one another (Table 14).

Table 14. Mean rate of decomposition and standard error for Schreber's moss. Letters indicate significantly different ($p<0.05$) sites based on Tukey's comparison of means.

Site	Stand age (years)	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
1	1	M	0.18a	(0.009)	0.83
3	16	M	0.20a	(0.006)	0.84
5	29	M	0.19a	(0.01)	0.82

The decomposition rate for Schreber's moss can be related to the chemical composition of the litter type. The litter content of lignin, nitrogen, C/N ratio, and manganese of the litter before it was deployed in the field was: 36.3%, 0.73%, 62, and 0.345 mg g^{-1}, respectively. These values reported are the lowest for nitrogen content and manganese, and highest for C/N ratio, which are consistent with the sphagnum species having the slowest decomposition rates of the other litter types used in this study (Table 5; Scheffer et al., 2001).

WOOD FERN (ASPIDIUM INTERMEDIUM)

There is no significant difference of decomposition rate of wood fern between sites ($p<0.05$) (Table 15) indicating that the age of plantation was not a factor in influencing the rate of decomposition of this litter type.

Table 15. Mean rate of decomposition and standard error of wood fern. Letters indicate significantly different ($p<0.05$) sites based on Tukey's comparison of means.

Site	Stand age (years)	Site Quality	Decomposition Rate (k) (year^{-1})	SE	R^2
8	2	MR	0.44a	(0.01)	0.87
10	18	MR	0.41a	(0.03)	0.76
12	29	R	0.45a	(0.01)	0.88

WHITE SPRUCE (PICEA GLAUCA)

There was a significant ($p<0.05$) difference in the decomposition of white spruce litter across sites (Table 16). When examined as a function of stand age for the lower and higher site qualities independently, there is a general increase in the rate of decomposition with stand age (Figure 14). The similarity of the slopes in the relationship between white spruce decomposition rates and stand age for the two classes of site quality (Figure 14) indicate that site quality does not play a significant role in decomposition rates. The correlation across all sites classes accounted for 66% of the variation and correlations were improved when broken out according to site class.

This may be related to the change in the environmental condition of the forest floor as the forest approaches maturity, resulting in increased canopy cover, which leads to more favourable soil moisture and temperature conditions. In addition, as the forest floor develops, the microbial community may be better adapted to the decomposition of white spruce litter.

Table 16. Mean decomposition rate and standard error of white spruce. Letters indicate significantly different ($p<0.05$) sites based on Tukey's comparison of means.

Site	Stand age (years)	Site Quality	Decomposition Rate (k) ($year^{-1}$)	SE	R^2
1	1	M	0.25c	(0.0007)	0.90
2	6	PM	0.26c	(0.008)	0.88
3	16	M	0.27bc	(0.01)	0.86
4	17	PM	0.27bc	(0.02)	0.87
5	29	M	0.32ab	(0.007)	0.96
6	31	PM	0.32ab	(0.005)	0.94
7	1	R	0.24c	(0.007)	0.89
8	2	MR	0.24c	(0.01)	0.78
9	13	MR	0.26c	(0.01)	0.88
10	18	MR	0.28bc	(0.005)	0.89
11	28	R	0.32ab	(0.008)	0.96
12	29	R	0.37a	(0.02)	0.93

Plantation age had an important influence on decomposition rate, as determined through the percentage of variation explained by stand age, one that is much greater than site quality, as per the similarity in slopes between the classes of site quality (Figure 14). This reflects the evolution in site conditions associated with age (e.g., vegetation, microbial community, development of the forest floor layers (LFH), canopy cover, more suitable soil moisture and temperature regimes, as evapotranspiration is higher in stands with greater canopy cover), were more influential in determining changes in decomposition rate, as opposed to site quality. It is important to note that substrate quality was not a factor in this assessment as the quality of the litter is the same throughout the field study.

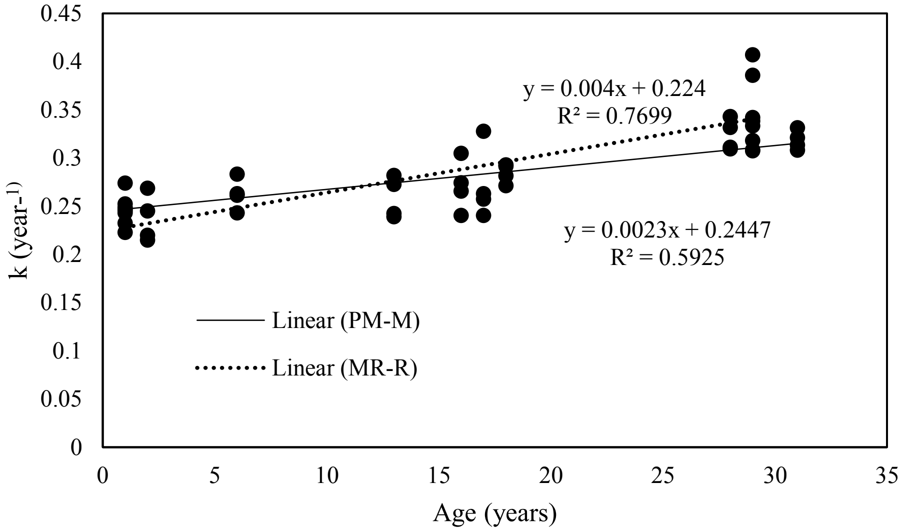


Figure 14. Relationship between decomposition rate (k, year^{-1}) and stand age (years) for two site quality groups (poor/medium-medium (PM-M), medium/rich-rich (MR-R)).

Table 17. Litter decomposition rates across sites and litter types. Values reported are mean rates (k) calculated for each litter type (n=4). Letters represent Tukey's multiple comparison of means (p<0.05) within a site. Site and litter type means are averaged across all litter types or site means respectively.

	Site Number												
	1	2	3	4	5	6	7	8	9	10	11	12	
Stand age (years)	1	6	16	17	29	31	1	2	13	18	28	29	
Site Quality	M	PM	M	PM	M	PM	R	MR	MR	MR	R	R	
Litter Type	Litter x Site Means												Litter Means
Bb/Ra		0.676a		0.724a		1.02a	0.512b		0.951a		1.06a		0.824
Bf	0.258b		0.314b		0.358a		0.263c		0.338c		0.353c		0.314
Br	0.344a		0.509a		0.375a								0.409
Bu							0.691a		0.771b		0.783b		0.748
Go		0.557b		0.490b		0.501b							0.516
Gr								0.244b		0.273c		0.294c	0.270
Rm		0.546b		0.484b		0.528b		0.420a		0.490a		0.538a	0.501
Sc	0.178c		0.204b		0.190b								0.191
Wf								0.440a		0.408b		0.449b	0.432
WS	0.253b	0.263c	0.271b	0.272c	0.318a	0.319c	0.238c	0.237b	0.259c	0.284c	0.324c	0.367c	0.284
Site Means	0.258	0.511	0.325	0.493	0.310	0.592	0.426	0.335	0.580	0.364	0.630	0.412	

4.1.3 Decomposition Method Considerations

The decomposition of litter fall in forests plays a fundamental role in nutrient cycling within the ecosystem (Ge et al., 2013; Purahong et al., 2013). Litterbags have been used as the standard method of measuring decomposition of different litter types in various studies (Moore et al., 2017). Moore et al. (2017) discuss how the decomposition rate established in the first year of field studies are reasonable predictors of 12-year decomposition rates in colder soils. The litterbag method has been beneficial in identifying the primary controls on decomposition, which has been proven by the CIDET and LIDET studies. The primary controls of importance are litter quality, climate, and microbial community. Climate influences rate at a broad scale, litter quality is both broad and local, while microbial communities influence decomposition rate on a local scale (Keiser 2017). Overall, the differences in decomposition rate between litter types is a result of differences in the litter composition, and the difference in the decomposition of a litter type between sites is due to stand age.

The litterbag method allowed for the determination of decomposition rate for ten litter species under conditions in Nova Scotia. Based on past studies (Ma et al., 2007; Zhang et al., 2008), the rate of decomposition calculated for each litter type in this thesis followed a first-order decay function.

Many studies found that litter decomposition was slower in sites that had a more open canopy as opposed to those with a closed canopy (Moore et al., 1999; Patricio et al., 2012). The rate of decomposition can be altered through moisture and temperature regimes and pH, as these factors influence the activity of decomposing microorganisms (Swift et al., 1979; Patricio et al., 2012). The findings presented here are consistent with these observations, finding that decomposition rates increased with plantation age, which also corresponded with an increase in canopy cover, and that site quality did not have a significant impact on decomposition.

4.3 Chemical and Physical Litter Composition

Data obtained for initial litter characterization are organized from greatest to least values below (Table 18). Grasses had low relative Klason lignin (29.4%) carbon contents (45.73%), and low manganese concentrations (0.54 mg g^{-1}), while also having the lowest nitrogen content (0.77%), calcium (0.52 mg g^{-1}), magnesium (0.33 mg g^{-1}), potassium (0.35 mg g^{-1}), and phosphorus (0.35 mg g^{-1}) concentrations when compared to the other litter types. Grasses also had the highest mean C/N ratio (60), demonstrating how the C/N ratio is a good indicator of decomposition rate, as grasses are one of the slowest decomposing litter types in this study. Blackberry/raspberry had the lowest C/N ratio (22.8), which is directly related to the rapid decomposition rate obtained for the litter type. Blackberry/raspberry litter had high nitrogen content (2.02%), manganese concentrations (2.66 mg g^{-1}), and phosphorus concentrations (1.259 mg g^{-1}).

Table 18. Litter characterization values listed from greatest to least for all litter types.

	Litter Type	KL (%) $\bar{x}$	Litter Type	N (%) $\bar{x}$	Litter Type	C (%) $\bar{x}$
Greatest	Bf	47.4 (0.2)	Bb/Ra	2.5 (0.2)	Bf	50.85 (0.04)
	Br	44.7 (0.1)	Br	2.02 (0.02)	WS	50.12 (0.02)
	WS	41.5 (0.1)	Wf	1.743 (0.005)	Rm	47.87 (0.03)
	Rm	36.9 (0.3)	Bu	1.6 (0.1)	Bu	46.57 (0.05)
	Wf	36.3 (0.2)	Go	1.30 (0.03)	Go	45.91 (0.02)
	Go	32.8 (0.3)	Rm	1.29 (0.01)	Bb/Ra	45.73 (0.04)
	Sc	29.4 (0.3)	WS	1.237 (0.008)	Br	45.603 (0.007)
	Bb/Ra	29.10 (0.04)	Bf	1.152 (0.005)	Sc	45.40 (0.07)
	Gr	29.0 (0.4)	Sc	0.77 (0.02)	Gr	44.17 (0.02)
Least	Bu	25.1 (0.2)	Gr	0.73 (0.02)	Wf	42.67 (0.04)

	Litter Type	C/N $\bar{x}$	Litter Type	Ca (mg g^{-1}) $\bar{x}$	Litter Type	Mg (mg g^{-1}) $\bar{x}$
Greatest	Gr	62 (1)	Bu	6.3 (0.1)	Wf	4.12 (0.08)
	Sc	60 (1)	Go	6.19 (0.05)	Bu	3.68 (0.08)
	Bf	44.2 (0.2)	Bb/Ra	6.1 (0.3)	Go	2.54 (0.01)
	WS	40.6 (0.2)	Rm	5.2 (0.2)	Bb/Ra	2.2 (0.1)
	Rm	37 (1)	Bf	3.32 (0.08)	Br	1.76 (0.04)
	Go	33.1 (0.4)	Wf	3.03 (0.09)	Rm	1.52 (0.06)
	Bu	30 (2)	Br	2.40 (0.03)	Sc	0.75 (0.02)
	Wf	25.34 (0.07)	Sc	17.0 (0.2)	Bf	0.622 (0.009)
	Br	22.8 (0.2)	WS	1.96 (0.05)	WS	0.482 (0.002)
Least	Bb/Ra	22.6 (0.7)	Gr	0.52 (0.04)	Gr	0.33 (0.03)
	Litter Type	K (mg g^{-1}) $\bar{x}$	Litter Type	P (mg g^{-1}) $\bar{x}$	Litter Type	Mn (mg g^{-1}) $\bar{x}$
Greatest	Wf	7.30 (0.01)	Wf	2.14 (0.04)	Bb/Ra	2.66 (0.03)
	Go	5.9 (0.2)	Bb/Ra	1.51 (0.03)	Bf	1.52 (0.02)
	Br	3.84 (0.06)	Bu	1.43 (0.07)	Wf	1.40 (0.06)
	Bb/Ra	3.62 (0.06)	Br	1.259 (0.008)	Go	1.03 (0.02)
	Bu	3.48 (0.08)	Go	0.982 (0.009)	Rm	0.96 (0.04)
	Bf	12.85 (0.07)	WS	0.951 (0.004)	WS	0.834 (0.003)
	Rm	12.5 (0.5)	Rm	0.928 (0.009)	Br	0.70 (0.01)
	Sc	11.2 (0.4)	Bf	0.84 (0.01)	Bu	0.54 (0.04)
	WS	1.1 (0.1	Sc	0.644 (0.007)	Gr	0.347 (0.009)
Least	Gr	0.89 (0.03)	Gr	0.35 (0.02)	Sc	0.345 (0.009)

White spruce needles had low calcium (2.40 mg g^{-1}), magnesium (0.482 mg g^{-1}), and potassium concentrations (0.89 mg g^{-1}), as well as low nitrogen content (1.237%). White spruce litter also had higher amounts of Klason lignin (41.5%), carbon content (50.12%), and C/N ratio values (40.6), the low nutrient content and high lignin content is consistent with the slower decomposition rates observed for the white spruce litter.

Calcium concentrations are important in the regulation of decomposition, as they influence the lignin-degrading microflora (Berg and McClaugherty, 2008). Calcium concentrations during decomposition tend to peak then decrease, corresponding to the turning point in decay where net lignin degradation begins, as seen in a Scots pine decomposition study (Berg and McClaugherty, 2008). In their study, Berg and

McClaugherty found that the leaching of most nutrients (with the exception of K due to the high solubility of the nutrient) was low, demonstrating how the nutrient loss from litter was related to microbial decomposition processes, rather than leaching. Although K and Mg are essential to plant life, there is no indication that they act as limiting nutrients in decomposition processes (Berg and McClaugherty, 2008).

Higher Klason lignin content, carbon content, and C/N ratio values had lower decomposition rates compared to the litter types with lower amounts of KL, C, and C/N ratios. This is also reflected in the different nutrients measured, as the litter types that were found to have slower decomposition rates had lower nutrients concentrations when first characterized.

4.3.1 Principal Components Analysis

A principal components analysis (PCA) was used to ascertain the dominant aspects of the influence of litter chemical composition on the rate of litter decomposition. This was undertaken to reduce the dimensionality of the dataset, identifying the dominant trends and allow for the data to be more easily interpreted. The variables used in the PCA were the chemical composition of each litter species (Table 18) and calculated decomposition rate (k, year^{-1}). The first four eigenvalues accounted for approximately 90% of the variability within the dataset (Table 19), although the focus will highlight the first two components, as they account for over 70% of the variability.

Table 19. Principal components with their associated eigenvalues, percent of variability and cumulative percentage of variability within the dataset.

Number	Eigenvalue	Percent	Cumulative Percent	P>ChiSq
1	4.6234	46.234	46.234	<.0001*
2	2.4588	24.588	70.821	<.0001*
3	0.9930	9.930	80.751	<.0001*
4	0.9212	9.212	89.963	<.0001*

The eigenvalues below (Table 20) represent a partition of the total variation in the dataset. The total number of eigenvalue sum to the number of variables when completed on the correlation matrix (n=10). The more positive, or more negative, values listed for each principal component (PC) below show the magnitude of loading of each variable for the different principal components.

The first principal component (PC1) accounts for approximately 46% of the variation and predominantly reflects the influence of the nutrient content (Table 20). Potassium (K, mg g^{-1}), phosphorus (P, mg g^{-1}), magnesium (Mg, mg g^{-1}), and nitrogen (N, %) show a strong positive relationship with the decomposition rate (k, $year^{-1}$), while the C/N ratio has a strong negative relationship with rate (Table 20; Figure 15). These results are consistent with those established by Zhang et al. (2008), where litter decomposition rates increased with N, P, K, Ca, and Mg, but decreased with C/N and lignin.

The second principal component accounts for an additional 25% of the variation in the data and primarily differentiates structural aspects of the litter (Table 20). Klason lignin and carbon are strong positive values (Table 20; Figure 15).

The decomposition rate is at a 45° angle to these components (Figure 15) indicating that PC1 and PC2 have equal weight in influencing the decomposition rate. Decomposition rate is positively related to PC1 indicating nutrient content has a positive influence on decomposition rate and negatively related to PC2, showing lignin and carbon content to have a negative influence on decomposition rate.

A factor of importance within the third and fourth components is manganese (Mn, mg g^{-1}). The first four principal component loadings values can be seen below (Table 20). Manganese has been recorded to influence decomposition rates in various studies as it plays a role in lignin decomposition (Perez and Jefferies, 1992; Berg et al., 1996; Heim and Frey, 2004; Trum et al., 2015). White-rot fungi secretes manganese peroxidase (MnP), which oxidizes Mn^{2+} to Mn^{3+} ions, thereby breaking down the complex lignin structure (Perez and Jefferies, 1992; Trum et al., 2015). The pH and soil redox potential of the site may influence the degradation of lignin, as Mn concentrations are often a reflection of the redox state. This provides insight to the positive relationship Mn shows with decomposition rate (Heim and Fray 2004; Trum et al., 2015).

Table 20. Eigenvectors for the first four principal components (PC).

	PC1	PC2	PC3	PC4
Ca	0.20013	-0.40511	0.39796	0.23851
Mg	0.39342	-0.21459	-0.15609	0.20961
K	0.38143	0.16460	-0.17050	0.32999
P	0.39163	0.20866	-0.33875	0.16542
Mn	0.23796	0.08929	-0.19747	-0.82811
N	0.37193	0.30009	0.29288	-0.04671
C	0.00904	0.44315	0.68365	-0.03789
C/N	-0.43788	-0.09371	-0.03460	0.05608
KL	-0.07043	0.54115	-0.10736	0.16715
k	0.33849	-0.35096	0.26184	-0.20607

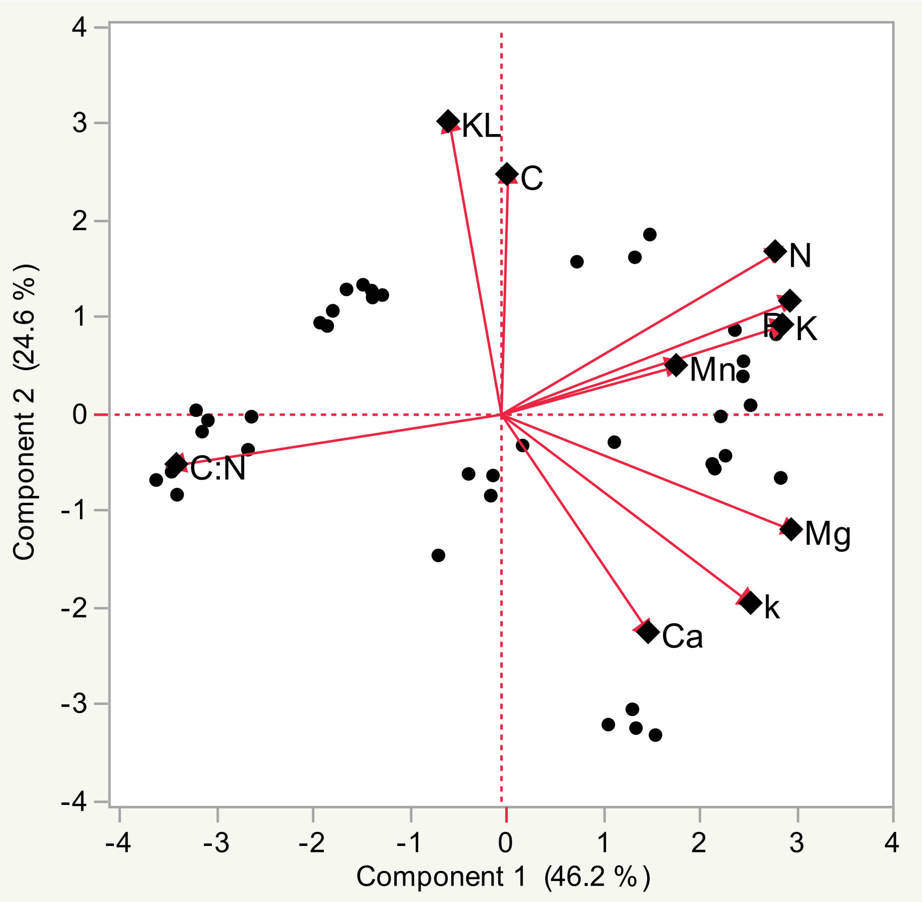


Figure 15. PCA results showing the first two components obtained, accounting for over 70% of the variation.

4.3.2 The Change in Litter Composition During Decomposition

The nutrient concentration of each of the litter materials changed during decomposition (Table 21). An increase in the concentration of element with time may reflect accumulation from an external source (increase in the numerator) or a disproportionate decrease in the denominator, which in this case is litter mass and is dominated by carbon. The Ca content of the litter was seen to increase suggesting that Ca is retained by the decomposer community as carbon is respired. An increase was also seen in Mn concentrations, which provides insight to the redox potential of the sites used.

The oxidation of Mn is important in litter decomposition as decomposing fungi actively cycle Mn for the purpose of breaking down complex aromatic structures, such as lignin (Keiluweit et al., 2015). Keiluweit et al. (2015) determined that litter-decomposing fungi accumulate reduced Mn^{2+} from the litter layer, and transform it into oxidative Mn^{3+} forms which aid in decay. In a decomposition study completed by Heim and Frey (2004), it was determined that Mn concentrations found in freshly fallen litter was a reflection of site pH, as enzymatic lignin breakdown increases in sites with lower soil pH.

Significant decreases in K concentrations are due to the solubility of this nutrient increasing the potential for leaching into the surrounding environment (Berg and McClaugherty, 2008). The relationship between K and Ca as discussed in Patricio et al. (2012), and references therein, is that higher K values in plant materials leads to lower concentrations of Ca. Results obtained from this study indicate that as K is leached out of the litter, and therefore concentrations are decreasing in early stages of decomposition, while an increase in Ca was observed. No relationship was established between higher concentrations of K and lower concentrations of Ca for the litter types used in this study.

Table 21. P-values obtained through ANOVA to determine the effect of time of litterbag deployment on nutrient concentration for each litter type.

Litter Type	P-Values			
	KL (%)	N (%)	C (%)	C/N
Bb/Ra	<.0001* (↑)	<.0001* (↑)	<.0001* (↑)	<.0001* (↓)
Bf	<.0001* (↑)	0.0004* (↑)	<.0001* (–)	0.0226* (↓)
Br	<.0001* (↑)	0.0273* (↑)	<.0001* (–)	0.1470 (↓)
Bu	<.0001* (↑)	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)
Go	<.0001* (↑)	0.0083* (↑)	<.0001* (–)	0.0129* (↓)
Gr	<.0001* (↑)	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)
Rm	<.0001* (↑)	<.0001* (↑)	<.0001* (–)	<.0001* (↓)
Sc	0.0643* (–)	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)
Wf	<.0001* (↑)	<.0001* (↑)	<.0001* (↑)	<.0001* (↓)
WS	<.0001* (↑)	<.0001* (↑)	<.0001* (–)	<.0001* (↓)

	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})	Mn (mg g^{-1})
Bb/Ra	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)	<.0001* (↑)	<.0001* (↑)
Bf	0.0763 (–)	0.0274* (↓)	<.0001* (↓)	<.0001* (↓)	0.0225* (↑)
Br	0.0026* (↑)	0.0559 (↓)	<.0001* (↓)	<.0001* (↓)	0.0114* (↑)
Bu	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)	<.0001* (↑)	<.0001* (↑)
Go	<.0001* (↑)	0.0024* (↓)	<.0001* (↓)	<.0001* (↓)	<.0001* (↑)
Gr	<.0001* (↑)	0.3451 (–)	0.0004* (↓)	<.0001* (↑)	0.0263* (↑)
Rm	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)	0.0007* (↑)	0.0212* (↑)
Sc	<.0001* (↑)	0.0256* (↑)	<.0001* (↓)	0.0196* (↑)	0.0011* (↑)
Wf	0.0309* (↑)	<.0001* (↓)	<.0001* (↓)	<.0001* (↓)	<.0001* (↑)
WS	<.0001* (↑)	<.0001* (↑)	<.0001* (↓)	<.0001* (↓)	<.0001* (↑)

There was a significant decrease in Mg concentrations throughout the duration of the field study for most litter types, with the exception of bracken fern and grasses. The 3e may be due to the leachability properties of this nutrient (Patricio et al., 2012), although the decrease is not as dramatic as it is seen in K. Unlike the results obtained by Rahman et al. (2013), the return of Mg, K, and P was higher than C. Nitrogen concentrations increased with increasing time, indicating a potential immobilization within the ecosystem, or a reflection of the loss of carbon.

The increase in Klason lignin (KL) for all litter types show that relative concentration of KL is increasing with time due to its recalcitrance and is consistent with the slower decomposition rates of those litters. As the plant material is altered through decomposition processes, lignin and recalcitrant materials remain, thereby demonstrating that decomposition rates slow down as the more complex structures require longer periods of time to degrade. As seen in Table 19, nitrogen concentrations are increasing with time, which provides insight into how an increase in nitrogen, or decrease in carbon, can be useful in determining later stages of decomposition. Berg et al. (1996) discusses how higher nitrogen content has a positive influence on the rate of early decomposition, but in later stages of decomposition it may have reverse effects. Many white-rot fungus species do not produce the lignin-degrading enzyme in presence of low-molecular and N-rich compounds, as per the Keyser et al. (1978) reference in Berg et al. (1996). This observation provides insight to nitrogen dynamics in later stages of decomposition.

4.3.3 Litter Nutrient Rate of Change Data

The chemical composition of litter was determined for each litter type at each sampling period. All data obtained from each sampling period is found in Appendix C. This data represents the mean (SE) values obtained for Ca, Mg, K, P, Mn, C, N, C/N, KL, SO_4^{2-}, Fe, Zn, Al, B, Cu, and ASL (%) at each sampling period, for each litter type at each site. Tukey's multiple comparison of means show the significant differences between sampling periods for each litter type, and each variable. This data is important for mathematical modelling which will be used in the development of management plans conducive to forestry conditions in Nova Scotia. This information is not included in the body of this thesis as the focus remains on how the litter composition influences the rate of decomposition, and general conclusions of how nutrients changed during early stages of decomposition. Further recommendations include examining the influence of stand age and site quality on the rates of changes of each nutrient for all ten litter types at each site.

4.4 Factors Controlling Decomposition

The three main factors that control decomposition are litter quality, climate, and microbial community (Rahman et al., 2013; Prakash et al., 2015; Keiser and Bradford, 2017). As determined through PCA, decomposition rate was primarily a function of the nutrient content of the litter and secondarily the quality of the litter as reflected in lignin content. Higher nutrient content and lower lignin litters decomposed at faster rates. It was found that litter types with higher nutrient concentrations decomposed at faster rates compared to litter types where nutrient concentrations were lower (Hendricks and Boring, 1992; Rahman et al., 2013).

Litter nutrient concentrations for white spruce needles were similar in Mg, 0.5 mg g^{-1} compared to 0.83 mg g^{-1} collected by Heim and Frey (2004), P (1.0 mg g^{-1} compared to 1.4 mg g^{-1} (Heim and Frey, 2004)), and Mn (0.8 mg g^{-1} compared to 1.1 mg g^{-1} (2004)). White spruce needle concentrations differed in Ca, 2.4 mg g^{-1}, compared to 7.5 mg g^{-1} (Heim and Frey, 2004), and different in K concentrations 0.9 mg g^{-1} which was much lower than the concentration found in Switzerland (5.4 mg g^{-1}; Heim and Frey, 2004). Nitrogen values reported for white spruce needles by Moore et al. (1999) ranged from 0.74% - 0.97%, which compare well to the average 1.2% reported in this study. Maple leaf litter compared well to the values reported by Moore et al. (1999), indicating that litter nutrient concentrations are similar to those reported in Canadian studies than those reported in other regions. The lower nutrient values reported for white spruce needles compared to those recorded in Switzerland (Heim and Frey, 2004) is verified in the difference in decomposition rates, as the rate calculated in this thesis was much smaller.

The rates of decomposition measured for bracken fern were similar to those found by Moore et al. (2002), where 64.5% of mass remained after three years, while an average of 60.0% mass remained after one-and-a-half years in this study. Moore et al. (2002) showed 56.2% of mass remained in spruce needles after two years, while 70.0% of mass remained in this study for 1.5 years. This shows that the decomposition of spruce needles is slower in Nova Scotia than in other areas of Canada. The decomposition rate for white spruce in a study completed by Heim and Frey (2004) in Switzerland was calculated to be 0.73 year^{-1}, showed that 73% of aboveground litter for white spruce had 33% of mass remaining after a two year period. This rate is much slower than that found in this study. The data from this study show decomposition rates are more similar to those found in Canadian studies compared to other regions (Moore et al., 2002).

Climate and microbial community are also important drivers of decomposition. In a particular climate, differences in mass-loss rates of litters should be reflective of the chemical and physical properties of the litter (Berg and McClaugherty, 2008). The data collected in this study show that the chemical and physical properties of the litter are reflected in the decomposition rate, and are more important than site conditions. In this study, litter composition was more important than site condition during the initial stages of decomposition. Climate, which includes precipitation, temperature, and evapotranspiration of a particular region, influences decomposition rates as warmer temperatures and more precipitation leads to higher moisture content in the soil, and therefore provides more favourable conditions for soil microorganisms to perform decomposition processes (Prescott et al., 2004). Microclimate could provide insight to sites with different decomposition rates for a litter type. For example, in the younger plantations, the lack of vegetation and tree growth could result in a windier site, with direct sunlight on the site, which can speed up evapotranspiration processes, drying the litter, and soil, and therefore slowing down microbial activity and limiting nutrient leaching from the litter inside the litterbags (Berg and McClaugherty, 2008).

The data collected for this thesis will be used to support the parameterization of FORECAST for conditions representative of Nova Scotia (Welham et al., N.D.). This project has been the first of its kind in the province, although the methods used within have been well established. Nutrient information collected provides insight to decomposition of litter within Nova Scotia's plantation forests and thereby providing information on nutrient cycling within the ecosystem.

CHAPTER 5: CONCLUSIONS

The litterbag method was successfully used in monitoring early stages of forest litter decomposition in Nova Scotia. The method was used to estimate litter quality parameters and site characteristics (age and quality) on decomposition for the duration of litterbag deployment, as monitored through a field study involving various sampling periods.

I confirmed the importance of litter quality in determining decomposition rates for various litter types that have been identified in previous studies (lignin, C/N ratio, Mn). The chemical composition of different litter types was more important than site conditions in determining decomposition rates. It presents a first dataset on decomposition rates for various litter types in plantation forests in Nova Scotia, Canada.

Litter decomposition rates and nutrient content reported in this thesis compared well to similar litter types studied in other Canadian studies, although white spruce needles had lower nutrient contents, and therefore slower decomposition rates, than those found in other regions (e.g. Europe). There was sufficient variation in decomposition for the various litter types used in this study, and should be considered independently in a decomposition model. Decomposition models need to consider differences in site characteristics when developing nutrient management plans, as stand age, and therefore characteristics conducive to age, plays an important role in decomposition rates in Nova Scotia.

Future Directions

I recommend the completion of the final two samplings to collect all 1440 litterbags. The analyses of these litterbags will complete the dataset and provide information on changing rates of decomposition for each litter type.

Further work in determining rate of change with each nutrient for different litter types can be explored. This may provide further insight to nutrient limitations and specific nutrients that may play an important role in controlling decomposition. Another factor that can be explored with this dataset is integrating the weather information obtained from the weather stations used at the different sites to further investigate the influence of soil temperature, moisture, precipitation, and air temperature on rates of decomposition.

Determining the composition of the microbial community across the different stand ages would also be beneficial to determine the influence of stand age as a result of changes in microbial community and its capacity to decompose various litter types. This could provide even more information toward nutrient cycling and soil processes in Nova Scotia's plantation forests.

Ultimately, the complete dataset will be used in the ecosystem-based model FORECAST as a research tool. This output will help government and industrial forest managers as they attempt to integrate nutrient management practices into current forest management practices. Information gathered from this study, including mass loss, nutrient concentrations, litter quality, climatic information, and site characteristics will provide a baseline of the efficiency of plantation forest processes representative of Nova

Scotia’s ecological conditions. Mathematical modelling will therefore benefit the integration of nutrient management practices to ensure future healthy harvest rotations are maintained for future generations.

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APPENDIX A

Site Characterization

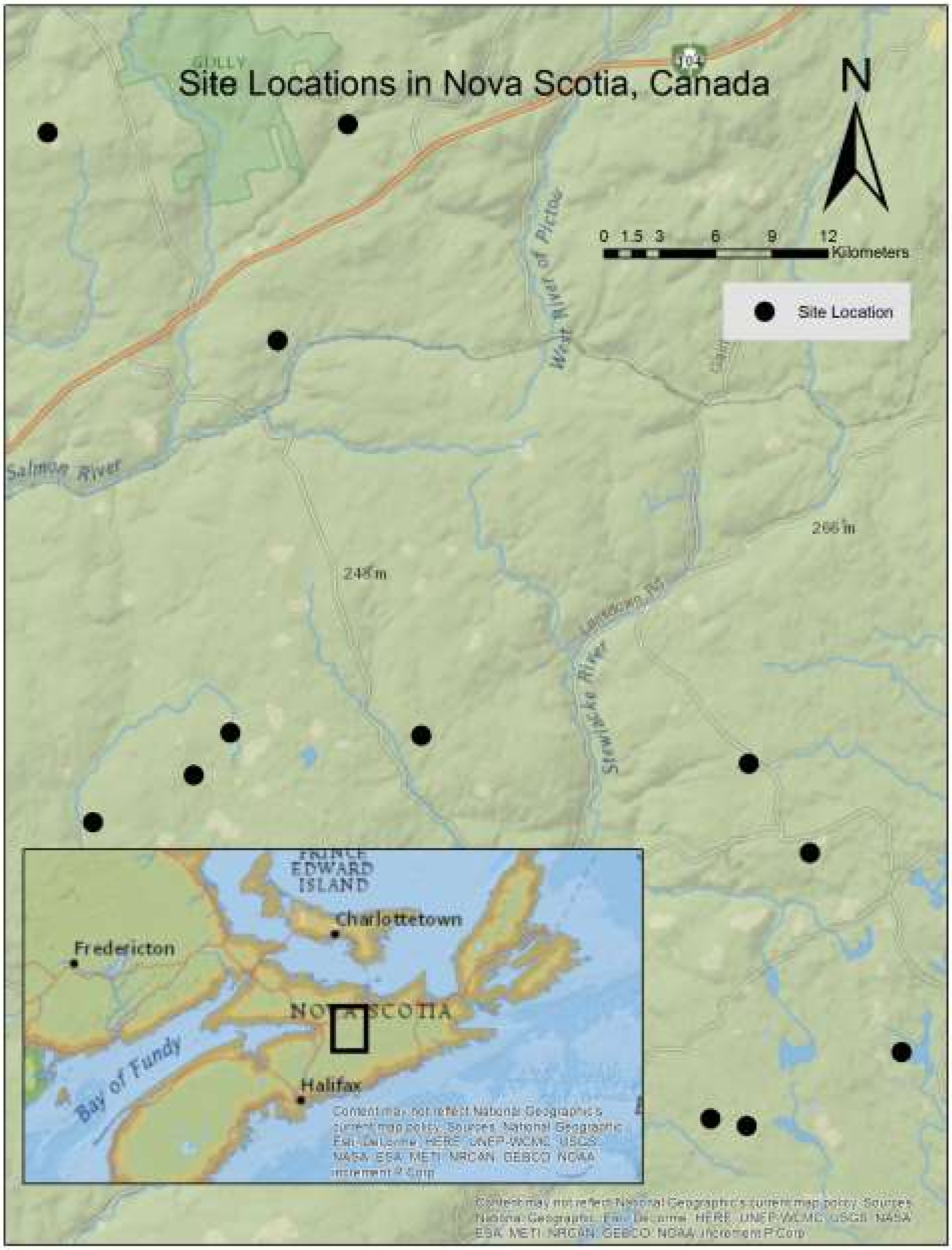

Figure A1. Locations of the 12 sampling sites.

Site 1

Figure A2. Aerial image of site (L) and plantation map (R). Black circles represent the location of the site where litterbags were deployed.

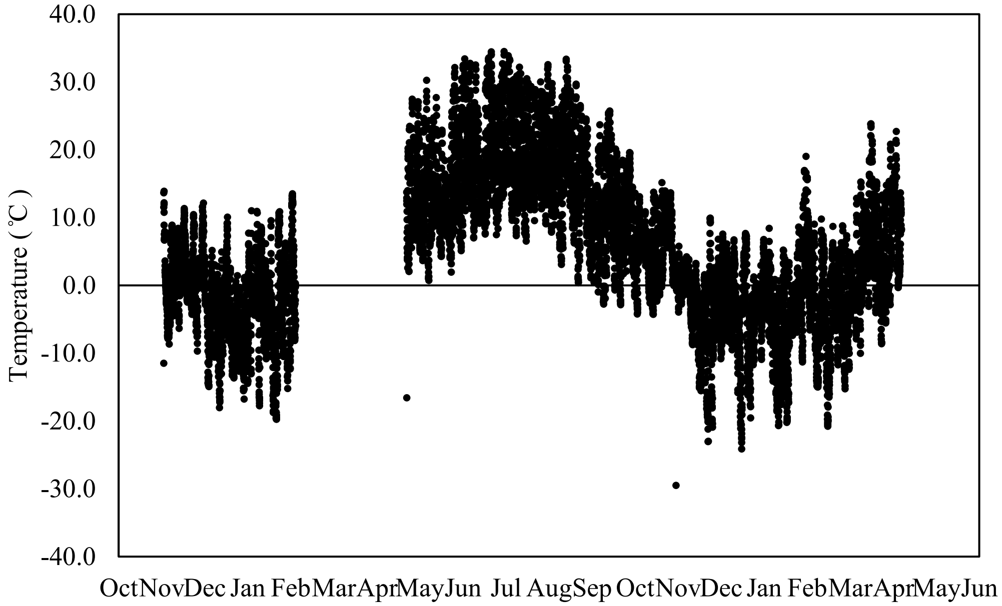

Figure A3. Air temperature (˚C) obtained from weather station at site 1 (1-year-old) from November 2015-May 2017.

