Soil and Compost Use Guidelines

1st Edition

Landscape NovaScotia

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Acknowledgements

We would like to recognise the project partners for funding and in-kind support, including the Landscape Nova Scotia Horticultural Trades Association, the Resource Recovery Fund Board of Nova Scotia, and the Halifax Regional Municipality Environmental Management Services Department. The project would not have been possible without their commitment to a coordinated understanding of the value and use of soil and compost products. We hope their vision for the growing importance of these products in landscaping and continued development of best practices will emerge from this initiative.

Despite the call of other priorities, a working group met and corresponded continually over the past year to help shape these guidelines. The working group brought together some of the most knowledgeable individuals working with these products on a regular basis. The group included the current president of Landscape Nova Scotia, Jeff Morton, and past-president, Doug Conrad. Several members of Landscape Nova Scotia including; Michael Pink, Alan Streatch, Stephen King, and David Stenhouse all devoted a significant amount of their time and energy to the project.

The project required the undivided attention of a full-time coordinator to bring these efforts forward. Gregor MacAskill brought technical expertise to the role, and authored the final publication.

We would also like to thank the staff of Landscape Nova Scotia, in particular the executive director, Michelle Lavigne, who helped with finances, printing, communications, and project logistics.

This project called for a wide range of industry, government, and academic input. We would like to thank all who participated, especially the following individuals for their valuable insights; Gordon Brewster, Sandy Roberton, Pierre Chenard, Phil Warman, Jeff Travers, George Coupar, Daryl Lingley, Walter Termeer, Barry Friesen, Grant Mosher, Peter Clark, Jason Hoffman, Lonie Ferguson, Stan Kochanoff, Blair Blakeney, David Patriquin, Bruce Avery, Richelle Gregg, and Paul Arnold.

We would like to thank all of the researchers and authors of related publications that provided the foundation for our discussions and writing. In particular we would like to recognise the British Columbia Landscaping Association and the United States Composting Council for their excellent work on soil standards and compost specifications respectively.

This has been a first-rate effort and a pleasure; we hope many will share in the benefits.

This document should be cited as:

Landscape Nova Scotia Horticultural Trades Association. 2003. Soil and Compost Use Guidelines 1st Edition. Published by Landscape Nova Scotia Horticultural Trades Association, Nova Scotia, Canada, 55pp.

The first edition of these guidelines will be circulated for at least one year in order to gather more input, and to incorporate current research and practical experience.

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Revisions of this document will appear on the publisher's website at:
http://www.landscapenovascotia.ca

Contents

Introduction

Shared goals
The project partners have voluntarily joined to address mutual goals for soil and compost use in Nova Scotia. We intend to distribute the guidelines widely, and we hope that everyone will benefit from a common understanding of the use and value of these products. Hopefully this effort will build momentum with good guidelines leading to better experiences with these products, and better experiences returning information to further improve guidelines.

The Landscape Nova Scotia Horticultural Trades Association (LNSHTA) aims to promote high standards in product quality, professional service and conduct in the horticultural trades industry; and to encourage the use of its' members by the public. The Halifax Regional Municipality (HRM) is similar to other communities that are engaged in composting and waste management programs, and using compost and soil products to provide safe, clean, and sustainable, parks, playgrounds, athletic fields, urban forests and other open spaces. The Resource Recovery Fund Board (RRFB Nova Scotia) have been part of the new waste management strategy adopted by Nova Scotians in 1996, where Nova Scotians are now able to divert over 50% of their waste from disposal at landfills through reducing, reusing, recycling and composting programs. RRFB administers most of the solid waste management strategy for the Province and supports education and awareness programs that promote both municipal and backyard composting.

Missing link
Until now there have not been any guidelines in this region for how to successfully manufacture soils or composts for landscaping purposes. Soil and compost products in Nova Scotia are only regulated according to health and environmental concerns. Health and environmental regulations are important, but they do not reveal whether these products are ideal for landscape and horticulture objectives. It is clear that all products must meet regulatory requirements, but these guidelines are helpful as an additional step that identifies important considerations for the home gardener or professional landscaper.

This project responds to the growing need for guidelines in the use of soil and compost products that will identify cost effective, operationally effective, environmentally sustainable, and safe products. Materials, processes, and consumer demands have evolved in recent years and will continue to do so. This will be an open document that will incorporate feedback from all parties.

Need for leadership
At the time of writing, the British Columbia Association of Landscape Architects had developed an excellent set of landscape standards that served as the starting point for our soil use guidelines. The Composting Council of Canada had also announced that it would pursue similar compost standards and use specifications to those developed by the United States Composting Council. Because partners in this project are taking a leadership role, it seemed natural that we bring together the best information from these and other sources for use in Nova Scotia.

Soils and Composts
In keeping with their leadership role, Landscape Nova Scotia and Nova Scotian communities including HRM, endorse environmentally sound and sustainable use of natural resources in Nova Scotia. With decreasing availability of natural soils for landscaping, there is a trend toward manufactured soils and blending of amendments with on-site soils in landscaping projects. Given the widespread introduction of composting programs and interest in renewable sources of organic materials, soil manufacturing and soil amendments are increasingly reliant on compost

products. These guidelines recognise the close relationship between soils and composts and, although they are each described in their own right, they are connected in this document.

Although it is difficult to replicate natural soils, the guidelines ultimately aim for a successful growing medium. Natural soils have evolved over thousands of years to incorporate locally adapted organisms and structural characteristics that contribute to important soil processes. For example, it would be difficult to re-create the combination of earthworms, insects, bacteria and other biota of natural soils. However, we can combine soil components together in order to create a desired soil texture, and we can add compost or other soil amendments that provide organic matter, microorganisms, and other critical elements. With the right start, manufactured mediums will begin functioning like natural soil systems over time.

How to use these guidelines

Each section of these guidelines is designed to be a stand-alone document that could be used as the basis for a contract or project specification. A home owner should also be able to use this guide in order to help make informed decisions. General information about soils, composts, conversion charts, calculations, and additional resources are included to help producers and consumers use the guidelines effectively. It is expected that this will bring better consistency to the world of growing media for the landscape industry.

If you are starting a renovation or landscape construction project, use the following guidelines matrix to quickly find the product information you will need. Over time the matrix will expand as uses are added or sub-divided, and new specialty soil and compost products are developed. More defined maintenance levels may also expand the matrix over time as we gain more experience with the long-term up-keep of our landscapes.

Guidelines matrix (quick reference to guidelines topics)

Product Use Category	High Maintenance	Medium Maintenance	Low Maintenance
Low Traffic Lawn Soil	p.7	p.7	p.7
High Traffic Lawn Soil	p. 8	p. 8	p. 8
Sportsfield Soil	p.9	p.9	p.9
Planting Area Soil	p.10	p.10	p.10
Lawn Compost	p.12	p.12	p.12
Topdressing Compost	p.13	p.13	p.13
Planting Area Compost	p.14	p.14	p.14
Mulch Cover Compost	p.15	p.15	p.15
Backfill Mix Compost	p.16	p.16	p.16
Erosion Control Compost	p.17	p.17	p.17
Sediment Filter Compost	p.18	p.18	p.18

Scope

What products?
There are many soil and compost products on the market today, in bagged, bulk, natural and manufactured forms. The guidelines are a screen through which any product may pass as long as it fits the objectives of the guidelines. If the screen is well built it can become the basis for evaluating all soil and compost products in Nova Scotia.