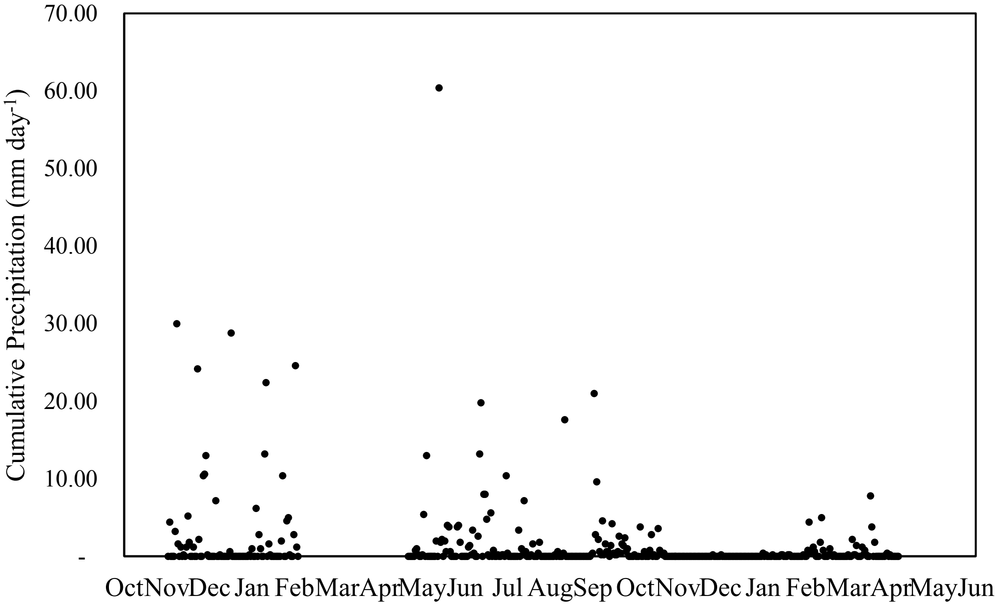

Figure A4. Cumulative precipitation levels (mm day^{-1}) obtained from weather station located at site 1 (1 year old).

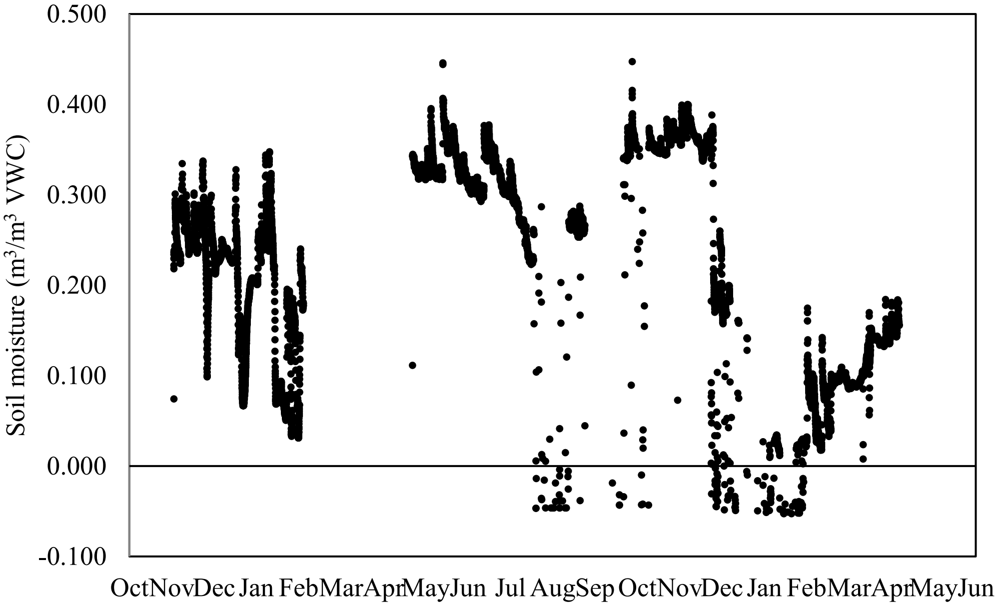

Figure A5. Soil moisture (m^3/m^3 VWC) reading between H and mineral soil layer at site 1 (1-year-old).

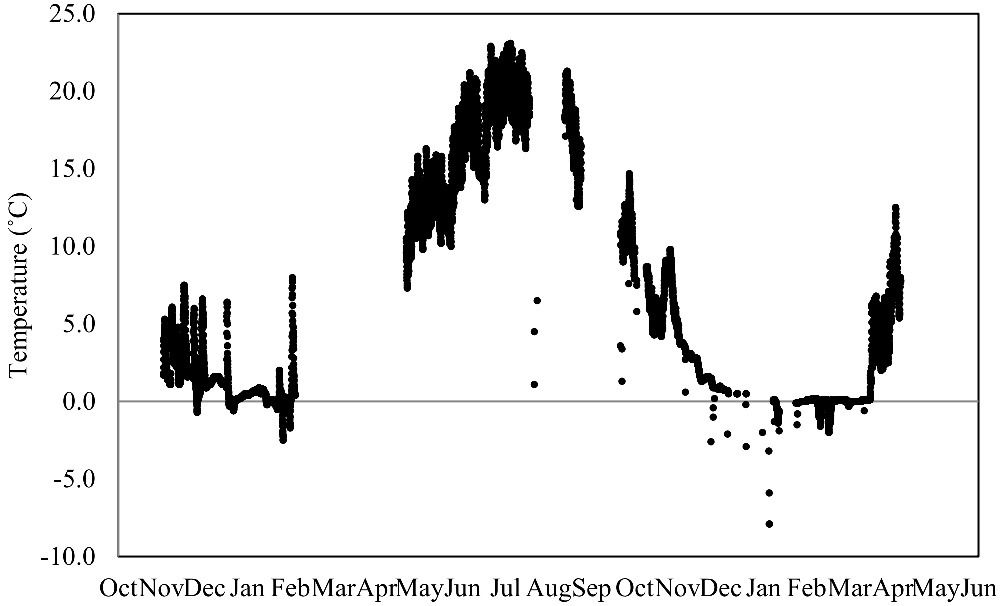

Figure A6. Soil temperature (˚C) readings between the humic layer and mineral soil layer of the forest floor at site 1 (1-year-old).

Table A1. Monthly averages of air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C), and monthly cumulative precipitation values obtained from the weather station.

Month	Air Temp. (˚C) Mean (SE)	Precipitation (mm) Cumulative	Soil Moisture (m^3/m^3 VWC) Mean (SE)	Soil Temp. (˚C) Mean (SE)
January	-4.2 (0.6)	1.66	0.204 (0.009)	0.8 (0.1)
February	-3.3 (0.8)	3.72	0.12 (0.01)	0.3 (0.1)
March	-3.4 (0.9)	0.60	0.079 (0.004)	-0.10 (0.06)
April	5.3 (0.8)	-	0.128 (0.004)	3.4 (0.6)
May	12.0 (1)	-	0.30 (0.02)	10.8 (0.6)
June	14.7 (0.7)	3.73	0.337 (0.004)	14.2 (0.4)
July	19.2 (0.6)	3.27	0.320 (0.004)	18.6 (0.3)
August	18.7 (0.3)	0.69	0.10 (0.02)	6.3 (2)
September	14.8 (0.9)	2.28	0.10 (0.02)	6.1 (2)
October	9.1 (0.7)	1.23	0.11 (0.03)	2.3 (1)
November	3.5 (0.6)	0.41	0.32 (0.02)	5.1 (0.4)
December	-1.7 (0.7)	4.73	0.284 (0.008)	2.0 (0.3)

Precipitation levels are not well represented as the measuring device does not provide levels of solid precipitation, and was easily obstructed due to ice formation, litter fall, or animal activity.

Table A2. Climate normals obtained from the Truro, NS weather station.

Month	Air Temperature (average (SD))	Precipitation (mm)	Soil Temperature (5 cm depth)
January	-6.9 (2.1)	114.6	0.0
February	-6.0 (2.4)	90.5	0.1
March	-1.8 (2)	104.2	0.0
April	4.2 (1.2)	84.8	4.9
May	10 (1.6)	94.5	11.8
June	14.8 (1.2)	92.8	14.1
July	18.4 (1.3)	85.2	0.0
August	18 (1.4)	79.6	0.0
September	13.7 (1.6)	103.5	16.0
October	8.0 (1.4)	104.5	10.0
November	3.1 (1.3)	115.0	5.7
December	-3.2 (2.6)	114.0	1.1

Table A3. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
14960	2014	Greenfield	Colchester	5018021.9	495429.5	193.965	Medium	Millbrook	Mi4/C	0

Table A4. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	Organic Matter (% LoI)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.2 (0.4)a	94 (2)a	3.53	2.4 (0.9)a	0.5 (0.2)a	0.6 (0.3)b	0.6 (0.3)a
FH	0.2 (0.3)a	79 (13)b		2.3 (0.9)a	0.8 (0.3)a	1.0 (0.3)a	0.7 (0.1)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2 (1)a	1.0 (0.6)b	0.008 (0.002)a	1.3 (0.9)b	1.1 (0.6)a	0.06 (0.03)a	59 (47)a
FH	3.0 (0.6)a	5 (3)a	0.009 (0.001)a	6 (4)a	1.5 (0.8)a	0.06 (0.03)a	27 (5)a
	C (%)	N (%)					
L	43 (2)a	1.1 (0.5)a					
FH	36 (6)b	1.4 (0.2)a					

*Tukey comparison of means was used to determine if the L and FH forest floor layers were significantly different ($P<0.05$). The results from this statistical test are represented as lowercase letters. The same letter grouping shows that the means are statistically different when comparing the forest floor layers.

Site 2

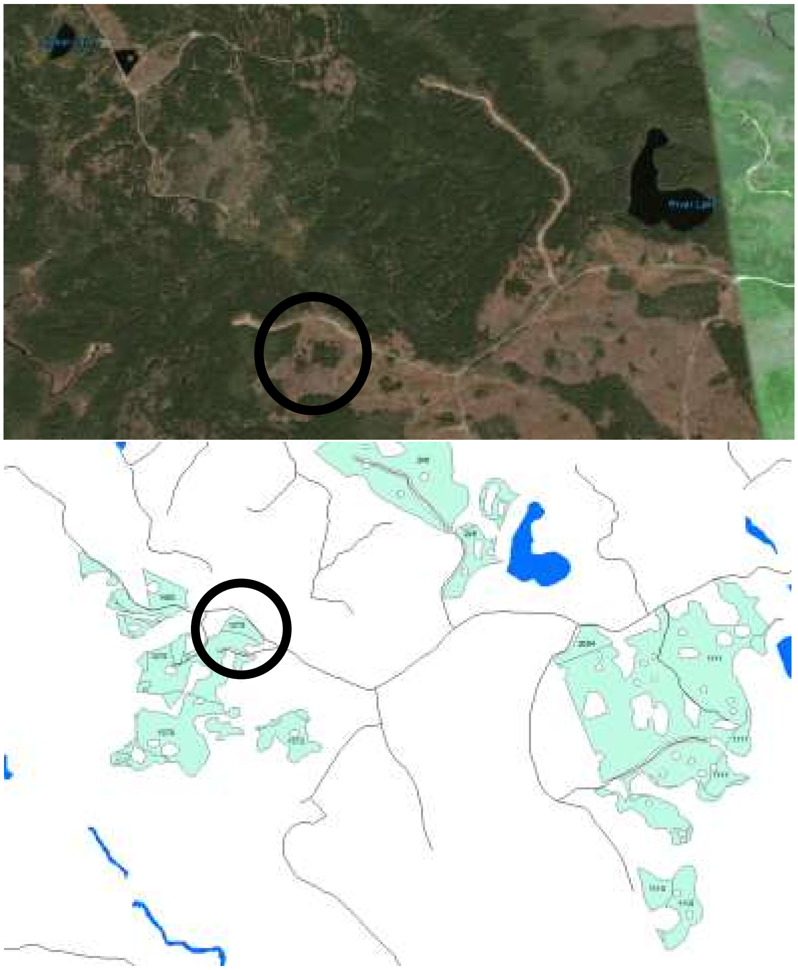

Figure A7. Aerial image of site (top) and plantation map with indicated site location (bottom).

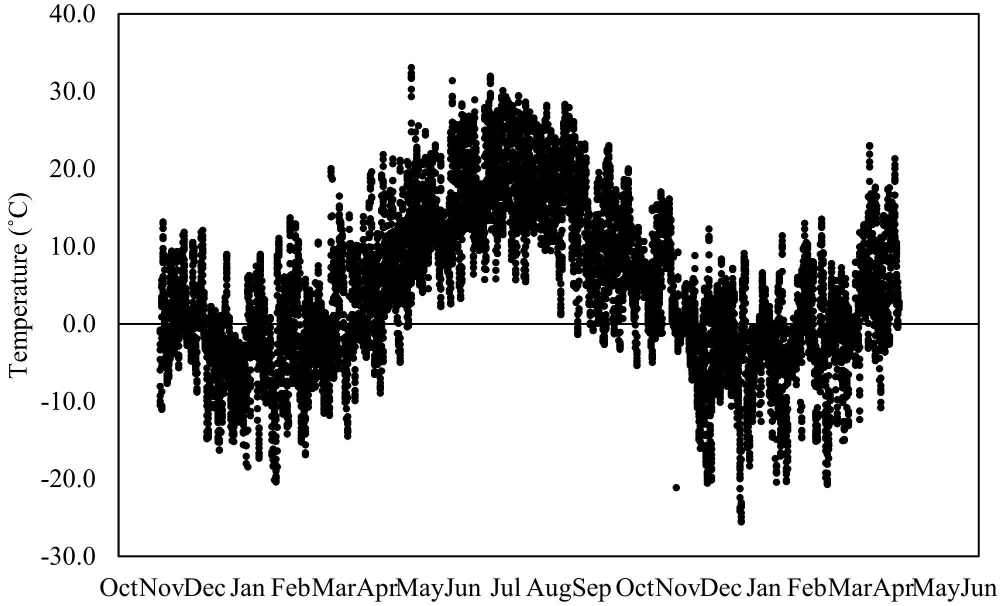

Figure A8. Air temperature (˚C) data obtained from the weather station located at site 2 (6 years old) from November 2015-May 2017.

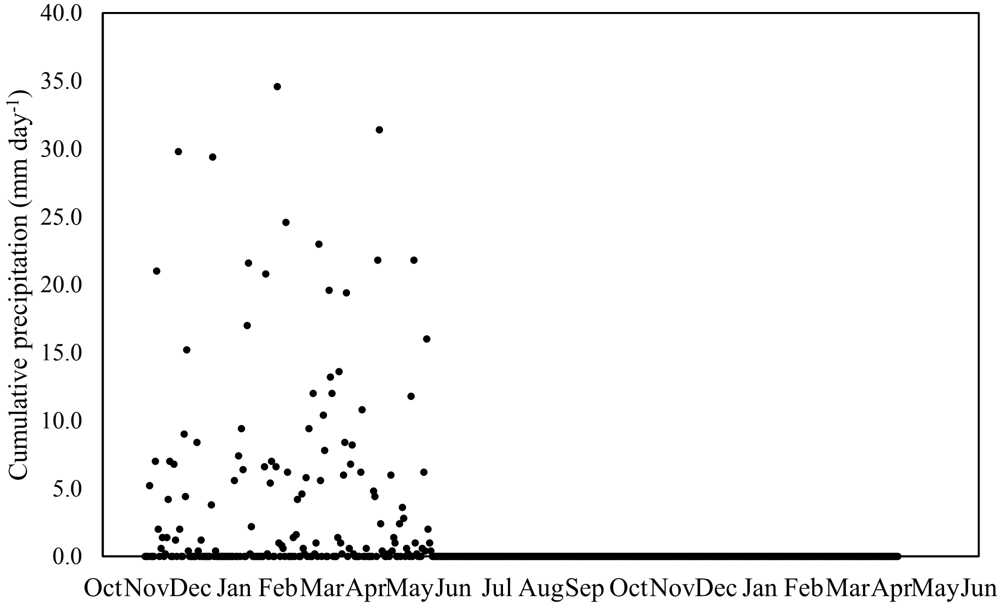

Figure A9. Cumulative precipitation (mm day^{-1}) data values obtained from the weather station located at site 2 (6 years old) from November 2015-May 2017.

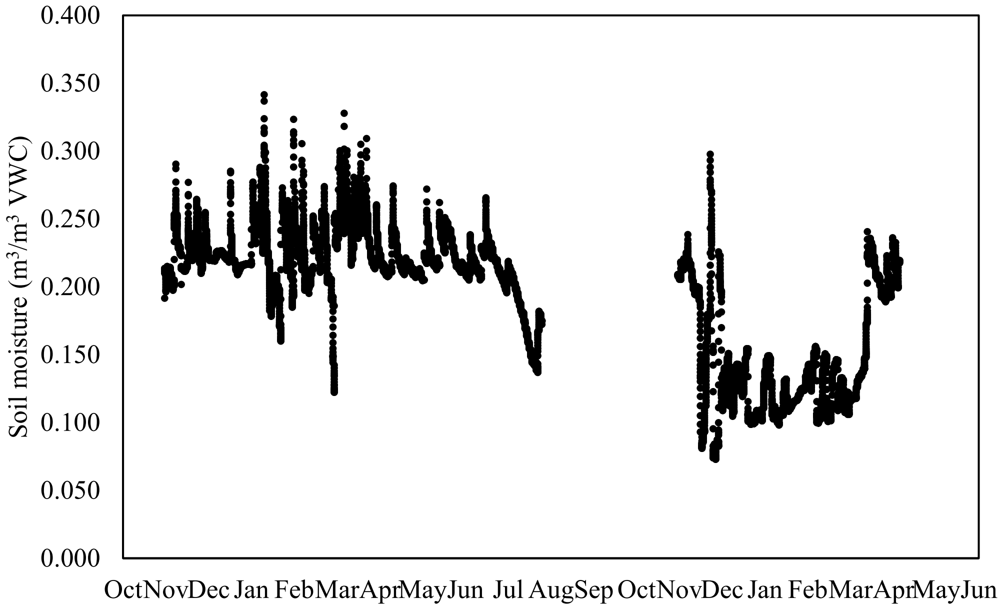

Figure A10. Soil moisture data (m^3/m^3 VWC) obtained from a weather station located at site 2 (6 years old) from November 2015-May 2017.

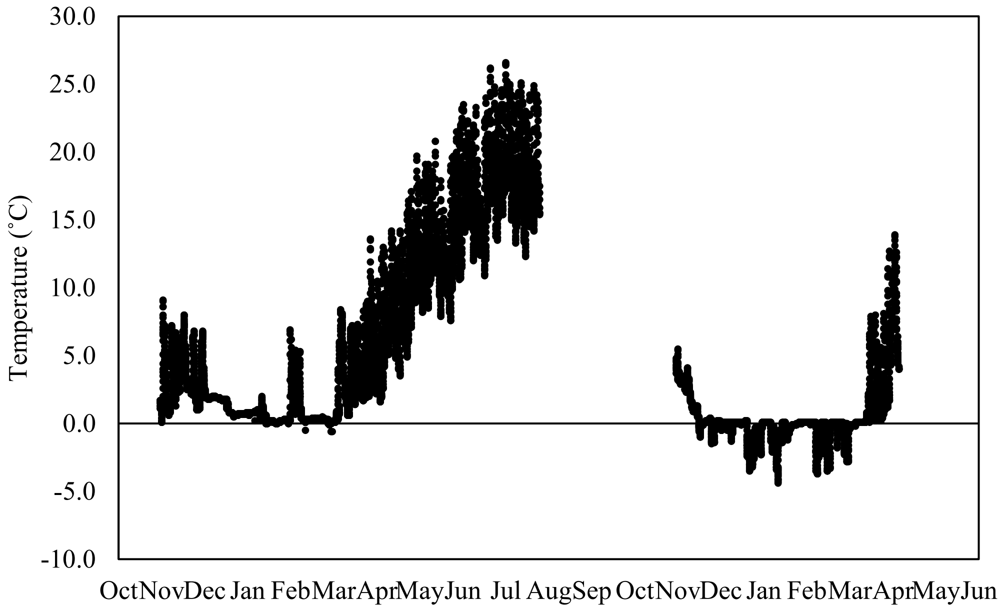

Figure A11. Soil temperature (˚C) data obtained from a weather station located at site 2 (6 years old) from November 2015-May 2017.

Table A5. Monthly mean (SE) for air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C), and monthly cumulative values for precipitation (mm).

Month	Air Temp. (˚C) Mean (SE)	Precipitation (mm) Cumulative	Soil Moisture (m^3/m^3 VWC) Mean (SE)	Soil Temp. (˚C) Mean (SE)
January	-4.3 (0.6)	57.2	0.174 (0.007)	0.3 (0.1)
February	-2.8 (0.7)	131.0	0.173 (0.008)	0.1 (0.1)
March	-2.1 (0.6)	118.5	0.183 (0.007)	0.03 (0.1)
April	4.1 (0.6)	128.2	0.215 (0.005)	3.7 (0.3)
May	9.5 (0.7)	118.6	0.218 (0.002)	9.4 (0.4)
June	14.1 (0.6)	26.8	0.224 (0.002)	13.8 (0.4)
July	18.2 (0.5)	-	0.218 (0.002)	17.6 (0.4)
August	18.0 (0.3)	-	0.169 (0.005)	18.0 (0.2)
September	14.4 (0.9)	-	-	-
October	8.8 (0.7)	-	-	-
November	4.0 (0.8)	-	0.212 (0.002)	3.0 (0.5)
December	-1.3 (0.6)	122.0	0.194 (0.006)	1.8 (0.2)

Table A6. Climate normals obtained from weather station located in Upper Stewiacke, NS.

Month	Air Temperature (˚C) Average (SD)	Precipitation (mm)
January	-6.8 (2.4)	137.5
February	-5.8 (2.3)	112.7
March	-1.6 (1.8)	124.9
April	4.2 (1.3)	101.5
May	9.9 (1.5)	98.9
June	14.7 (1)	98.4
July	18.4 (1.3)	94.6
August	18.1 (1.2)	94.4
September	14.0 (1.3)	113.6
October	8.3 (1.3)	109.9
November	3.3 (1)	135.9
December	-2.8 (2.5)	141.3

Table A7. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
1370	2009	River Lake	Halifax	5003458.5	513628.8	178.526	Poor-Medium	Halifax	Hx/C-3	0

Table A8. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.25 (0.30)a	75 (15)a	3.1	2 (1)a	0.5 (0.3)b	0.8 (0.5)a	0.4 (0.2)a
FH	0.16 (0.081)a	68 (20)a		1.9 (0.5)a	1.0 (0.5)a	0.5 (0.2)a	0.54 (0.08)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	1.6 (0.8)b	0.3 (0.3)b	0.006 (0.002)a	0.4 (0.3)b	0.6 (0.4)a	0.04 (0.03)a	74 (45)a
FH	2.6 (0.7)a	3 (2)a	0.008 (0.001)a	7 (5)a	0.7 (0.5)a	0.037 (0.006)a	29 (10)b
	C (%)	N (%)					
L	42 (2)a	0.7 (0.4)a					
FH	29 (9)b	0.99 (0.09)a					

Site 3

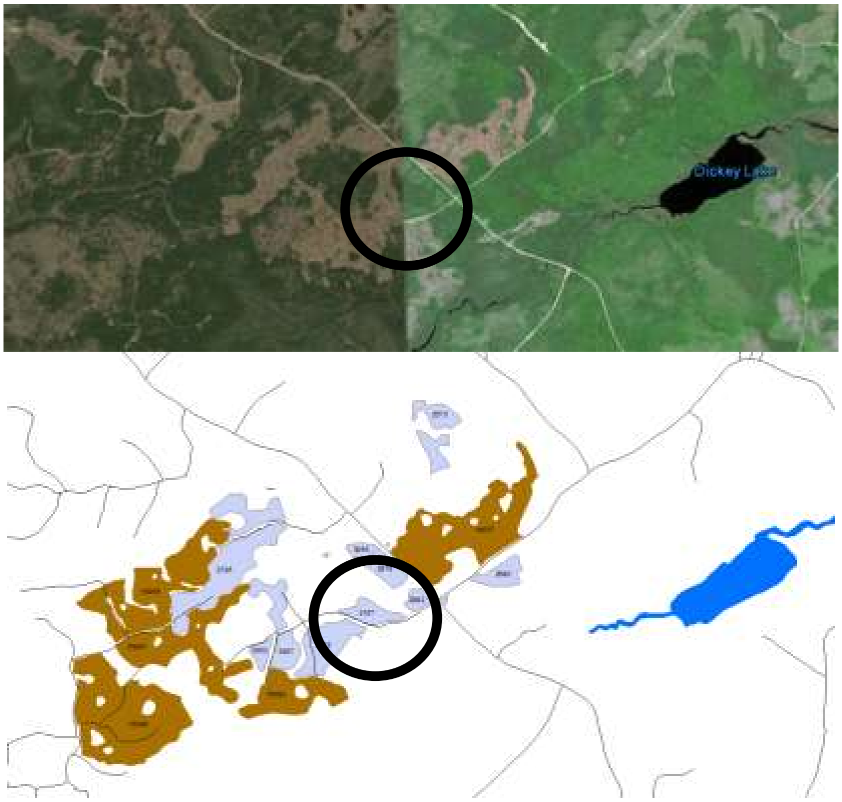

Figure A12. Aerial view of plantation (top) and plantation map with indicated site location (bottom).

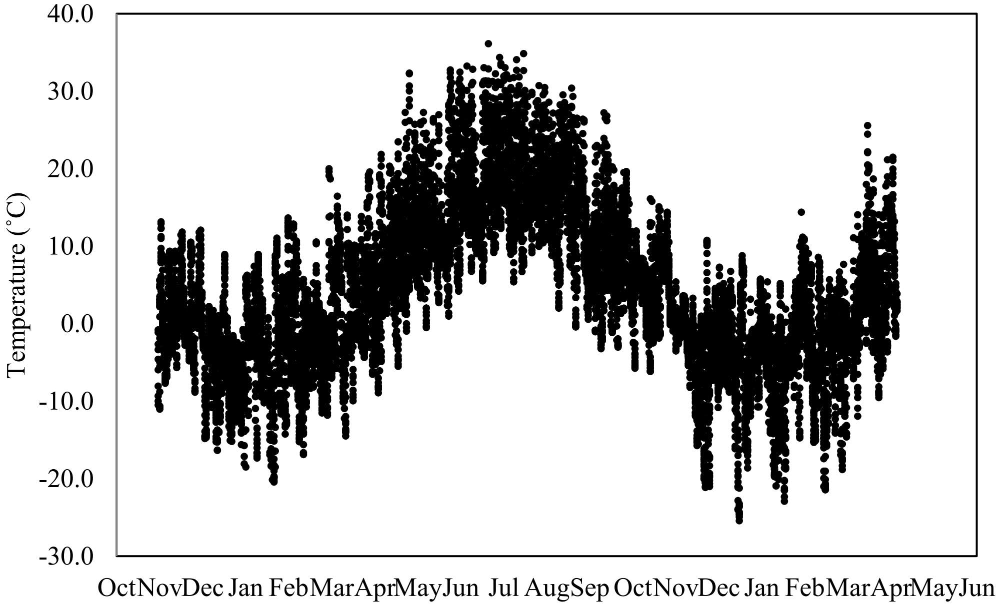

Figure A13. Air temperature (˚C) data collected from a weather station located at site 3 (16 years old).

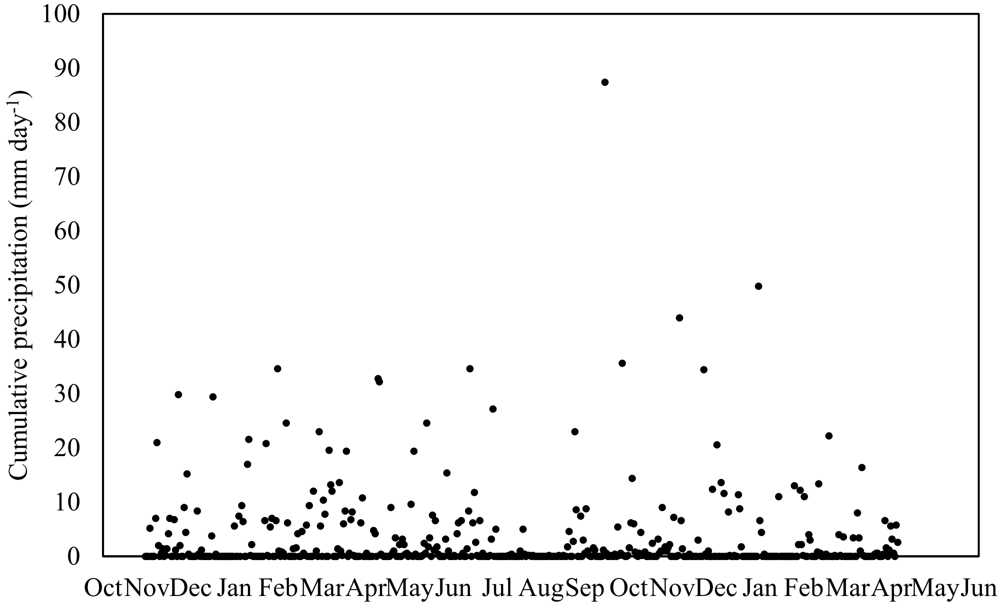

Figure A14. Cumulative precipitation (mm day^{-1}) data obtained from a weather station located at site 3 (16 years old).

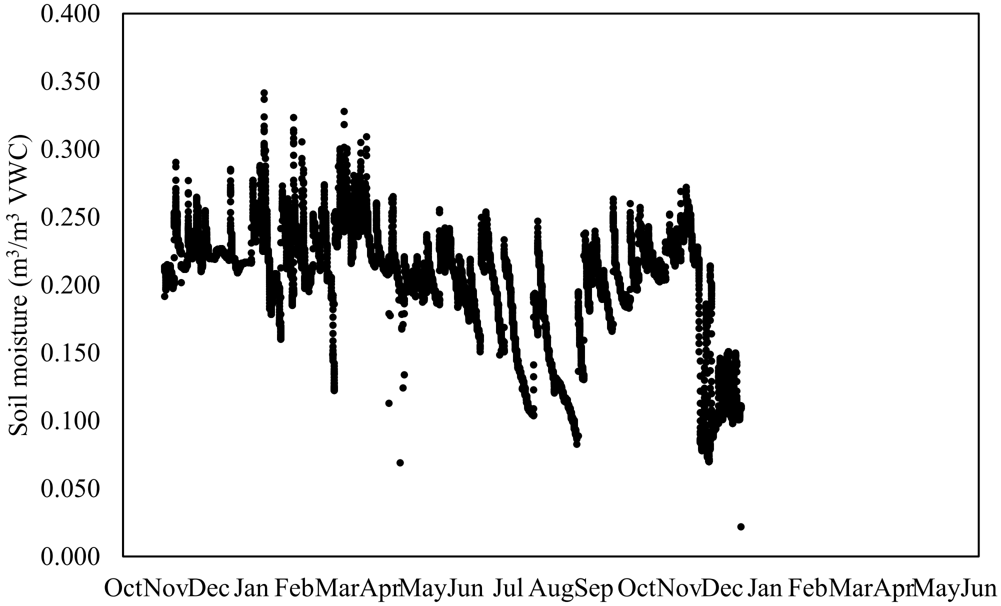

Figure A15. Soil moisture data (m^3/m^3 VWC) collected between the humic and mineral soil layer from a weather station located at site 3 (16 years old).

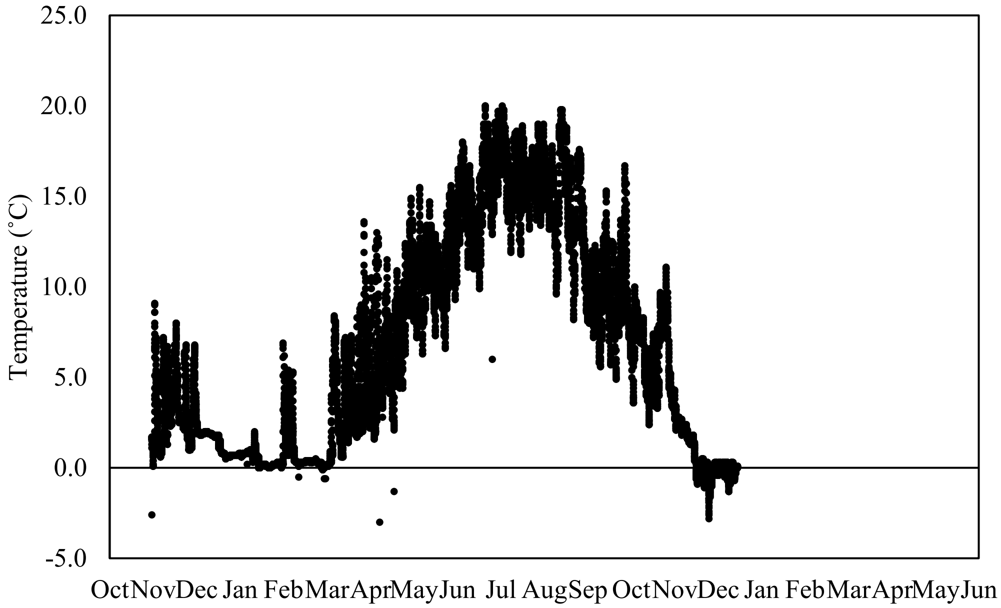

Figure A16. Soil temperature (˚C) data collected between the humic and mineral soil layer from a weather station located at site 3 (16 years old).

Table A9. Monthly mean (SE) for air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C), and monthly cumulative values for precipitation (mm).

Month	Air Temp. (˚C) Mean (SE)	Precipitation (mm) Cumulative	Soil Moisture (m^3/m^3 VWC) Mean (SE)	Soil Temp. (˚C) Mean (SE)
January	-4.5 (0.6)	77.7	0.293 (0.007)	0.9 (0.1)
February	-3.4 (0.8)	104.0	0.227 (0.006)	0.7 (0.2)
March	-2.8 (0.6)	87.8	0.223 (0.005)	0.6 (0.2)
April	3.7 (0.7)	79.2	0.240 (0.002)	4.3 (0.3)
May	9.6 (0.7)	122.0	0.207 (0.002)	8.0 (0.5)
June	14.1 (0.7)	87.4	0.207 (0.003)	11.6 (0.4)
July	18.2 (0.5)	108.6	0.195 (0.004)	15.6 (0.3)
August	17.9 (0.3)	8.0	0.150 (0.006)	15.7 (0.2)
September	14.3 (0.9)	63.8	0.155 (0.009)	13.7 (0.5)
October	8.5 (0.7)	162.4	0.204 (0.004)	9.4 (0.4)
November	2.8 (0.7)	89.8	0.219 (0.002)	5.1 (0.4)
December	-1.8 (0.7)	106.4	0.190 (0.007)	1.8 (0.2)

Please refer to Table A6 for Environment Canada's climate normals obtained from the data collected at the Upper Stewiacke, NS weather station.

Table A10. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates Northing	UTM Coordinates Easting	Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
3167	1999	Dickey Lake	Colchester	5016881.7	515025.8	269.590	Medium	Halifax	Hx/C-3	66(22)

Table A11. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.11 (0.07)a	93 (7)a	3.48	5 (2)a	0.9 (0.2)a	2 (2)a	0.7 (0.2)b
FH	0.10 (0.03)a	71 (9)b		2 (1)b	1.1 (0.3)a	1.6 (0.3)a	0.87 (0.06)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.6 (0.6)b	0.3 (0.2)b	0.008 (0.002)a	0.03 (0.03)b	1.5 (0.7)a	0.06 (0.03)a	41 (13)a
FH	3.5 (0.4)a	4 (2)a	0.009 (0.003)a	5 (2)a	2 (1)a	0.05 (0.03)a	25 (2)b
	C (%)	N (%)					
L	44 (1)a	1.1 (0.3)b					
FH	35 (4)b	1.4 (0.1)a					

Site 4

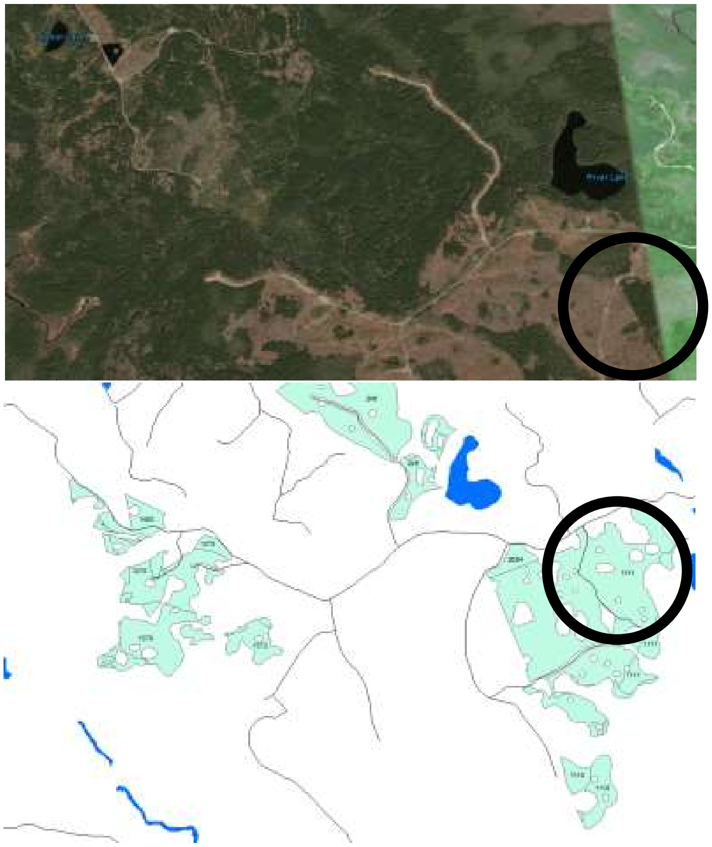

Figure A17. Aerial view of plantation (top) and plantation map with indicated site location (bottom).