What uses?
There is some experience and information yet to be gathered and the current guidelines try not to exceed the limits of our present knowledge. Although soils and composts are used widely in residential gardens and agricultural fields, we have not yet created use categories for food crops. We have already had a demand for this, and once enough information is gathered this may be added in the future. We also understand that there may be specialty soils and composts for particular uses, but we have started with larger use categories and we intend to add others as expertise and resources permit over time. As new research and experience reveal best practices they will help refine the guidelines.

What maintenance levels?
The guidelines have been formed with the view that soil and compost products cannot be described in isolation from their intended use and eventual maintenance. Therefore each section of the soil guidelines describes products for a particular use and maintenance level. All maintenance levels are considered appropriate for a successful landscape, as long as you select the proper soil accordingly.

What about other guidelines, standards, and specifications?
Each section of these guidelines will provide the acceptable values for each parameter that should be considered in selecting a soil or compost. These guidelines do not describe the details of installation. Landscape Nova Scotia has already prepared landscape installation standards for topsoil, seeding, sodding, trees and shrubs. These guidelines should be read in conjunction with the installation standards to ensure success of the carefully selected soil and compost products.

These guidelines seek voluntary involvement from industry, government and the public, and they are meant to complement other guidelines, standards, and specifications. We recognise that other valuable local experience and requirements should be upheld. We hope that wherever parties agree to adopt the guidelines, soil and compost use will be improved. As guidelines are increasingly followed and incorporated into specifications documents and projects, they may become norms or standards.

Glossary

"A" horizon topsoil: The use of on-site topsoil is encouraged if it will not adversely affect the requirements for the soil medium. The "A" horizon includes the accumulated organic matter and is often distinguished from lower soil layers by its' darker colour. With appropriate amendments where necessary, this is a valuable component of the growing medium.

Soil: According to the Canadian System of Soil Classification, Third Edition, soil is the naturally occurring, unconsolidated, mineral or organic material at the earth's surface that is capable of supporting plant growth.

Compost: According to the Canadian Council for Ministers of the Environment, compost is a solid mature product resulting from composting, the managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic stage. For these guidelines, we refer to category "A" compost according to CCME guidelines (see Appendix C) unless stated otherwise. See the section on "General Compost Information" to learn more about compost products.

Growing medium: This medium is any natural or manufactured soil, soil substitute, or mixture whose chemical and physical properties fall within the ranges required.

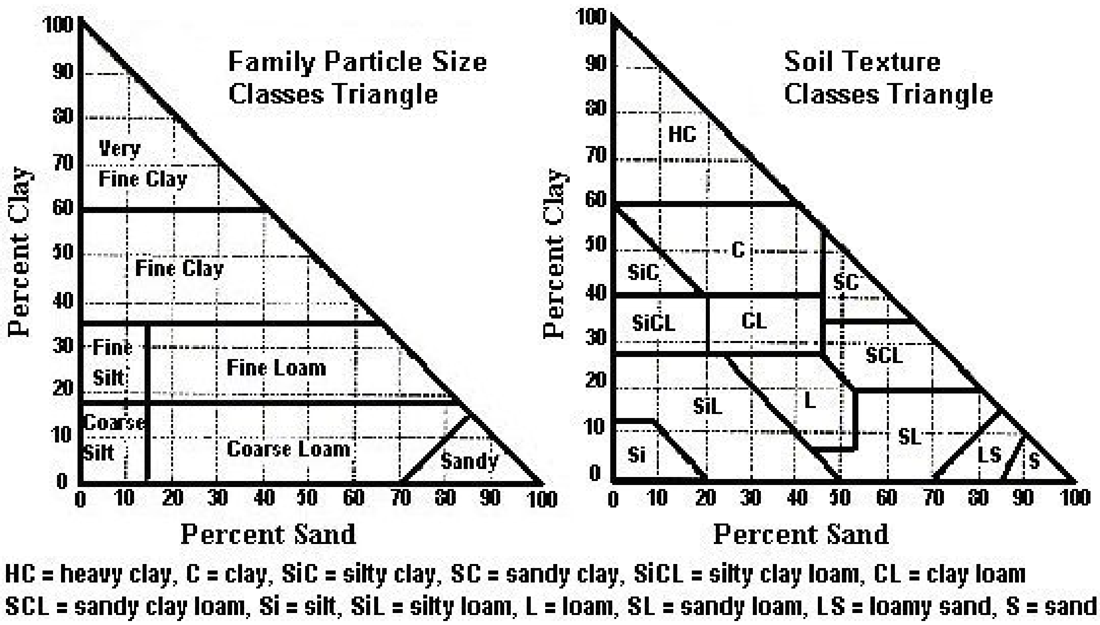
High (H) maintenance areas: For these areas, the textural classification for growing media by the System of Soil Classification will tend to be "loamy sand" or "sandy loam". These growing media are designed for rapid drainage and increased resistance to compaction, but require a higher level of maintenance to ensure adequate moisture and nutrient availability. Topdressing will often be required, irrigation is recommended in all instances and is necessary for all areas "on slab" or under cover.

Moderate (M) maintenance areas: For these areas, the textural classification for growing media by the Canadian System of Soil Classification will tend to be "sandy loam" or "loam". These media create a balance between good drainage, and water/nutrient retention and are suited to moderate, normal maintenance practices. Topdressing may be required periodically, and irrigation is recommended, however such areas can be adequately managed through appropriate use of manual irrigation.

Low (L) maintenance areas: For these areas, the textural classification for this growing medium by the Canadian System of Soil Classification will tend to be "loam", "silt loam", or "clay loam". These soils have greater water and nutrient retention and produce results that are equivalent to medium and high maintenance areas if there is proper initial plant selection and organic amendments. Percolation and resistance to compaction will be reduced therefore some control of use may be necessary, especially during wet conditions. Topdressing is rarely necessary and irrigation may be provided, but more frequently only temporary watering is done for establishment purposes.

Salt sensitive plants: Particularly in relation to compost use, these are some examples of salt sensitive species (plants preferring salt concentration below 0.8 dS or mmhos); beans, carrots, onions, peas, apple trees, blackberries, sweet cherries, raspberries, and strawberries. Compost can still be used with these and other sensitive plants, but large additions of high salt compost should be avoided or the compost should be watered beforehand to remove salts.

Canadian System of Soil Classification Soil Particle and Soil Textural Triangles: A textural class description of soils can tell a lot about soil-plant interactions, since the physical properties of soils are determined largely by texture. In mineral soils, the cation exchange capacity is related closely to the amount of silt and clay in the soil. The water holding capacity is determined in large part by the particle size distribution. Fine textured soils with a high percentage of silt and clay hold more water than coarse textured sandy soils. Finer textured soils are more compact, have slower movement of air and water, tend to warm up more slowly, and can be difficult to maintain under heavy usage. However the relationship between soil textural class and soil productivity cannot be applied to all soils, since soil texture is only one of the many factors that influence plant growth.



Coarse Gravel: Particles between 19 - 40mm ($^{3}/_{4}$ - $1^{1}/_{2}$")

Fine Gravel: Particles between 2 - 19mm ($^{1}/_{8}$ - $^{3}/_{4}$")

Sand: Particles between 0.05 - 2mm (0.002 - $^{1}/_{8}$") Sand can be further subdivided into a range of particle sizes and shapes that may be important for your particular needs.

Silt: Particles between 0.002 - 0.05mm (0.00008 - 0.002")

Clay: Particles below 0.002mm (below 0.00008")

Soil Use Guidelines

When starting a landscaping project, soil is often one of the first considerations. Soil must be in place before planting seeds or installing plants, and soils will help determine what will thrive on your site. If there is a shortage of soil, or the soil is not appropriate for your goals, you will need to assess other sources. These soil use guidelines may be helpful in selecting new soils for your landscape.

You can also use the guidelines to identify problems with your existing soil and help determine what products might improve outcomes. You may test your soil periodically and come back to the guidelines to verify that your soils are suited to your needs.

Whether in natural or manufactured forms, soils can vary a great deal. Natural soils vary depending on climatic conditions, local geology and geography, and according to the plants and animals that interact with soils. Manufactured soils also vary greatly depending on the natural components that are selected for blending with manufactured composts and other common amendments. You will want a soil or soil product that meets the needs of your particular plants and wildlife.

Plants for example have specific soil requirements, some prefer acidic rather than basic soils, some prefer excellent drainage while others prefer high moisture retention, and all have certain nutrient requirements and a need for minimum soil depths. These soil guidelines indicate the appropriate soil parameters for different uses and maintenance levels. The guidelines are written primarily for turf since this is currently the largest landscape use for soils. There is also a section for planting beds and more use categories will be added over time.

Some basic requirements apply to all soils and should be considered for all soil product and use decisions. Your soil medium should be free of sticks, construction materials, wood chips, plants including their roots, pollutants or other foreign substances toxic to plants or animals. It should not contain any other materials that will detract from the desirable properties of a soil for landscaping purposes.

The specific measures set out in this section are based on the general soil information provided with the soil and compost use guidelines. This information, and the specific values set for each parameter, are the result of input from local landscapers, soil manufacturers, government staff, and academic researchers. Starting with an excellent soil will lead to much greater success in your landscaping efforts.

SOIL FOR LOW TRAFFIC LAWNS

PROJECT DESCRIPTION
Low traffic lawn areas include typical home lawns or public lawn areas subjected to occasional pedestrian traffic, but no sporting activities. These soils will help you establish a lawn groundcover on sloped or level areas, shoulders and other spaces by seeding or sodding. The selected soils should be used in conjunction with the LNSHTA Seeding, Sodding, and Topsoil Installation Specifications.

SOIL MEDIUM
This soil medium takes advantage of the reduced threat of compaction, and favours increased nutrient and water holding capacity.

Maintenance:	H	M	L
	Measures for entire growing medium		
Total Nitrogen	0.1-0.2%	0.2-0.4%	0.4-0.6%
Available Phosphorus	30-100ppm	30-100ppm	30-100ppm
Available Potassium	50-500ppm	50-500ppm	50-500ppm
Carbon : Nitrogen	Up to 25:1	Up to 25:1	Up to 25:1
Coarse Gravel (19-40mm)	0-1%	0-1%	0-3%
All Gravel (2-40mm)	0-5%	0-5%	0-10%
Organic Matter (OM)	>2%	>3%	>5%
Acidity (pH)	6.0-7.0	6.0-7.0	6.0-7.0
Drainage	No standing water 90 minutes after heavy rain or watering		Grading for drainage
	Textural qualities excluding gravel and OM		
Sand (0.05-2mm)	50-70%	40-60%	30-50%
Silt (0.002-0.05mm)	10-25%	15-35%	20-45%
Clay (less than 0.002mm)	5-20%	10-25%	10-30%
Clay and Silt Combined	30-50%	40-60%	50-70%

MINIMUM SOIL DEPTH *

Maintenance	Over Prepared Subgrade which retains A Horizon	Over Prepared Subgrade where the Subsoil Drains Rapidly	Over Prepared Subgrade where the Subsoil Drains Slowly
High	100mm (4")	150mm (6")	150mm (6")
Low	150mm (6")	200mm (8")	225mm (9")

*Note: These are finished soil depths, rolled or firm to foot-printing, therefore an allowance of 20% settling is often required when ordering soil products by volume.

SOIL FOR HIGH TRAFFIC LAWNS

PROJECT DESCRIPTION
High traffic lawn areas may include institutional properties, some home lawns, or public lawn areas subjected to regular pedestrian traffic and occasional recreation activities. These lawn areas may be established on sloped or level areas, shoulders and other areas by seeding or sodding. The selected soils should be used in conjunction with LNSHTA Seeding, Sodding, and Topsoil Installation Specifications.

SOIL MEDIUM
This soil medium will have a relatively high structural strength but will require more care due to lower water and nutrient holding capacity.

Maintenance:	H	M	L
	Measures for entire growing medium		
Total Nitrogen	0.1-0.2%	0.2-0.4%	0.4-0.6%
Available Phosphorus	30-100ppm	30-100ppm	30-100ppm
Available Potassium	50-500ppm	50-500ppm	50-500ppm
Carbon : Nitrogen	Up to 25:1	Up to 25:1	Up to 25:1
Coarse Gravel (19-40mm)	0-1%	0-1%	0-3%
All Gravel (2-40mm)	0-5%	0-5%	0-10%
Organic Matter (OM)	>1%	>3%	>5%
Acidity (pH)	6.0-7.0	6.0-7.0	6.0-7.0
Drainage	No standing water 60 minutes after heavy rain or watering		Grading for drainage
	Textural qualities excluding gravel and OM		
Sand (0.05-2mm)	70-80%	60-70%	40-60%
Silt (0.002-0.05mm)	10-25%	15-35%	20-50%
Clay (less than 0.002mm)	5-15%	5-20%	10-25%
Clay and Silt Combined	20-30%	30-40%	40-60%

MINIMUM SOIL DEPTH *

Maintenance	Over Prepared Subgrade which retains A Horizon	Over Prepared Subgrade where the Subsoil Drains Rapidly	Over Prepared Subgrade where the Subsoil Drains Slowly
High	100mm (4")	150mm (6")	150mm (6")
Low	150mm (6")	200mm (8")	225mm (9")

*Note: These are finished soil depths, rolled or firm to foot-printing, therefore an allowance of 20% settling is often required when ordering soil products by volume.

SOIL FOR RECREATION AREAS AND SPORTSFIELDS

PROJECT DESCRIPTION
This section will enable you to establish turf for recreational sportsfields and play areas where intensive pedestrian traffic and cleated footwear is anticipated. This soil may also be used in topdressing sportsfields for leveling purposes, keeping in mind that the soil should be the same as the existing field soil to avoid layering effects. The selected soils should be used in conjunction with the LNSHTA Seeding, Sodding, and Topsoil Installation Specifications.

SOIL MEDIUM
This soil medium provides high structural strength to help resist compaction, and to enhance drainage for improved use and availability after rainfall. The nutrient and water retention capacity is reduced by lower clay content but this is accepted to accommodate the high impact use.