Table A12. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
1111	1998	River Lake	Halifax	5003191.9	514991.8	193.005	Poor-Medium	Halifax	Hx/C-3	73(9)

Table A13. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.14 (0.08)a	88 (11)a	2.86	5 (2)a	0.7 (0.4)a	0.8 (0.3)a	0.6 (0.2)a
FH	0.16 (0.06)a	76 (12)a		1.9 (0.6)b	0.7 (0.3)a	0.5 (0.2)a	0.5 (0.2)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.1 (0.5)b	0.3 (0.2)b	-	0.4 (0.4)a	0.6 (0.3)a	0.07 (0.03)a	52 (17)a
FH	3 (1)a	1 (1)a	-	2 (2)a	0.2 (0.1)b	0.04 (0.01)b	48 (30)a
	C (%)	N (%)					
L	44 (1)a	0.9 (0.3)a					
FH	39 (3)b	1.0 (0.3)a					

Site 5

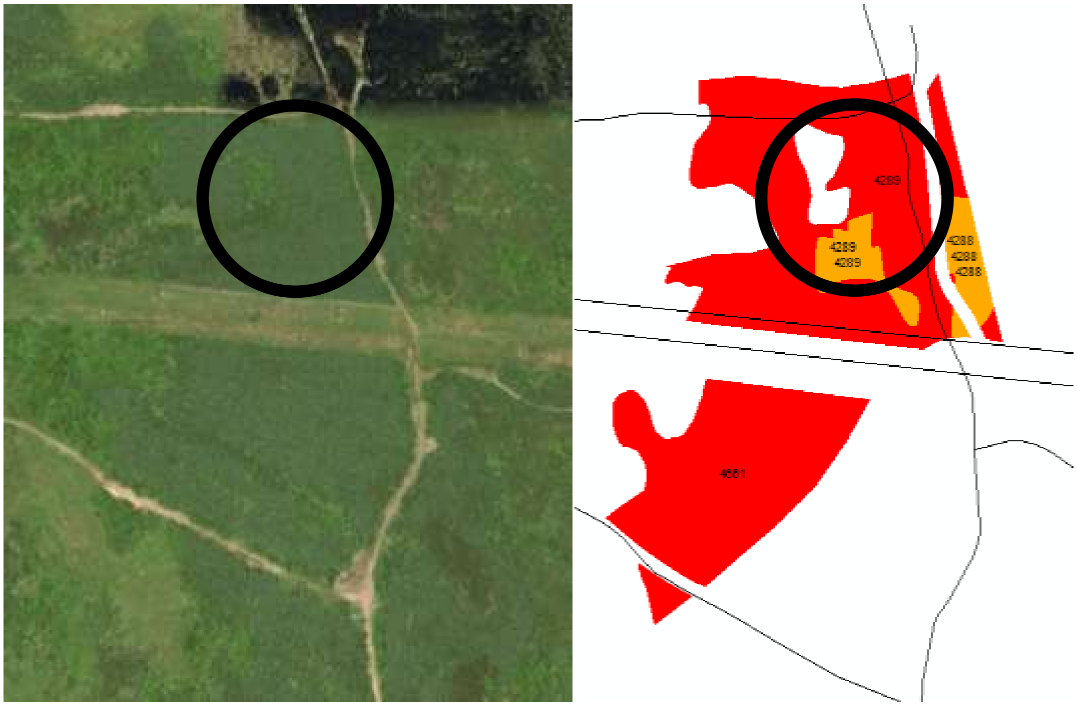

Figure A18. Aerial view of plantation (L) and plantation map with indicated site location (R).

Table A14. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
4289	1986	Riversdale	Colchester	5032780.0	497229.6	214.587	Medium	Thom	Tm5/C	99 (1)

Table A15. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.15 (0.05)a	90 (7)a	3.48	6 (1)a	0.60 (0.06)a	0.98 (0.07)a	0.7 (0.1)b
FH	0.09 (0.02)b	71 (9)b		3 (2)b	0.6 (0.2)a	0.99 (0.09)a	0.8 (0.1)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.2 (0.2)b	0.2 (0.1)b	-	0.11 (0.03)b	0.4 (0.1)a	0.048 (0.007)a	47 (5)a
FH	3.9 (0.4)a	3 (2)a	-	3 (2)a	0.5 (0.6)a	0.04 (0.01)a	25 (2)b
	%C	%N					
L	45.3 (0.3)a	1.0 (0.1)b					
FH	29 (3)b	1.52 (0.08)a					

Site 6

Figure A19. Aerial view of plantation (L) and plantation map with indicated site location (R).

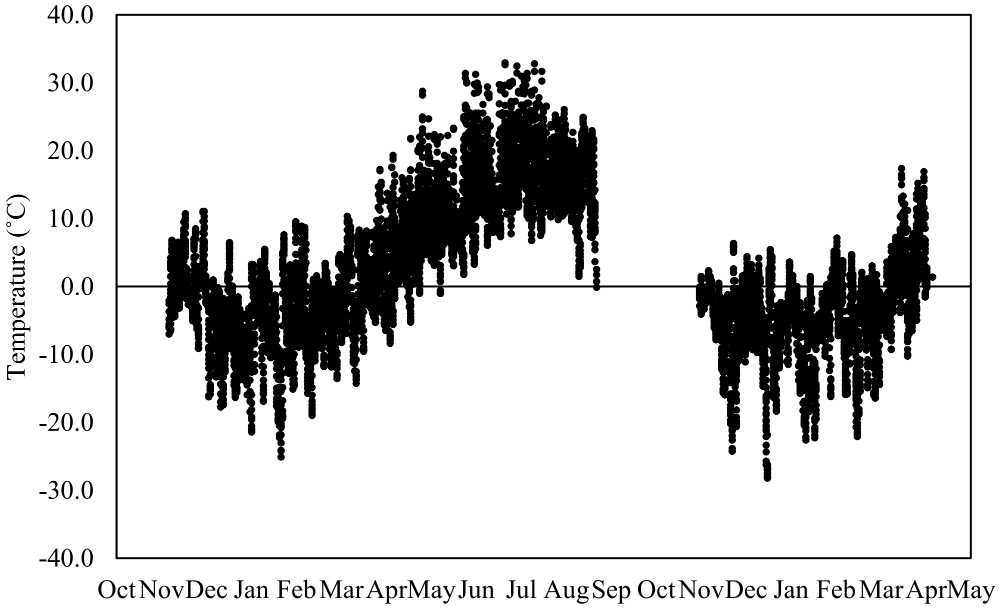

Figure A20. Air temperature (˚C) data collected from a weather station located at site 6 (31 years old).

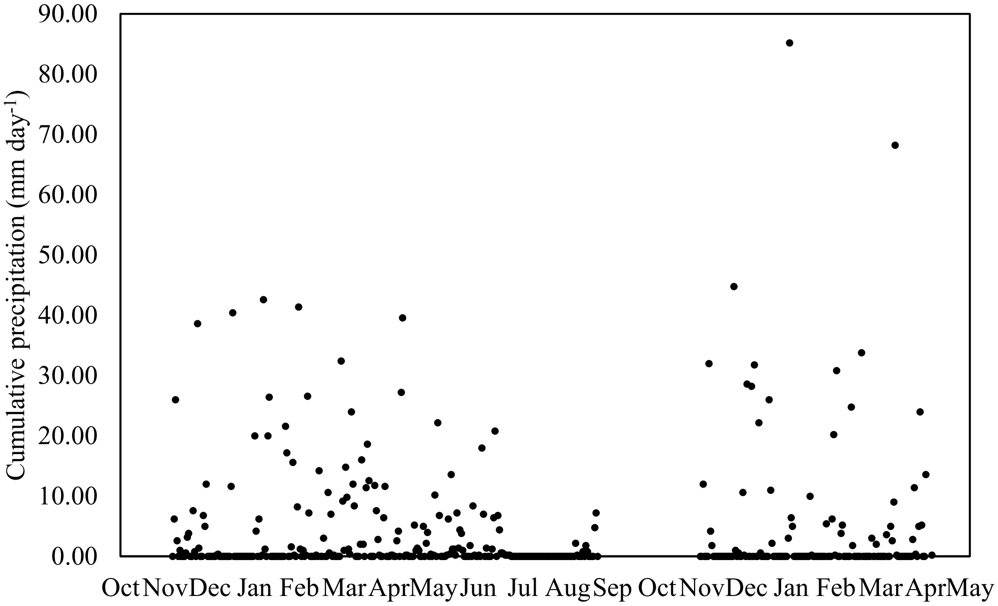

Figure A21. Cumulative precipitation (mm day^{-1}) data obtained from a weather station located at site 6 (31 years old).

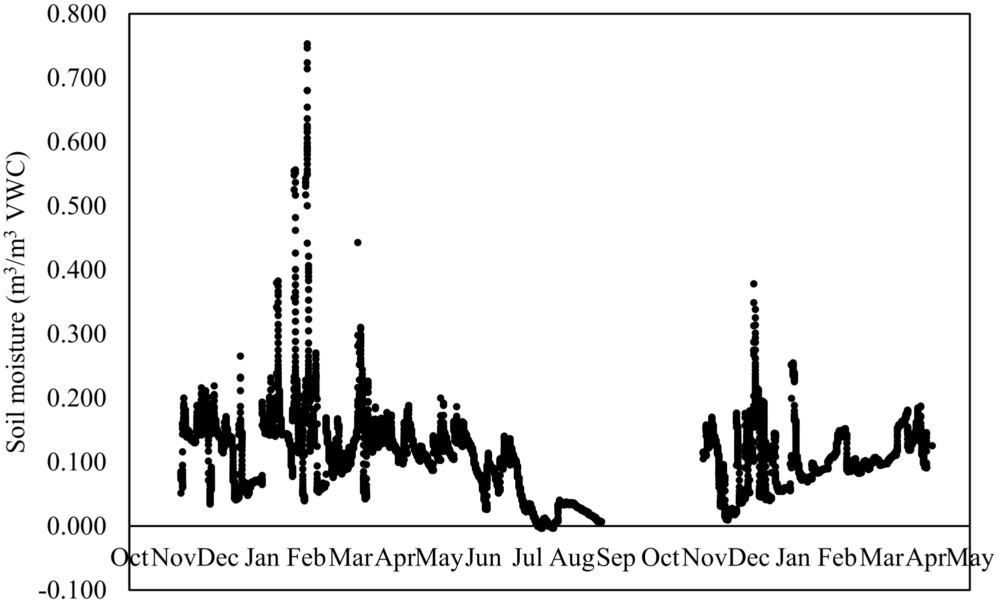

Figure A22. Soil moisture (m^3/m^3 VWC) data collected between the humic and mineral soil layer from a weather station located at site 6 (31 years old).

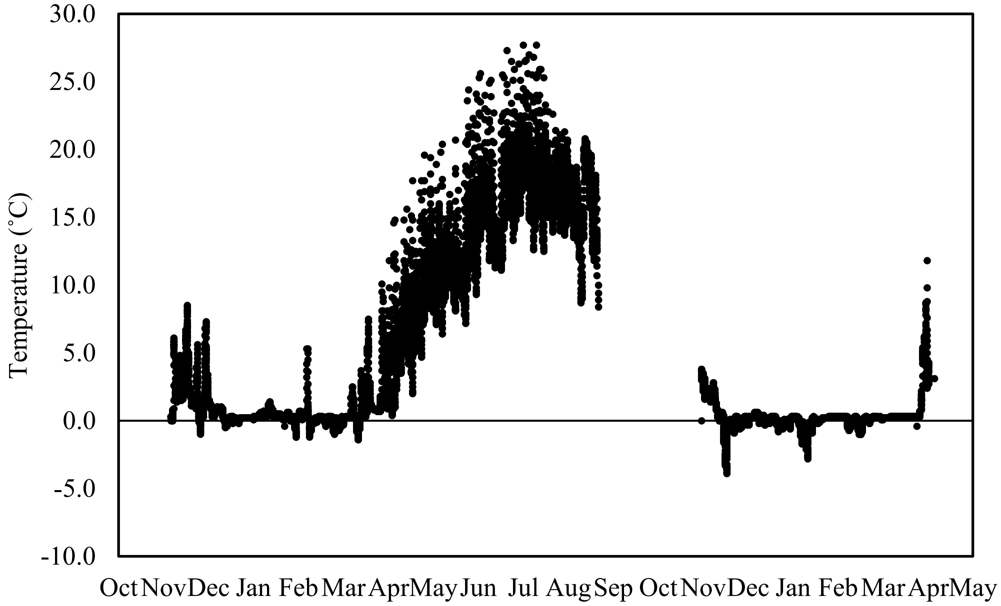

Figure A23. Soil temperature (˚C) data collected between the humic and mineral soil layer from a weather station located at site 6 (31 years old).

Table A16. Monthly mean (SE) for air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C), and monthly cumulative values for precipitation (mm).

Month	Air Temp. (˚C) Mean (SE)	Precipitation (mm) Cumulative	Soil Moisture (m^3/m^3 VWC) Mean (SE)	Soil Temp. (˚C) Mean (SE)
January	-5.9 (0.6)	138.2	0.100 (0.006)	0.16 (0.04)
February	-5.3 (0.7)	135.6	0.14 (0.01)	0.14 (0.07)
March	-4.7 (0.5)	106.5	0.106 (0.004)	0.09 (0.05)
April	1.5 (0.5)	149.4	0.136 (0.005)	1.5 (0.2)
May	7.7 (0.6)	133.6	0.121 (0.003)	8.5 (0.5)
June	11.9 (0.6)	76.4	0.111 (0.006)	12.9 (0.4)
July	16.5 (0.5)	43.4	0.075 (0.006)	17.0 (0.4)
August	16.3 (0.3)	-	0.018 (0.003)	17.1 (0.2)
September	14.1 (1)	-	0.018 (0.002)	15.5 (0.7)
October	-	-	-	-
November	-1.4 (0.2)	-	0.125 (0.005)	2.4 (0.2)
December	-2.8 (0.7)	133.9	0.112 (0.007)	1.1 (0.2)

Please refer to Table A6 for Environment Canada's climate normals obtained from the data collected at the Upper Stewiacke, NS weather station.

Table A17. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
2457	1984	Loon Lake	Halifax	5005993.4	520848.4	184.541	Poor-Medium	Gibraltar	Ga/C-4	92 (8)

Table A18. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.11 (0.07)a	90 (6)a	3.21	3.7 (0.7)a	0.6 (0.2)a	1.0 (0.2)a	0.7 (0.1)a
FH	0.08 (0.03)a	66 (8)b		2.4 (0.9)b	0.6 (0.1)a	0.9 (0.1)a	0.75 (0.08)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.4 (0.2)b	0.2 (0.1)b	-	0.19 (0.08)b	0.6 (0.3)a	0.05 (0.02)a	46 (9)a
FH	3.4 (0.3)a	3 (2)a	-	2.5 (0.8)a	0.5 (0.4)a	0.03 (0.02)a	28 (2)b
	C (%)	N (%)					
L	45.3 (0.8)a	1.0 (0.2)b					
FH	38 (3)b	1.3 (0.1)a					

Site 7

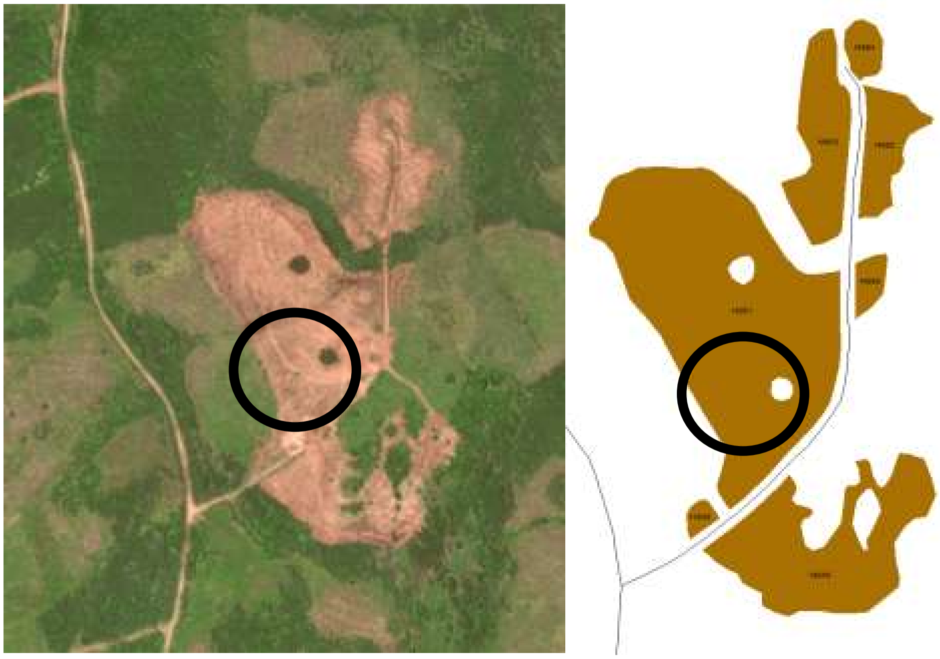

Figure A24. Aerial view of plantation (L) and plantation map with indicated site location (R).

Table A19. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
14951	2014	Greenfield	Colchester	5016433.6	494068.7	179.800	Rich	Millbrook	Mi4/C	0

Table A20. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.11 (0.09)a	82 (7)a	3.22	1.3 (0.6)a	0.4 (0.2)a	1.0 (0.6)a	0.5 (0.2)a
FH	0.2 (0.4)a	66 (18)a		1.0 (0.3)a	0.4 (0.2)a	0.7 (0.3)a	0.4 (0.2)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.1 (0.9)a	0.6 (0.5)b	0.006 (0.001)a	0.8 (0.9)a	0.6 (0.3)a	0.04 (0.03)a	64 (46)a
FH	1.7 (0.7)a	2 (2)a	0.008 (0.003)a	4 (4)a	0.8 (0.3)a	0.0023 (0.005)a	72 (46)a
	C (%)	N (%)					
L	42 (1)a	0.9 (0.5)a					
FH	38 (7)a	0.7 (0.3)a					

Site 8

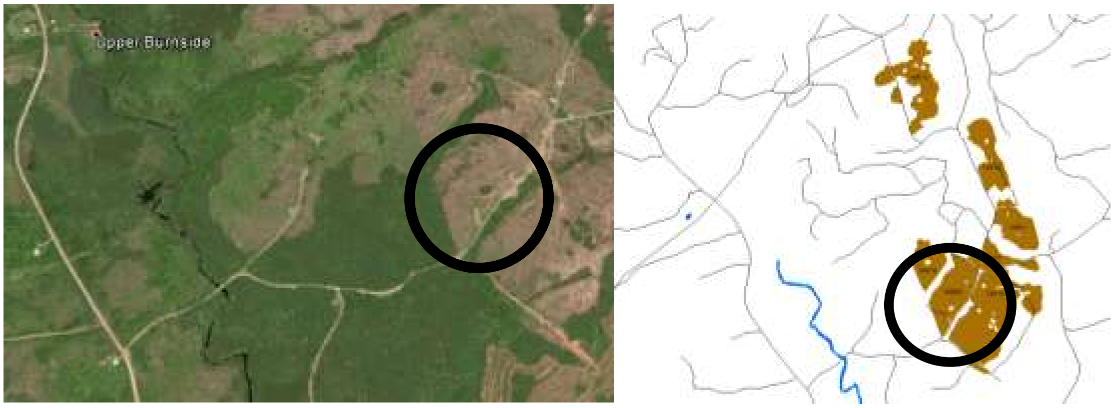

Figure A25. Aerial view of plantation (L) and plantation map with indicated site location (R).

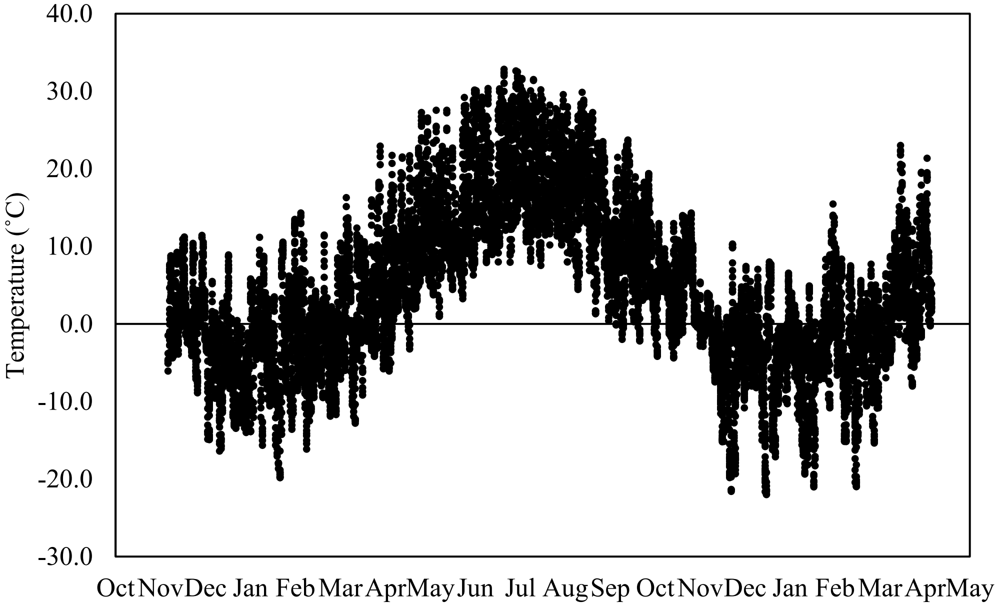

Figure A26. Air temperature (˚C) data collected from a weather station placed at site 8 (2 years old).

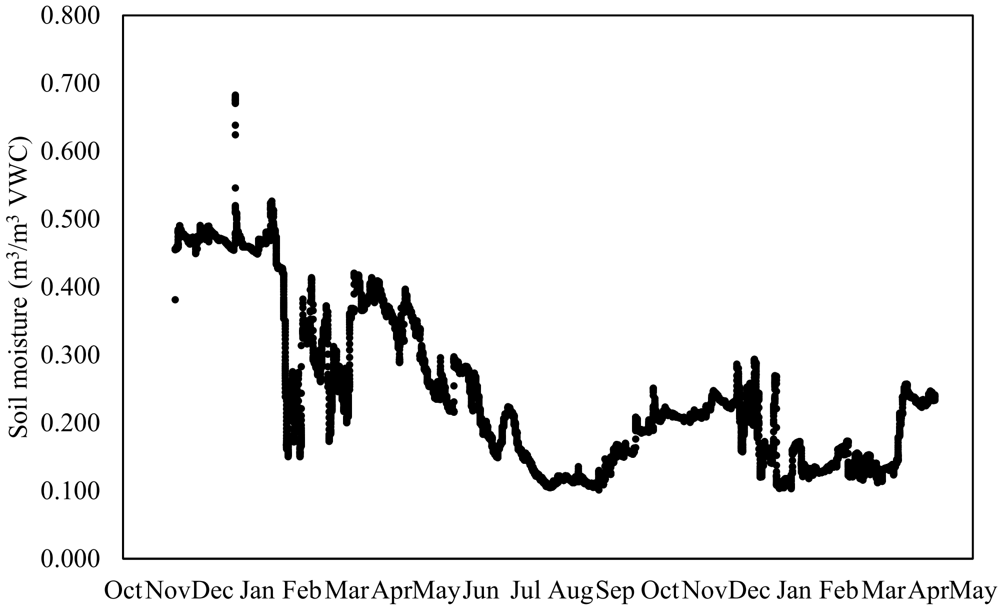

Figure A27. Soil moisture (m^3/m^3 VWC) data collected between the humic and mineral soil layer from a weather station located at site 8 (2 years old).

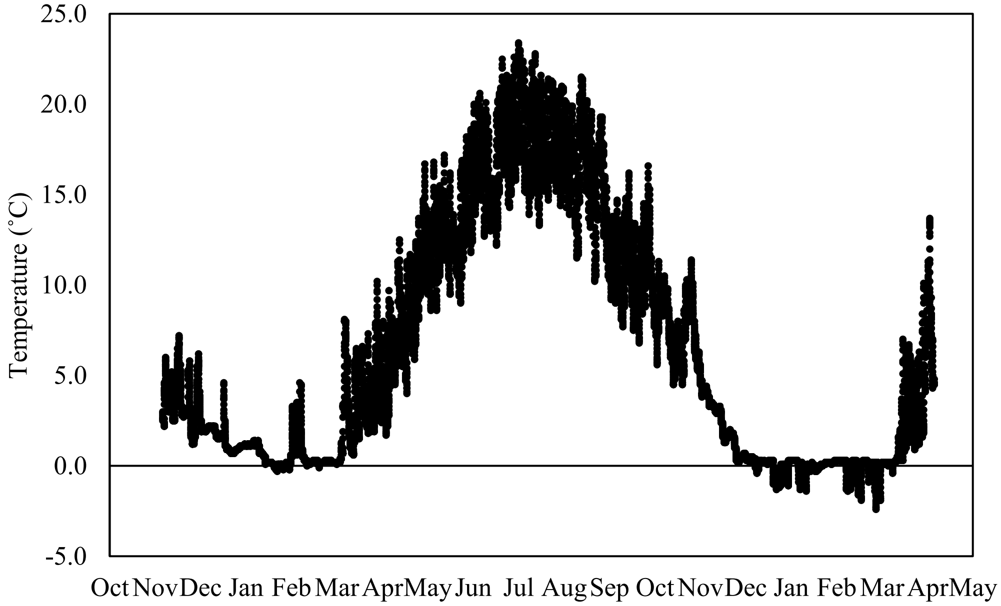

Figure A28. Soil temperature (˚C) data collected between the humic and mineral soil layer from a weather station located at site 8 (2 years old).

Table A21. Monthly mean (SE) for air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C).

Month	Air Temp. (˚C) Mean (SE)	Soil Moisture (m^3/m^3 VWC) Mean (SE)	Soil Temp. (˚C) Mean (SE)
January	-4.3 (0.6)	0.022 (0.004)	0.31 (0.02)
February	-3.2 (0.8)	0.008 (0.006)	0.24 (0.02)
March	-2.8 (0.5)	0.004 (0.004)	0.21 (0.01)
April	3.9 (0.6)	0.057 (0.003)	0.30 (0.01)
May	9.7 (0.7)	0.035 (0.003)	0.303 (0.009)
June	14.3 (0.7)	0.008 (0.004)	0.247 (0.006)
July	18.8 (0.6)	-0.010 (0.003)	0.176 (0.005)
August	18.3 (0.3)	-0.017 (0.003)	0.118 (0.001)
September	14.5 (0.9)	0.017 (0.006)	0.126 (0.003)
October	8.9 (0.7)	0.056 (0.004)	0.189 (0.004)
November	3.7 (0.6)	0.064 (0.001)	0.211 (0.001)
December	-1.8 (0.7)	0.046 (0.004)	0.35 (0.02)

Please refer to Table A2 for Environment Canada’s climate normals obtained from the data collected at the Truro, NS weather station. Precipitation data was not recorded from data logger.

Table A22. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
14509	2013	Riversdale	Colchester	5017920.7	502651.3	162.535	Medium-Rich	Millbrook	Mi4/D	0

Table A23. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.1 (0.1)a	89 (4)a	3.17	1.4 (0.5)a	0.4 (0.2)b	0.7 (0.4)a	0.5 (0.2)a
FH	0.12 (0.05)a	70 (19)a		1.4 (0.7)a	0.6 (0.1)a	0.7 (0.2)a	0.6 (0.2)b
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	1.9 (0.8)a	0.6 (0.5)b	-	1 (1)a	1.0 (0.8)a	0.03 (0.01)a	64 (38)a
FH	2.8 (0.8)a	3 (2)a	-	6 (5)a	1.0 (0.5)a	0.029 (0.006)a	36 (16)a
	C (%)	N (%)					
L	43 (1)a	0.8 (0.4)a					
FH	37 (6)b	1.1 (0.3)a					

Site 9

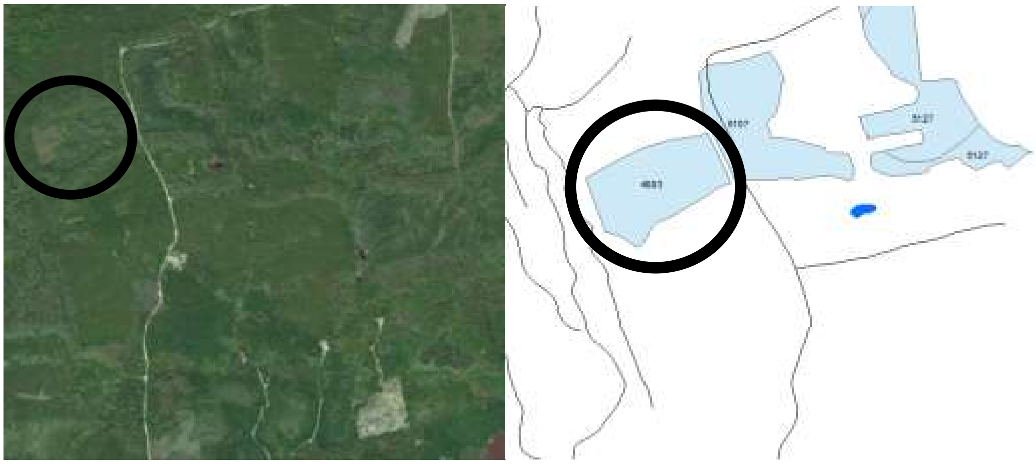

Figure A29. Aerial plantation view (L) and plantation map with indicated site location (R).

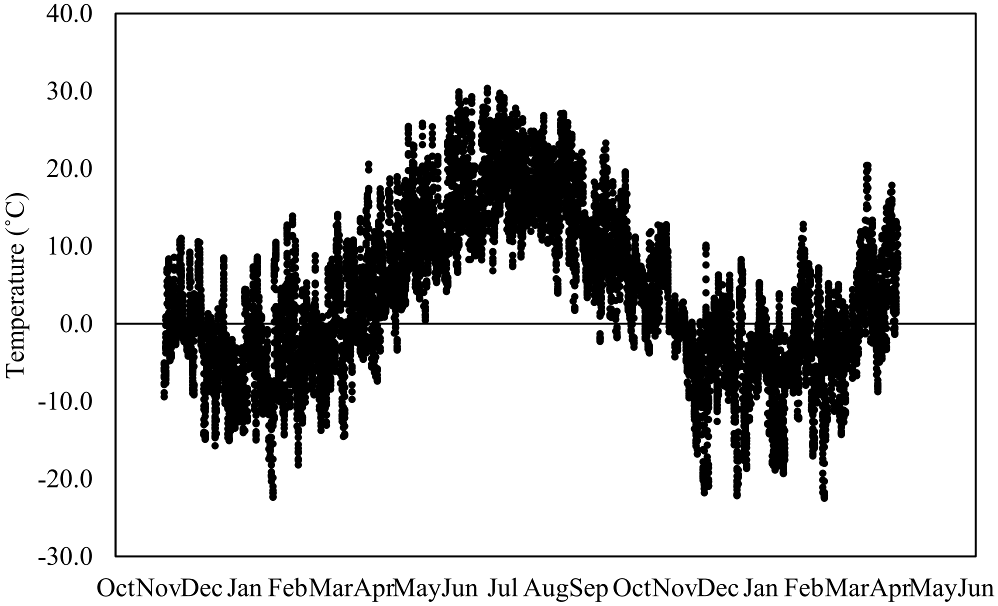

Figure A30. Air temperature (˚C) data collected from a weather station placed at site 9 (13 years old).

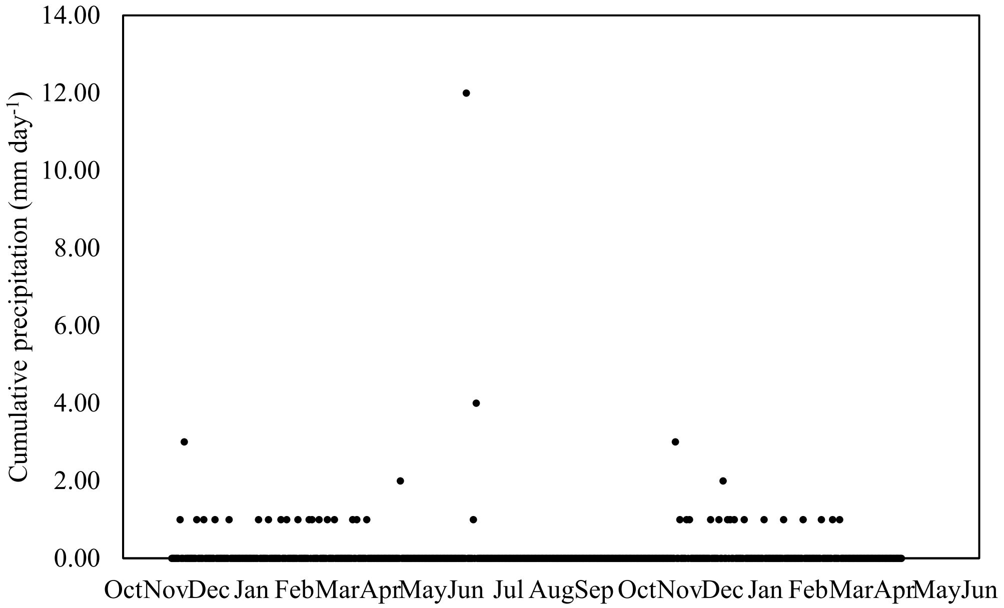

Figure A31. Cumulative precipitation (mm day^{-1}) data obtained from a weather station located at site 9 (13 years old).

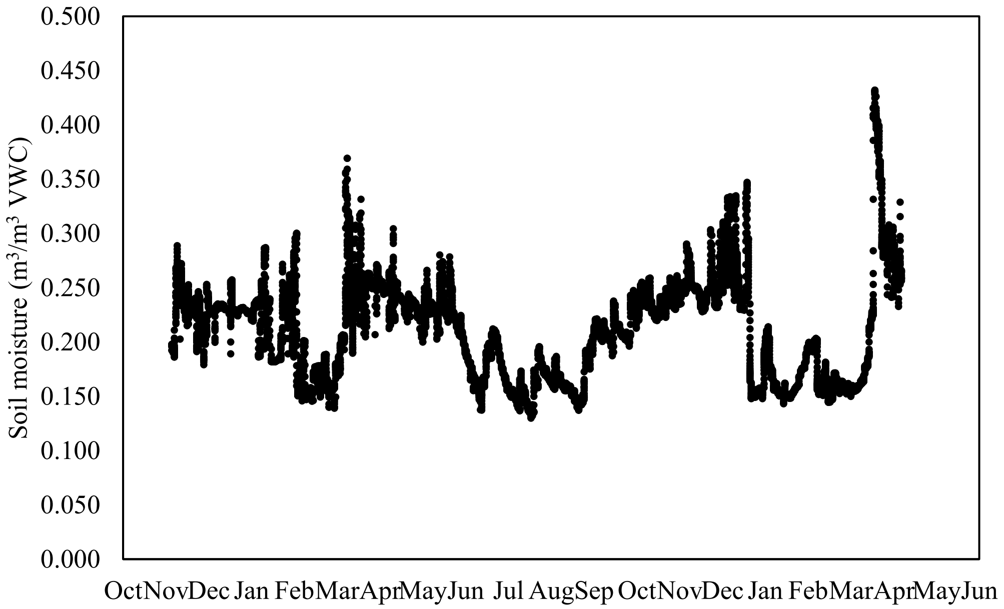

Figure A32. Soil moisture (m^3/m^3 VWC) data collected between the humic and mineral soil layer from a weather station located at site 9 (13 years old).

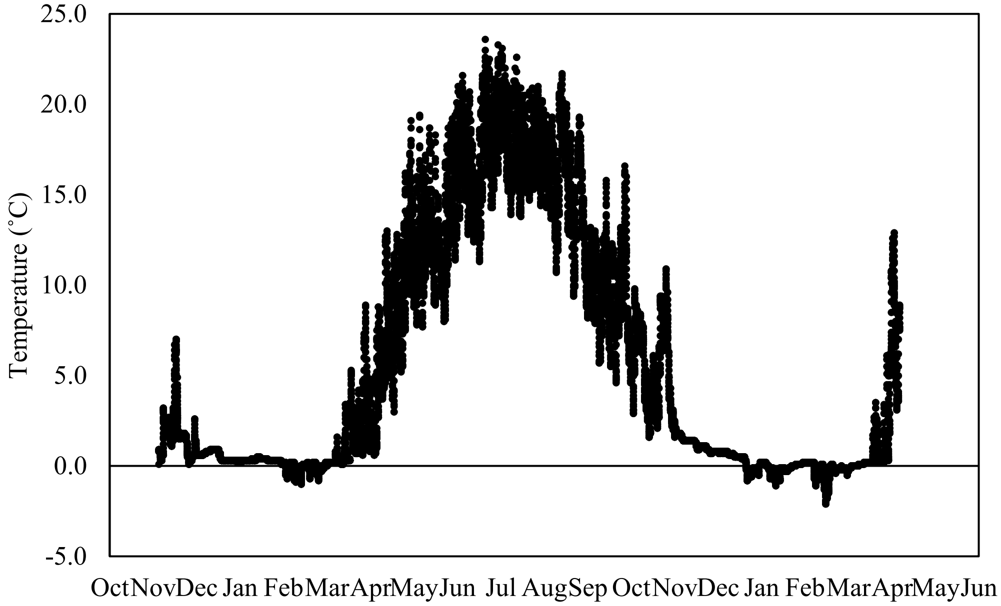

Figure A33. Soil temperature (˚C) data collected between the humic and mineral soil layer from a weather station located at site 9 (13 years old).

Table A24. Monthly mean (SE) for air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C), and monthly cumulative values for precipitation (mm).