Maintenance:	H	M	L
	Measures for entire growing medium		
Total Nitrogen	0.1-0.2%	0.2-0.4%	0.4-0.6%
Available Phosphorus	30-100ppm	30-100ppm	30-100ppm
Available Potassium	50-500ppm	50-500ppm	50-500ppm
Carbon : Nitrogen	Up to 25:1	Up to 25:1	Up to 25:1
Coarse Gravel (19-40mm)	0-1%	0-1%	0-3%
All Gravel (2-40mm)	0-5%	0-5%	0-10%
Organic Matter (OM)	>1%	>3%	>5%
Acidity (pH)	6.0-7.0	6.0-7.0	6.0-7.0
Drainage	No standing water 60 minutes after heavy rain or watering		Grading for drainage
	Textural qualities excluding gravel and OM		
Sand (0.05-2mm)	80-90%	60-80%	50-60%
Silt (0.002-0.05mm)	5-15%	10-25%	20-35%
Clay (less than 0.002mm)	5-10%	5-15%	5-20%
Clay and Silt Combined	10-20%	20-40%	40-50%

MINIMUM SOIL DEPTH *

Maintenance	Over Prepared Subgrade which retains A Horizon	Over Prepared Subgrade where the Subsoil Drains Rapidly	Over Prepared Subgrade where the Subsoil Drains Slowly
High	100mm (4")	150mm (6")	200mm (8")
Low	150mm (6")	200mm (8")	225mm (9")

*Note: These are finished soil depths, rolled or firm to foot-printing, therefore an allowance of 20% settling is often required when ordering soil products by volume.

SOIL FOR PLANTING AREAS AND PLANTERS

PROJECT DESCRIPTION
This section will help you establish trees, shrubs, ground covers, and other plants. The selected soils should be used in conjunction with the LNSHTA Trees and Shrubs Specifications, and Topsoil Installation Specifications.

SOIL MEDIUM
This soil medium should meet the requirements for a wide range of plants, however you should ensure that your soils meet the specific needs of your plants.

Maintenance:	H	M	L
	Measures for entire medium		
Total Nitrogen	0.1-0.2%	0.2-0.4%	0.4-0.6%
Available Phosphorus	30-100ppm	30-100ppm	30-100ppm
Available Potassium	50-500ppm	50-500ppm	50-500ppm
Carbon : Nitrogen	Up to 25:1	Up to 25:1	Up to 25:1
Coarse Gravel (19-40mm)	0-1%	0-1%	0-3%
All Gravel (2-40mm)	0-5%	0-5%	0-10%
Organic Matter (OM)	>2%	>4%	>8%
Acidity (pH) ♣	5.5-7.0	5.5-7.0	5.5-7.0
Drainage	No standing water 90 minutes after heavy rain or watering		Grading for drainage
	Textural qualities excluding gravel and OM		
Sand (0.05-2mm)	50-70%	40-60%	30-50%
Silt (0.002-0.05mm)	10-40%	15-50%	20-60%
Clay (less than 0.002mm)	5-30%	5-35%	10-40%
Clay and Silt Combined	30-50%	40-60%	50-70%

♣Some plants including Azaleas may do well in lower pH soils, while for example Viburnum or Juniper may do well in higher pH soils, and you should adjust your soil pH for your plants needs.

MINIMUM SOIL DEPTH *

	Over Prepared Subgrade which retains A Horizon	Over Prepared Subgrade where the Subsoil Drains Rapidly	Over Prepared Subgrade where the Subsoil Drains Slowly
Ground Cover	150mm (6”)	150mm (6”)	225mm (9”)
Small Shrubs	300mm (12")	450mm (18")	450-500mm (18-20")
Large Shrubs	450mm (18")	600mm (24")	600-900mm (24-36")

*Note: These are moderate maintenance finished soil depths, rolled or firm to foot-printing, therefore an allowance of 20% settling is often required when ordering soil products by volume.

Compost Use Guidelines

Unlike soils, compost will not be presented as a growing medium. Compost is primarily used as an amendment for growing mediums, and can also be a product that with a function other than supporting plant and animal growth. As a result, the parameters in this section are different to reflect the important considerations in compost use. As for soils, more parameters may be added over time with our growing understanding of compost products. The use of composts from centralized production facilities is still relatively new and it will take some time to determine all of the measures that indicate their value in landscaping.

Composts and composting are currently regulated in Nova Scotia by the provincial Department of Environment and Labour, according to the Canadian Council for Ministers of the Environment (CCME) Guidelines for Compost Quality. The CCME Guidelines for Compost Quality are designed to protect human health and the environment. This is one critical consideration in selecting a compost product, and we only endorse the use of compost that has met provincial approval. Appendix C contains more detailed information on the regulation of compost and the classification of these products into CCME "A" and "B" categories.

In general, compost should be a well-decomposed, stable, weed-free organic matter source. It should be derived from agricultural, food, or industrial residuals, treated biosolids, yard trimmings, or source-separated or mixed solid waste. The compost must not contain any sharp foreign matter measuring over 3mm in any dimension or any foreign matter greater than 25mm in any dimension.

Although this is subjective, compost should not possess any objectionable odours. A well-decomposed compost should have an earthy smell regardless of the feedstocks used, whereas an immature compost could smell like fresh manure or decaying feedstock materials. In some cases this may not be a concern, but in others odours may be an important consideration. For all compost parameters it is best to clearly communicate expectations and requirements so that producers and consumers continue to build excellent experiences with these products.

Even composts that meet all of these criteria can vary in ways that are significant to landscaping. Compost may be screened to different sizes for particular uses, composts from certain feedstocks or with different nutrient content may have particular benefits. The physical characteristics of composts, especially moisture and bulk density, will be important operational considerations.

The measures set out in this section are based on the general compost information described at the end of the soil and compost guidelines. As for the Soil Use Guidelines, the information and measures are based on a wide range of input from local landscapers, soil manufacturers, government staff, and academic researchers. Composts are rapidly becoming a major component of local landscapes and it is important that these products are used in the best possible way.

COMPOST FOR ESTABLISHING LAWNS

PROJECT DESCRIPTION
This will consist of incorporating compost within the root zone to improve soil quality and plant growth. This applies to all types of turf establishment methods including seeding, sodding, and hydroseeding.

COMPOST MEDIUM
In addition to the measures below, this compost should have no objectionable odors and should not resemble the raw material from which it was derived.

Parameter	**Range**
pH	5.5 - 8.0
Moisture Content	35% - 60% on a fresh weight basis
Organic Matter	Over 35% of dry weight by loss on ignition test
Total Nitrogen	Over 1% of dry weight
Particle Size	Pass through a 1.27cm (1/2") screen or smaller
Compost Quality: Grade A or B according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Trace elements (mg/kg of dry compost): As<75, Cd<20, Co<150, Cr<1060, Cu<760, Hg<5, Mo<20, Ni<180, Pb<500, Se<14, Zn<1850 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^{o}C above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	4.0 dS (mmhos/cm) for laying sod, less than 1.25 dS (mmhos/cm) for seeding, seedlings, or salt sensitive species.