Month	Air Temp. (˚C)	Precipitation (mm)	Soil Moisture (m^3/m^3 VWC)	Soil Temp. (˚C)
	Mean (SE)	Cumulative	Mean (SE)	Mean (SE)
January	-5.2 (0.6)	3.0	0.222 (0.005)	0.34 (0.05)
February	-4.5 (0.8)	3.0	0.191 (0.005)	0.07 (0.04)
March	-3.9 (0.6)	4.0	0.165 (0.002)	-0.17 (0.05)
April	3.1 (0.6)	3.0	0.257 (0.007)	1.7 (0.3)
May	8.9 (0.7)	2.0	0.240 (0.002)	8.8 (0.5)
June	13.7 (0.7)	12.0	0.221 (0.004)	13.7 (0.4)
July	18.0 (0.5)	5.0	0.174 (0.004)	17.5 (0.4)
August	17.5 (0.3)	0.0	0.160 (0.003)	17.3 (0.2)
September	14.0 (0.8)	0.0	0.171 (0.004)	14.6 (0.6)
October	8.4 (0.7)	0.0	0.216 (0.003)	9.0 (0.4)
November	2.8 (0.7)	4.0	0.238 (0.002)	4.4 (0.4)
December	-2.6 (0.7)	7.0	0.241 (0.003)	1.3 (0.1)

Due to animal activity, the precipitation levels obtained from this weather station are inaccurate. Please refer to Table A2 for Environment Canada's climate normals obtained from the data collected at the Truro, NS weather station.

Table A25. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates Northing	UTM Coordinates Easting	Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
4883	2002	Polson	Colchester	5040609.7	488582.8	288.891	Medium-Rich	Cobequid	Cd2/D	84 (10)

Table A26. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.06 (0.04)b	92 (4)a	3.40	4 (2)a	0.7 (0.2)a	0.8 (0.4)a	0.7 (0.2)a
FH	0.12 (0.04)a	58 (22)b		2 (1)b	0.7 (0.2)a	0.8 (0.1)a	0.8 (0.2)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.7 (0.7)a	0.3 (0.1)b	0.008 (0.001)a	0.4 (0.2)a	1.3 (0.6)a	0.09 (0.02)a	32 (9)a
FH	3.4 (0.9)a	2 (1)a	0.02 (0.03)a	5 (5)a	1.2 (0.8)a	0.05 (0.02)b	22 (3)b
	C (%)	N (%)					
L	43 (1)a	1.4 (0.3)a					
FH	33 (4)b	1.5 (0.2)a					

Site 10

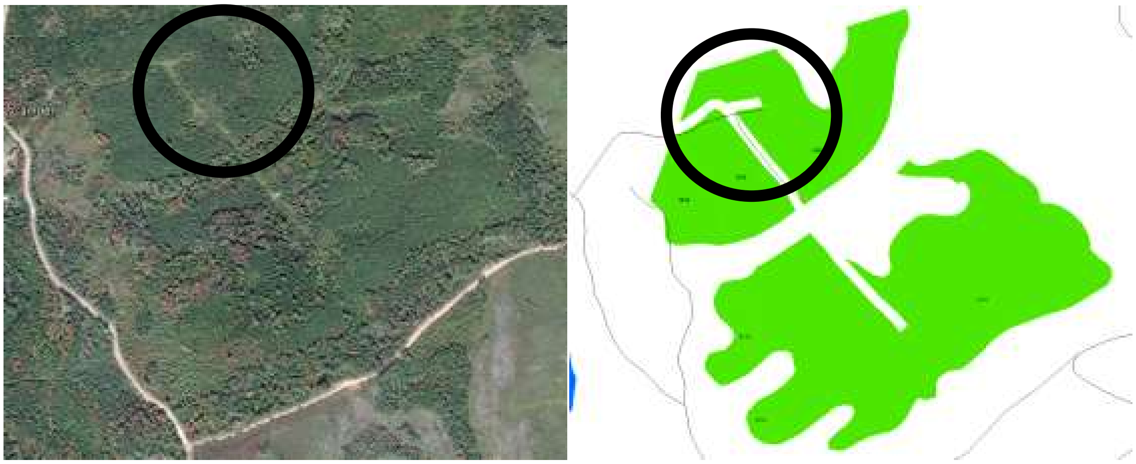

Figure A34. Aerial view of plantation (L) and plantation map and indicated site location (R).

Air temperature data will not be presented due to instrumental error. Precipitation data obtained from the weather station at site 10 showed minimal readings and therefore will not be included.

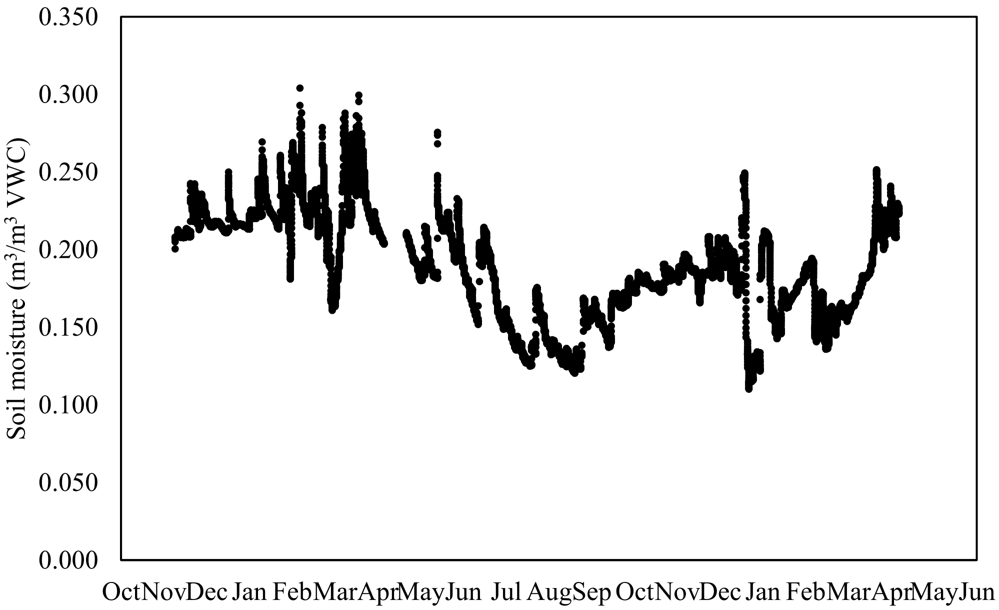

Figure A35. Soil moisture (m^3/m^3 VWC) data collected between the humic and mineral soil layer from a weather station located at site 10 (18 years old).

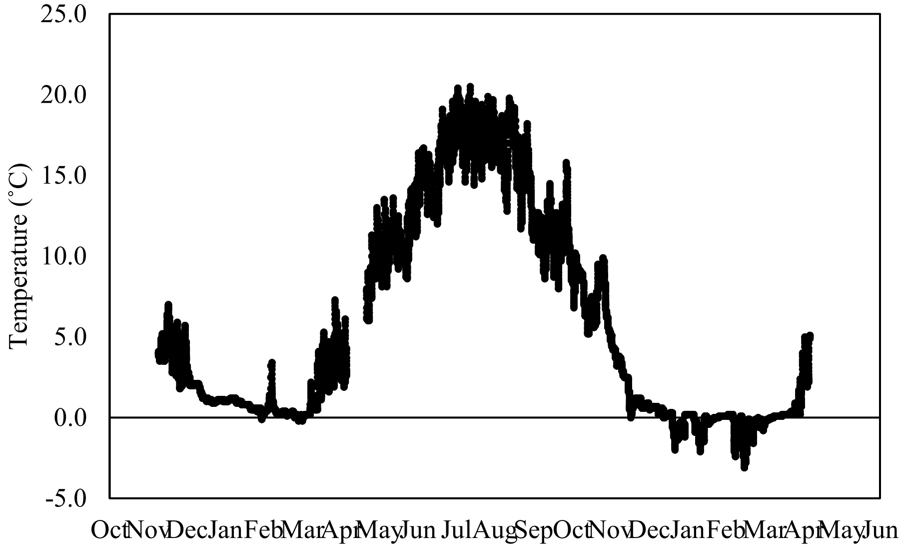

Figure A36. Soil temperature (˚C) data collected between the humic and mineral soil layer from a weather station located at site 10 (18 years old).

Table A27. Monthly mean (SE) soil moisture (m^3/m^3 VWC), and soil temperature (˚C) values obtained from the weather station located at site 10.

Month	Soil Moisture (m^3/m^3 VWC)	Soil Temp. (˚C)
	Mean (SE)	Mean (SE)
January	0.197 (0.004)	0.6 (0.1)
February	0.201 (0.004)	0.22 (0.008)
March	0.188 (0.005)	-0.1 (0.1)
April	0.216 (0.003)	1.6 (0.2)
May	0.200 (0.003)	8.1 (0.6)
June	0.202 (0.003)	11.8 (0.3)
July	0.172 (0.004)	16.1 (0.3)
August	0.142 (0.002)	17.2 (0.1)
September	0.141 (0.003)	15.3 (0.4)
October	0.164 (0.002)	10.8 (0.3)
November	0.181 (0.001)	6.9 (0.3)
December	0.202 (0.002)	2.5 (0.2)

Please refer to Table A2 for Environment Canada’s climate normals obtained from the data collected at the Truro, NS weather station.

Table A28. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
4305	1997	Camden	Colchester	5014643.9	490246.1	133.576	Medium-Rich	Thom	Tm3/D	75 (19)

Table A29. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.09 (0.04)a	91 (5)a	4.50	6 (4)a	0.6 (0.1)a	0.9 (0.2)b	0.59 (0.07)b
FH	0.06 (0.03)a	81 (13)a		4 (3)a	0.6 (0.1)a	1.2 (0.1)a	0.76 (0.08)a
	SO$_4^{2-}$ (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	1.8 (0.2)b	0.3 (0.1)b	-	0.5 (0.6)b	2.1 (0.5)a	0.06 (0.02)a	51 (8)a
FH	2.8 (0.3)a	2.1 (0.8)a	-	4 (3)a	3 (2)a	0.06 (0.02)a	34 (5)b
	C (%)	N (%)					
L	45 (1)a	0.9 (0.1)b					
FH	38 (4)b	1.1 (0.1)a					

Site 11

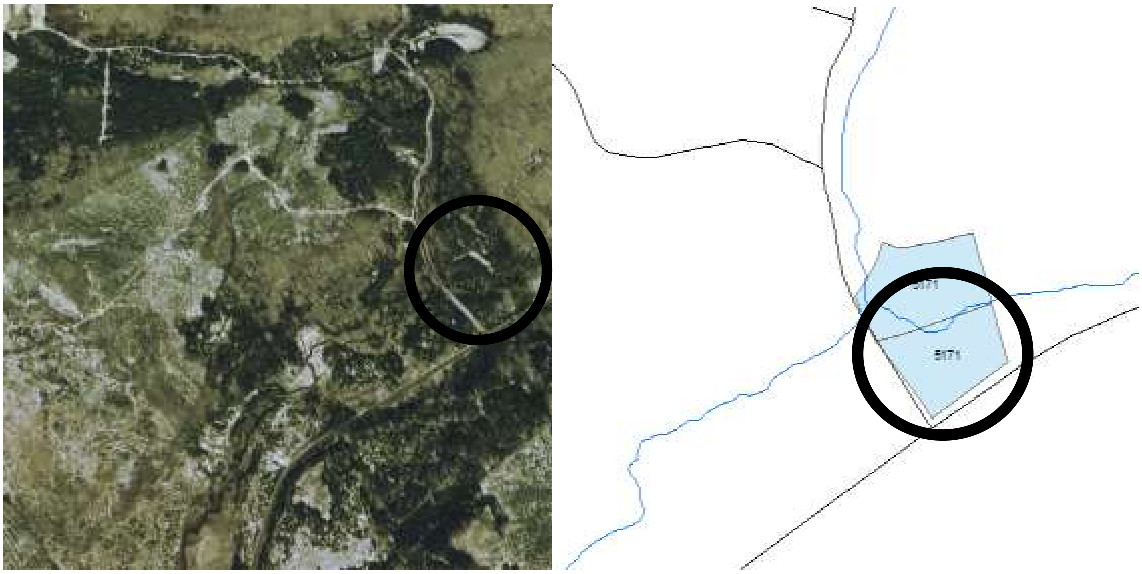

Figure A37. Aerial view of plantation (L) and plantation map with indicated site location (R).

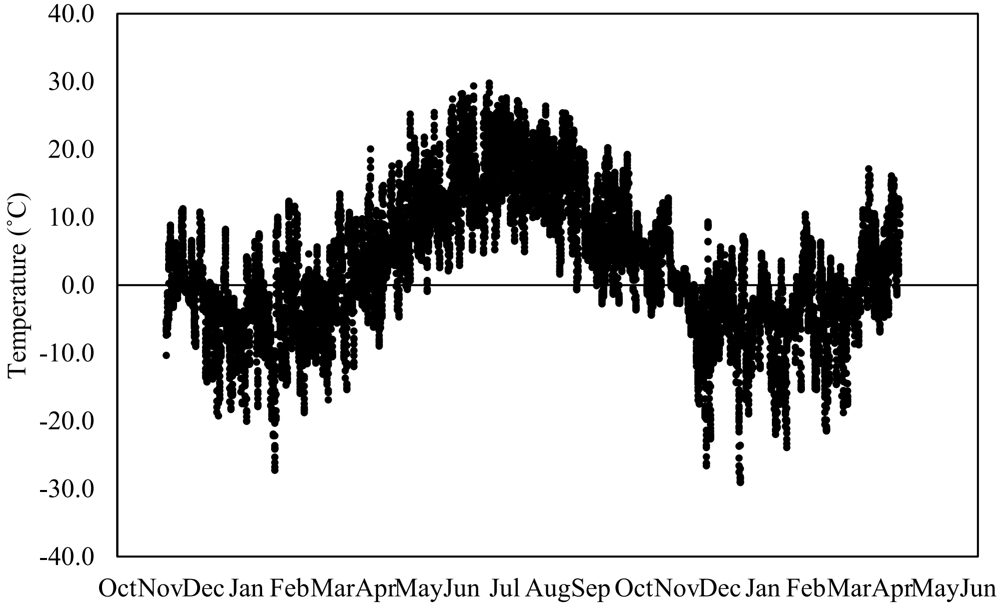

Figure A38. Air temperature (˚C) data collected from a weather station placed at site 11 (28 years old).

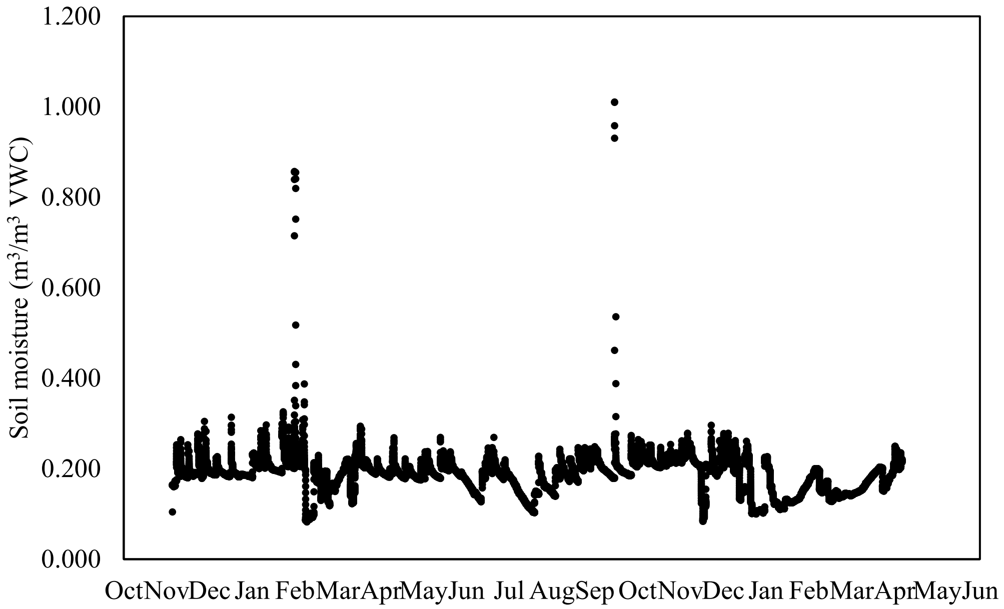

Figure A39. Soil moisture (m^3/m^3 VWC) data collected between the humic and mineral soil layer from a weather station located at site 11 (28 years old).

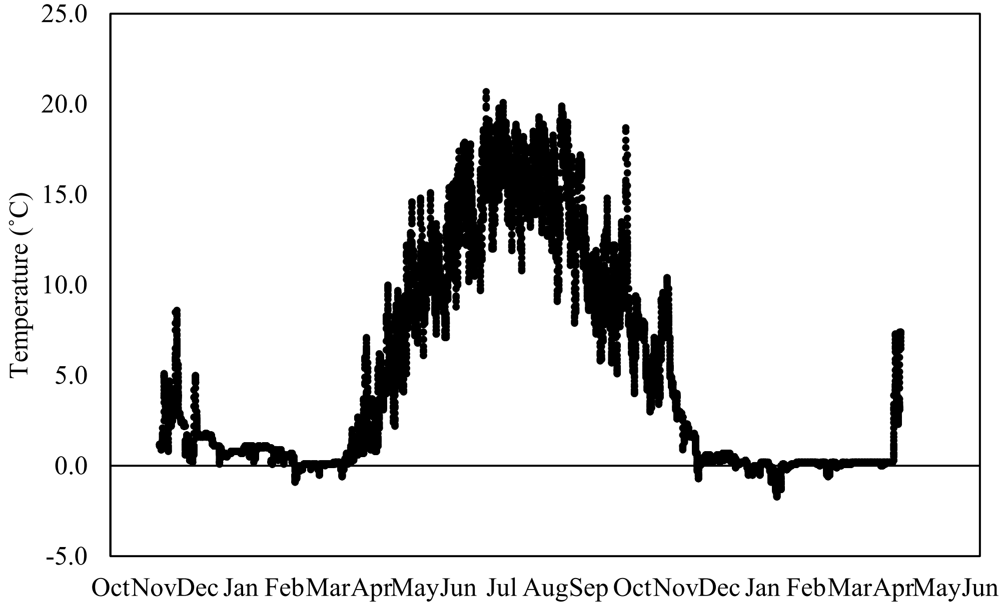

Figure A40. Soil temperature (˚C) data collected between the humic and mineral soil layer from a weather station located at site 11 (28 years old).

Table A30. Monthly mean (SE) for air temperature (˚C), soil moisture (m^3/m^3 VWC), soil temperature (˚C), and monthly cumulative values for precipitation (mm).

Month	Air Temp. (˚C)	Precipitation (mm)	Soil Moisture (m^3/m^3 VWC)	Soil Temp. (˚C)
	Mean (SE)	Cumulative	Mean (SE)	Mean (SE)
January	-5.5 (0.6)	0.5	0.180 (0.005)	0.55 (0.07)
February	-4.9 (0.8)	1.0	0.183 (0.007)	0.34 (0.08)
March	-4.3 (0.5)	1.5	0.158 (0.004)	0.07 (0.02)
April	2.3 (0.6)	0.0	0.191 (0.003)	0.8 (0.2)
May	8.3 (0.6)	0.0	0.195 (0.002)	7.0 (0.4)
June	13.2 (0.7)	0.0	0.192 (0.003)	11.6 (0.4)
July	16.9 (0.5)	0.0	0.181 (0.004)	15.4 (0.4)
August	16.6 (0.3)	0.0	0.150 (0.005)	15.7 (0.2)
September	12.9 (0.8)	1.0	0.207 (0.003)	13.8 (0.5)
October	7.6 (0.7)	0.0	0.210 (0.007)	9.3 (0.4)
November	2.6 (0.7)	0.0	0.217 (0.002)	5.4 (0.4)
December	-2.5 (0.7)	3.0	0.201 (0.004)	1.6 (0.2)

*Precipitation levels obtained from weather station are not accurate.

Please refer to Table A2 for Environment Canada's climate normals obtained from the Truro, NS weather station. Precipitation data will not be presented for site 11 due to instrumental error.

Table A31. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
5171	1987	Mount Thom	Pictou	5040915.6	499875.5	164.809	Rich	Millbrook	Mi3/F	97(4)

Table A32. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.14 (0.08)a	90 (6)a	3.47	5 (2)a	0.74 (0.08)b	1.0 (0.1)b	0.70 (0.09)a
FH	0.10 (0.04)a	65 (15)b		3.1 (0.9)b	1.3 (0.3)a	1.2 (0.2)a	0.77 (0.07)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.2 (0.2)b	0.6 (0.4)b	-	0.8 (0.4)b	0.59 (0.09)a	0.05 (0.02)a	46 (7)a
FH	2.9 (0.5)a	6 (3)a	-	8 (6)a	0.4 (0.2)a	0.05 (0.02)a	27 (4)b
	C (%)	N (%)					
L	44.5 (0.6)a	1.0 (0.2)b					
FH	33 (7)b	1.2 (0.2)a					

Site 12

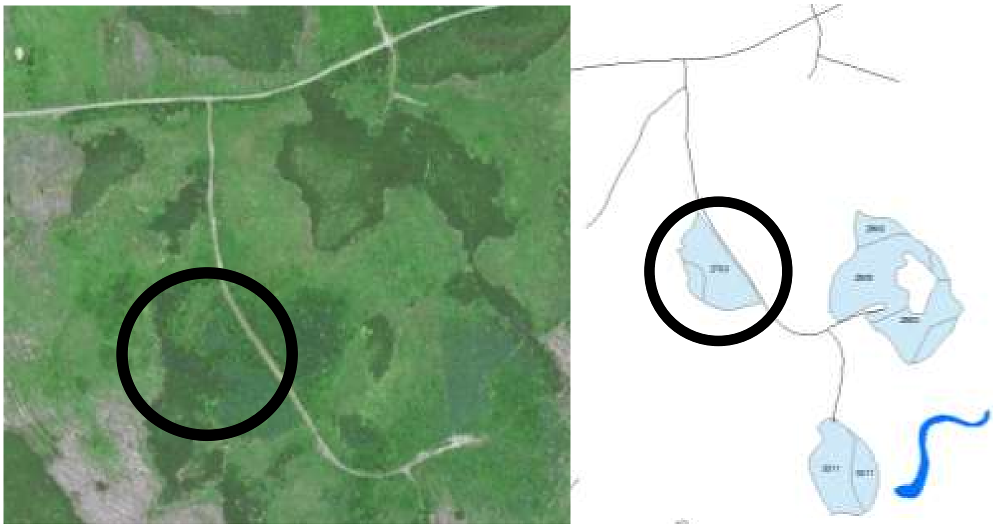

Figure A40. Aerial view of plantation (L) and plantation map with indicated site location (R).

Table A33. Site information regarding the plot ID, year planted, location (within NS, County, and UTM coordinates (Zone 20)), altitude, site quality, soil group and type, and canopy cover.

Plot ID	Year Planted	Location	County (NS)	UTM Coordinates		Altitude (m)	Site Quality	Soil Group	Soil Type	Canopy Cover (%)
				Northing	Easting					
2783	1986	Dickey Lake	Colchester	5013518.1	517356.2	200.153	Rich	Perch Lake	Ph4/C	94(6)

Table A34. Site characteristics obtained for the L and FH layers of the forest floor.

FF Layer	Bulk Density (g cm^{-3})	LoI (%)	pH	Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
L	0.12 (0.05)a	86.4 (0.8)a	3.27	4.2 (0.9)a	0.6 (0.1)a	0.9 (0.2)a	0.8 (0.1)a
FH	0.08 (0.02)a	79 (8)a		2.4 (0.8)b	0.59 (0.08)a	0.9 (0.2)a	0.8 (0.1)a
	SO_4^{2-} (mg g^{-1})	Al (mg g^{-1})	Cu (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})	C/N
L	2.5 (0.4)b	0.2 (0.1)b	-	0.2 (0.1)b	0.9 (0.2)a	0.06 (0.02)a	42 (6)a
FH	3.9 (0.2)a	2.2 (0.9)a	-	2 (1)a	0.8 (0.6)a	0.05 (0.03)a	27 (3)b
	C (%)	N (%)					
L	45.1 (0.4)a	1.1 (0.2)b					
FH	39 (3)b	1.47 (0.09)a					

APPENDIX B

Litter Mass Data

Site 1

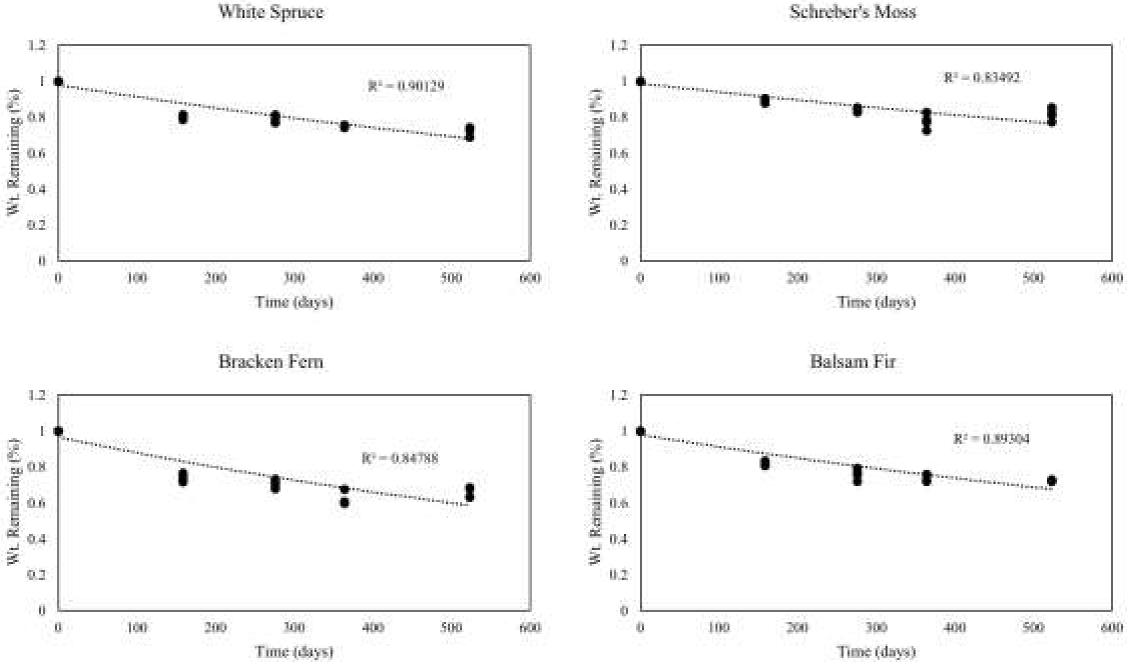

Figure B1. Site 1 litter mass data presented as weight of remaining litter (%) against the duration of days in field. The line of best fit presented here represents an exponential model. The litter types monitored on this site are white spruce (WS), Schreber's moss (Sc), bracken fern (Br), and balsam fir (Bf).

Table B1. Mean (SE) proportion of litter mass remaining for the four litter types monitored at this site. Tukey's test for significant difference between sampling periods is reported as lower-case letters.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Balsam fir	158	0.815	(0.006)b
	276	0.76	(0.02)b
	364	0.74	(0.01)a
	523	0.724	(0.002)b
Bracken fern	158	0.74	(0.01)c
	276	0.71	(0.01)c
	364	0.63	(0.02)b
	523	0.66	(0.01)c

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Schreber’s moss	158	0.894	(0.006)a
	276	0.842	(0.007)a
	364	0.78	(0.02)a
	523	0.82	(0.02)a
White spruce	158	0.803	(0.007)b
	276	0.79	(0.01)b
	364	0.748	(0.003)a
	523	0.72	(0.01)b

Table B2. Mean decomposition rates and standard error for litter types monitored at site 1. Letters represent Tukey’s multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Balsam Fir	0.258	(0.006)b
Bracken Fern	0.34	(0.02)a
Schreber’s Moss	0.178	(0.009)c
White Spruce	0.253	(0.007)b

Site 2

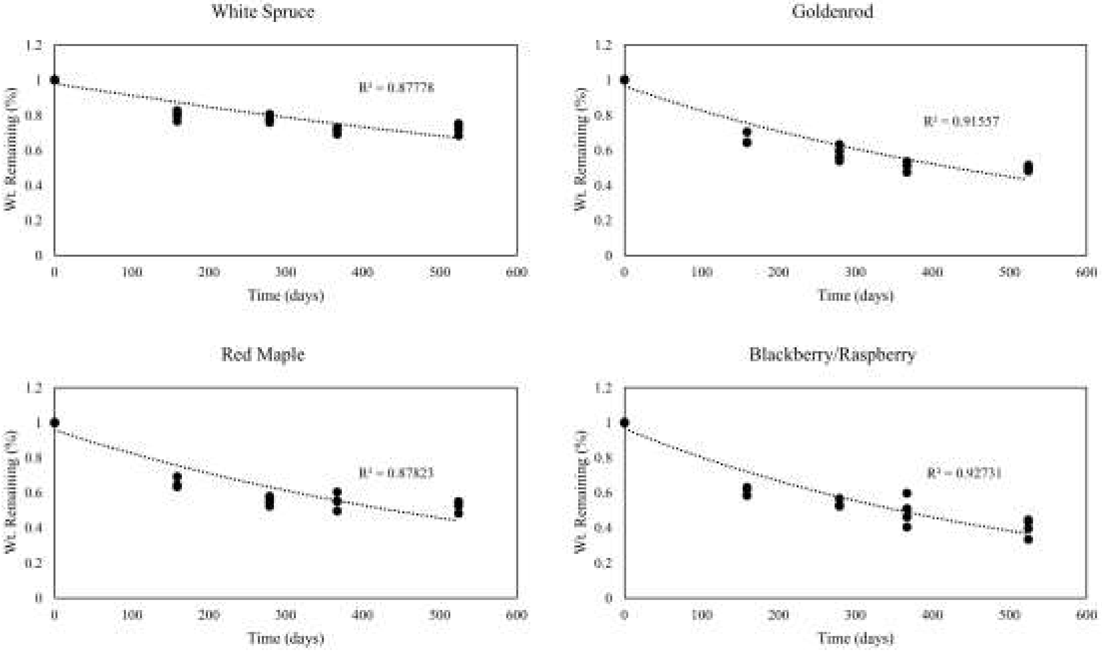

Figure B2. Site 2 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce, goldenrod, red maple, and blackberry/raspberry.

Table B3. Summary of mean proportional of litter mass remaining for each litter type at each sampling period. The standard error and Tukey's test (p<0.05) results are shown through letters.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Blackberry/raspberry	159	0.61	(0.01)b
	279	0.54	(0.01)b
	367	0.49	(0.04)b
	524	0.40	(0.03)c
Goldenrod	159	0.66	(0.02)b
	279	0.58	(0.02)b
	367	0.51	(0.01)b
	524	0.496	(0.008)b
Red maple	159	0.65	(0.01)b
	279	0.56	(0.02)b
	367	0.55	(0.02)b
	524	0.52	(0.02)b
White spruce	159	0.80	(0.01)a
	279	0.78	(0.01)a
	367	0.717	(0.008)a
	524	0.72	(0.01)a

Table B4. Mean decomposition rates and standard error for litter types found at Site 2. Letters represent Tukey's multiple comparison of means indicating significantly ($p<0.05$) different rates between litter types.

Litter Type	Decomposition rate	
	(year^{-1})	SE
Blackberry/Raspberry	0.68	(0.04)a
Goldenrod	0.557	(0.006)b
Red Maple	0.55	(0.02)b
White Spruce	0.263	(0.008)c

Site 3

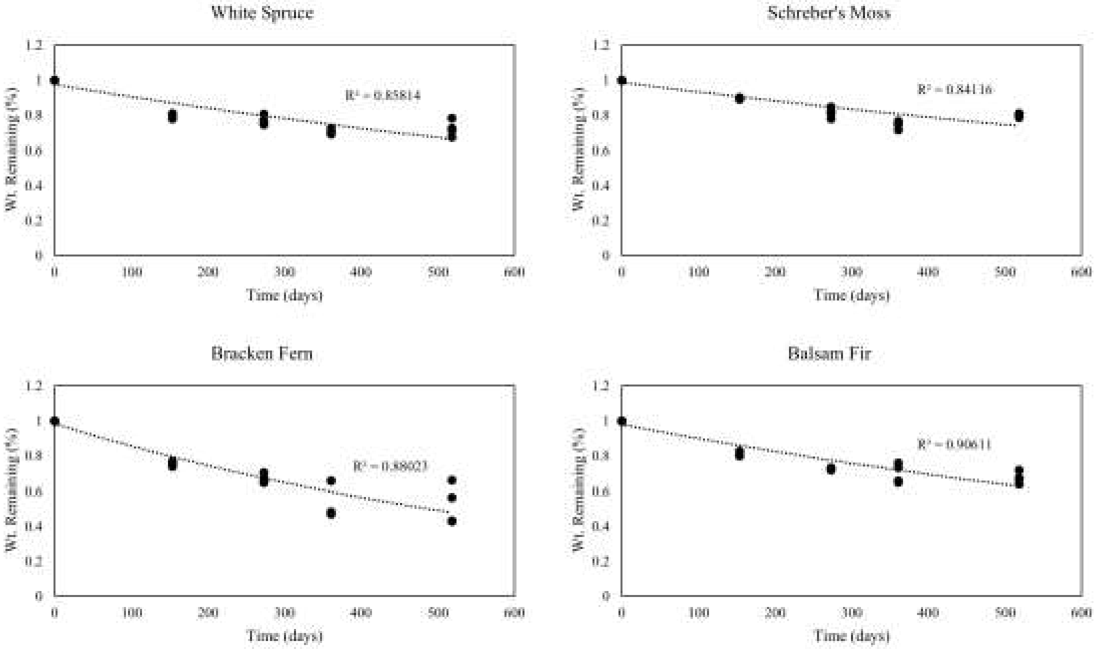

Figure B3. Site 3 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored on this site are white spruce (WS), Schreber's moss (Sc), bracken fern (Br), and balsam fir (Bf).

Table B5. The mean proportion of litter mass remaining and standard error for all four litter types at each sampling period (expressed as days in field). Tukey's test ($p<0.05$) results are shown as letters.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Balsam fir	153	0.814	(0.007)b
	273	0.727	(0.003)b
	361	0.70	(0.03)a
	518	0.68	(0.02)a
Bracken fern	153	0.754	(0.007)c
	273	0.67	(0.01)c
	361	0.57	(0.05)b
	518	0.52	(0.06)b
Schreber's moss	153	0.895	(0.002)a
	273	0.82	(0.01)a
	361	0.75	(0.01)a
	518	0.800	(0.005)a
White spruce	153	0.794	(0.007)b
	273	0.77	(0.01)ab
	361	0.706	(0.006)a
	518	0.72	(0.02)a

Table B6. Mean decomposition rate and standard error for litter types found at Site 3. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Balsam Fir	0.31	(0.01)b
Bracken Fern	0.51	(0.07)a
Schreber's moss	0.204	(0.006)b
White Spruce	0.27	(0.01)b

Site 4

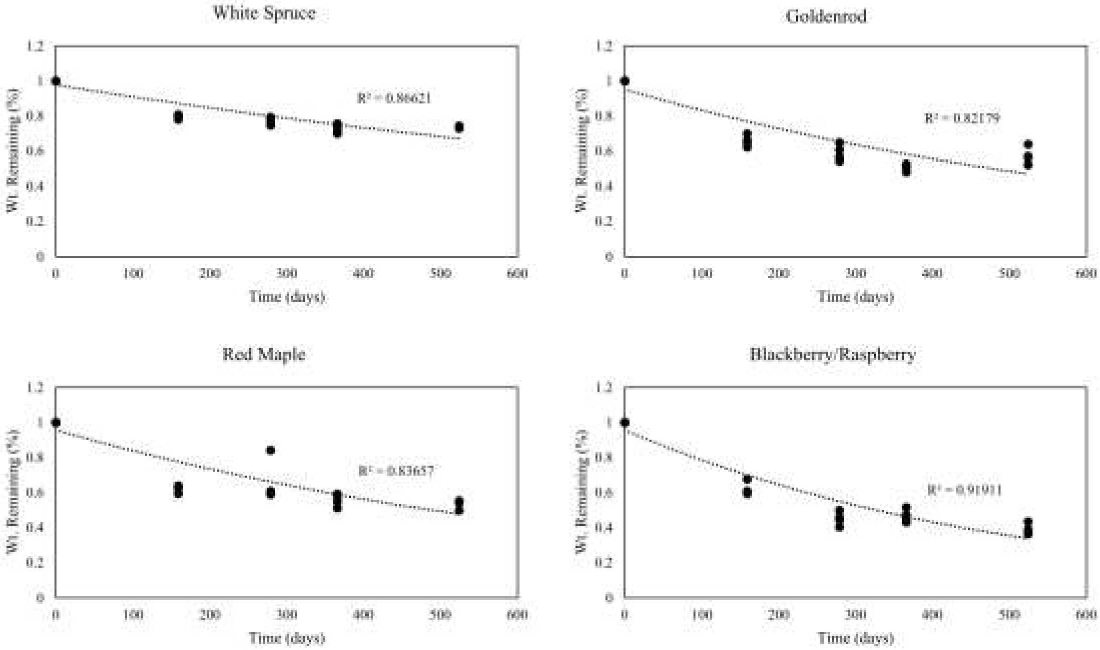

Figure B4. Site 4 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), goldenrod (Go), red maple (Rm), and blackberry/raspberry (Bb/Ra).

Table B7. Mean proportion of litter remaining for the different litter types at each sampling periods. The standard error and results from Tukey's test are stated below.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Blackberry/raspberry	159	0.62	(0.02)b
	279	0.45	(0.02)c
	366	0.47	(0.02)c
	524	0.39	(0.02)c
Goldenrod	159	0.66	(0.02)b
	279	0.59	(0.02)bc
	366	0.51	(0.01)bc
	524	0.57	(0.02)b
Red maple	159	0.62	(0.01)b
	279	0.66	(0.06)ab
	366	0.56	(0.02)b
	524	0.54	(0.01)b
White spruce	159	0.797	(0.006)a
	279	0.77	(0.01)a
	366	0.73	(0.01)a
	524	0.734	(0.006)a

Table B8. Mean decomposition rates and standard error for litter types monitored at Site 4. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Blackberry/Raspberry	0.724	(0.009)a
Goldenrod	0.49	(0.02)b
Red Maple	0.48	(0.02)b
White Spruce	0.27	(0.02)c

Site 5

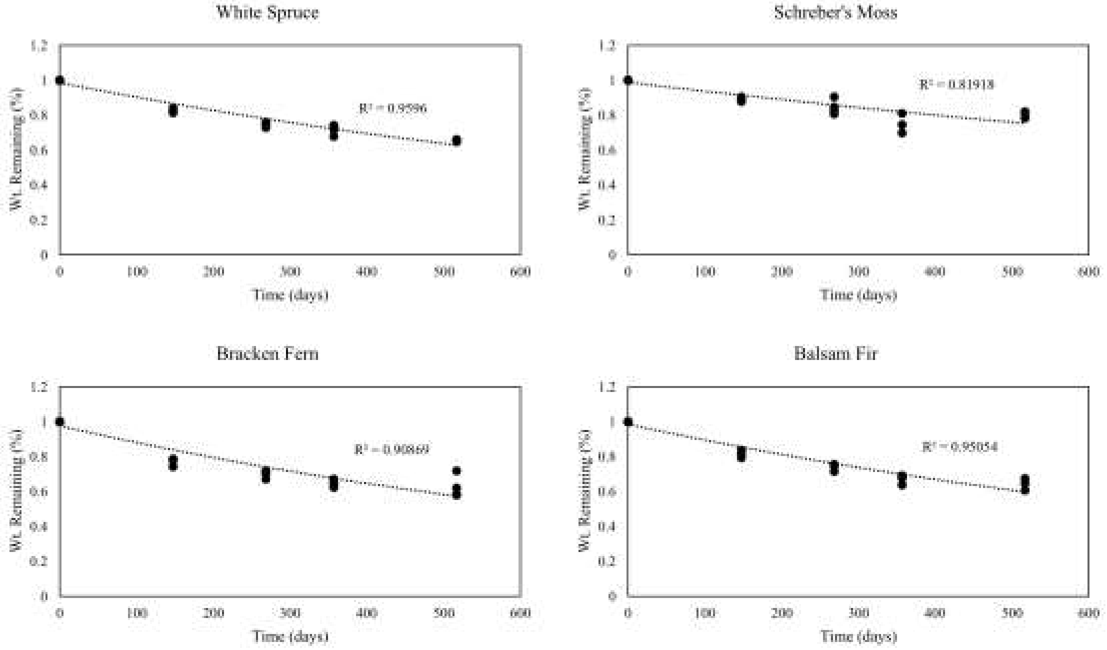

Figure B5. Site 5 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored on this site are white spruce (WS), Schreber's moss (Sc), bracken fern (Br), and balsam fir (Bf).

Table B9. Mean proportion of mass remaining and standard error for each litter type at each sampling period. Tukey's test denotes significant differences between litter types at each sampling period.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Balsam fir	147	0.82	(0.01)b
	269	0.742	(0.008)b
	357	0.67	(0.01)bc
	524	0.64	(0.02)b
Bracken fern	147	0.77	(0.01)c
	269	0.70	(0.01)b
	357	0.646	(0.009)c
	524	0.63	(0.03)b
Schreber's moss	147	0.891	(0.006)a
	269	0.85	(0.02)a
	357	0.75	(0.03)a
	524	0.801	(0.009)a
White spruce	147	0.824	(0.006)b
	269	0.745	(0.007)b
	357	0.72	(0.03)ab
	524	0.655	(0.003)b

Table B10. Mean decomposition rates and standard error for litter types monitored at Site 5. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Balsam fir	0.36	(0.02)a
Bracken fern	0.38	(0.02)a
Schreber's moss	0.19	(0.01)b
White Spruce	0.318	(0.007)a

Site 6

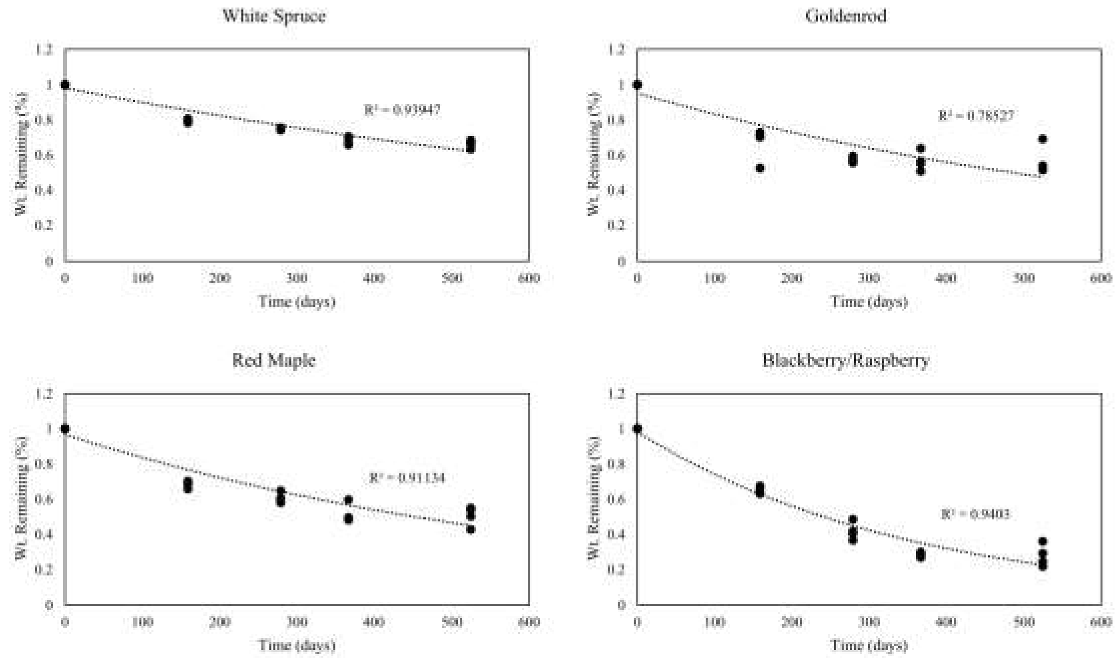

Figure B6. Site 6 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), goldenrod (Go), red maple (Rm), and blackberry/raspberry (Bb/Ra).

Table B11. Mean proportion of litter mass remaining with standard error and the results from Tukey's multiple comparison of means for each litter type at this site, and for each sampling period.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Blackberry/raspberry	159	0.65	(0.01)b
	279	0.42	(0.02)c
	367	0.280	(0.007)c
	524	0.28	(0.03)c
Goldenrod	159	0.67	(0.05)b
	279	0.571	(0.009)b
	367	0.57	(0.03)b
	524	0.58	(0.03)ab
Red maple	159	0.68	(0.01)b
	279	0.61	(0.01)b
	367	0.53	(0.04)b
	524	0.50	(0.03)b
White spruce	159	0.795	(0.005)a
	279	0.747	(0.003)a
	367	0.69	(0.01)a
	524	0.66	(0.01)a

Table B12. Mean decomposition rates and standard error for litter types monitored at Site 6. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	($year^{-1}$)	SE
Blackberry/Raspberry	1.02	(0.05)a
Goldenrod	0.50	(0.05)b
Red Maple	0.53	(0.04)b
White Spruce	0.319	(0.005)c

Site 7

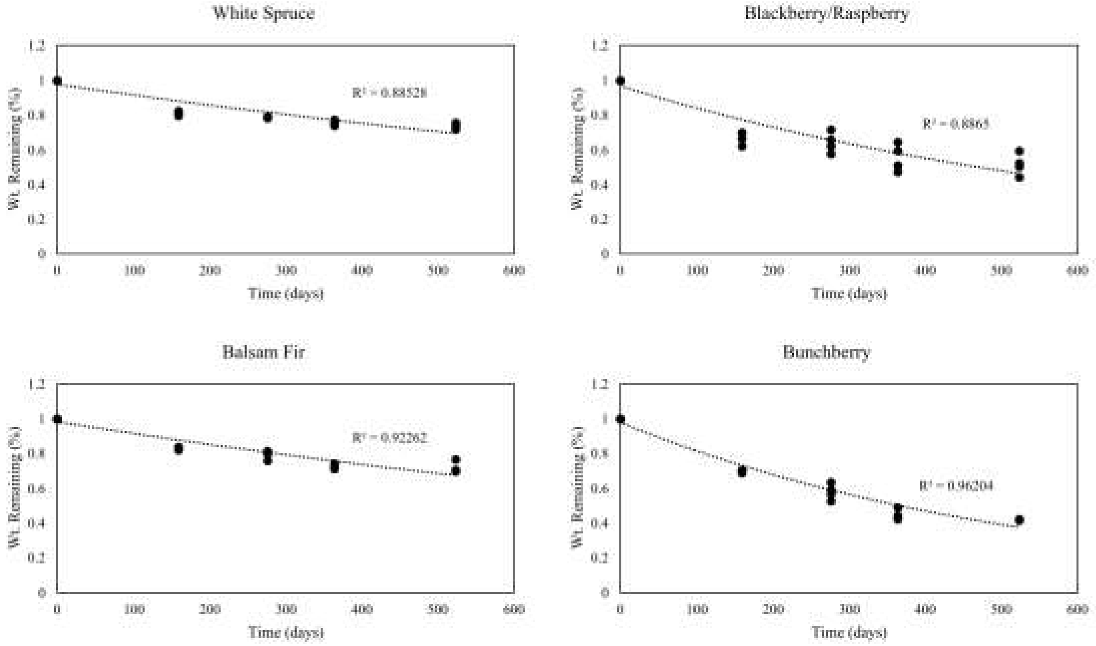

Figure B7. Site 7 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), blackberry/raspberry (Bb/Ra), balsam fir (Bf), and bunchberry (Bu).

Table B13. Mean proportion of litter mass remaining and standard error for four litter types monitored at this site. The results of Tukey's multiple comparison of means are denoted as letters.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Blackberry/raspberry	158	0.67	(0.02)b
	276	0.64	(0.03)b
	364	0.55	(0.04)b
	523	0.51	(0.03)b
Balsam fir	158	0.830	(0.004)a
	276	0.79	(0.01)a
	364	0.724	(0.007)a
	523	0.72	(0.02)a
Bunchberry	158	0.698	(0.005)b
	276	0.58	(0.02)b
	364	0.45	(0.02)c
	523	0.420	(0.003)c
White spruce	158	0.809	(0.006)a
	276	0.787	(0.002)a
	364	0.755	(0.007)a
	523	0.740	(0.007)a

Table B14. Mean decomposition rates and standard error for litter types monitored at Site 7. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate (year^{-1})	SE
Blackberry/raspberry	0.51	(0.05)b
Balsam fir	0.263	(0.008)c
Bunchberry	0.69	(0.05)a
White Spruce	0.238	(0.007)c

Site 8

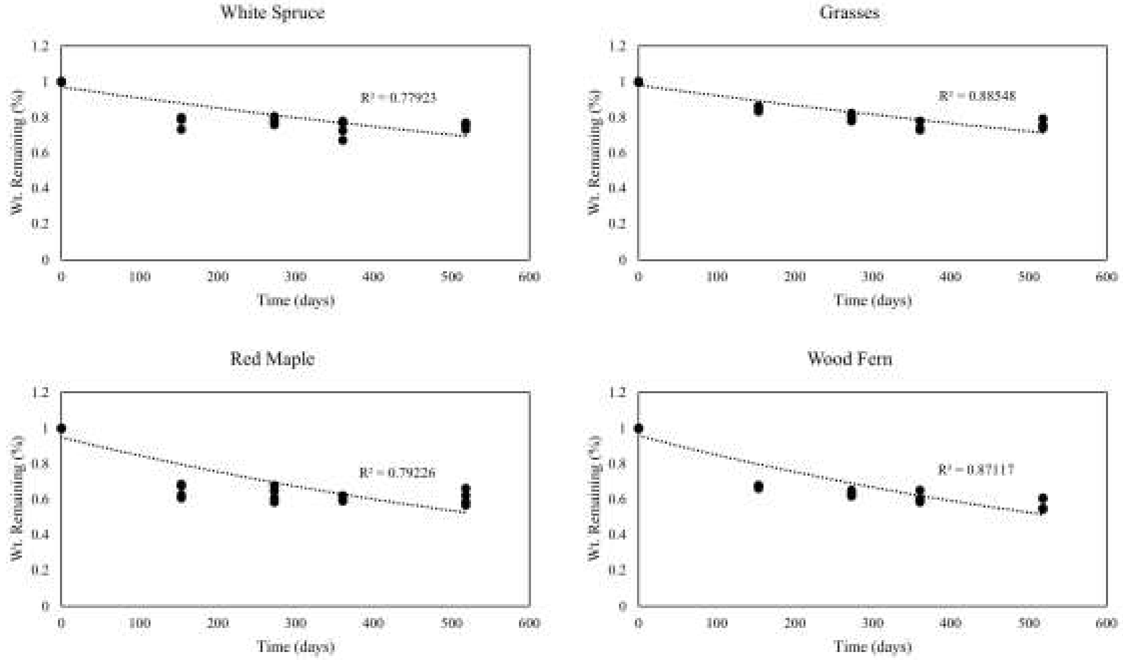

Figure B8. Site 8 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), grasses (Gr), red maple (Rm), and wood fern (Wf).

Table B15. Mean proportion of litter mass remaining and standard error for four litter types monitored at this site. Tukey's test results are denoted as letters (p<0.05).

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Grasses	153	0.845	(0.007)a
	273	0.80	(0.01)a
	361	0.75	(0.02)a
	518	0.76	(0.01)a
Red maple	153	0.65	(0.02)c
	273	0.63	(0.02)b
	361	0.602	(0.007)b
	518	0.61	(0.02)b
Wood fern	153	0.674	(0.005)c
	273	0.631	(0.008)b
	361	0.68	(0.02)b
	518	0.58	(0.02)b
White spruce	153	0.78	(0.02)b
	273	0.79	(0.01)a
	361	0.74	(0.02)a
	518	0.756	(0.008)a

Table B16. Mean decomposition rates and standard error for litter types monitored at Site 8. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types (<0.05).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Grasses	0.24	(0.03)b
Red Maple	0.42	(0.02)a
Wood Fern	0.44	(0.01)a
White Spruce	0.24	(0.01)b

Site 9

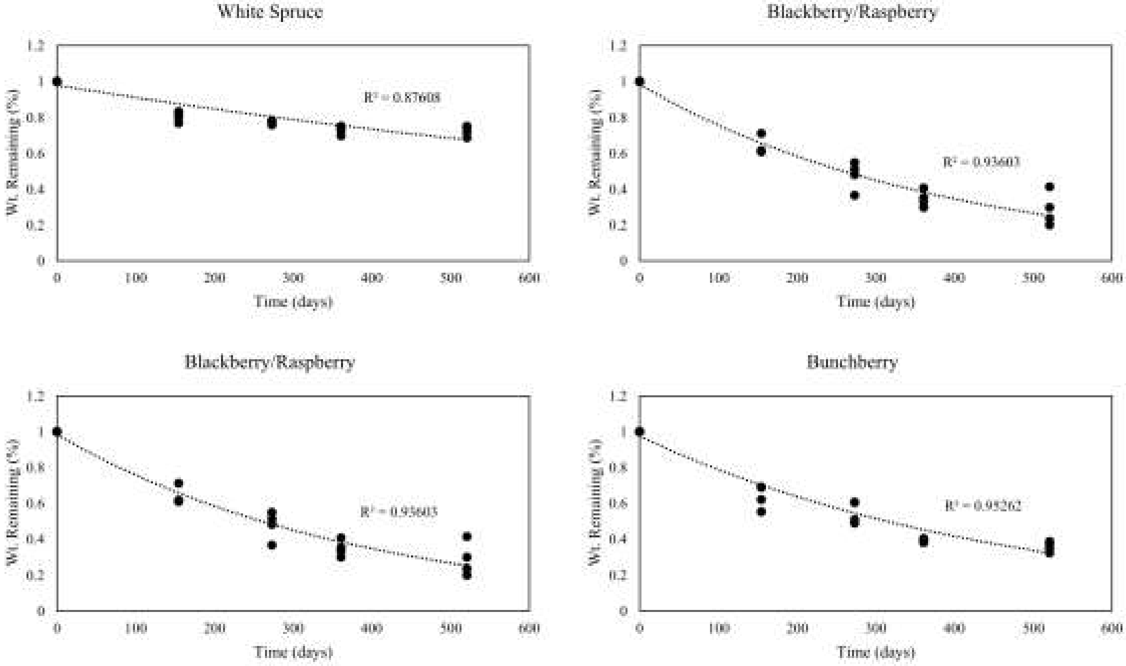

Figure B9. Site 9 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), blackberry/raspberry (Bb/Ra), balsam fir (Bf), and bunchberry (Bu).

Table B17. Mean proportion of litter mass remaining and standard error for each litter type at each sampling period. Tukey's test results are presented as letters.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Blackberry/raspberry	154	0.64	(0.02)b
	273	0.48	(0.04)b
	361	0.35	(0.02)b
	520	0.29	(0.05)b
Balsam fir	154	0.795	(0.006)a
	273	0.72	(0.01)a
	361	0.69	(0.02)a
	520	0.64	(0.02)a
Bunchberry	154	0.64	(0.03)b
	273	0.55	(0.03)b
	361	0.393	(0.007)b
	520	0.36	(0.01)b
White spruce	154	0.80	(0.01)a
	273	0.773	(0.006)a
	361	0.73	(0.01)a
	520	0.73	(0.01)a

Table B18. Mean decomposition rates (k, year^{-1}) and standard error for litter types monitored at Site 9. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Blackberry/Raspberry	0.95	(0.06)a
Balsam fir	0.34	(0.02)c
Bunchberry	0.77	(0.02)b
White Spruce	0.26	(0.01)c

Site 10

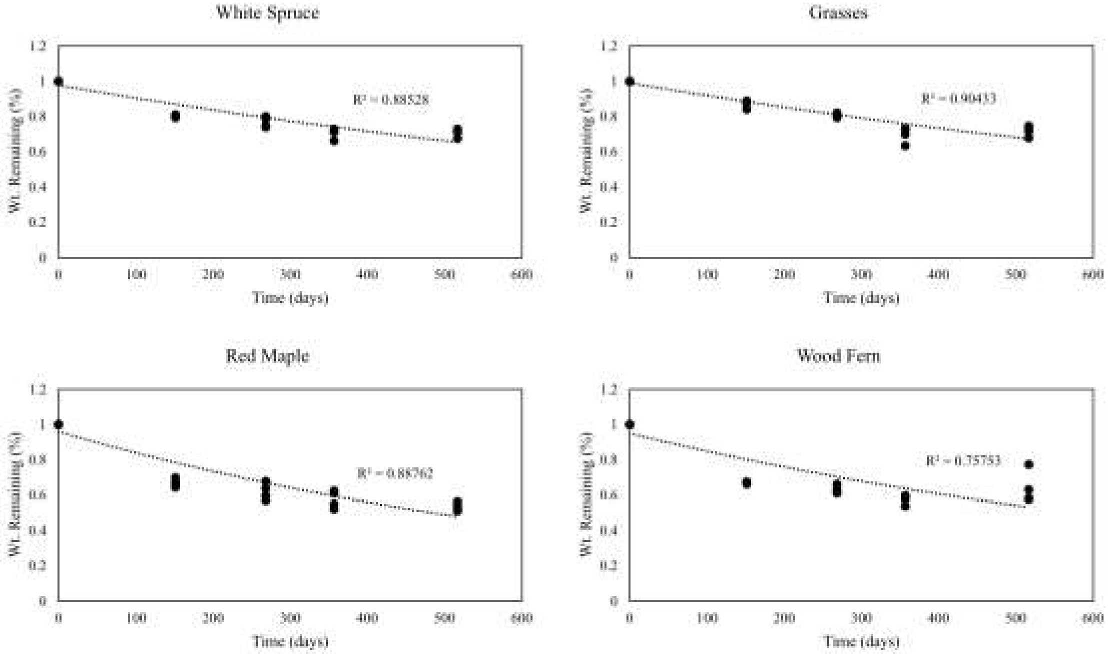

Figure B10. Site 10 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), grasses (Gr), red maple (Rm), and wood fern (Wf).

Table B19. Mean proportion of litter mass remaining and standard error at each sampling period for each litter type. Tukey's multiple comparison of means shows significance between litter types at each sampling through a lettering system.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Grasses	151	0.869	(0.009)a
	279	0.808	(0.005)a
	357	0.70	(0.02)a
	516	0.72	(0.01)a
Red maple	151	0.67	(0.01)c
	279	0.62	(0.02)b
	357	0.58	(0.02)b
	516	0.54	(0.01)b
Wood fern	151	0.670	(0.0003)c
	279	0.63	(0.01)b
	357	0.58	(0.01)b
	516	0.64	(0.05)ab
White spruce	151	0.801	(0.004)b
	279	0.77	(0.02)a
	357	0.70	(0.01)a
	516	0.71	(0.01)a

Table B20. Mean decomposition rates and standard error for litter types monitored at Site 10. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate ($year^{-1}$)	SE
Grasses	0.273	(0.007)c
Red Maple	0.49	(0.02)a
Wood fern	0.41	(0.03)b
White Spruce	0.284	(0.005)c

Site 11

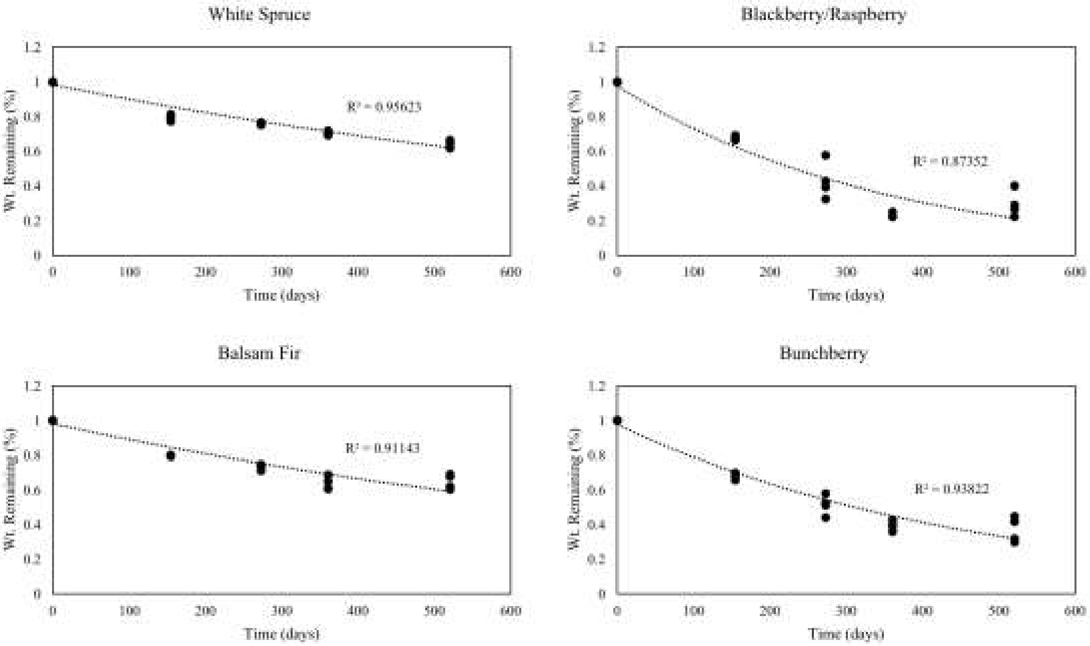

Figure B11. Site 11 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), blackberry/raspberry (Bb/Ra), balsam fir (Bf), and bunchberry (Bu).

Table B21. The mean proportion of litter mass remaining and standard error for blackberry/raspberry, balsam fir, bunchberry, and white spruce at site 11. Tukey's test results are shown below as letters.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Blackberry/Raspberry	154	0.675	(0.007)b
	273	0.43	(0.05)b
	361	0.230	(0.008)d
	520	0.30	(0.04)b
Balsam fir	154	0.798	(0.002)a
	273	0.733	(0.007)a
	361	0.64	(0.02)b
	520	0.65	(0.02)a
Bunchberry	154	0.681	(0.009)b
	273	0.51	(0.03)b
	361	0.39	(0.01)c
	520	0.37	(0.04)b
White spruce	154	0.796	(0.008)a
	273	0.756	(0.003)a
	361	0.707	(0.005)a
	520	0.65	(0.01)a

Table B22. Mean decomposition rates and standard error for litter types monitored at Site 11. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Blackberry/Raspberry	1.06	(0.06)c
Balsam fir	0.35	(0.02)a
Bunchberry	0.78	(0.04)b
White Spruce	0.324	(0.008)a

Site 12

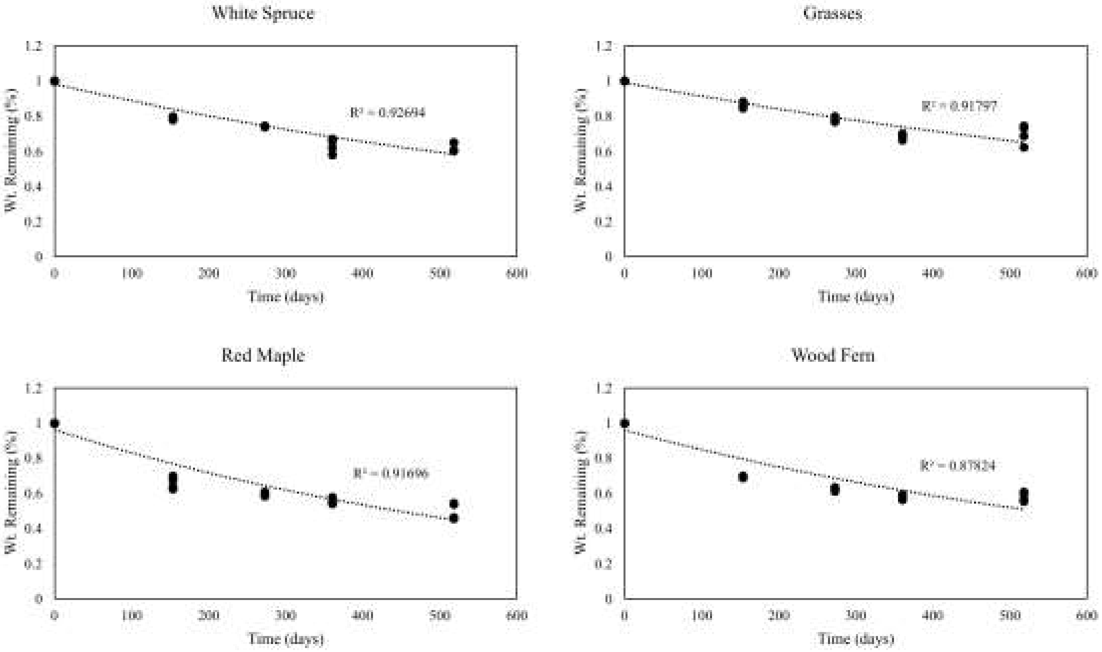

Figure B12. Site 12 litter mass data presented as weight of remaining litter (%) vs the duration of days in the field. The line of best fit presented here represents an exponential model. The litter types monitored are white spruce (WS), grasses (Gr), red maple (Rm), and wood fern (Wf).

Table B23. Mean proportion of litter mass remaining and standard error for each litter type collected at each sampling. Tukey's test results are listed as letters below.

Litter Type	Field Deployment Duration (days)	Mean Proportion of Litter Mass Remaining	SE
Grasses	153	0.864	(0.008)a
	273	0.783	(0.007)a
	361	0.687	(0.008)a
	524	0.70	(0.03)a
Red maple	153	0.66	(0.02)c
	273	0.594	(0.005)d
	361	0.555	(0.008)c
	524	0.50	(0.02)c
Wood fern	153	0.693	(0.002)c
	273	0.625	(0.005)c
	361	0.577	(0.008)c
	524	0.58	(0.01)bc
White spruce	153	0.789	(0.005)b
	273	0.744	(0.003)b
	361	0.63	(0.04)b
	524	0.63	(0.01)ab

Table B24. Mean decomposition rates and standard error for litter types monitored at Site 12. Letters represent Tukey's multiple comparison of means indicating significantly different rates between litter types ($p<0.05$).

Litter Type	Decomposition rate	
	(year^{-1})	SE
Grasses	0.29	(0.02)a
Red Maple	0.54	(0.03)c
Wood Fern	0.45	(0.01)b
White Spruce	0.37	(0.02)a

APPENDIX C

Litter Composition Data

Summarized chemical compositional values obtained for each litter type are shown below. Tables reporting summarized data for each site shows significance ($p<0.05$) between sampling periods through Tukey's multiple comparison of means. Litter types with nutrient levels that reported over 15% of non-detect values were not included in the tables below.

Nutrient Characterization

Table C1. Litter nutrient concentrations ($\bar{x}$ (SE)) for all litter types.

Litter Type	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
Bb/Ra	29.10 (0.04)f	2.02 (0.02)b	45.91 (0.02)e	22.8 (0.2)f
Bf	47.4 (0.2)a	1.152 (0.005)d	50.85 (0.04)a	44.2 (0.2)b
Br	44.7 (0.1)b	2.5 (0.2)a	45.603 (0.007)f	22.6 (0.7)f
Bu	25.1 (0.2)g	1.29 (0.01)d	42.67 (0.04)i	33.1 (0.4)e
Go	32.8 (0.3)e	1.6 (0.1)c	46.57 (0.05)d	30 (2)e
Gr	29.4 (0.3)f	0.77 (0.02)e	45.73 (0.04)f	60 (1)a
Rm	29.0 (0.4)f	1.30 (0.03)d	47.87 (0.03)c	37 (1)d
Sc	36.3 (0.2)d	0.73 (0.02)e	45.40 (0.07)g	62 (1)a
Wf	36.9 (0.3)d	1.743 (0.005)c	44.17 (0.02)h	25.34 (0.07)f
WS	41.5 (0.1)c	1.237 (0.008)d	50.12 (0.02)b	40.6 (0.2)c
	Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
Bb/Ra	6.19 (0.05)c	2.54 (0.01)c	7.30 (0.01)c	1.259 (0.008)c
Bf	6.3 (0.1)b	0.622 (0.009)gh	3.62 (0.06)e	0.928 (0.009)d
Br	3.32 (0.08)d	1.76 (0.04)e	12.85 (0.07)a	1.51 (0.03)b
Bu	17.0 (0.2)a	3.68 (0.08)b	5.9 (0.2)d	0.982 (0.009)d
Go	6.1 (0.3)b	2.2 (0.1)d	12.5 (0.5)a	1.43 (0.07)b
Gr	0.52 (0.04)f	0.33 (0.03)i	1.1 (0.1)f	0.35 (0.02)g
Rm	5.2 (0.2)c	1.52 (0.06)f	3.84 (0.06)e	0.84 (0.01)e
Sc	1.96 (0.05)e	0.75 (0.02)g	3.48 (0.08)e	0.644 (0.007)f
Wf	3.03 (0.09)d	4.12 (0.08)a	11.2 (0.4)b	2.14 (0.04)a
WS	2.40 (0.03)e	0.482 (0.002)hi	0.89 (0.03)f	0.951 (0.004)d
	SO_4^{2-} (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
Bb/Ra	2.66 (0.02)c	0.31 (0.02)a	2.66 (0.03)a	0.0242 (0.0005)d
Bf	2.04 (0.02)e	0.066 (0.001)de	1.40 (0.06)b	0.0346 (0.0005)c
Br	2.96 (0.07)b	0.066 (0.001)de	0.70 (0.01)ef	0.0159 (0.0005)e
Bu	5.0 (0.1)a	0.102 (0.005)cd	0.347 (0.009)g	0.0189 (0.0008)e
Go	2.6 (0.1)c	0.064 (0.002)de	0.96 (0.04)cd	0.074 (0.002)a
Gr	1.64 (0.06)f	0.127 (0.002)c	0.54 (0.04)f	0.0155 (0.0008)e
Rm	2.22 (0.03)e	0.056 (0.002)e	1.03 (0.02)c	0.0231 (0.0006)d
Sc	1.64 (0.04)f	0.21 (0.02)b	0.345 (0.009)g	0.0240 (0.0005)d
Wf	3.01 (0.02)b	0.073 (0.003)de	1.52 (0.02)b	0.0389 (0.0006)b
WS	2.389 (0.009)d	0.069 (0.002)de	0.834 (0.003)de	0.0231 (0.0003)d

	Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
Bb/Ra	0.071 (0.006)cd	0.035 (0.001)b	0.0067 (5E-4)b	36 (1) cd
Bf	0.22 (0.01)b	0.0130 (4E-4)d	-	12.7 (0.7)f
Br	-	0.0152 (9E-4)d	-	58 (0.7)b
Bu	0.63 (0.03)a	0.043 (0.002)a	-	42 (2)c
Go	-	0.035 (0.002)b	0.0097 (8E-4)a	30 (2)d
Gr	0.070 (0.002)d	-	-	12.7 (0.2)f
Rm	-	0.027 (0.002)c	0.0065 (5E-4)b	66 (2)a
Sc	0.17 (0.02)b	-	-	8.4 (0.1)f
Wf	0.071 (0.004)d	0.0264 (3E-4)c	-	14.4 (0.6)ef
WS	0.15 (0.03)bc	-	-	19.2 (0.5)e

Overall Mean Concentrations of Nutrients and Litter Quality Characteristics for all Litter Types

Table C2. Mean concentrations (SE) of calcium, magnesium, potassium, phosphorus, manganese, Klason lignin, nitrogen, carbon, and C/N ratio for each litter type. Tukey's multiple comparison of means was used to compare litter types.

Litter	KL (%)		N (%)		C (%)		C/N	
Type	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Bb/Ra	38.5d	(0.6)	2.79	(0.05)a	46.0	(0.1)d	17.2	(0.3)h
Bf	50.8a	(0.2)	1.19	(0.02)f	50.3	(0.1)a	43.1	(0.5)c
Br	48.7ab	(0.5)	2.31	(0.07)b	45.5	(0.1)de	20.6	(0.6)g
Bu	31.1e	(0.8)	2.04	(0.08)cd	46.2	(0.2)g	22.1	(0.9)fg
Go	41.3cd	(0.7)	1.95	(0.06)d	46.2	(0.1)d	24.9	(0.8)f
Gr	32.6e	(0.3)	0.85	(0.02)g	45.0	(0.2)ef	54	(1)a
Rm	47.2b	(0.9)	1.48	(0.03)e	47.4	(0.1)c	33.1	(0.6)e
Sc	41cd	(1)	0.97	(0.03)g	45.1	(0.2)ef	48	(1)b
Wf	44.1c	(0.6)	2.16	(0.04)bc	44.1	(0.2)f	20.8	(0.3)g
WS	47.9b	(0.3)	1.371	(0.009)e	49.2	(0.2)b	36.2	(0.3)d
	Ca (mg g^{-1})		Mg (mg g^{-1})		K (mg g^{-1})		P (mg g^{-1})	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Bb/Ra	6.8c	(0.2)	1.74	(0.05)d	2.2	(0.2)bc	1.42	(0.02)a
Bf	6.2c	(0.1)	0.53	(0.01)h	1.5	(0.1)cd	0.79	(0.01)e
Br	4.0de	(0.1)	1.55	(0.06)e	3.0	(0.6)ab	1.15	(0.03)b
Bu	24.5a	(0.8)	3.08	(0.08)b	2.1	(0.3)bcd	1.21	(0.03)b
Go	9.0b	(0.3)	1.96	(0.06)c	3.3	(0.6)ab	1.14	(0.03)b
Gr	0.8g	(0.04	0.35	(0.01)h	0.78	(0.05)d	0.43	(0.01)g
Rm	6.5c	(0.1)	1.09	(0.03)f	1.5	(0.1)cd	0.93	(0.01)d
Sc	3.1ef	(0.1)	0.88	(0.03)g	1.5	(0.1)cd	0.68	(0.01)f
Wf	4.4d	(0.4)	3.87	(0.09)a	3.4	(0.5)a	1.42	(0.05)a
WS	2.45f	(0.03)	0.505	(0.005)h	1.27	(0.05)d	1.00	(0.01)c

	Mn (mg g^{-1})	
	$\bar{x}$	SE
Bb/Ra	2.91a	(0.09)
Bf	1.87b	(0.07)
Br	0.77ef	(0.03)
Bu	0.62ef	(0.04)
Go	1.47c	(0.06)
Gr	0.59f	(0.02)
Rm	1.15d	(0.04)
Sc	0.52f	(0.03)
Wf	1.78b	(0.04)
WS	0.834e	(0.007)

Change in Litter Chemical Composition with Time

Site 1

Table C3. Mean (SE) compositional values obtained for litter types monitored at site 1 over each sampling period.