COMPOST DEPTH AND METHODS
These methods should be used in conjunction with the LNSHTA Seeding, Sodding, and Topsoil Installation Specifications. A 2.5 to 5cm (1-2") compost layer should be uniformly applied over the entire area and incorporated to a depth of 12.5-17.5cm (5-7") for a 20% to 30% inclusion rate using a rotary tiller or other appropriate equipment. Higher inclusion rates are necessary for upgrading marginal soils. Fertilizer and pH adjusting agents (e.g., lime or sulfur) may be applied before incorporation. Rake soil surface smooth prior to seeding, sodding, or hydroseeding. The soil surface should be reasonably free of clods, roots, stones greater than 1.27cm (1/2"), and other material which will interfere with planting and subsequent site maintenance. Water thoroughly after seeding, sprigging, or sodding.

COMPOST FOR TOPDRESSING LAWNS & SPORTSFIELDS

PROJECT DESCRIPTION
This guideline describes a compost-sand mix for topdressing sportsfields in order to improve soil nutrients, turf growth, and to relieve compaction. This section may also be used for topdressing low and high traffic lawns, and depending on the method of application and texture of the existing soil, the sand content may be reduced.

COMPOST MEDIUM
Medium should be made from 7 parts by volume of screened, mature CCME Grade “A” compost, and 3 parts by volume of sand. It should be free of any foreign matter over a 3 mm ($^{1}/_{8}$”) dimension that could cause injury. The compost should contain over 1% nitrogen, and over 40% organic matter on a dry weight basis. In addition, this compost should have no objectionable odors and should not resemble the raw material from which it was derived.

Parameter	**Range**
pH	5.5 - 8.0
Moisture Content	35% - 50%
Organic Matter	Over 35% of dry weight by loss on ignition test
Total Nitrogen	Over 1% of dry weight
Particle Size	Pass through 1.25cm (½”) screen or smaller. The sand should be prepared from crushed rock, washed and screened to consist of not more than 3% fine gravel (particles > 2mm), at least 60% medium and coarse sand (particles from 0.05-2mm), not more than 5% silt (particles from 0.002-0.05mm), and not more than 3% clay (particles <0.002mm).
Compost Quality: Grade A according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Trace elements (mg/kg of dry compost): As<13, Cd<3, Co<34, Cr<210, Cu<100, Hg<0.8, Mo<5, Ni<62, Pb<150, Se<2, Zn<500 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^{o}C above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	4.0 dS (mmhos/cm) for most areas, less than 1.25 dS (mmhos/cm) with seeding, seedlings, or salt sensitive species.

COMPOST DEPTH AND METHODS
Compost should be uniformly applied over the entire area at an average depth of 1.25cm (½”) using a topdressor or other appropriate equipment. Higher inclusion rates are necessary for upgrading marginal soils. Prior to topdressing, the field should be heavily aerated and mowed to a height of 5cm (2”). Topdressing should not be done when the field is wet, and topdressing should be followed by dragging to help incorporate the material into aeration openings. Overseeding can be done on the same day before topdressing application, unless seeding will be done with equipment that can place seed directly into the soil. Seeding should be done at a time of year that is ideal for germination, unless the area can be watered every day that there is insufficient rain, until the groundcover is established.

COMPOST FOR PLANTING BEDS

PROJECT DESCRIPTION
This will consist of incorporating compost within the root zone in order to improve soil quality and plant growth. This guideline applies to all types of plantings, including trees, shrubs, vines, ground covers, and herbaceous plants.

COMPOST MEDIUM
In addition to the measures below, this compost should have no objectionable odors and should not resemble the raw material from which it was derived. For acid loving plants, only use a compost that has not received additional liming agents or ash by-products.

Parameter	Range
pH	5.5 - 7.0
Moisture Content	35% - 60%
Organic Matter	Over 35% of dry weight by loss on ignition test
Total Nitrogen	Over 1% of dry weight
Particle Size	Pass through 2.5cm (1”) screen or smaller
Compost Quality: Grade A according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Trace elements (mg/kg of dry compost): As<13, Cd<3, Co<34, Cr<210, Cu<100, Hg<0.8, Mo<5, Ni<62, Pb<150, Se<2, Zn<500 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^{o}C above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	2.5 dS (mmhos/cm) for most established plants, less than 1.25 dS (mmhos/cm) for seeds, seedlings, or salt sensitive species.

COMPOST DEPTH AND METHODS
Compost should be uniformly applied over the planting area at an average depth of 2.5 to 5cm (1-2”). Uniformly incorporate the compost to a depth of 15-20cm (6-8”) using a rotary tiller or other appropriate equipment. Lower compost application rates may be necessary for salt sensitive crops or where composts with higher salt levels are used. Pre-plant fertilizer and pH adjusting agents (e.g., lime and sulfur) may be applied in conjunction with compost incorporation as necessary. Rake soil surface smooth prior to seeding, sprigging, sodding, or hydroseeding. The soil surface should be reasonably free of large clods, roots, stones greater than 5cm (2"), and other material which will interfere with planting and subsequent site maintenance. Water thoroughly after planting.

COMPOST AS A LANDSCAPE BACKFILL MIX COMPONENT

PROJECT DESCRIPTION
This will consist of excavating a planting hole and blending compost with the excavated soil to improve soil quality and plant growth. This applies to all types of bare root, containerized, balled, and burlapped plant material.

COMPOST MEDIUM
In addition to the measures below, this compost should have no objectionable odors and should not resemble the raw material from which it was derived. For acid loving plants, provide only compost that has not received additional liming agents or ash by-products.

Parameter	**Range**
pH	5.5 - 8.0
Moisture Content	35% - 60%
Organic Matter	Over 35% of dry weight by loss on ignition test
Total Nitrogen	Over 1% of dry weight
Particle Size	Pass through 2.5cm (1") screen or smaller
Compost Quality: Grade A or B according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Trace elements (mg/kg of dry compost): As<75, Cd<20, Co<150, Cr<1060, Cu<760, Hg<5, Mo<20, Ni<180, Pb<500, Se<14, Zn<1850 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^oC above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	3.0 dS (mmhos/cm) for most applications, less than 1.25 dS (mmhos/cm) for seeds, seedlings, or salt sensitive species.

Composts containing available nutrients, primarily nitrogen, are preferred, while the use of unstable or immature compost is not approved. Care should be given when using composts possessing a basic pH (>7) near acid loving plants.

COMPOST DEPTH AND METHODS
These methods should be used in conjunction with the LNSHTA Trees and Shrubs Specifications. Uniformly blend compost with existing soil in sufficient quantity to raise organic matter levels to those indicated for planting beds in the soils section of this document (see Appendix B for related calculations). Backfill and firm the soil blend around the root-ball within the planting hole. Water thoroughly during and after planting.

COMPOST AS A LANDSCAPE MULCH

PROJECT DESCRIPTION
This will consist of applying compost to the soil surface after planting to help inhibit weed growth, conserve soil moisture, and reduce soil erosion.

COMPOST MEDIUM
In addition to the measures below, this compost should have no objectionable odors and should not resemble the raw material from which it was derived. For acid loving plants, only use a compost that has not received additional liming agents or ash by-products.

Parameter	Range
pH	5.5 - 8.0
Moisture Content	35% - 60%
Organic Matter	No requirement
Total Nitrogen	No requirement
Particle Size	Acceptable size is based on customer preference and mulching objectives*
Compost Quality: Grade A or B according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Trace elements (mg/kg of dry compost): As<75, Cd<20, Co<150, Cr<1060, Cu<760, Hg<5, Mo<20, Ni<180, Pb<500, Se<14, Zn<1850 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^oC above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	Must be less than 1.25 dS (mmhos/cm) for seeds, seedlings, or salt sensitive species.