Litter Type	Days in Field	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)d	50.12 (0.06)a	41 (1)a
	158	61 (2)a	1.249 (0.009)cd	50.7 (0.6)a	40.6 (0.8)a
	276	45.5 (0.7)bc	1.34 (0.01)bc	50.09 (0.02)a	37.4 (0.4)b
	364	49.5 (0.7)b	1.352 (0.007)b	50.14 (0.05)a	37.1 (0.2)b
	523	49 (1)b	1.49 (0.04)a	49.72 (0.08)a	33.4 (0.8)c
Sc	0	36.3 (0.4)a	0.73 (0.03)b	45.4 (0.1)a	62 (3)a
	158	38 (1)a	0.86 (0.09)ab	43.2 (0.3)b	51 (4)ab
	276	39 (1)a	0.93 (0.05)ab	45.2 (0.3)a	49 (3)ab
	364	37 (2)a	1.1 (0.1)a	46.0 (0.2)a	45 (8)b
	523	60 (14)a	1.03 (0.06)ab	43.7 (0.4)b	43 (3)b
Br	0	44.5 (0.2)a	2.0 (0.1)a	45.60 (0.01)b	23 (1)a
	158	48 (2)a	2.2 (0.3)a	44.0 (0.2)c	21 (3)a
	276	52 (2)a	2.2 (0.3)a	45.6 (0.1)b	22 (3)a
	364	49 (2)a	2.7 (0.4)a	46.6 (0.2)a	18 (3)a
	523	51 (2)a	2.4 (0.3)a	45.4 (0.1)b	20 (3)a
Bf	0	47.4 (0.5)b	1.15 (0.02)a	50.8 (0.1)b	44.2 (0.7)a
	158	51 (1)a	1.00 (0.04)a	49.5 (0.1)c	50 (2)a
	276	49.8 (0.8)ab	1.08 (0.09)a	49.1 (0.2)c	46 (4)a
	364	52.6 (0.7)a	1.06 (0.02)a	51.9 (0.3)a	49.1 (0.8)a
	523	52 (1)a	1.20 (0.07)a	51.1 (0.3)ab	43 (2)a
		Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
WS	0	2.4 (0.1)ab	0.482 (0.009)a	0.9 (0.1)ab	0.95 (0.01)ab
	158	1.99 (0.08)b	0.456 (0.009)a	1.2 (0.1)a	0.99 (0.03)ab
	276	2.6 (0.1)a	0.50 (0.02)a	1.0 (0.2)a	1.04 (0.05)a
	364	2.4 (0.1)ab	0.482 (0.009)a	0.9 (0.1)a	0.95 (0.01)ab
	523	2.35 (0.04)ab	0.49 (0.02)a	0.5 (0.1)a	0.91 (0.01)b
Sc	0	1.96 (0.09)b	0.75 (0.06)a	3.5 (0.2)a	0.64 (0.01)a
	158	2.6 (0.3)ab	0.79 (0.02)a	0.91 (0.04)c	0.59 (0.05)a
	276	2.9 (0.1)ab	1.03 (0.04)a	1.68 (0.07)b	0.74 (0.04)a
	364	3.3 (0.4)a	1.01 (0.07)a	1.0 (0.1)c	0.69 (0.05)a
	523	3.3 (0.5)a	1.0 (0.1)a	1.0 (0.2)c	0.66 (0.04)a
Br	0	3.3 (0.2)a	1.73 (0.09)a	12.7 (0.1)a	1.49 (0.06)a
	158	3.6 (0.6)a	1.7 (0.2)a	2.2 (0.2)b	1.1 (0.1)ab
	276	3.1 (0.7)a	1.0 (0.4)a	1.0 (0.2)cd	1.0 (0.1)ab
	364	4.9 (0.6)a	2.1 (0.2)a	1.4 (0.2)c	1.2 (0.1)ab
	523	3.8 (0.5)a	1.4 (0.3)a	0.5 (0.1)d	0.9 (0.1)b
Bf	0	6.3 (0.3)a	0.62 (0.02)a	3.6 (0.2)a	0.93 (0.03)a
	158	4.2 (0.5)a	0.333 (0.009)b	0.70 (0.07)b	0.69 (0.03)b
	276	5.4 (0.9)a	0.35 (0.02)b	0.7 (0.2)b	0.65 (0.06)b
	364	5.4 (0.8)a	0.34 (0.02)b	0.5 (0.2)b	0.65 (0.02)b
	523	5.7 (0.3)a	0.39 (0.02)b	0.4 (0.1)b	0.70 (0.04)b

		SO_4^{2-} (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	2.39 (0.04)b	0.069 (0.009)a	0.83 (0.01)ab	0.023 (0.001)a
	158	2.22 (0.03)c	0.09 (0.01)a	0.76 (0.02)b	0.0205 (9E-4)a
	276	2.38 (0.05)b	0.078 (0.004)a	0.86 (0.02)a	0.0239 (8E-4)a
	364	2.39 (0.04)b	0.069 (0.009)a	0.83 (0.01)ab	0.023 (0.001)a
	523	2.57 (0.02)a	0.10 (0.01)a	0.78 (0.02)ab	0.024 (0.001)a
Sc	0	1.64 (0.07)ab	0.21 (0.04)a	0.34 (0.02)a	0.0240 (9E-4)c
	158	1.9 (0.2)ab	0.37 (0.05)a	0.4 (0.1)a	0.039 (0.002)bc
	276	1.4 (0.1)bc	0.30 (0.02)a	0.41 (0.04)a	0.052 (0.003)ab
	364	0.8 (0.2)c	0.32 (0.08)a	0.6 (0.2)a	0.060 (0.004)a
	523	2.2 (0.2)a	1.0 (0.6)a	0.52 (0.09)a	0.066 (0.009)a
Br	0	2.9 (0.2)a	0.068 (0.003)a	0.69 (0.03)a	0.016 (0.001)b
	158	3.8 (0.5)a	0.14 (0.02)a	0.7 (0.1)a	0.022 (0.002)ab
	276	3.0 (0.3)a	0.22 (0.08)a	0.6 (0.1)a	0.04 (0.01)a
	364	3.3 (0.6)a	0.157 (0.007)a	0.9 (0.1)a	0.032 (0.004)ab
	523	3.6 (0.5)a	0.15 (0.04)a	0.78 (0.08)a	0.022 (0.003)ab
Bf	0	2.05 (0.07)a	0.066 (0.004)a	1.4 (0.2)b	0.035 (0.001)a
	158	2.01 (0.08)a	0.091 (0.009)a	2.5 (0.2)ab	0.033 (0.002)a
	276	2.1 (0.2)a	0.070 (0.008)a	2.9 (0.4)a	0.037 (0.003)a
	364	2.08 (0.06)a	0.16 (0.04)a	2.9 (0.4)a	0.05 (0.01)a
	523	2.4 (0.1)a	0.18 (0.06)a	2.9 (0.1)a	0.043 (0.003)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.15 (0.03)a	-	-	19.2 (0.5)a
	158	0.123 (0.005)a	-	-	2.4 (0.1)d
	276	0.138 (0.003)a	-	-	20 (1)a
	364	0.15 (0.03)a	-	-	15.5 (0.2)b
	523	0.17 (0.02)a	-	-	13.1 (0.5)c
Sc	0	0.17 (0.02)a	-	-	8.4 (0.1)b
	158	0.66 (0.4)a	-	-	13.6 (0.5)a
	276	0.32 (0.02)a	-	-	2.6 (0.2)c
	364	0.30 (0.05)a	-	-	4.3 (0.3)c
	523	1.1 (0.5)a	-	-	3.7 (0.9)c
Br	0	-	-	-	13.2 (0.9)a
	158	0.062 (0.007)a	-	0.0067 (5E-4)a	11.8 (0.5)ab
	276	0.20 (0.05)a	-	0.0067 (5E-4)a	3.4 (0.6)c
	364	0.108 (0.009)a	-	0.009 (0.002)a	7 (2)bc
	523	0.10 (0.04)a	-	-	5.6 (0.4)c
Bf	0	0.22 (0.01)a	-	-	12.7 (0.7)a
	158	0.20 (0.01)a	-	-	5.3 (0.8)b
	276	0.20 (0.02)a	-	-	13.8 (0.7)a
	364	0.26 (0.04)a	-	-	5.4 (0.2)b
	523	0.28 (0.03)a	-	-	5.4 (0.3)b

Site 2

Table C4. Mean (SE) compositional values obtained for litter types monitored at site 2 over each sampling period.

Litter Type	Days in Field	KL (%) x̄ (SE)	N (%) x̄ (SE)	C (%) x̄ (SE)	C/N x̄ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)a	50.12 (0.06)a	41 (1)a
	159	60 (4)a	1.25 (0.02)a	47 (4)a	38 (3)a
	279	46.5 (0.9)bc	1.36 (0.03)a	50.23 (0.02)a	37.1 (0.8)a
	367	51 (2)b	1.3 (0.2)a	52.3 (0.3)a	43 (4)a
	524	49.9 (0.9)b	1.45 (0.03)a	50.1 (0.1)a	34.6 (0.5)a
Go	0	32.8 (0.6)c	1.6 (0.2)a	46.6 (0.1)ab	30 (4)a
	159	40 (2)ab	1.8 (0.2)a	44.7 (0.3)b	26 (3)a
	279	45 (1)a	1.9 (0.3)a	45.9 (0.9)ab	26 (5)a
	367	39 (2)b	2.2 (0.3)a	47.0 (0.1)a	23 (3)a
	524	45 (1)ab	2.2 (0.2)a	46.3 (0.2)ab	21 (2)a
Rm	0	29 (1)c	1.30 (0.09)ab	47.87 (0.09)b	37 (3)a
	159	51.0 (0.2)ab	1.24 (0.05)b	45.7 (0.1)c	37 (2)a
	279	49 (1)b	1.45 (0.08)ab	47.2 (0.1)b	33 (2)a
	367	50.9 (0.5)ab	1.8 (0.1)a	49.1 (0.3)a	28 (2)a
	524	54 (1)a	1.7 (0.2)ab	47.88 (0.06)b	29 (3)a
Bb/Ra	0	29.1 (0.1)c	2.02 (0.06)c	45.91 (0.05)b	22.8 (0.7)a
	159	36.6 (0.8)b	2.5 (0.2)bc	44.0 (0.2)c	18 (1)b
	279	40.5 (0.5)ab	3.1 (0.2)ab	46.4 (0.1)b	15.0 (0.9)bc
	367	35.8 (0.6)b	3.0 (0.2)ab	47.4 (0.3)a	16 (1)bc
	524	44 (2)a	3.7 (0.2)a	46.4 (0.1)b	12.8 (0.6)c
		Ca (mg g^{-1}) x̄ (SE)	Mg (mg g^{-1}) x̄ (SE)	K (mg g^{-1}) x̄ (SE)	P (mg g^{-1}) x̄ (SE)
WS	0	1.89 (0.06)c	0.485 (0.003)a	2.78 (0.02)a	1.21 (0.01)a
	159	2.20 (0.07)b	0.47 (0.01)a	0.8 (0.2)b	1.00 (0.03)b
	279	2.46 (0.06)ab	0.48 (0.01)a	0.7 (0.2)b	0.967 (0.009)bc
	367	2.52 (0.07)a	0.52 (0.03)a	0.51 (0.05)b	0.914 (0.004)cd
	524	2.47 (0.08)ab	0.49 (0.05)a	0.5 (0.1)b	0.83 (0.02)d
Go	0	6.1 (0.5)a	2.2 (0.2)a	12.5 (0.9)a	1.4 (0.1)a
	159	8 (1)a	1.8 (0.1)a	0.93 (0.09)b	1.05 (0.09)a
	279	10 (2)a	2.1 (0.2)a	0.64 (0.07)b	1.1 (0.1)a
	367	10 (2)a	1.7 (0.2)a	0.8 (0.1)b	1.1 (0.1)a
	524	10 (1)a	1.8 (0.2)a	0.9 (0.2)b	1.00 (0.05)a
Rm	0	5 (1)b	1.5 (0.2)a	3.8 (0.2)a	0.84 (0.04)a
	159	6.0 (0.2)ab	0.97 (0.01)b	0.9 (0.1)b	0.77 (0.03)a
	279	6.2 (0.4)ab	0.8 (0.1)b	0.5 (0.1)b	0.86 (0.04)a
	367	6.7 (0.5)ab	0.9 (0.1)b	0.79 (0.08)b	0.89 (0.04)a
	524	7.7 (0.1)a	1.0 (0.1)ab	0.4 (0.2)b	1.0 (0.1)a
Bb/Ra	0	6.2 (0.1)a	2.54 (0.03)a	7.30 (0.03)a	1.26 (0.02)a
	159	5.9 (0.2)a	1.33 (0.07)b	0.71 (0.08)b	1.3 (0.1)a
	279	6.3 (0.5)a	1.5 (0.1)b	0.53 (0.05)b	1.42 (0.07)a
	367	6.6 (0.4)a	1.3 (0.2)b	0.60 (0.05)b	1.4 (0.1)a
	524	7.5 (0.9)a	1.4 (0.1)b	0.65 (0.08)b	1.6 (0.1)a

		SO_4^{2-} (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)c	0.062 (0.005)b	0.817 (0.004)a	0.0190 (4E-4)b
	159	2.30 (0.02)b	0.096 (0.005)a	0.80 (0.02)a	0.0222 (5E-4)ab
	279	2.31 (0.05)b	0.10 (0.01)a	0.82 (0.02)a	0.028 (0.003)a
	367	2.66 (0.03)a	0.061 (0.002)b	0.82 (0.03)a	0.029 (0.002)a
	524	2.44 (0.04)b	0.072 (0.004)ab	0.74 (0.08)a	0.027 (0.002)a
Go	0	2.6 (0.3)b	0.064 (0.004)a	0.96 (0.08)b	0.074 (0.004)c
	159	3.4 (0.3)ab	0.109 (0.006)a	1.23 (0.06)ab	0.132 (0.006)b
	279	4.0 (0.6)ab	0.12 (0.02)a	1.7 (0.1)a	0.19 (0.01)a
	367	4.1 (0.5)ab	0.17 (0.06)a	1.7 (0.2)a	0.18 (0.02)a
	524	4.5 (0.3)a	0.18 (0.02)a	1.8 (0.2)a	0.199 (0.007)a
Rm	0	2.22 (0.08)b	0.056 (0.004)a	1.03 (0.05)a	0.023 (0.002)c
	159	2.26 (0.09)b	0.23 (0.03)a	0.9 (0.09)a	0.039 (0.004)bc
	279	2.6 (0.1)b	0.2 (0.1)a	0.83 (0.04)a	0.036 (0.002)bc
	367	2.7 (0.2)b	0.3 (0.1)a	0.93 (0.02)a	0.057 (0.006)ab
	524	3.3 (0.2)a	0.21 (0.04)a	0.95 (0.09)a	0.08 (0.01)a
Bb/Ra	0	2.66 (0.06)d	0.31 (0.05)a	2.66 (0.09)ab	0.024 (0.001)c
	159	3.3 (0.4)cd	0.8 (0.4)a	2.1 (0.2)b	0.035 (0.005)bc
	279	4.5 (0.3)bc	0.16 (0.01)a	2.6 (0.1)ab	0.045 (0.002)ab
	367	4.6 (0.3)b	0.3 (0.1)a	2.3 (0.2)ab	0.037 (0.003)bc
	524	5.9 (0.3)a	0.030 (0.06)a	3.0 (0.3)a	0.058 (0.005)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)b	-	-	19.2 (0.5)a
	159	0.128 (0.003)ab	-	-	2.4 (0.3)c
	279	0.142 (0.008)a	-	-	18 (3) a
	367	0.134 (0.002)ab	-	-	13 (2)b
	524	0.1348 (9E-4)ab	-	-	13.2 (0.9)b
Go	0	-	0.035 (0.002)a	0.0097 (8E-4)b	30 (2)a
	159	-	0.0177 (6E-4)b	0.0137 (8E-4)ab	18 (1)b
	279	-	0.019 (0.003)b	0.019 (0.002)a	7 (2)c
	367	-	0.0136 (9E-4)b	0.016 (0.002)ab	11 (2)bc
	524	-	0.013 (0.002)b	0.017 (0.001)a	10 (1)c
Rm	0	-	-	0.0065 (5E-4)a	55 (2)a
	159	-	-	0.0087 (2E-4)a	9.4 (0.5)c
	279	-	-	0.0075 (3E-4)a	5.3 (0.4)c
	367	-	-	0.04 (0.02)a	14.7 (0.2)b
	524	-	-	0.04 (0.02)a	5.5 (0.6)c
Bb/Ra	0	0.071 (0.006)b	0.035 (0.001)a	0.0067 (5E-4)a	36 (1)a
	159	0.09 (0.01)ab	0.019 (0.002)b	0.009 (0.002)a	25 (1)b
	279	0.11 (0.01)ab	0.020 (0.002)b	0.0080 (4E-4)a	11.2 (0.9)c
	367	0.15 (0.05)ab	0.016 (0.003)b	0.0015 (7E-4)a	15 (1)c
	524	0.20 (0.04)a	0.013 (0.001)b	0.0077 (5E-4)a	16 (3)c

Site 3

Table C5. Mean (SE) compositional values obtained for litter types monitored at site 3 over each sampling period.

Litter Type	Days in Field	KL (%) x̄ (SE)	N (%) x̄ (SE)	C (%) x̄ (SE)	C/N x̄ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)c	50.12 (0.06)a	41 (1)a
	153	56 (2)a	1.227 (0.008)c	41 (5)a	33 (4)a
	273	46 (1)bc	1.38 (0.03)b	50.26 (0.06)a	36.4 (0.8)a
	361	51 (2)b	1.48 (0.01)a	50.4 (0.3)a	34.1 (0.1)a
	518	49 (1)b	1.47 (0.02)ab	50.20 (0.03)a	34.3 (0.5)a
Sc	0	36.3 (0.4)b	0.73 (0.03)b	45.4 (0.1)ab	62 (2)a
	153	41 (1)ab	0.88 (0.07)ab	43.2 (0.4)c	50 (3)ab
	273	46 (3)a	1.1 (0.1)a	46.2 (0.6)ab	43 (5)b
	361	40 (2)ab	1.2 (0.1)a	46.8 (0.6)a	39 (3)b
	518	37.9 (0.7)b	0.97 (0.02)ab	44.4 (0.1)bc	45.6 (0.9)b
Br	0	44.5 (0.2)a	2.0 (0.1)b	45.60 (0.01)ab	23 (1)a
	153	49.1 (0.5)a	2.27 (0.06)b	44.11 (0.08)c	19.5 (0.5)ab
	273	53 (2)a	2.3 (0.2)b	45.49 (0.08)b	20 (2)a
	361	46 (3)a	2.7 (0.1)ab	46.6 (0.3)a	17.2 (0.8)ab
	518	49 (3)a	3.3 (0.2)a	45.3 (0.4)b	14 (1)b
Bf	0	47.4 (0.5)c	1.15 (0.02)a	50.8 (0.1)bc	44.2 (0.7)a
	153	51.4 (0.3)ab	1.07 (0.04)a	50.3 (0.2)c	47 (1)a
	273	50.8 (0.7)b	1.10 (0.06)a	49.4 (0.2)d	45 (2)a
	361	54 (1)a	1.3 (0.2)a	52.3 (0.3)a	43 (4)a
	518	52.8 (0.4)ab	1.21 (0.05)a	51.5 (0.2)ab	43 (2)a

		Ca (mg g^{-1}) x̄ (SE)	Mg (mg g^{-1}) x̄ (SE)	K (mg g^{-1}) x̄ (SE)	P (mg g^{-1}) x̄ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)bc	2.78 (0.02)a	1.21 (0.01)a
	153	2.20 (0.05)b	0.47 (0.01)c	1.2 (0.1)b	1.03 (0.02)b
	273	2.58 (0.09)a	0.542 (0.003)ab	0.9 (0.2)bc	1.00 (0.03)b
	361	2.74 (0.05)a	0.56 (0.02)a	0.8 (0.1)bc	1.01 (0.01)b
	518	2.59 (0.04)a	0.52 (0.02)abc	0.6 (0.1)c	0.86 (0.04)c
Sc	0	1.96 (0.09)b	0.75 (0.03)a	3.5 (0.2)a	0.64 (0.01)a
	153	2.7 (0.8)ab	0.79 (0.06)a	1.04 (0.07)b	0.64 (0.02)a
	273	3.49 (0.09)a	1.1 (0.2)a	1.1 (0.2)b	0.72 (0.05)a
	361	3.7 (0.6)a	1.0 (0.2)a	1.1 (0.3)b	0.78 (0.09)a
	518	3.5 (0.1)a	0.93 (0.07)a	0.74 (0.06)b	0.637 (0.008)a
Br	0	3.3 (0.2)b	1.73 (0.09)a	12.7 (0.1)a	1.49 (0.06)a
	153	4.3 (0.1)ab	1.94 (0.07)a	2.0 (0.6)b	1.17 (0.05)ab
	273	3.9 (0.3)ab	1.7 (0.1)a	0.9 (0.2)b	1.07 (0.07)b
	361	4.5 (0.3)ab	1.5 (0.2)a	1.0 (0.1)b	1.26 (0.05)ab
	518	4.9 (0.4)a	1.5 (0.3)a	0.81 (0.06)b	1.5 (0.1)a
Bf	0	6.3 (0.3)a	0.62 (0.02)a	3.6 (0.2)a	0.93 (0.03)a
	153	5.1 (0.1)a	0.38 (0.02)b	0.75 (0.04)b	0.71 (0.01)b
	273	4.9 (0.4)a	0.38 (0.02)b	1.0 (0.2)b	0.729 (0.007)b
	361	5.6 (0.8)a	0.36 (0.05)b	0.65 (0.04)b	0.72 (0.09)b
	518	4.7 (0.6)a	0.35 (0.02)b	0.54 (0.06)b	0.66 (0.03)b

		SO$_4^{2-}$ (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})
		$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
WS	0	1.98 (0.01)d	0.062 (0.005)a	0.817 (0.004)b	0.0190 (4E-4)b
	153	2.31 (0.02)c	0.070 (0.006)a	0.82 (0.03)b	0.0217 (8E-4)ab
	273	2.36 (0.04)c	0.081 (0.007)a	0.88 (0.03)ab	0.0242 (9E-4)ab
	361	2.78 (0.07)a	0.067 (0.003)a	0.92 (0.01)a	0.027 (0.002)a
	518	2.57 (0.03)b	0.069 (0.004)a	0.84 (0.02)ab	0.0232 (5E-4)ab
Sc	0	1.64 (0.07)ab	0.21 (0.04)b	0.34 (0.02)b	0.0240 (9E-4)c
	153	2.0 (0.1)ab	0.35 (0.02)ab	0.44 (0.06)ab	0.0389 (8E-4)bc
	273	2.3 (0.4)a	0.5 (0.1)a	0.74 (0.08)a	0.068 (0.004)a
	361	1.2 (0.2)b	0.26(0.05)ab	0.7 (0.1)a	0.050 (0.008)ab
	518	2.12 (0.06)ab	0.27 (0.02)ab	0.72 (0.07)a	0.050 (0.006)ab
Br	0	2.9 (0.2)b	0.068 (0.003)c	0.69 (0.03)b	0.016 (0.001)b
	153	4.0 (0.1)b	0.14 (0.01)abc	0.78 (0.02)ab	0.022 (0.001)b
	273	3.1 (0.4)b	0.11 (0.01)bc	0.83 (0.02)ab	0.033 (0.002)a
	361	3.3 (0.2)b	0.15 (0.02)ab	1.1 (0.2)ab	0.041 (0.004)a
	518	5.5 (0.3)a	0.19 (0.03)a	1.2 (0.1)a	0.043 (0.003)a
Bf	0	2.05 (0.07)a	0.066 (0.004)a	1.4 (0.2)b	0.035 (0.001)b
	153	2.03 (0.05)a	0.085 (0.009)a	2.5 (0.1)a	0.035 (0.002)b
	273	2.1 (0.1)a	0.059 (0.002)a	2.4 (0.1)a	0.032 (0.001)b
	361	2.2 (0.3)a	0.080 (0.008)a	2.6 (0.2)a	0.050 (0.005)a
	518	2.29 (0.08)a	0.009 (0.005)a	2.4 (0.2)a	0.037 (0.004)ab

		Al (mg g^{-1})	B (mg g^{-1})	Cu (mg g^{-1})	ASL (%)
		$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
WS	0	0.119 (0.002)b	-	-	19.2 (0.5)a
	153	0.121 (0.004)b	-	-	2.8 (0.2)c
	273	0.140 (0.003)a	-	-	19 (2)a
	361	0.142 (0.006)a	-	-	13.7 (0.4)b
	518	0.140 (0.003)a	-	-	12.9 (0.4)b
Sc	0	0.17 (0.02)b	-	-	8.4 (0.1)b
	153	0.26 (0.02)ab	-	-	12.5 (0.4)a
	273	0.4 (0.2)a	-	-	2.8 (0.2)d
	361	0.28 (0.07)ab	-	-	5.2 (0.3)c
	518	0.28 (0.02)ab	-	-	5.1 (0.2)c
Br	0	-	-	-	13.2 (0.9)a
	153	0.0518 (8E-4)b	-	0.0065 (3E-4)a	11.9 (0.1)a
	273	0.069 (0.006)b	-	0.0075 (5E-4)a	6 (2)b
	361	0.10 (0.02)ab	-	0.0077 (5E-4)a	8 (1)ab
	518	0.14 (0.02)a	-	0.0062 (3E-4)a	8 (1)ab
Bf	0	0.22 (0.01)a	-	-	12.7 (0.7)a
	153	0.177 (0.005)a	-	-	6.7 (0.6)b
	273	0.18 (0.01)a	-	-	13.9 (0.3)a
	361	0.20 (0.02)a	-	-	5.4 (0.4)b
	518	0.198 (0.008)a	-	-	5.2 (0.2)b

Site 4

Table C6. Mean (SE) compositional values obtained for litter types monitored at site 4 over each sampling period.

Litter Type	Days in Field	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)b	50.12 (0.06)a	41 (1)a
	159	56.3 (0.5)a	1.46 (0.05)a	40 (6)a	28 (5)b
	279	49 (1)b	1.38 (0.03)ab	50.43 (0.03)a	36.5 (0.7)ab
	366	50.7 (0.5)b	1.47 (0.03)a	50.27 (0.07)a	34.2 (0.7)ab
	524	47.7 (0.8)b	1.48 (0.02)a	50.14 (0.03)a	33.9 (0.4)ab
Go	0	32.8 (0.6)b	1.6 (0.2)a	46.6 (0.1)a	30 (4)a
	159	42 (1)a	1.7 (0.1)a	44.4 (0.2)b	26 (2)a
	279	46 (1)a	1.7 (0.1)a	46.7 (0.3)a	29 (2)a
	366	42 (1)a	2.10 (0.08)a	46.93 (0.03)a	22.5 (0.9)a
	524	45 (1)a	2.0 (0.1)a	46.2 (0.2)a	24 (2)a
Rm	0	29 (1)b	1.30 (0.09)b	47.87 (0.09)a	37 (3)a
	159	53.8 (0.6)a	1.4 (0.1)b	46.2 (0.2)b	33 (3)ab
	279	51 (1)a	1.39 (0.01)b	46.8 (0.2)b	33.7 (0.4)ab
	366	51 (1)a	1.52 (0.07)ab	48.5 (0.3)a	32 (2)ab
	524	54 (1)a	1.83 (0.06)a	48.5 (0.2)a	26.6 (0.8)b
Bb/Ra	0	29.1 (0.1)c	2.02 (0.06)b	45.91 (0.05)b	22.8 (0.7)a
	159	36.2 (0.5)b	2.49 (0.06)b	44.2 (0.5)c	17.7 (0.3)b
	279	40.6 (0.9)a	3.3 (0.1)a	46.1 (0.2)b	14.1 (0.5)c
	366	39 (1)ab	3.3 (0.2)a	47.3 (0.2)a	14.6 (0.7)c
	524	37.8 (0.4)ab	3.4 (0.2)a	46.2 (0.1)ab	14 (1)c
		Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.89 (0.03)b	0.485 (0.003)ab	2.78 (0.02)a	1.21 (0.01)a
	159	2.15 (0.04)b	0.46 (0.01)b	1.0 (0.2)b	0.98 (0.02)b
	279	2.47 (0.04)a	0.50 (0.01)ab	0.8 (0.2)bc	0.97 (0.02)bc
	366	2.6 (0.1)a	0.54 (0.03)a	0.9 (0.2)bc	0.97 (0.06)bc
	524	2.5 (0.1)a	0.44 (0.03)b	0.27 (0.06)c	0.81 (0.01)c
Go	0	6.1 (0.5)b	2.2 (0.2)a	12.5 (0.9)a	1.4 (0.1)a
	159	9.7 (0.3)a	2.1 (0.1)a	1.3 (0.4)b	1.0 (0.1)b
	279	9.1 (0.5)ab	1.97 (0.09)a	0.76 (0.08)b	0.96 (0.09)b
	366	11 (1)a	1.9 (0.2)ab	0.8 (0.1)b	1.03 (0.02)b
	524	8.9 (0.7)ab	1.2 (0.1)b	0.8 (0.2)b	0.99 (0.04)b
Rm	0	5.2 (0.5)b	1.5 (0.2)a	3.8 (0.2)a	0.84 (0.04)a
	159	5.5 (0.4)b	0.87 (0.06)bc	0.74 (0.09)b	0.89 (0.03)a
	279	7.8 (0.4)a	1.22 (0.04)ab	1.1 (0.3)b	0.98 (0.03)a
	366	8.2 (0.3)a	1.12 (0.09)abc	0.3 (0.1)b	0.90 (0.06)a
	524	6.6 (0.3)ab	0.74 (0.08)c	1.2 (0.3)b	0.95 (0.05)a
Bb/Ra	0	6.2 (0.1)a	2.54 (0.03)a	7.30 (0.03)a	1.26 (0.02)b
	159	5.9 (0.3)a	1.5 (0.1)b	0.9 (0.1)bc	1.31 (0.01)b
	279	7.6 (0.2)a	1.4 (0.1)b	1.1 (0.1)b	1.75 (0.04)a
	366	6.5 (0.4)a	1.8 (0.1)b	0.72 (0.07)bc	1.55 (0.07)ab
	524	7.2 (0.8)a	1.3 (0.2)b	0.6 (0.1)c	1.5 (0.1)ab

		SO$_4^{2-}$ (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)c	0.062 (0.005)a	0.817 (0.004)ab	0.0190 (4E-4)c
	159	2.29 (0.04)b	0.075 (0.007)a	0.75 (0.02)b	0.0212 (6E-4)bc
	279	2.36 (0.08)b	0.071 (0.006)a	0.83 (0.01)ab	0.0240 (4E-4)ab
	366	2.72 (0.09)a	0.09 (0.02)a	0.86 (0.04)a	0.025974 (5E-6)a
	524	2.55 (0.06)ab	0.072 (0.004)a	0.92 (0.05)b	0.025 (0.003)ab
Go	0	2.6 (0.3)c	0.064 (0.004)c	0.96 (0.08)c	0.074 (0.004)c
	159	3.3 (0.2)abc	0.13 (0.03)b	1.2 (0.1)bc	0.150 (0.004)b
	279	3.2 (0.3)bc	0.104 (0.008)bc	1.2 (0.1)bc	0.18 (0.01)ab
	366	4.2 (0.2)ab	0.14 (0.01)b	1.68 (0.05)ab	0.197 (0.009)a
	524	4.3 (0.3)a	0.22 (0.01)a	1.8 (0.2)a	0.20 (0.01)a
Rm	0	2.22 (0.08)c	0.056 (0.004)b	1.03 (0.05)ab	0.023 (0.002)c
	159	2.6 (0.1)bc	0.19 (0.02)a	0.87 (0.05)b	0.030 (0.001)bc
	279	2.89 (0.05)ab	0.13 (0.01)ab	1.5 (0.2)a	0.042 (0.005)ab
	366	2.7 (0.2)bc	0.13 (0.02)ab	1.06 (0.08)ab	0.048 (0.006)a
	524	3.3 (0.1)a	0.16 (0.02)a	1.0 (0.1)ab	0.048 (0.002)a
Bb/Ra	0	2.66 (0.06)c	0.31 (0.05)a	2.66 (0.09)ab	0.024 (0.001)b
	159	3.83 (0.07)b	0.4 (0.1)a	2.2 (0.1)b	0.031 (0.001)b
	279	4.9 (0.2)ab	0.23 (0.02)a	3.0 (0.2)ab	0.07 (0.01)a
	366	5.2 (0.2)a	0.17 (0.01)a	2.7 (0.2)ab	0.040 (0.003)b
	524	5.7 (0.5)a	0.08 (0.04)a	3.3 (0.4)a	0.053 (0.008)ab

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)b	-	-	19.2 (0.5)a
	159	0.123 (0.004)ab	-	-	2.7 (0.1)c
	279	0.134 (0.003)ab	-	-	16.0 (0.7)b
	366	0.15 (0.01)a	-	-	14.3 (0.5)b
	524	0.137 (0.003)ab	-	-	13.9 (0.4)b
Go	0	-	0.035 (0.002)a	0.0097 (8E-4)b	30 (2)a
	159	-	0.021 (0.001)b	0.0142 (5E-4)a	18.9 (0.7)b
	279	-	0.017 (0.001)bc	0.0149 (6E-4)a	6.4 (0.8)c
	366	-	0.017 (0.001)bc	0.015 (0.001)a	10.7 (0.5)c
	524	-	0.0127 (5E-4)c	0.015 (0.001)a	8.8 (0.4)c
Rm	0	-	-	0.0065 (5E-4)b	66 (2)a
	159	-	-	0.011 (0.001)a	9.2 (0.3)c
	279	-	-	0.0102 (8E-4)a	6.7 (0.3)c
	366	-	-	0.0089 (7E-4)ab	16.4 (0.7)b
	524	-	-	0.0085 (5E-4)ab	6.0 (0.6)c
Bb/Ra	0	0.071 (0.006)b	0.035 (0.001)a	0.0067 (5E-4)b	36 (1)a
	159	0.102 (0.009)b	0.020 (0.002)b	0.0072 (5E-4)ab	24 (1)b
	279	0.123 (0.007)ab	0.019 (0.001)b	0.00896 (1E-5)a	11.9 (0.7)c
	366	0.13 (0.01)ab	0.019 (0.002)b	0.0079 (6E-4)ab	15 (1)b
	524	0.18 (0.03)a	0.012 (0.001)b	0.0080 (4E-4)ab	24 (2)b

Site 5

Table C7. Mean (SE) compositional values obtained for litter types monitored at site 5 over each sampling period.

Litter Type	Days in Field	KL (%) x̄ (SE)	N (%) x̄ (SE)	C (%) x̄ (SE)	C/N x̄ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)b	50.12 (0.06)a	41 (1)a
	147	56.2 (0.6)a	1.27 (0.03)b	48.69 (0.09)b	38.2 (0.7)a
	269	46.8 (0.6)bc	1.54 (0.06)a	48.9 (0.5)b	32 (1)b
	357	51.1 (0.5)ab	1.48 (0.02)a	50.13 (0.09)a	34.0 (0.4)b
	516	48 (4)b	1.59 (0.03)a	49.7 (0.4)ab	31.3 (0.8)b
Sc	0	36.3 (0.4)b	0.73 (0.03)b	45.4 (0.1)ab	62 (3)a
	147	40 (1)ab	0.97 (0.06)ab	43.6 (0.5)c	45 (2)b
	269	45 (2)a	1.2 (0.1)a	46.5 (0.4)a	41 (4)b
	357	39 (2)ab	1.1 (0.1)ab	46.5 (0.4)a	44 (4)b
	516	40 (2)ab	1.08 (0.04)a	44.7 (0.4)bc	41 (1)b
Br	0	44.5 (0.2)c	2.0 (0.1)a	45.60 (0.01)b	23 (1)a
	147	46.2 (0.7)bc	1.91 (0.07)a	44.2 (0.1)c	23.1 (0.7)a
	269	53 (1)a	2.1 (0.2)a	45.91 (0.07)b	22 (3)a
	357	49 (1)ab	2.24 (0.06)a	46.97 (0.07)a	21.0 (0.6)a
	516	49 (1)ab	2.0 (0.2)a	45.6 (0.1)b	23 (2)a
Bf	0	47.4 (0.5)b	1.15 (0.02)a	50.8 (0.1)b	44.2 (0.7)a
	147	50.7 (0.6)ab	1.04 (0.06)a	49.9 (0.2)c	48 (2)a
	269	50.5 (0.7)ab	1.11 (0.04)a	49.4 (0.1)c	45 (2)a
	357	53.2 (0.9)a	1.4 (0.1)a	51.7 (0.2)a	39 (3)a
	516	51 (1)a	1.3 (0.2)a	51.4 (0.1)ab	42 (5)a
		Ca (mg g^{-1}) x̄ (SE)	Mg (mg g^{-1}) x̄ (SE)	K (mg g^{-1}) x̄ (SE)	P (mg g^{-1}) x̄ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)b	2.78 (0.02)a	1.21 (0.01)a
	147	2.38 (0.05)b	0.493 (0.005)b	1.7 (0.1)b	1.02 (0.02)b
	269	2.92 (0.03)a	0.570 (0.008)a	1.03 (0.05)d	1.00 (0.01)b
	357	3.1 (0.2)a	0.57 (0.03)a	1.35 (0.04)c	1.00 (0.01)b
	516	3.22 (0.09)a	0.60 (0.02)a	0.82 (0.06)d	0.95 (0.03)b
Sc	0	1.96 (0.09)b	0.75 (0.03)ab	3.5 (0.2)a	0.64 (0.01)b
	147	3.2 (0.2)b	0.92 (0.05)a	1.2 (0.1)b	0.73 (0.03)ab
	269	3.7 (0.1)ab	0.97 (0.09)a	1.1 (0.1)b	0.84 (0.04)a
	357	2.4 (0.1)b	0.49 (0.04)b	0.78 (0.07)b	0.46 (0.03)c
	516	5.2 (0.8)a	0.91 (0.05)a	0.85 (0.08)b	0.70 (0.02)b
Br	0	3.3 (0.2)a	1.73 (0.09)a	12.7 (0.1)a	1.49 (0.06)a
	147	2.54 (0.06)a	1.33 (0.07)ab	0.9 (0.2)b	0.91 (0.02)b
	269	4.1 (0.3)a	1.4 (0.1)ab	1.6 (0.5)b	0.99 (0.07)b
	357	4.4 (0.2)a	1.48 (0.09)ab	1.06 (0.09)b	1.02 (0.02)b
	516	4.3 (0.3)a	1.1 (0.1)b	0.70 (0.08)b	0.94 (0.06)b
Bf	0	6.3 (0.3)a	0.62 (0.02)a	3.6 (0.2)a	0.93 (0.03)a
	147	5.6 (0.2)a	0.38 (0.02)b	0.82 (0.08)b	0.72 (0.03)a
	269	5.1 (0.9)a	0.40 (0.01)b	0.86 (0.05)b	0.68 (0.04)a
	357	6.4 (0.6)a	0.39 (0.01)b	0.83 (0.07)b	0.78 (0.07)a
	516	6 (1)a	0.37 (0.04)b	0.6 (0.1)b	0.7 (0.1)a

		SO_4^{2-} (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})
		$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
WS	0	1.98 (0.01)d	0.062 (0.005)b	0.817 (0.004)b	0.0190 (0.0004)c
	147	2.27 (0.03)c	0.073 (0.002)b	0.824 (0.004)b	0.0245 (0.0003)b
	269	2.51 (0.02)b	0.072 (0.003)b	0.925 (0.009)a	0.0288 (0.0007)a
	357	2.78 (0.07)a	0.068 (0.002)b	0.88 (0.03)ab	0.032 (0.002)a
	516	2.88 (0.03)a	0.086 (0.002)b	0.89 (0.03)ab	0.0289 (0.004)a
Sc	0	1.64 (0.07)b	0.21 (0.04)bc	0.34 (0.02)c	0.0240 (0.0009)d
	147	2.2 (0.2)ab	0.22 (0.01)a	0.59 (0.07)abc	0.047 (0.004)bc
	269	2.8 (0.2)a	0.30 (0.01)ab	0.72 (0.07)a	0.063 (0.003)ab
	357	0.7 (0.2)c	0.14 (0.01)c	0.37 (0.04)bc	0.033 (0.002)cd
	516	2.50 (0.09)a	0.37 (0.03)a	0.64 (0.08)ab	0.07 (0.01)a
Br	0	2.9 (0.2)a	0.068 (0.003)c	0.69 (0.03)a	0.016 (0.001)a
	147	3.27 (0.09)a	0.10 (0.01)bc	0.57 (0.02)a	0.024 (0.002)a
	269	2.9 (0.4)a	0.10 (0.01)bc	0.64 (0.04)a	0.033 (0.007)a
	357	2.6 (0.1)a	0.116 (0.001)b	0.70 (0.03)a	0.034 (0.005)a
	516	3.5 (0.3)a	0.18 (0.01)a	0.68 (0.07)a	0.035 (0.005)a
Bf	0	2.05 (0.07)a	0.066 (0.004)b	1.4 (0.2)b	0.035 (0.001)b
	147	2.2 (0.1)a	0.082 (0.004)ab	2.8 (0.1)a	0.035 (0.001)b
	269	2.1 (0.1)a	0.064 (0.002)b	2.6 (0.2)a	0.0380 (8E-4)b
	357	2.4 (0.2)a	0.088 (0.009)ab	2.6 (0.2)a	0.047 (0.003)a
	516	2.6 (0.4)a	0.104 (0.006)a	2.4 (0.4)a	0.041 (0.003)ab

		Al (mg g^{-1})	B (mg g^{-1})	Cu (mg g^{-1})	ASL (%)
		$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
WS	0	0.119 (0.002)c	-	-	19.2 (0.5)a
	147	0.130 (0.003)bc	-	-	3.4 (0.1)c
	269	0.139 (0.002)b	-	-	18.2 (0.5)a
	357	0.131 (0.004)b	-	-	13.5 (0.7)b
	516	0.157 (0.004)a	-	-	13 (1)b
Sc	0	0.17 (0.02)bc	-	-	8.4 (0.1)b
	147	0.22 (0.02)b	-	-	12.8 (0.2)a
	269	0.303 (0.006)a	-	-	3.2 (0.1)d
	357	0.12 (0.01)c	-	-	4.2 (0.2)c
	516	0.34 (0.02)a	-	-	4.6 (0.2)c
Br	0	-	-	-	13.2 (0.9)a
	147	-	-	-	11.11 (0.09)a
	269	-	-	-	3.4 (0.6)c
	357	-	-	-	5.6 (0.4)b
	516	-	-	-	4.8 (0.4)bc
Bf	0	0.22 (0.01)a	-	-	12.7 (0.7)a
	147	0.193 (0.009)a	-	-	6.2 (0.7)b
	269	0.19 (0.01)a	-	-	14.5 (0.4)a
	357	0.20 (0.01)a	-	-	5.5 (0.3)b
	516	0.22 (0.02)a	-	-	6 (1)b

Site 6

Table C8. Mean (SE) compositional values obtained for litter types monitored at site 6 over each sampling period.

Litter Type	Days in Field	KL (%) x̄ (SE)	N (%) x̄ (SE)	C (%) x̄ (SE)	C/N x̄ (SE)
WS	0	41.5 (0.5)b	1.24 (0.03)c	50.12 (0.06)a	41 (1)a
	159	56.9 (0.5)a	1.29 (0.01)c	48.70 (0.04)b	37.6 (0.5)b
	279	46.7 (0.3)b	1.45 (0.02)b	48.73 (0.07)b	33.6 (0.3)c
	367	49 (2)b	1.58 (0.02)a	50.0 (0.2)a	31.6 (0.4)cd
	524	45 (4)b	1.51 (0.01)a	48.2 (0.3)b	30.0 (0.4)d
Go	0	32.8 (0.6)c	1.6 (0.2)a	46.6 (0.1)a	30 (4)a
	159	42.2 (0.7)b	2.1 (0.1)a	44.8 (0.4)b	22 (1)a
	279	47.0 (0.7)ab	2.4 (0.1)a	47.3 (0.2)a	20 (1)a
	367	41 (0.5)b	2.1 (0.3)a	47.0 (0.3)a	24 (5)a
	524	51 (3)a	2.3 (0.1)a	46.25 (0.02)a	29 (1)a
Rm	0	29 (1)b	1.30 (0.09)ab	47.87 (0.09)b	37 (3)a
	159	50 (1)a	1.10 (0.06)b	45.8 (0.2)d	42 (3)a
	279	48 (1)a	1.4 (0.2)ab	46.5 (0.1)c	35 (3)a
	367	49 (2)a	1.5 (0.1)ab	48.6 (0.2)a	32 (3)a
	524	53.4 (0.8)a	1.6 (0.1)a	47.90 (0.03)ab	30 (2)a
Bb/Ra	0	29.1 (0.1)c	2.02 (0.06)b	45.91 (0.05)a	22.8 (0.7)a
	159	47.5 (0.5)a	2.53 (0.08)b	44.7 (0.4)b	17.7 (0.6)b
	279	38.4 (0.8)b	3.3 (0.2)a	46.40 (0.03)a	14 (1)c
	367	39.6 (0.9)b	3.3 (0.1)a	46.59 (0.05)a	14.2 (0.6)c
	524	41 (1)b	3.2 (0.2)a	46.7 (0.3)a	14.6 (0.6)bc
		Ca (mg g^{-1}) x̄ (SE)	Mg (mg g^{-1}) x̄ (SE)	K (mg g^{-1}) x̄ (SE)	P (mg g^{-1}) x̄ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)c	2.79 (0.02)a	1.21 (0.01)a
	159	2.26 (0.05)b	0.49 (0.01)c	1.34 (0.04)b	1.02 (0.02)b
	279	2.66 (0.07)a	0.56 (0.01)b	1.01 (0.07)cd	1.03 (0.03)b
	367	2.93 (0.09)a	0.604 (0.006)ab	1.11 (0.06)bc	1.04 (0.01)b
	524	2.84 (0.07)a	0.61 (0.02)a	0.83 (0.07)d	0.94 (0.03)b
Go	0	6.1 (0.5)b	2.2 (0.2)a	12.5 (0.9)a	1.4 (0.1)a
	159	9.8 (0.3)ab	2.2 (0.1)a	1.3 (0.2)b	1.19 (0.08)a
	279	10.8 (0.6)a	2.5 (0.2)a	0.95 (0.05)b	1.24 (0.04)a
	367	9 (2)ab	1.6 (0.4)a	1.1 (0.1)b	1.11 (0.08)a
	524	11.8 (0.5)a	1.8 (0.2)a	0.64 (0.04)b	1.05 (0.05)a
Rm	0	5.2 (0.5)b	1.5 (0.2)a	3.8 (0.2)a	0.84 (0.04)ab
	159	6.3 (0.7)ab	0.98 (0.09)b	0.79 (0.08)cd	0.70 (0.05)b
	279	6.6 (0.1)ab	1.06 (0.02)ab	0.96 (0.06)bc	0.93 (0.08)ab
	367	7.0 (0.4)ab	0.90 (0.09)b	0.4 (0.1)d	0.92 (0.08)ab
	524	7.9 (0.5)a	0.91 (0.09)b	1.3 (0.1)b	1.01 (0.08)a
Bb/Ra	0	6.2 (0.1)b	2.54 (0.03)a	7.30 (0.03)a	1.26 (0.02)b
	159	5.15 (0.03)b	1.76 (0.09)b	2 (1)b	1.27 (0.06)b
	279	7.6 (0.6)ab	1.7 (0.2)b	1.0 (0.1)b	1.7 (0.2)a
	367	9.3 (0.9)a	2.1 (0.3)ab	1.1 (0.1)b	1.8 (0.1)a
	524	9.5 (0.8)a	1.5 (0.2)b	0.97 (0.05)b	1.57 (0.02)ab

		SO_4^{2-} (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)c	0.062 (0.005)a	0.817 (0.004)b	0.0190 (4E-4)c
	159	2.38 (0.04)b	0.073 (0.002)a	0.80 (0.02)b	0.0240 (7E-4)b
	279	2.51 (0.07)b	0.080 (0.005)a	0.90 (0.03)a	0.0257 (9E-4)b
	367	2.97 (0.06)a	0.082 (0.007)a	0.96 (0.02)a	0.0299 (7E-4)a
	524	2.83 (0.04)a	0.081 (0.009)a	0.92 (0.01)a	0.026 (0.001)b
Go	0	2.6 (0.3)a	0.064 (0.004)b	0.96 (0.08)b	0.074 (0.004)b
	159	3.7 (0.4)a	0.11 (0.03)b	1.4 (0.1)ab	0.125 (0.004)ab
	279	4.6 (0.3)a	0.16 (0.02)ab	1.9 (0.1)a	0.18 (0.01)a
	367	3 (1)a	0.15 (0.03)ab	1.4 (0.3)ab	0.15 (0.03)a
	524	5.1 (0.4)a	0.25 (0.03)a	2.2 (0.2)a	0.182 (0.007)a
Rm	0	2.22 (0.08)b	0.056 (0.004)b	1.03 (0.05)a	0.023 (0.002)b
	159	2.2 (0.1)b	0.16 (0.04)a	1.0 (0.1)a	0.036 (0.002)b
	279	2.7 (0.2)b	0.12 (0.02)ab	1.3 (0.2)a	0.036 (0.003)b
	367	2.7 (0.2)ab	0.13 (0.01)ab	1.11 (0.07)a	0.044 (0.005)ab
	524	3.3 (0.2)a	0.18 (0.01)a	1.1 (0.1)a	0.06 (0.01)a
Bb/Ra	0	2.66 (0.06)b	0.31 (0.05)a	2.66 (0.09)bc	0.024 (0.001)c
	159	5 (2)ab	0.30 (0.07)a	2.06 (0.07)c	0.0249 (9E-4)c
	279	5.2 (0.4)ab	0.21 (0.02)a	3.1 (0.3)b	0.048 (0.004)b
	367	6.1 (0.2)a	0.19 (0.05)a	4.6 (0.1)a	0.054 (0.003)b
	524	6.0 (0.3)ab	0.34 (0.04)a	4.8 (0.3)a	0.080 (0.005)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)b	-	-	19.2 (0.5)a
	159	0.119 (0.002)b	-	-	2.9 (0.1)d
	279	0.139 (0.001)ab	-	-	17.9 (0.4)ab
	367	0.159 (0.009)a	-	-	14.6 (0.4)c
	524	0.159 (0.008)a	-	-	15 (1)bc
Go	0	-	0.035 (0.002)a	0.0097 (8E-4)b	30 (2)a
	159	-	0.022 (0.002)b	0.0160 (7E-4)ab	20.3 (0.9)b
	279	-	0.023 (0.002)b	0.018 (0.001)a	11 (1)c
	367	-	0.021 (0.001)b	0.015 (0.003)ab	11 (2)c
	524	-	0.016 (0.001)b	0.0186 (9E-4)a	10.3 (0.2)c
Rm	0	-	0.027 (0.002)a	0.0065 (5E-4)b	66 (2)a
	159	-	0.0137 (8E-4)b	0.013 (0.002)a	14.5 (0.5)bc
	279	-	0.014 (0.001)b	0.0092 (6E-4)ab	16.4 (0.6)b
	367	-	0.013 (0.001)b	0.0095 (3E-4)ab	12 (4)bc
	524	-	-	0.0090 (4E-4)ab	7.6 (0.4)c
Bb/Ra	0	0.071 (0.006)d	0.035 (0.001)a	0.0067 (5E-4)c	36 (1)a
	159	0.09 (0.01)cd	0.021 (0.001)b	0.006982 (6E-6)bc	8.4 (0.3)e
	279	0.14 (0.01)bc	0.021 (0.003)bc	0.0090 (3E-4)ab	24 (1)b
	367	0.176 (0.006)ab	0.016 (0.001)bc	0.0095 (5E-5)a	13.1 (0.6)d
	524	0.22 (0.02)a	0.011 (0.002)c	0.0100 (7E-4)a	20.5 (0.9)c

Site 7

Table C9. Mean (SE) compositional values obtained for litter types monitored at site 7 over each sampling period.

Litter Type	Days in Field	KL (%)	N (%)	C (%)	C/N
		x̄ (SE)	x̄ (SE)	x̄ (SE)	x̄ (SE)
WS	0	41.5 (0.5)d	1.24 (0.03)d	50.12 (0.06)a	41 (1)a
	158	54.7 (0.4)a	1.28 (0.01)cd	48.56 (0.09)c	38.0 (0.3)b
	276	45.1 (0.8)cd	1.34 (0.01)bc	47.6 (0.07)d	35.6 (0.4)bc
	364	48.0 (0.8)bc	1.31 (0.03)ab	50.38 (0.08)a	35.7 (0.7)bc
	523	49 (2)b	1.444 (0.009)a	49.23 (0.05)b	34.1 (0.2)c
Bb/Ra	0	29.1 (0.1)c	2.02 (0.06)c	45.91 (0.05)a	22.8 (0.7)a
	158	46 (1)a	2.42 (0.04)bc	43.8 (0.4)a	18.1 (0.4)b
	276	36.3 (0.9)b	2.7 (0.2)ab	45.9 (0.3)a	17.0 (0.9)b
	364	38 (1)b	3.0 (0.3)ab	46 (1)a	16 (1)b
	523	37 (1)b	3.2 (0.2)a	46.4 (0.1)a	14.5 (0.9)b
Bf	0	47.4 (0.5)c	1.15 (0.02)a	50.8 (0.1)a	44.2 (0.7)a
	158	49 (2)bc	1.14 (0.03)a	49.1 (0.2)bc	43 (1)a
	276	49.5 (0.6)abc	1.07 (0.09)a	48.1 (0.3)c	46 (3)a
	364	53.1 (0.6)a	1.1 (0.1)a	50.6 (0.2)ab	46 (4)a
	523	51.6 (0.6)ab	1.2 (0.1)a	50.4 (0.6)ab	41 (3)a
Bu	0	25.1 (0.3)c	1.29 (0.03)c	42.67 (0.08)a	33.1 (0.7)a
	158	26.4 (0.6)c	1.67 (0.05)b	39.4 (0.2)b	23.7 (0.8)b
	276	26.6 (0.8)c	1.9 (0.1)b	39.7 (0.2)b	21 (1)b
	364	32.0 (0.4)b	2.4 (0.1)a	42.2 (0.5)a	17.3 (0.7)c
	523	36 (1)a	2.71 (0.03)a	42.7 (0.3)a	15.8 (0.2)c

		Ca (mg g^{-1})	Mg (mg g^{-1})	K (mg g^{-1})	P (mg g^{-1})
		x̄ (SE)	x̄ (SE)	x̄ (SE)	x̄ (SE)
WS	0	1.89 (0.03)b	0.485 (0.003)a	2.78 (0.02)a	1.21 (0.01)a
	158	1.90 (0.05)b	0.45 (0.01)a	1.0 (0.1)b	0.97 (0.01)b
	276	2.13 (0.06)ab	0.47 (0.02)a	0.7 (0.2)b	0.93 (0.02)b
	364	2.3 (0.1)a	0.46 (0.03)a	0.5 (0.1)b	0.971 (0.009)b
	523	2.2 (0.1)ab	0.50 (0.04)a	0.8 (0.2)b	0.91 (0.02)b
Bb/Ra	0	6.2 (0.1)a	2.54 (0.03)a	7.30 (0.03)a	1.26 (0.02)a
	158	5.3 (0.3)a	1.5 (0.1)b	0.81 (0.04)b	1.21 (0.01)a
	276	6.0 (0.2)a	1.5 (0.1)b	0.46 (0.06)c	1.20 (0.04)a
	364	6 (1)a	1.5 (0.1)b	0.7 (0.1)bc	1.3 (0.2)a
	523	5.9 (0.3)a	1.3 (0.1)b	0.62 (0.04)bc	1.47 (0.07)a
Bf	0	6.3 (0.3)a	0.62 (0.02)a	3.6 (0.2)a	0.93 (0.03)a
	158	6.3 (0.3)a	0.60 (0.05)a	1.6 (0.2)b	0.82 (0.03)ab
	276	6.1 (0.4)a	0.61 (0.09)a	1.3 (0.2)b	0.71 (0.04)b
	364	6.6 (0.7)a	0.56 (0.06)a	1.0 (0.1)b	0.68 (0.07)b
	523	6.2 (0.5)a	0.56 (0.06)a	0.8 (0.2)b	0.73 (0.06)ab
Bu	0	17.0 (0.4)c	3.7 (0.1)a	5.9 (0.3)a	0.98 (0.02)c
	158	20.0 (0.7)bc	2.62 (0.07)b	0.9 (0.1)c	0.96 (0.02)c
	276	25 (1)ab	3.11 (0.07)ab	0.93 (0.07)c	1.11 (0.07)bc
	364	31 (2)a	3.3 (0.2)ab	0.4 (0.1)c	1.4 (0.1)ab
	523	30 (2)a	2.6 (0.4)b	1.85 (0.06)b	1.44 (0.06)a

		SO_4^{2-} (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)d	0.062 (0.005)c	0.817 (0.004)a	0.0190 (0.0004)a
	158	2.28 (0.04)c	0.15 (0.02)a	0.73 (0.02)a	0.022 (0.001)a
	276	2.24 (0.02)c	0.077 (0.005)bc	0.78 (0.02)a	0.024 (0.002)a
	364	2.69 (0.03)a	0.11 (0.01)b	0.79 (0.03)a	0.029 (0.003)a
	523	2.54 (0.04)b	0.081 (0.003)bc	0.82 (0.05)a	0.026 (0.004)a
Bb/Ra	0	2.66 (0.06)c	0.31 (0.05)a	2.66 (0.09)a	0.024 (0.001)b
	158	3.57 (0.07)bc	0.44 (0.09)a	2.2 (0.1)a	0.028 (0.002)ab
	276	3.7 (0.2)b	0.8 (0.4)a	2.18 (0.02)a	0.039 (0.005)ab
	364	4.6 (0.5)ab	0.6 (0.4)a	2.5 (0.4)a	0.05 (0.01)ab
	523	5.2 (0.2)a	0.37 (0.04)a	2.2 (0.3)a	0.053 (0.003)a
Bf	0	2.05 (0.07)a	0.066 (0.004)a	1.4 (0.2)a	0.035 (0.001)a
	158	2.19 (0.05)a	0.073 (0.004)a	1.5 (0.4)a	0.038 (0.003)a
	276	2.1 (0.1)a	0.056 (0.004)a	1.3 (0.4)a	0.043 (0.005)a
	364	2.1 (0.2)a	0.09 (0.02)a	1.6 (0.4)a	0.044 (0.005)a
	523	2.4 (0.2)a	0.2 (0.1)a	1.6 (0.6)a	0.046 (0.001)a
Bu	0	5.0 (0.2)a	0.102 (0.009)a	0.35 (0.02)b	0.019 (0.002)b
	158	3.13 (0.04)b	0.41 (0.05)a	0.37 (0.03)b	0.031 (0.003)ab
	276	3.9 (0.2)b	0.18 (0.01)a	0.50 (0.03)b	0.039 (0.004)ab
	364	4.8 (0.3)a	0.8 (0.4)a	0.68 (0.06)ab	0.05 (0.01)ab
	523	5.61 (0.09)a	0.44 (0.06)a	1.1 (0.3)a	0.05 (0.01)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)a	-	-	19.2 (0.5)a
	158	0.16 (0.03)a	-	-	3.7 (0.3)c
	276	0.129 (0.005)a	-	-	21 (1)a
	364	0.167 (0.008)a	-	-	15.6 (0.7)b
	523	0.150 (0.007)a	-	-	13.0 (0.7)b
Bb/Ra	0	0.071 (0.006)a	0.035 (0.001)a	0.0067 (5E-4)a	36 (1)a
	158	0.12 (0.02)a	0.022 (0.001)b	0.0075 (3E-4)a	8.4 (0.3)d
	276	0.3 (0.2)a	0.023 (0.001)b	0.0077 (7E-4)a	26.1 (0.5)b
	364	0.4 (0.3)a	0.018 (0.002)bc	0.0072 (3E-4)a	16 (1)c
	523	0.31 (0.04)a	0.0135 (5E-4)c	0.0072 (3E-4)a	24.3 (0.9)b
Bf	0	0.22 (0.01)a	0.0130 (4E-4)a	-	12.7 (0.7)a
	158	0.236 (0.009)a	0.0113 (3E-4)a	-	5.4 (0.5)b
	276	0.23 (0.02)a	0.011 (0.001)a	-	14.4 (0.4)a
	364	0.24 (0.02)a	0.012 (0.002)a	-	4.6 (0.6)b
	523	0.4 (0.1)a	0.012 (0.001)a	-	4.6 (0.9)b
Bu	0	0.63 (0.03)b	0.043 (0.002)a	-	42 (2)a
	158	0.92 (0.09)b	0.0394 (7E-4)a	-	32.5 (0.6)b
	276	1.02 (0.06)b	0.044 (0.001)a	-	31 (1)b
	364	1.5 (0.3)a	0.048 (0.007)a	-	19 (1)c
	523	1.55 (0.07)a	0.004 (0.006)a	-	15.9 (0.8)c

Site 8

Table C10. Mean (SE) compositional values obtained for litter types monitored at site 8 over each sampling period.

Litter Type	Days in Field	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)b	50.12 (0.06)a	41 (1)a
	153	55 (3)a	1.28 (0.03)ab	48.47 (0.03)c	38.0 (0.8)ab
	273	45 (1)bc	1.29 (0.03)ab	47.65 (0.05)d	37.0 (0.9)ab
	361	49 (1)ab	1.45 (0.07)a	50.4 (0.1)a	35 (2)b
	518	47.3 (0.7)bc	1.40 (0.02)ab	49.32 (0.04)b	35.3 (0.6)b
Gr	0	29.4 (0.6)b	0.77 (0.04)a	45.73 (0.09)a	60 (3)a
	153	35.6 (0.3)a	0.76 (0.03)a	43.54 (0.09)d	58 (2)a
	273	32.7 (0.4)ab	0.79 (0.06)a	44.9 (0.1)bc	58 (4)a
	361	33.8 (0.4)ab	0.90 (0.08)a	45.7 (0.1)ab	52 (4)a
	518	32 (2)ab	0.93 (0.05)a	44.7 (0.3)c	49 (3)a
Rm	0	29 (1)b	1.30 (0.09)a	47.87 (0.09)b	37 (3)a
	153	50 (1)a	1.35 (0.03)a	46.0 (0.1)c	34.2 (0.9)a
	273	52.5 (0.9)a	1.3 (0.2)a	47.1 (0.1)b	39 (8)a
	361	50.4 (0.5)a	1.38 (0.05)a	48.90 (0.08)a	35 (1)a
	518	54 (1)a	1.4 (0.1)a	47.7 (0.3)b	35 (3)a
Wf	0	36.9 (0.5)c	1.74 (0.01)d	44.17 (0.03)c	25.3 (0.1)a
	153	42.3 (0.3)b	2.00 (0.02)cd	42.6 (0.1)d	21.4 (0.3)b
	273	44.8 (0.4)ab	2.13 (0.07)bc	43.02 (0.06)d	20.3 (0.7)bc
	361	45.0 (0.7)ab	2.26 (0.07)ab	45.8 (0.2)a	20.3 (0.6)bc
	518	47 (1)a	2.48 (0.08)a	44.9 (0.2)b	18.2 (0.7)c
		Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)ab	2.78 (0.02)a	1.21 (0.01)a
	153	2.22 (0.06)b	0.38 (0.06)b	0.9 (0.2)b	0.88 (0.02)b
	273	2.62 (0.06)a	0.51 (0.02)a	1.1 (0.2)b	0.96 (0.04)b
	361	2.60 (0.04)a	0.50 (0.03)ab	1.0 (0.2)b	0.96 (0.03)b
	518	2.51 (0.03)a	0.50 (0.01)ab	0.6 (0.2)b	0.86 (0.03)b
Gr	0	0.52 (0.07)a	0.33 (0.06)a	1.1 (0.3)a	0.35 (0.04)a
	153	0.53 (0.04)a	0.26 (0.03)a	0.35 (0.02)b	0.35 (0.02)a
	273	0.7 (0.2)a	0.37 (0.08)a	0.49 (0.03)ab	0.39 (0.04)a
	361	0.6 (0.1)a	0.30 (0.05)a	0.52 (0.01)ab	0.38 (0.04)a
	518	0.7 (0.1)a	0.29 (0.03)a	0.7 (0.2)ab	0.16 (0.08)a
Rm	0	5.2 (0.5)a	1.5 (0.2)a	3.8 (0.2)a	0.84 (0.04)a
	153	5.9 (0.2)a	0.79 (0.08)b	0.9 (0.1)b	0.88 (0.06)a
	273	5.5 (0.5)a	0.84 (0.08)b	0.63 (0.04)bc	0.9 (0.1)a
	361	6.6 (0.1)a	0.85 (0.05)b	0.3 (0.1)c	0.87 (0.05)a
	518	8 (2)a	1.3 (0.2)ab	1.1 (0.1)b	0.82 (0.07)a
Wf	0	3.0 (0.2)a	4.1 (0.2)a	11.2 (0.7)a	2.14 (0.09)a
	153	3.6 (0.1)a	3.68 (0.06)a	1.7 (0.2)b	1.17 (0.02)b
	273	3.8 (0.2)a	4.3 (0.3)a	1.5 (0.4)b	1.28 (0.05)b
	361	4.0 (0.2)a	3.67 (0.08)a	1.0 (0.6)b	1.14 (0.02)b
	518	10 (5)a	3.6 (0.4)a	1.0 (0.1)b	1.32 (0.09)b

		SO_4^{2-} (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)d	0.062 (0.005)a	0.817 (0.004)ab	0.0190 (4E-4)b
	153	2.19 (0.03)cd	0.13 (0.03)a	0.66 (0.07)b	0.023 (0.002)ab
	273	2.30 (0.03)bc	0.09 (0.02)a	0.85 (0.02)a	0.0256 (0.0003)a
	361	1.7 (0.1)a	0.088 (0.007)a	0.89 (0.04)a	0.029 (0.001)a
	518	2.57 (0.05)ab	0.091 (0.009)a	0.85 (0.03)a	0.025 (0.002)a
Gr	0	1.6 (0.1)a	0.127 (0.004)a	0.54 (0.08)a	0.015 (0.001)a
	153	1.77 (0.04)a	0.4 (0.1)a	0.41 (0.04)a	0.030 (0.008)a
	273	1.1 (0.1)b	0.15 (0.03)a	0.6 (0.1)a	0.029 (0.004)a
	361	0.5 (0.1)b	0.20 (0.04)a	0.57 (0.08)a	0.04 (0.01)a
	518	2.1 (0.1)a	0.24 (0.08)a	0.44 (0.08)a	0.04 (0.01)a
Rm	0	2.22 (0.08)b	0.056 (0.004)b	1.03 (0.05)b	0.023 (0.002)b
	153	2.40 (0.05)ab	0.21 (0.04)a	1.2 (0.1)ab	0.044 (0.009)ab
	273	2.6 (0.3)ab	0.14 (0.01)ab	1.13 (0.08)ab	0.038 (0.002)ab
	361	2.35 (0.09)ab	0.128 (0.008)ab	1.3 (0.1)ab	0.045 (0.003)ab
	518	3.0 (0.2)a	0.18 (0.03)a	1.54 (0.06)a	0.051 (0.006)a
Wf	0	3.01 (0.04)b	0.073 (0.005)a	1.52 (0.04)a	0.039 (0.001)b
	153	3.44 (0.06)b	0.5 (0.1)a	1.45 (0.03)a	0.056 (0.006)ab
	273	3.9 (0.1)b	0.22 (0.02)a	2.0 (0.1)a	0.072 (0.006)a
	361	3.6 (0.1)b	0.117 (0.004)a	1.77 (0.09)a	0.062 (0.004)ab
	518	4.9 (0.4)a	0.5 (0.3)a	1.8 (0.3)a	0.071 (0.008)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)a	-	-	19.2 (0.5)ab
	153	0.134 (0.007)a	-	-	5 (1)c
	273	0.16 (0.02)a	-	-	21 (2)a
	361	0.151 (0.006)a	-	-	16 (2)b
	518	0.159 (0.007)a	-	-	9.1 (0.5)c
Gr	0	0.070 (0.002)a	-	-	12.7 (0.2)a
	153	0.11 (0.03)a	-	-	12.50 (0.06)a
	273	0.12 (0.03)a	-	-	14.33 (0.09)a
	361	0.15 (0.03)a	-	-	3.5 (0.1)b
	518	0.18 (0.06)a	-	-	7 (2)b
Rm	0	-	0.027 (0.002)a	0.0065 (5E-4)b	66 (2)a
	153	-	0.015 (0.001)b	0.012 (0.001)a	14.0 (0.3)b
	273	-	0.013 (0.001)b	0.0085 (6E-4)ab	14.4 (0.4)b
	361	-	0.0124 (9E-4)b	0.0084 (6E-4)ab	7.8 (0.3)c
	518	-	0.014 (0.002)b	0.0090 (9E-4)ab	9.2 (0.4)c
Wf	0	0.071 (0.004)a	0.0264 (3E-4)a	-	14.4 (0.6)a
	153	0.12 (0.02)a	0.0271 (4E-4)a	0.0107 (9E-4)a	11.6 (0.2)b
	273	0.097 (0.009)a	0.030 (0.001)a	0.0085 (8E-4)ab	12.2 (0.1)b
	361	0.089 (0.004)a	0.0262 (6E-4)a	0.0075 (3E-4)b	4.6 (0.3)c
	518	0.6 (0.5)a	0.026 (0.002)a	0.0075 (5E-4)b	4.7 (0.4)c

Site 9

Table C11. Mean (SE) compositional values obtained for litter types monitored at site 9 over each sampling period.

	Days in Field	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
WS	0	41.5 (0.5)d	1.24 (0.03)b	50.12 (0.06)b	41 (1)a
	154	45.2 (0.9)c	1.26 (0.03)b	48.3 (0.1)d	38.4 (0.9)ab
	273	45.8 (0.6)bc	1.34 (0.03)ab	47.67 (0.05)e	35.7 (0.8)bc
	361	50.5 (0.9)a	1.42 (0.02)a	50.49 (0.08)a	35.7 (0.6)bc
	520	48.6 (0.8)ab	1.46 (0.03)a	49.46 (0.08)c	34.0 (0.7)c
Bb/Ra	0	29.1 (0.1)c	2.02 (0.06)a	45.91 (0.05)bc	22.8 (0.7)a
	154	46.9 (0.7)a	2.5 (0.1)a	44.9 (0.3)c	18 (1)ab
	273	38 (1)b	2.9 (0.2)a	46.5 (0.2)ab	16.1 (0.9)b
	361	43 (1)ab	3.1 (0.2)a	46.9 (0.2)ab	16 (1)b
	520	43 (2)ab	3.0 (0.4)a	47.2 (0.4)a	17 (3)ab
Bf	0	47.4 (0.5)b	1.15 (0.02)a	50.8 (0.1)a	44.2 (0.7)a
	154	51.4 (0.6)ab	1.21 (0.09)a	49.3 (0.2)a	41 (3)a
	273	51.6 (0.4)ab	1.20 (0.09)a	48.7 (0.3)a	41 (3)a
	361	56 (4)a	1.36 (0.06)a	51.0 (0.2)a	38 (2)a
	520	52.6 (0.5)ab	1.5 (0.1)a	52 (1)a	36 (3)a
Bu	0	25.1 (0.3)d	1.29 (0.03)d	42.67 (0.08)b	33.1 (0.7)a
	154	27.8 (0.6)cd	1.75 (0.09)c	39.9 (0.1)c	23 (1)b
	273	30 (1)c	2.16 (0.04)b	40.0 (0.1)c	18.5 (0.3)c
	361	34.1 (0.9)b	2.65 (0.06)a	43.6 (0.4)a	16.4 (0.3)cd
	520	39.7 (0.9)a	2.83 (0.03)a	43.8 (0.2)a	15.4 (0.2)d
		Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)bc	2.78 (0.02)a	1.21 (0.01)a
	154	2.12 (0.07)c	0.46 (0.01)c	1.5 (0.3)b	0.96 (0.05)b
	273	2.40 (0.07)b	0.49 (0.02)bc	1.0 (0.1)bc	0.91 (0.02)b
	361	2.66 (0.06)a	0.52 (0.02)ab	0.96 (0.04)bc	0.93 (0.01)b
	520	2.78 (0.04)a	0.55 (0.01)a	0.57 (0.04)c	0.93 (0.02)b
Bb/Ra	0	6.2 (0.1)a	2.54 (0.03)a	7.30 (0.03)a	1.26 (0.02)a
	154	5.5 (0.1)a	1.3 (0.1)b	0.92 (0.06)b	1.27 (0.09)a
	273	7.0 (0.4)a	1.6 (0.1)b	0.9 (0.1)b	1.57 (0.08)a
	361	7.4 (0.5)a	1.6 (0.1)b	1.5 (0.5)b	1.3 (0.3)a
	520	7 (1)a	1.3 (0.3)b	0.9 (0.1)b	1.5 (0.2)a
Bf	0	6.3 (0.3)a	0.62 (0.02)a	3.6 (0.2)a	0.93 (0.03)a
	154	6.4 (0.1)a	0.70 (0.06)a	2.1 (0.4)b	0.92 (0.05)a
	273	6.2 (0.5)a	0.66 (0.05)a	1.9 (0.4)bc	0.78 (0.08)a
	361	8.1 (0.5)a	0.76 (0.06)a	1.6 (0.4)bc	0.81 (0.04)a
	520	7.1 (0.7)a	0.62 (0.06)a	0.7 (0.1)c	0.77 (0.08)a
Bu	0	17.0 (0.4)c	3.7 (0.1)a	5.9 (0.3)a	0.98 (0.02)b
	154	20.5 (0.5)c	2.6 (0.1)bc	0.95 (0.04)b	1.04 (0.05)b
	273	27 (1)b	3.6 (0.3)a	1.1 (0.2)b	1.31 (0.07)a
	361	33 (2)a	3.5 (0.3)ab	0.65 (0.09)b	1.53 (0.04)a
	520	31 (2)ab	2.3 (0.2)c	1.8 (0.8)b	1.40 (0.04)a

		SO$_4^{2-}$ (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)c	0.062 (0.005)a	0.817 (0.004)ab	0.0190 (4E-4)b
	154	2.19 (0.05)b	0.10 (0.02)a	0.76 (0.02)b	0.0220 (8E-4)b
	273	2.20 (0.03)b	0.064 (0.006)a	0.78 (0.02)ab	0.0219 (7E-4)b
	361	2.65 (0.03)a	0.071 (0.002)a	0.87 (0.03)a	0.030 (0.001)a
	520	2.79 (0.05)a	0.079 (0.004)a	0.87 (0.03)a	0.0280 (8E-4)a
Bb/Ra	0	2.66 (0.06)c	0.31 (0.05)ab	2.66 (0.09)a	0.024 (0.001)b
	154	3.6 (0.2)bc	0.31 (0.03)ab	2.05 (0.06)a	0.032 (0.002)b
	273	4.6 (0.2)ab	0.23 (0.02)ab	2.7 (0.2)a	0.046 (0.006)ab
	361	5.0 (0.3)ab	0.192 (0.005)b	3.5 (0.3)a	0.046 (0.004)ab
	520	5.6 (0.8)a	0.35 (0.04)a	4 (1)a	0.08 (0.02)a
Bf	0	2.05 (0.07)a	0.066 (0.004)bc	1.4 (0.2)a	0.035 (0.002)c
	154	2.31 (0.07)a	0.078 (0.006)ab	0.9 (0.2)a	0.037 (0.001)c
	273	2.2 (0.2)a	0.053 (0.002)c	1.2 (0.3)a	0.0405 (9E-4)bc
	361	2.4 (0.1)a	0.073 (0.006)abc	1.0 (0.3)a	0.056 (0.005)a
	520	2.6 (0.3)a	0.096 (0.008)a	1.1 (0.2)a	0.049 (0.003)ab
Bu	0	5.0 (0.2)bc	0.102 (0.009)b	0.35 (0.02)b	0.019 (0.002)b
	154	3.35 (0.09)d	0.31 (0.02)a	0.44 (0.02)b	0.034 (0.005)ab
	273	4.3 (0.1)c	0.24 (0.03)a	0.60 (0.04)b	0.05 (0.01)ab
	361	5.47 (0.03)ab	0.33 (0.04)a	0.89 (0.06)a	0.07 (0.01)a
	520	7.2 (0.3)a	0.35 (0.03)a	1.0 (0.1)a	0.064 (0.004)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)c	-	-	19.2 (0.5)a
	154	0.129 (0.006)bc	-	-	12 (1)b
	273	0.133 (0.007)bc	-	-	20.0 (0.7)a
	361	0.142 (0.001)ab	-	-	14.2 (0.7)b
	520	0.153 (0.002)a	-	-	7.9 (0.5)c
Bb/Ra	0	0.071 (0.006)b	0.035 (0.001)a	0.0067 (5E-4)b	36 (1)a
	154	0.09 (0.02)b	0.020 (0.001)b	0.0077 (3E-4)ab	7.5 (0.1)d
	273	0.128 (0.009)b	0.021 (0.003)b	0.0085 (3E-4)ab	23 (1)b
	361	0.13 (0.01)b	0.016 (0.002)b	0.0085 (3E-4)ab	18.4 (0.7)c
	520	0.25 (0.04)a	-	0.010 (0.001)a	18.2 (0.8)c
Bf	0	0.22 (0.01)a	-	-	12.7 (0.7)a
	154	0.25 (0.01)a	-	-	4.9 (0.4)b
	273	0.23 (0.01)a	-	-	12.6 (0.6)a
	361	0.26 (0.01)a	-	-	4.2 (0.3)b
	520	0.28 (0.03)a	-	-	4.7 (0.3)b
Bu	0	0.63 (0.03)d	0.043 (0.002)ab	-	42 (2)a
	154	0.88 (0.03)cd	0.040 (0.003)ab	-	32.6 (0.7)b
	273	1.05 (0.06)bc	0.049 (0.003)ab	-	31 (2)b
	361	1.43 (0.03)ab	0.056 (0.007)a	-	20.8 (0.7)c
	520	1.6 (0.2)a	0.037 (0.004)b	-	15.7 (0.7)c

Site 10

Table C12. Mean (SE) compositional values obtained for litter types monitored at site 10 over each sampling period.