*When using compost for mulching, specific products may be considered more physically or visually acceptable for a given planting area. Coarser-textured compost mulches are more effective in reducing weed growth and preventing water and wind erosion.

COMPOST DEPTH AND METHODS
Compost mulch should be uniformly applied over the entire area at an average depth of 5-7.5cm (2-3") as soon as possible after weed removal and planting. Avoid placing mulch against the trunk or stem of any plant material. Water thoroughly before and after mulching to saturate the root zone and entire mulch layer. All stones, roots, or other debris larger than 5cm (2") should be removed from the surface of the mulched area.

Generally, biosolids composts should not be applied at a depth greater than 5cm (2"), while most yard trimmings composts can be applied to a depth of 7.5cm (3").

COMPOST AS A SOIL MULCH FOR EROSION CONTROL

PROJECT DESCRIPTION
This will consist of applying compost to a sloped surface to stabilize soil and reduce erosion, or to enhance riparian buffer areas.

COMPOST MEDIUM
In addition to the measures below, this compost should have no objectionable odors and should not resemble the raw material from which it was derived.

Parameter	**Range**
pH	5.5 - 8.0
Moisture Content	35% - 60%
Organic Matter	Over 35% of dry weight by loss on ignition test
Total Nitrogen	Over 1% of dry weight if planting or seeding
Particle Size	Less than 1.27cm (1/2') if planting or seeding, less than 5.08cm (2") otherwise since a range of particle sizes is most effective.
Compost Quality: Grade A according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Trace elements (mg/kg of dry compost): As<13, Cd<3, Co<34, Cr<210, Cu<100, Hg<0.8, Mo<5, Ni<62, Pb<150, Se<2, Zn<500 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^{o}C above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	Must be less than 1.25 dS (mmhos/cm) for seeds, seedlings, or salt sensitive species.

COMPOST DEPTH AND METHODS
Compost mulch should be uniformly applied to a minimum depth of 7.5 to 10cm (3-4”) to slopes of up to 1:2 in steepness. Slopes with problem soils and more runoff will require greater application rates. In areas of lower precipitation, application rates of 5cm (2”) may be acceptable. Spread the compost uniformly, then compact the compost layer using appropriate equipment. Alternatively, use blowing equipment to project compost directly on the soil surface, thereby preventing water from moving between the soil-compost interface. Apply compost layer approximately 1m (3’) over the top of the slope or overlap it into existing vegetation. On highly unstable soils, use compost with appropriate structural and diversion measures.

COMPOST AS A FILTER BERM FOR SEDIMENT CONTROL

PROJECT DESCRIPTION
This will consist of constructing a raised berm of compost on a soil surface to contain soil erosion**,** control the movement of sediment off site, and to filter storm water.

COMPOST MEDIUM
In addition to the measures below, this compost should have no objectionable odors and should not resemble the raw material from which it was derived.

Parameter	Range
pH	5.5 - 8.0
Moisture Content	35% - 60%
Organic Matter	Over 35% of dry weight by loss on ignition test
Total Nitrogen	Over 1% of dry weight if planting or seeding
Particle Size	Less than 1.27cm (1/2') if planting or seeding, lass than 5.08cm (2") otherwise, and a variety of sizes within this range create a stable berm.
Compost Quality: Grade A for filtering, Grade B for basic sediment control, according to current NSDEL regulations (see Appendix C, only finished compost measures are presented here)	Grade A trace elements for filtering (mg/kg of dry compost): As<13, Cd<3, Co<34, Cr<210, Cu<100, Hg<0.8, Mo<5, Ni<62, Pb<150, Se<2, Zn<500 Grade B trace elements for sediment control (mg/kg of dry compost): As<75, Cd<20, Co<150, Cr<1060, Cu<760, Hg<5, Mo<20, Ni<180, Pb<500, Se<14, Zn<1850 Maturity: C/N ratio < 25 Oxygen uptake < 150mg O_2/kg of volatile solids per hour cress and radish seed germination showing no phytotoxic effects no reheating to greater than 20 ^{o}C above ambient temperature Foreign material: no sharp foreign matter over 3mm in any dimension, or any foreign matter over 25mm in any dimension Pathogens: faecal coliforms <1000 most probable number/g of total dry solids salmonella sp. < 3 most probable number/4g total dry solids
Soluble Salt Concentration	Must be less than 1.25 dS (mmhos/cm) if seeds, seedlings, or salt sensitive species will be planted on or adjacent to the berm.

COMPOST VOLUME AND METHODS
Parallel to the base of the slope or other affected areas, construct a 54cm to 72cm (1½ -2’) high by 144cm (4’) wide berm of compost. For maximum water filtration ability, construct a 54cm to 72cm (1½ to 2') high trapezoidal berm which is 108cm (3’) wide at the top and 144cm (4’) wide at the base. In extreme conditions and where specified by a Landscape Architect/Designer, a second berm can be constructed at the top of the slope or silt fencing can be installed in conjunction with the compost berm. If used, the silt fence fabric should be laid on the soil surface with the lip facing up slope. The compost berm should be constructed at the base of the sediment fence and over the fence fabric lip. Do not use filter berms in any runoff channels and reconstruct a berm after deterioration.

General Soil Information

INTRODUCTION

We hope this section containing general soil information will help you understand the guidelines and help explain the parameters and measures we have identified. This section also explains some of the soil properties that are not included in the guidelines, and just because these are not included in the guidelines does not mean that they are less important. In the future, some of these additional soil properties may be included to improve our soil selection and maintenance practices. For now we can describe all components of the soil so we begin to understand the complete soil system.

Sometimes it will seem that soils are overwhelmingly complex, but it is important to work through this information carefully. Sometimes too little information can be dangerous in that it leads to the false sense that there are simple answers to your landscape problems. The more you understand the soil system, the more you will be able to quickly identify solution "packages" that might be necessary when there are several problems with your soil. Detecting and addressing the real problems rather than guessing may prevent unnecessary inputs and costly renovations.

We have organized this general soil information into physical, chemical, and biological soil components, followed by a discussion of organic matter, and activities that build healthy soils. Each of these soil elements are inter-related and we hope that by the end you will have a better understanding of how they come together in soil processes that help plants grow.

In the end, focusing on soil health should become a key component in all landscape management programs. Our view is that the best defense against pests, disease, and other landscape problems is to create the right conditions for healthy soil and plant processes. The soil system is essential to plants, and soil health is something we can easily influence through our creation and maintenance of landscapes.

PHYSICAL COMPONENTS

Our discussion starts with the physical building blocks of soils that will be home to important chemical processes and soil organisms. Soil is made up of various sized particles that are classified as sand, silt, and clay. Each particle class contributes to different soil features and generally some of each is necessary for a healthy soil.