Litter Type	Days in Field	KL (%) x̄ (SE)	N (%) x̄ (SE)	C (%) x̄ (SE)	C/N x̄ (SE)
WS	0	41.5 (0.5)c	1.24 (0.03)b	50.12 (0.06)a	41 (0.1)a
	151	45.8 (0.4)b	1.25 (0.02)b	48.75 (0.06)b	39.0 (0.5)a
	269	46.6 (0.9)b	1.35 (0.02)b	47.70 (0.06)c	35.4 (0.6)b
	357	51 (1)a	1.47 (0.04)a	50.3 (0.2)a	34 (1)b
	516	49.0 (0.9)ab	1.481 (0.007)a	49.3 (0.2)b	33.3 (0.3)b
Gr	0	29.4 (0.6)c	0.77 (0.04)a	45.73 (0.09)a	60 (3)a
	151	31.7 (0.6)b	0.75 (0.05)a	43.0 (0.4)d	58 (3)a
	269	33.5 (0.4)ab	0.80 (0.02)a	44.8 (0.2)bc	56 (2)a
	357	34.4 (0.5)a	0.90 (0.07)a	45.49 (0.08)ab	52 (4)a
	516	32.8 (0.5)ab	0.93 (0.05)a	44.56 (0.08)c	48 (2)a
Rm	0	29 (1)b	1.30 (0.09)b	47.87 (0.09)b	37 (3)a
	151	50.7 (0.7)a	1.45 (0.07)ab	46.2 (0.1)c	32 (1)ab
	269	56 (5)a	1.53 (0.09)ab	46.6 (0.1)c	31 (2)ab
	357	52 (1)a	1.74 (0.04)a	48.7 (0.2)a	28.1 (0.6)b
	516	53.3 (0.7)a	1.74 (0.07)a	47.4 (0.2)b	27 (1)b
Wf	0	36.9 (0.5)d	1.74 (0.01)c	44.17 (0.03)a	25.3 (0.1)a
	151	42.6 (0.6)c	2.10 (0.02)b	42.5 (0.1)a	20.3 (0.2)b
	269	47 (1)b	2.16 (0.07)ab	43.1 (0.1)a	20.0 (0.7)b
	357	46.3 (0.5)b	2.5 (0.1)a	45.80 (0.07)a	18.7 (0.9)b
	516	50.1 (0.2)a	2.24 (0.09)ab	43 (2)a	19.4 (0.1)b
		Ca (mg g^{-1}) x̄ (SE)	Mg (mg g^{-1}) x̄ (SE)	K (mg g^{-1}) x̄ (SE)	P (mg g^{-1}) x̄ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)a	2.78 (0.02)a	1.21 (0.01)a
	151	1.96 (0.05)c	0.412 (0.005)a	1.1 (0.1)b	0.94 (0.01)b
	269	2.20 (0.03)bc	0.42 (0.03)a	1.0 (0.2)b	0.90 (0.03)b
	357	2.6 (0.1)ab	0.4 (0.1)a	1.06 (0.08)b	0.98 (0.03)b
	516	2.7 (0.1)a	0.50 (0.01)a	0.72 (0.07)b	0.93 (0.03)b
Gr	0	0.52 (0.07)b	0.33 (0.06)a	1.1 (0.3)a	0.3 (0.04)a
	151	0.8 (0.1)ab	0.38 (0.04)a	0.55 (0.09)a	0.39 (0.03)a
	269	0.85 (0.06)ab	0.36 (0.01)a	0.79 (0.09)a	0.46 (0.02)a
	357	1.0 (0.1)a	0.42 (0.08)a	0.9 (0.1)a	0.50 (0.05)a
	516	1.2 (0.1)a	0.37 (0.03)a	0.9 (0.1)a	0.50 (0.04)a
Rm	0	5.2 (0.5)c	1.5 (0.2)a	3.8 (0.2)a	0.84 (0.04)b
	151	5.7 (0.2)bc	0.9 (0.1)b	1.11 (0.02)b	1.01 (0.04)ab
	269	6.7 (0.3)ab	0.95 (0.06)b	0.90 (0.03)b	1.09 (0.06)ab
	357	7.1 (0.2)a	0.94 (0.05)b	0.9 (0.3)b	1.14 (0.04)a
	516	7.3 (0.3)a	0.9 (0.1)b	1.11 (0.08)b	1.12 (0.09)a
Wf	0	3.0 (0.2)b	4.1 (0.2)ab	11.2 (0.7)a	2.14 (0.09)a
	151	3.5 (0.1)b	3.4 (0.3)ab	2.8 (0.2)b	1.30 (0.05)bc
	269	4.6 (0.2)a	4.7 (0.2)a	2.1 (0.4)bc	1.37 (0.04)b
	357	5.0 (0.3)a	4.3 (0.4)ab	1.5 (0.2)bc	1.31 (0.06)bc
	516	4.74 (0.07)a	3.2 (0.3)b	0.71 (0.03)c	1.08 (0.02)c

		SO$_4^{2-}$ (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)c	0.062 (0.005)b	0.817 (0.004)ab	0.0190 (4E-4)b
	151	2.16 (0.03)bc	0.17 (0.02)a	0.73 (0.01)ab	0.0205 (5E-4)b
	269	2.30 (0.06)b	0.08 (0.01)b	0.6 (0.2)b	0.023 (0.001)ab
	357	2.9 (0.1)a	0.09 (0.02)b	1.02 (0.08)a	0.031 (0.004)a
	516	2.71 (0.03)a	0.087 (0.004)b	0.93 (0.04)ab	0.026 (0.001)ab
Gr	0	1.6 (0.1)b	0.127 (0.004)a	0.54 (0.08)a	0.015 (0.001)c
	151	1.80 (0.06)b	0.8 (0.5)a	0.61 (0.07)a	0.019 (0.001)c
	269	1.16 (0.04)c	0.16 (0.03)a	0.64 (0.03)a	0.0249 (7E-4)bc
	357	0.8 (0.1)c	0.16 (0.01)a	0.75 (0.09)a	0.032 (0.003)ab
	516	2.3 (0.1)a	0.19 (0.02)a	0.8 (0.1)a	0.035 (0.004)a
Rm	0	2.22 (0.08)c	0.056 (0.004)b	1.03 (0.05)a	0.023 (0.002)a
	151	2.70 (0.08)bc	0.17 (0.03)ab	1.2 (0.1)a	0.031 (0.002)a
	269	3.0 (0.1)b	0.12 (0.01)b	1.37 (0.05)a	0.039 (0.004)a
	357	3.05 (0.06)ab	0.138 (0.005)ab	1.6 (0.2)a	0.07 (0.02)a
	516	3.5 (0.2)a	0.25 (0.05)a	2.5 (0.9)a	0.09 (0.03)a
Wf	0	3.01 (0.04)c	0.073 (0.005)c	1.52 (0.04)b	0.039 (0.001)c
	151	3.70 (0.06)b	0.40 (0.06)a	1.50 (0.06)b	0.052 (0.002)bc
	269	3.31 (0.07)bc	0.23 (0.02)b	1.90 (0.08)a	0.062 (0.03)ab
	357	3.5 (0.2)b	0.13 (0.01)bc	2.2 (0.1)a	0.066 (0.004)ab
	516	4.17 (0.06)a	0.158 (0.006)bc	2.19 (0.08)a	0.072 (0.007)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)b	-	-	19.2 (0.5)a
	151	0.137 (0.004)ab	-	-	11.7 (0.7)b
	269	0.135 (0.005)b	-	-	19 (2)a
	357	0.17 (0.02)a	-	-	11 (1)b
	516	0.154 (0.004)ab	-	-	7.4 (0.2)b
Gr	0	0.070 (0.002)a	-	-	12.7 (0.2)a
	151	0.3 (0.2)a	-	-	14.1(0.4)a
	269	0.11 (0.03)a	-	-	13.8 (0.1)a
	357	0.097 (0.008)a	-	-	3.4 (0.2)c
	516	0.14 (0.02)a	-	-	8.1 (0.7)b
Rm	0	-	0.027 (0.002)a	0.0065 (5E-4)b	66 (2)a
	151	-	0.017 (0.002)b	0.0117 (5E-4)ab	14.8 (0.4)b
	269	-	0.0143 (7E-4)b	0.013 (0.003)a	14 (1)bc
	357	-	0.015 (0.001)b	0.0109 (4E-4)ab	8.7 (0.2)cd
	516	-	0.0105 (5E-4)b	0.0110 (4E-4)ab	5.9 (0.2)d
Wf	0	0.071 (0.004)a	0.0264 (3E-4)c	-	14.4 (0.6)a
	151	0.12 (0.02)a	0.0279 (4E-4)bc	0.0097 (3E-4)a	12.0 (0.3)b
	269	0.08 (0.01)a	0.0332 (9E-4)a	0.0085 (3E-4)ab	11.6 (0.2)b
	357	0.086 (0.008)a	0.030 (0.001)ab	0.0082 (6E-4)abc	4.9 (0.6)c
	516	0.101 (0.009)a	0.0255 (9E-4)c	0.0065 (3E-4)c	3.8 (0.2)c

Site 11

Table C13. Mean (SE) compositional values obtained for litter types monitored at site 11 over each sampling period.

Litter Type	Days in Field	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
WS	0	41.5 (0.5)d	1.24 (0.03)c	50.12 (0.06)a	41 (1)a
	154	49.9 (0.9)a	1.31 (0.02)bc	48.24 (0.06)c	36.8 (0.5)b
	273	46.2 (0.7)bc	1.35 (0.02)b	47.4 (0.08)d	35.2 (0.4)b
	361	50 (1)ab	1.54 (0.02)a	49.9 (0.1)a	32.4 (0.4)c
	520	45 (1)a	1.56 (0.02)a	48.9 (0.2)b	31.3 (0.4)c
Bb/ Ra	0	29.1 (0.1)d	2.02 (0.06)c	45.91 (0.05)a	22.8 (0.7)a
	154	47.5 (0.4)a	2.50 (0.08)bc	45.6 (0.9)a	18.3 (0.4)b
	273	40 (1)c	3.1 (0.2)ab	46.0 (0.2)a	15.0 (1)bc
	361	45 (2)ab	3.2 (0.2)a	46.1 (0.2)a	14.5 (0.8)c
	520	42.6 (0.7)bc	3.0 (0.2)ab	46.3 (0.2)a	16 (1)bc
Bf	0	47.4 (0.5)b	1.15 (0.02)a	50.8 (0.1)a	44.2 (0.7)a
	154	51.8 (0.4)a	1.17 (0.04)a	49.6 (0.2)b	42 (2)a
	273	52 (1)a	1.2 (0.1)a	48.1 (0.1)c	40 (4)a
	361	51 (1)a	1.5 (0.2)a	50.2 (0.2)ab	36 (5)a
	520	50.6 (0.5)ab	1.4 (0.2)a	50.1 (0.2)ab	37 (5)a
Bu	0	25.1 (0.3)c	1.29 (0.03)c	42.67 (0.08)ab	33.1 (0.7)a
	154	27.4 (0.7)c	1.58 (0.05)c	39.5 (0.2)b	25.1 (0.9)b
	273	35 (3)b	2.07 (0.09)b	40.9 (0.8)ab	20 (1)c
	361	36.2 (0.9)b	2.65 (0.04)a	43.4 (0.1)a	16.4 (0.3)d
	520	44 (1)a	2.7 (0.2)a	41 (1)ab	15.2 (0.3)d
		Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)c	2.78 (0.02)a	1.21 (0.01)a
	154	2.57 (0.05)b	0.48 (0.03)c	1.2 (0.3)b	0.94 (0.04)bc
	273	3.0 (0.1)ab	0.57 (0.01)bc	1.0 (0.1)b	0.92 (0.03)c
	361	3.46 (0.05)a	0.67 (0.02)ab	1.18 (0.04)b	1.00 (0.02)bc
	520	3.2 (0.3)a	0.74 (0.07)a	0.81 (0.08)b	1.07 (0.05)ab
Bb/ Ra	0	6.2 (0.1)b	2.54 (0.03)a	7.30 (0.03)a	1.26 (0.02)a
	154	6.4 (0.4)b	1.70 (0.09)b	1.1 (0.2)b	1.28 (0.07)a
	273	8 (1)ab	1.8 (0.2)b	1.1 (0.2)b	1.7 (0.2)a
	361	9.4 (0.3)a	1.6 (0.1)b	1.01 (0.09)b	1.7 (0.1)a
	520	8.6 (0.3)ab	1.7 (0.2)b	0.9 (0.1)b	1.5 (0.1)a
Bf	0	6.3 (0.3)a	0.62 (0.02)a	3.6 (0.2)a	0.93 (0.03)a
	154	6.7 (0.4)a	0.60 (0.03)a	1.7 (0.1)b	0.82 (0.02)a
	273	7.1 (0.3)a	0.73 (0.08)a	1.4 (0.2)bc	0.80 (0.08)a
	361	9 (1)a	0.69 (0.05)a	0.98 (0.04)c	0.9 (0.1)a
	520	7.6 (0.9)a	0.66 (0.07)a	0.9 (0.1)c	0.9 (0.1)a
Bu	0	17.0 (0.4)c	3.7 (0.1)a	5.9 (0.3)a	0.98 (0.02)b
	154	20.0 (0.5)c	3.1 (0.1)a	1.39 (0.02)b	1.01 (0.04)b
	273	25.7 (0.7)b	3.4 (0.3)a	1.2 (0.2)b	1.4 (0.1)a
	361	32 (1)a	3.1 (0.2)a	0.4 (0.1)c	1.38 (0.05)a
	520	27 (2)b	2.12 (0.08)b	1.17 (0.08)b	1.39 (0.05)a

		SO$_4^{2-}$ (mg g^{-1}) $\bar{x}$ (SE)	Fe (mg g^{-1}) $\bar{x}$ (SE)	Mn (mg g^{-1}) $\bar{x}$ (SE)	Zn (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.98 (0.01)d	0.062 (0.005)b	0.817 (0.004)a	0.0190 (0.0004)c
	154	2.19 (0.02)cd	0.19 (0.04)ab	0.90 (0.06)a	0.025 (0.001)b
	273	2.38 (0.03)c	0.16 (0.01)ab	0.87 (0.02)a	0.029 (0.001)b
	361	2.81 (0.09)b	0.22 (0.03)a	0.98 (0.05)a	0.036 (0.002)a
	520	3.12 (0.07)a	0.27 (0.05)a	0.96 (0.06)a	0.0344 (0.0006)a
Bb/Ra	0	2.66 (0.06)c	0.31 (0.05)b	2.66 (0.09)b	0.024 (0.001)c
	154	3.8 (0.1)bc	0.51 (0.01)ab	2.4 (0.1)b	0.032 (0.003)bc
	273	4.9 (0.6)ab	1.2 (0.4)ab	3.3 (0.6)ab	0.053 (0.008)ab
	361	5.8 (0.2)a	1.5 (0.2)a	4.5 (0.4)a	0.061 (0.008)ab
	520	5.5 (0.3)a	1.3 (0.2)a	4.0 (0.5)ab	0.07 (0.01)a
Bf	0	2.05 (0.07)a	0.066 (0.004)b	1.4 (0.2)a	0.035 (0.001)a
	154	2.21 (0.08)a	0.128 (0.007)b	1.5 (0.2)a	0.038 (0.001)a
	273	2.4 (0.2)a	0.20 (0.05)ab	1.3 (0.2)a	0.3 (0.2)a
	361	2.6 (0.4)a	0.21 (0.04)ab	1.4 (0.3)a	0.050 (0.003)a
	520	2.7 (0.3)a	0.31 (0.07)a	1.6 (0.3)a	0.051 (0.004)a
Bu	0	5.0 (0.2)bc	0.102 (0.009)d	0.35 (0.02)c	0.019 (0.002)d
	154	3.29 (0.09)d	0.37 (0.06)cd	0.42 (0.01)c	0.029 (0.004)cd
	273	4.4 (0.2)c	0.73 (0.06)bc	0.66 (0.04)b	0.042 (0.005)bc
	361	5.5 (0.1)b	1.1 (0.1)b	0.83 (0.07)b	0.051 (0.003)b
	520	6.5 (0.3)a	1.7 (0.3)a	1.08 (0.09)a	0.091 (0.005)a

		Al (mg g^{-1}) $\bar{x}$ (SE)	B (mg g^{-1}) $\bar{x}$ (SE)	Cu (mg g^{-1}) $\bar{x}$ (SE)	ASL (%) $\bar{x}$ (SE)
WS	0	0.119 (0.002)d	-	-	19.2 (0.5)a
	154	0.156 (0.009)cd	-	-	10.3 (0.6)b
	273	0.187 (0.004)bc	-	-	19.2 (0.5)a
	361	0.23 (0.02)ab	-	-	8.5 (0.4)bc
	520	0.26 (0.03)a	-	-	8.2 (0.4)c
Bb/Ra	0	0.071 (0.006)c	0.035 (0.001)a	0.0067 (5E-4)a	36 (1)a
	154	0.13 (0.01)bc	0.025 (0.001)b	0.0077 (8E-4)a	8.4 (0.4)d
	273	0.4 (0.1)ab	0.019 (0.001)c	0.011 (0.002)a	21 (1)b
	361	0.8 (0.1)a	0.012 (0.001)d	0.0100 (4E-4)a	16.5 (0.8)c
	520	0.7 (0.1)a	-	9.987E-3 (7E-6)a	18 (1)bc
Bf	0	0.22 (0.01)b	-	-	12.7 (0.7)a
	154	0.254 (0.006)ab	-	-	5.9 (0.6)b
	273	0.30 (0.04)ab	-	-	13.2 (0.3)a
	361	0.32 (0.04)ab	-	-	6 (1)b
	520	0.37 (0.05)a	-	-	5.4 (0.7)b
Bu	0	0.63 (0.03)d	0.043 (0.002)a	-	42 (2)a
	154	0.90 (0.04)cd	0.0436 (8E-4)a	-	32 (1)b
	273	1.28 (0.03)bc	0.044 (0.002)a	-	27 (3)b
	361	1.74 (0.03)b	0.046 (0.003)a	-	19.0 (0.9)c
	520	2.4 (0.2)a	0.027 (0.003)b	-	12.8 (0.5)c

Site 12

Table C14. Mean (SE) compositional values obtained for litter types monitored at site 12 over each sampling period.

Litter Type	Days in Field	KL (%) $\bar{x}$ (SE)	N (%) $\bar{x}$ (SE)	C (%) $\bar{x}$ (SE)	C/N $\bar{x}$ (SE)
WS	0	41.5 (0.5)a	1.24 (0.03)c	50.12 (0.06)a	41 (1)a
	153	46.8 (0.3)a	1.30 (0.01)bc	48.15 (0.05)c	37.0 (0.3)b
	273	47 (1)a	1.39 (0.02)b	47.59 (0.06)c	34.3 (0.6)bc
	361	47 (2)a	1.63 (0.04)a	49.7 (0.2)a	30.5 (0.9)d
	518	47 (2)a	1.56 (0.02)a	48.9 (0.2)b	31.3 (0.4)cd
Gr	0	29.4 (0.6)b	0.77 (0.04)ab	45.73 (0.09)a	60 (3)ab
	153	31.9 (0.8)ab	0.69 (0.03)b	43.62 (0.04)a	64 (3)a
	273	35 (2)a	0.9 (0.1)ab	45.5 (0.4)a	50 (5)abc
	361	34 (1)a	0.97 (0.05)ab	46.0 (0.1)a	48 (3)bc
	518	34.0 (0.6)ab	1.04 (0.05)a	47 (2)a	45 (2)c
Rm	0	29 (1)c	1.30 (0.09)c	47.87 (0.09)ab	37 (3)a
	153	50.4 (0.4)b	1.46 (0.05)bc	45.4 (0.3)b	31 (1)ab
	273	51.29 (0.09)b	1.6 (0.1)abc	46.5 (0.2)ab	30 (2)ab
	361	52.6 (0.4)ab	1.8 (0.1)ab	48.43 (0.08)a	27 (1)b
	518	54.8 (0.4)a	1.96 (0.09)a	48 (1)ab	24.4 (0.6)b
Wf	0	36.9 (0.5)d	1.74 (0.01)c	44.17 (0.03)b	25.3 (0.1)a
	153	42.0 (0.3)c	2.02 (0.07)b	42.58 (0.07)d	21.2 (0.7)b
	273	46.7 (0.7)b	2.20 (0.03)b	43.23 (0.07)c	19.7 (0.2)bc
	361	47.1 (0.9)ab	2.53 (0.04)a	46.0 (0.1)a	18.1 (0.3)cd
	518	49.6 (0.5)a	2.57 (0.07)a	45.6 (0.1)a	17.7 (0.5)d
		Ca (mg g^{-1}) $\bar{x}$ (SE)	Mg (mg g^{-1}) $\bar{x}$ (SE)	K (mg g^{-1}) $\bar{x}$ (SE)	P (mg g^{-1}) $\bar{x}$ (SE)
WS	0	1.89 (0.03)c	0.485 (0.003)a	2.78 (0.02)a	1.21 (0.01)a
	153	2.74 (0.04)b	0.45 (0.01)a	0.98 (0.05)b	0.90 (0.01)a
	273	2.96 (0.02)b	0.49 (0.01)a	1.04 (0.05)b	0.90 (0.02)a
	361	3.6 (0.1)a	0.58 (0.06)a	0.90 (0.06)b	1.0 (0.4)a
	518	3.59 (0.09)a	0.58 (0.06)a	0.82 (0.04)b	0.94 (0.02)a
Gr	0	0.52 (0.07)d	0.33 (0.06)a	1.1 (0.3)a	0.35 (0.04)c
	153	0.67 (0.05)cd	0.30 (0.02)a	0.36 (0.02)a	0.34 (0.02)c
	273	0.86 (0.04)bc	0.39 (0.02)a	1.0 (0.3)a	0.429 (0.009)bc
	361	1.25 (0.08)a	0.42 (0.04)a	0.95 (0.05)a	0.52 (0.03)ab
	518	1.13 (0.08)ab	0.36 (0.03)a	0.94 (0.02)a	0.59 (0.04)a
Rm	0	5.2 (0.5)a	1.5 (0.2)a	3.8 (0.2)a	0.84 (0.04)b
	153	6.6 (0.5)a	1.2 (0.1)ab	1.2 (0.2)b	1.03 (0.08)ab
	273	6.5 (0.6)a	1.15 (0.04)ab	1.01 (0.02)b	1.08 (0.04)ab
	361	7.3 (0.5)a	1.13 (0.07)ab	1.25 (0.07)b	1.09 (0.04)a
	518	7.3 (0.4)a	1.02 (0.07)b	1.20 (0.02)b	1.13 (0.02)a
Wf	0	3.0 (0.2)c	4.1 (0.2)a	11.2 (0.7)a	2.14 (0.09)a
	153	3.53 (0.08)bc	3.9 (0.1)a	1.9 (0.4)b	1.22 (0.02)b
	273	4.3 (0.3)ab	4.1 (0.1)a	1.5 (0.2)b	1.23 (0.05)b
	361	5.1 (0.5)a	4.33 (0.08)a	1.19 (0.08)b	1.26 (0.02)b
	518	5.2 (0.2)a	2.6 (0.4)b	0.79 (0.06)b	1.15 (0.04)b

		SO$_4^{2-}$ (mg g^{-1})	Fe (mg g^{-1})	Mn (mg g^{-1})	Zn (mg g^{-1})
		$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
WS	0	1.98 (0.01)d	0.062 (0.005)b	0.817 (0.004)a	0.0190 (4E-4)c
	153	2.20 (0.03)c	0.138 (0.009)a	0.77 (0.01)a	0.026 (0.001)b
	273	2.39 (0.02)c	0.065 (0.003)b	0.826 (0.005)a	0.0263 (3E-4)b
	361	2.79 (0.07)b	0.072 (0.008)b	0.99 (0.07)a	0.034 (0.002)a
	518	2.99 (0.05)a	0.090 (0.006)b	0.9 (0.1)a	0.034 (0.001)a
Gr	0	1.6 (0.1)b	0.127 (0.004)c	0.54 (0.08)ab	0.015 (0.001)c
	153	1.73 (0.06)b	0.22 (0.02)a	0.45 (0.02)b	0.019 (0.002)bc
	273	1.141 (0.005)c	0.099 (0.003)c	0.70 (0.06)ab	0.030 (0.003)abc
	361	0.9 (0.1)c	0.148 (0.008)bc	0.73 (0.08)a	0.036 (0.005)ab
	518	2.49 (0.09)a	0.20 (0.02)ab	0.50 (0.05)ab	0.044 (0.008)a
Rm	0	2.22 (0.08)c	0.056 (0.004)c	1.03 (0.05)a	0.023 (0.002)b
	153	2.87 (0.06)b	0.24 (0.03)a	0.9 (0.1)a	0.043 (0.003)ab
	273	3.1 (0.1)b	0.12 (0.01)bc	0.96 (0.08)a	0.055 (0.008)a
	361	3.3 (0.1)b	0.133 (0.006)b	0.97 (0.06)a	0.06 (0.01)a
	518	4.0 (0.1)a	0.230 (0.008)a	1.2 (0.1)a	0.061 (0.009)a
Wf	0	3.01 (0.04)c	0.073 (0.005)b	1.52 (0.04)b	0.039 (0.001)b
	153	3.6 (0.1)b	0.38 (0.07)a	1.48 (0.06)b	0.049 (0.004)b
	273	3.1 (0.2)bc	0.21 (0.04)b	1.68 (0.04)b	0.067 (0.006)b
	361	3.3 (0.1)bc	0.127 (0.004)b	2.1 (0.1)a	0.081 (0.002)ab
	518	4.7 (0.1)a	0.22 (0.01)b	2.2 (0.1)a	0.14 (0.03)a

		Al (mg g^{-1})	B (mg g^{-1})	Cu (mg g^{-1})	ASL (%)
		$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)	$\bar{x}$ (SE)
WS	0	0.119 (0.002)b	-	-	19.2 (0.5)a
	153	0.132 (0.005)b	-	-	9.8 (0.6)b
	273	0.124 (0.002)b	-	-	17.5 (0.6)a
	361	0.143 (0.005)ab	-	-	9.2 (0.4)b
	518	0.166 (0.009)a	-	-	7.8 (0.4)b
Gr	0	0.070 (0.002)b	-	-	12.7 (0.2)b
	153	0.060 (0.003)b	-	-	16.2 (0.1)a
	273	0.059 (0.002)b	-	-	4.5 (0.6)d
	361	0.086 (0.006)ab	-	-	4.4 (0.1)d
	518	0.18 (0.05)a	-	-	8.4 (0.4)c
Rm	0	-	0.027 (0.002)a	0.0065 (5E-4)b	66 (2)a
	153	-	0.0154 (6E-4)b	0.013 (0.002)a	15.1 (0.4)b
	273	-	0.0130 (8E-4)b	0.0107 (5E-4)ab	15.5 (0.4)b
	361	-	0.0132 (8E-4)b	0.0112 (6E-4)a	10.1 (0.4)c
	518	-	0.0104 (3E-4)b	0.0112 (3E-4)a	6.2 (0.3)c
Wf	0	0.071 (0.004)b	0.0264 (3E-4)ab	-	14.4 (0.6)a
	153	0.11 (0.03)b	0.0278 (7E-4)a	0.0087 (5E-4)a	11.8 (0.2)b
	273	0.09 (0.01)b	0.029 (0.001)a	0.0080 (4E-4)ab	11.5 (0.3)b
	361	0.098 (0.004)b	0.0284 (7E-4)a	0.0087 (3E-4)a	5.1 (0.4)c
	518	0.18 (0.01)a	0.0235 (5E-4)b	0.0077 (3E-4)ab	4.25 (0.06)c

APPENDIX D

Soil Survey Map Key

Soil types were gathered from Soil Survey Description Maps found on Agriculture and Agri-Food Canada's website: (http://sis.agr.gc.ca/cansis/publications/surveys/ns/index.html). Three different maps were used: Halifax County, Colchester County, and Pictou County. The descriptions and legends used in the site characterization chapter are seen below in Appendix C.

Colchester County
(Report No. 19, 1991)
Explanation of Map Unit Symbol

$$\frac{Map\ Unit}{Slope\ Class}$$

<u>Definition of Legend Terms</u>

Soil Association

A group of related soils developed on similar parent materials, which differ due to different soil drainage characteristics.

Map Units

Map units No. 1, 3, and 5: dominant soil component comprises 85% of the map unit. Map units No. 2, 4, 6 and 7: dominant soils comprises 60% of the Map unit, and the significant soil component will comprise at least 25% of the Map unit.

Drainage Classes

Rapidly Drained: soil water removed rapidly.
Well Drained: soil water removed readily.
Moderately Well Drained: soil water removed slowly.
Imperfectly Drained: soil remains wet for a significant part of the growing season,
Poorly Drained: soil remains wet most of the time the soil is not froze.
Very Poorly Drained: water at or near the surface for most of the time the soil is not frozen.

Slope Classes

A	0-0.5%	Level
B	0.2-2.0%	Nearly level
C	2.0-5.0%	Very gentle slopes
D	5.0-10.0%	Gentle slopes
E	10-15%	Moderate slopes
F	16-30%	Strong slopes
G	30-45%	Very strong slopes

Stoniness Classes

Table D1. Stoniness classes for stones greater than 25 cm in diameter.

Class Name	Surface Coverage
Non stony	Less than 0.01%
Slightly stony	0.01-0.1%
Moderately stony	0.1-3%
Very stony	3-15%
Exceedingly stony	15-50%
Excessively stony	Greater than 50%

Rockiness Classes (bedrock exposure)

Table D2. Rockiness classes (bedrock exposure).

Class Name	Surface Coverage
Non rocky	Less than 2%
Slightly rocky	2-10 %
Moderately rocky	10-25%

Table D3. Cobequid soil type map symbol description.

Soil Association or Land Type	Soil Material	Symbol	Map Unit Description Soil Components		Stoniness	Rockiness
			Dominant Soils	Significant Soils		
Cobequid	50 to 70 cm of gravelly loam over compact, dark yellowish brown, gravelly to very gravelly sandy loam, shallow, stony till derived from metamorphic and igneous rocks	Cd1	Well drained soils		Very stony	Slightly to moderately rocky
		Cd2	Well drained soils (Cd1)	Imperfectly drained soils (Cd3)	Very stony	Slightly to moderately rocky
		Cd3	Imperfectly drained soils		Very stony	Slightly to moderately rocky
		Cd4	Imperfectly drained soils (Cd3)	Poorly Drained Soils (Cd5)	Very stony	Slightly rocky
		Cd5	Poorly drained soils		Very stony	Non rocky
		Cd6	Poorly drained soils (Cd5)	Very poorly drained organic soils (Ct)	Very stony	Non rocky
Millbrook	60 to 80 cm of gravelly sandy loam to loam over	Mi2	Imperfectly drained soils	Moderately well drained soils	Slightly to moderately stony	Non rocky

Soil Association or Land Type	Soil Material	Symbol	Map Unit Description Soil Components		Stoniness	Rockiness
			Dominant Soils	Significant Soils		
	compact, dark reddish brown, gravelly loam to gravelly clay loam till	Mi3	Imperfectly drained soils		Slightly to moderately stony	Non rocky
		Mi4	Imperfectly drained soils (Mi3)	Poorly drained soils (Mi5)	Slightly to moderately stony	Non rocky
		Mi5	Poorly drained soils		Slightly to moderately stony	Non rocky
		Mi6	Poorly drained soils (Mi5)	Very poorly drained organic soils (Ct)	Slightly to moderately stony	Non rocky
Perch Lake	70 to 90 cm of gravelly loam to very gravelly sandy loam over compact, dark brown gravelly sandy loam, shallow, stony till derived from Horton sandstone and arenite	Ph1	Well drained soils		Very to exceedingly stony	Slightly to moderately rocky
		Ph2	Well drained soils (Ph1)	Imperfectly drained soils (Ph3)	Very to exceedingly stony	Slightly to moderately rocky
		Ph3	Imperfectly drained soils		Very to exceedingly stony	Slightly to moderately rocky
		Ph4	Imperfectly drained soils (Ph3)	Poorly Drained Soils (Ph5)	Very to exceedingly stony	Slightly to moderately rocky
		Ph5	Poorly drained soils		Very to exceedingly stony	Slightly to moderately rocky
		Ph6	Poorly drained soils (Ph5)	Very poorly drained organic soils (Ct)	Very to exceedingly stony	Slightly to moderately rocky
		Ph7	Well drained soils (Ph1)	Poorly drained soils (Ph5)	Very to exceedingly stony	Slightly to moderately rocky
Thom	60 to 80 cm of gravelly sandy loam to gravelly silt loam over compact, dark brown gravelly loam to	Tm1	Well drained soils		Very stony	Slightly rocky
		Tm2	Well drained soils (Tm1)	Imperfectly drained soils (Tm3)	Very stony	Slightly rocky
		Tm3	Imperfectly drained soils		Very stony	Non rocky

Soil Association or Land Type	Soil Material	Symbol	Map Unit Description Soil Components		Stoniness	Rockiness
			Dominant Soils	Significant Soils		
	gravelly sandy loam till derived from hard sedimentary and metamorphic rocks	Tm4	Imperfectly drained soils (Tm3)	Poorly Drained Soils (Tm5)	Moderately stony	Non rocky
		Tm5	Poorly drained soils		Moderately stony	Non rocky
		Tm6	Poorly drained soils (Tm3)	Very poorly drained organic soils (Ct)	Moderately stony	Non rocky

Halifax County
(Report No. 13, 1981)
Convention

$$Soil\ Symbol: \frac{Series}{Topography - Stoniness}$$

Definition of Legend Terms

Topography

Table D4. Topography

		Slope Limit
A	Level or nearly level	0-2%
B	Undulating	3-8%
C	Rolling	9-16%
D	Strongly rolling to hilly	17-30%

Stoniness

0 - Stone free
1 - Slightly stony; no hindrance to cultivation
2 - Moderately stony; enough stone to interfere with cultivation unless removed
3 - Very stony; sufficient stone to be a severe handicap to cultivation
4 - Excessively stony; non-arable; too stony for cultivation

Table D5. Halifax County soil type map soil description.

Symbol	Soil Series or Land Type	Description of Surface and Subsoil	Parent Material	Topography	Drainage
Ga	Gibraltar	Brown sandy loam over strong-brown sandy loam	Pale-brown coarse sandy loam till derived from granite	Gently undulating to gently rolling	Good to excessive drainage
Hx	Halifax	Brown sandy loam over yellowish sandy loam	Olive to yellowish-brown stony sandy loam till derived from quartzite	Gently undulating to gently rolling	Good to excessive drainage

Pictou County
(Report No. 19, 1990)
Explanation of Map Unit Symbol

$$\frac{Map\ Unit}{Slope\ Class}$$

<u>Definition of Legend Terms</u>

Soil Association
A group of related soils developed on similar parent materials, which differ due to different soil drainage characteristics.

Map Units
Map units No. 1, 3, and 5: dominant soil component comprises 85% of the map unit. Map units No. 2, 4, 6 and 7: dominant soils comprises 60% of the Map unit, and the significant soil component will comprise at least 25% of the Map unit.

Drainage Classes
Rapidly Drained: soil water removed rapidly.
Well Drained: soil water removed readily.
Moderately Well Drained: soil water removed slowly.
Imperfectly Drained: soil remains wet for a significant part of the growing season,
Poorly Drained: soil remains wet most of the time the soil is not froze.
Very Poorly Drained: water at or near the surface for most of the time the soil is not frozen.

Slope Classes

A	0-0.5%	Level
B	0.2-2.0%	Nearly level
C	2.0-5.0%	Very gentle slopes

D	5.0-10.0%	Gentle slopes
E	10-15%	Moderate slopes
F	16-30%	Strong slopes
G	30-45%	Very strong slopes
H	45-70%	Extreme slopes

Stoniness Classes

Table D6. Stoniness classes for stones greater than 25 cm in diameter.

Class Name	Surface Coverage
Non stony	Less than 0.01%
Slightly stony	0.01-0.1%
Moderately stony	0.1-3%
Very stony	3-15%
Exceedingly stony	15-50%
Excessively stony	Greater than 50%

Rockiness Classes (bedrock exposure)

Table D7. Rockiness classes (bedrock exposure)

Class Name	Surface Coverage
Non rocky	Less than 2%
Slightly rocky	2-10 %
Moderately rocky	10-25%

Table D8. Millbrook soil type map symbol description.

Soil Association or Land Type	Soil Material	Symbol	Map Unit Description			
			Soil Components		Stoniness	Rockiness
			Dominant Soils	Significant Soils		
Millbrook	60 to 80 cm of gravelly sandy loam to loam over compact, dark reddish brown, gravelly loam to gravelly clay loam till.	Mi2	Imperfectly drained soils (Mi3)	Moderately well drained soils	Slightly to moderately stony	Non rocky
		Mi3	Imperfectly drained soils		Slightly to moderately stony	Non rocky
		Mi4	Imperfectly drained soils (Mi3)	Poorly drained soils (Mi5)	Slightly to moderately stony	Non rocky
		Mi5	Poorly drained soils		Slightly to moderately stony	Non rocky