Sand

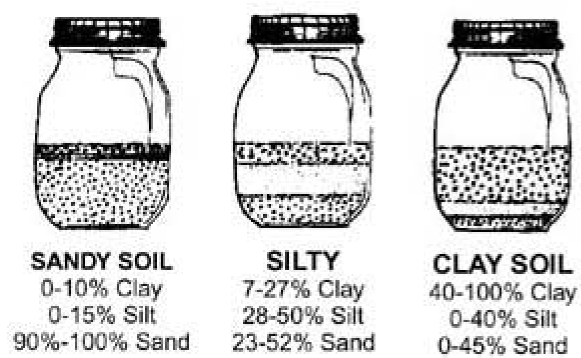
The largest particles are sand; they range from 0.05 - 2mm (0.002 - $^{1}/_{8}$") and come in many different shapes. Under heavy traffic, sandy soils still tend to retain spaces between particles and allow air into the rootzone and water to drain quickly through the soil. Sand particles do not stick together, they feel gritty when wet and tend to stay loose and workable. They do not compact easily, they are often easy to dig, and they tend to warm up early in the season. However, sandy soils hold very few nutrients or water, do not help bind soil particles into soil aggregates, may be too hot during the middle of summer, and are susceptible to rapid changes in pH.

Silt

This particle is smaller than sand, ranging from 0.002 - 0.05mm (0.00008 - 0.002"). Under heavy pedestrian traffic, they can compress leaving less space between the particles, thereby allowing less air and water to pass through them. When these particles are wet, they do clump together more than sand, and they tend to feel slippery. Silt holds more nutrients and water, but drains more slowly and compacts more easily.

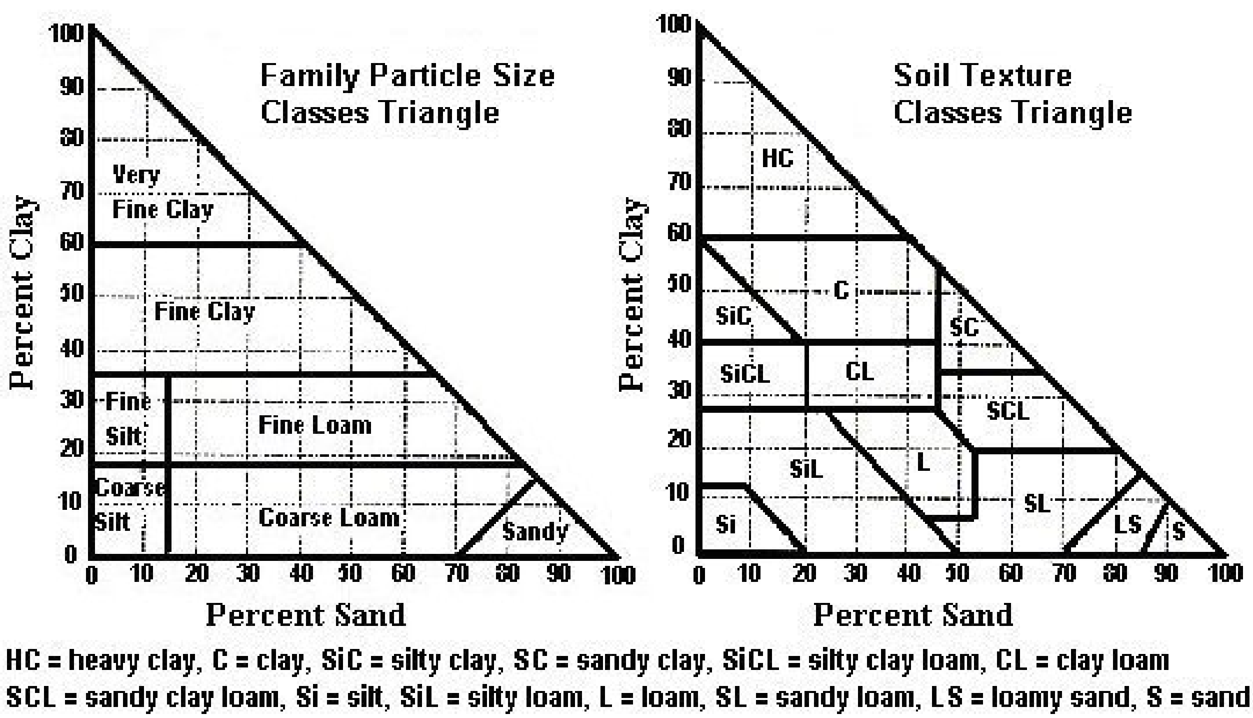
Clay
Clay particles are the smallest in size and are all below 0.002mm (below 0.00008"). These particles bind to each other very well and can form large aggregates. A wet clay soil can be shaped into a ball with a smooth surface, or rolled without falling apart. Clay particles are often considered more difficult to cultivate and are the most susceptible to compaction. Clay soils hold the most water and nutrients but may be slower to warm up in the spring.

Texture
Most soils are a combination of sand, silt and clay, especially in landscaped areas. Soil texture reflects the combination of sand, silt, and clay, and can often be determined by feel. Gritty feeling soil is sandy or coarse textured, while smooth or slippery feeling soil with more silt and clay content is fine textured. Blends of sand, silt, and clay create different soil types that have been identified through a Canadian system of soil classification (below).



You can put a cup of your soil in a glass jar (tall and narrow jars work best) to help estimate how much sand, silt, and clay is present. Use three parts water with one part soil, shake the jar and let it sit for 24 hours, then you will see three layers appear in the jar. The bottom layer is the sand because it is heaviest and settles first, then silt, then clay particles are the smallest and lightest on top. You can roughly estimate what percentage of each is in your soil to determine soil texture using the chart below. If you need a precise measure, soil testing labs will be better equipped to determine your soil type (see Appendix D).

Canadian system of soil classification texture and particle size triangles



There are several soil properties that are influenced by soil texture including aeration, water holding capacity and drainage, temperature, and nutrient retention and availability. Each of these characteristics influences the growth of your plants and the type of plants that will thrive in your soil.

Aeration is determined by the pore spaces (porosity) in your soil. Greater soil porosity will provide more aeration to roots and microorganisms that are important for plant health. Sand particles do not stick together so they tend to maintain the spaces between them even when subject to pedestrian traffic or recreational use. Silt and clay are able to stick together in soil aggregates, but these may deteriorate under heavy pedestrian traffic. However, silt and clay soils with good aggregation can be highly aerated compared to sandy soils.

Water holding capacity is important for resisting drought, but lower water holding capacity may also be helpful for resisting compaction in high traffic areas. Water holding capacity is again related to pore space, where sandy soils retain less water and drain quickly, while silt and clay soils tend to hold more water and drain more slowly. Your desired water holding capacity and drainage properties will be determined by the intended use and the amount of traffic you will expect.

Temperature will be determined in part by the water holding capacity of the soil since it takes more energy from the sun to warm a wet soil than it does to warm a dry soil. Therefore the finer texture silt and clay soils that retain more water tend to take longer to warm up. This may be a problem in the spring when you want your plants to start growing, but a cooler soil in the hot summer months may help microorganisms and your plant roots continue to function well. Temperature has a significant influence on the level of microbial activity in the soil, where warmer soils will have higher activity up to a certain point. Higher microbial activity will lead to more rapid decomposition of organic matter. The increased activity may help release nutrients but organic matter in sandy soils does not last as long as it does in silt or clay soils.

Nutrient holding capacity is partly related to soil texture, where the amount of surface area on particles is important for binding nutrients. Smaller particles like silt and clay have more surface area relative to their size; therefore they are able to hold more nutrients, while larger sand particles are very poor for nutrient retention.

Properties of sand, silt, and clay soils

Soil Texture	Particles	Aeration	Water Holding	Drainage	Temperature	Nutrient Holding
Sand	Large	Narrow*	Low	Fast	Hot	Low
Silt	Small	Wide*	High	Slow	Warm	Medium
Clay	Very Small	Wide	High	Very slow	Cool	High

* The range of aeration provided by sand will be narrow while the range provided by silt and clay is wide and depends on the amount of traffic. Sandy soil porosity will be lower than for soils with more silt and clay, unless these are subjected to heavy traffic.

In our region you would not want only sand, silt, or clay, but the right balance of each which will result in good overall soil properties for your use. The various particles will also combine into soil aggregates to give additional benefits through improved soil structure.

Structure

Soil structure is determined by the way sand, silt, and clay particles combine, often with organic matter, to form soil aggregates or "clumps". Soil structure cannot be determined at the installation stage; it will be something that develops over time. Structure starts with sand, silt, and clay particles that clump together in different shapes, but aggregation is improved by insects and other microorganisms working through the soil and digesting different materials, freezing and thawing of your soil, wetting and drying of the soil, and the formation and decomposition of organic matter. Good soil structure will help with aeration, water holding and drainage, nutrient holding, and the degree of resistance to root growth.

You can help the development of soil structure by "feeding" the worms, insects, fungi, and other organisms that help develop soil structure. In particular, helping organisms decompose organic matter will contribute to improved soil structure since organic matter is used to form the most stable soil aggregates. As mentioned earlier, silt and clay can bind together with sand to form soil aggregates, but these are more easily broken apart by rain and traffic than aggregates that include organic matter.

Structure will be negatively impacted by the use of heavy equipment on your soil and by heavy pedestrian traffic. If you know the texture of your soil, you can indirectly monitor the structure by measuring the bulk density of your soil. Bulk density is the weight of soil for a given volume, and is usually measured in grams per cubic centimeter. You can calculate an approximate measure of bulk density by measuring several soil cores from your lawn or field. Air dry the soil and weigh it, if you know the volume of each core, you can determine the weight per cubic centimeter of soil. The following table shows the normal bulk density ranges for different soil types, and the typical limits beyond which root development will be inhibited.

Normal and problematic soil bulk densities according to soil texture

	Bulk Density (g/cc)	
Soil Texture	**Normal Range**	**Range for Root Problems**
Sandy Loams and Sands	1.2 - 1.6	over 1.7
Clay Loams and Silt Loams	1.1 - 1.4	over 1.6
Clay	1.0 - 1.3	over 1.4

Texture and structure may affect the types of plants that will do best in your soil. You want to create the best conditions for your plant so it will out-compete others that may try to live there. For instance, soils contain seeds that are always waiting for the right conditions to germinate, while other seeds are carried to your soil by the wind or animals. Light sandy soils often help drought loving plants such as crab grasses and sedums (succulents). On the other hand, heavy soils susceptible to compaction are home to prostrate knotweed and annual bluegrass. We have identified balanced soils for different uses and expected maintenance of lawns in this set of guidelines, if you know what conditions your particular plants need you can use the information here to create the best possible soil blend.

Amendments

If you already have a soil that you want to work with on-site, you may wish to amend the soil to help your plants. The "General Compost Information" section will give a comparison of different soil amendments, but a few ideas are presented here. If you are going to amend your soil with sand, silt, or clay to change the texture, try to incorporate the amendment deep into your soil. Adding the amendment to the top of your soil may lead to layering problems that prevent proper drainage and aeration throughout the entire root zone. Topdressing can be done in conjunction with aeration, but renovation or establishment of a lawn or planting area is the best time to work those amendments deep into the soil.

Depth

In addition to having the right texture, structure, and organic amendments in your soil, you must determine how deep your soil should be. In general, the depth of your soil should be more than the maximum root depth of your plants. Shallow soils may lead to fibrous surface roots that will suffer during drought periods, and will not form a stable anchor for your plant. Deeper soils will have greater water storage capacity and will allow the formation of deep tap roots that penetrate to lower water reserves. We have indicated in the guidelines that if you have a deeper soil you will not need to water your soil as much and you can still expect successful results. Water is so important for maintaining plant structure (avoiding wilting), gas exchange (water is used and lost when taking in carbon dioxide), and in nutrient uptake (nutrients are often suspended in water and that is taken into roots). The next section will talk more about nutrients and soil chemistry.

CHEMICAL COMPONENTS

Soil chemistry is very complex and only the main nutrients, fertility factors, and maintenance options are briefly described here. Soil chemistry builds on the physical elements of soils and will also be tied to the next section on biological elements of soils.

Fertility
Fertility refers to the availability of nutrients in your soil. Nutrients are categorized into macro and micro-nutrients, and we will present these nutrients, their sources, and some of the factors that affect their availability in soils.

There are six nutrients that are considered macro-nutrients for almost all plants, meaning they are needed in relatively large quantities. These macro-nutrients include nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg). Plants also require many micro-nutrients, where smaller quantities of these are needed but they are just as important. Plants will generally suffer if any of the following six micro-nutrients are not available; iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), and molybdenum (Mo). Just like humans, plants need a balanced diet of nutrients, and health will be compromised if these nutrients are in short supply. If for example no boron is available, a plant may suffer reduced growth no matter how much NPK fertilizer is added, the plant will be restricted by the limiting nutrient.

Although all nutrients are important, only the three nutrients described in the guidelines will be discussed in detail here. In general, consult other reading material or a professional for advice suited to your plant needs.

Nitrogen
Nitrogen is required for all parts of plant growth, and is often in short supply especially if plants are "harvested". In a turf system for example, we have the option of harvesting by bag mowing and moving the clippings off-site, or we can choose to leave clippings on the lawn. Clippings contain all of the nutrients your plant requires including nitrogen, and when they work back into the soil they are converted to organic matter by soil microorganisms. Organic matter will store some of the nutrients and some will be released for plant growth. Mulch mowing to leave the clippings on the lawn will usually reduce nitrogen fertilizer requirements by half.[1] Leaving nutrients to cycle in the soil-plant system is the easiest and most effective way of fertilizing.

Adding organic amendments such as manure or compost is a specialized version of the natural breakdown of plant and animal material that occurs naturally in the soil. We simply harvest the plant or animal material and break it down in a formal composting process then return it to the soil system. This will build up the storage of nutrients in the soil and release some nutrients directly for plants.

We can also get nitrogen from the air, which contains approximately 78% nitrogen. This is done naturally by microorganisms that convert the air's nitrogen into forms that are used by plants, in a process called nitrogen fixation. Nitrogen fixation is mostly performed by microorganisms that live in the roots of legume plants, but it is also performed by microorganisms that live freely in the soil. If a lawn soil contains a healthy population of nitrogen fixing microorganisms and the turf clippings are returned to the soil, this can eliminate your need for nitrogen fertilizer.

The industrial process that creates fertilizer uses fossil fuels to help capture or "fix" nitrogen from the air. This is the most expensive means of adding nitrogen to the soil, but is currently a widely used and simple method for providing nitrogen.

In the guidelines, we have specified minimum nitrogen levels for successful soils, but we have also indicated maximum carbon to nitrogen ratios. If an amendment with a large amount of carbon is added to a soil, the nitrogen in the amendment or even in the soil may be temporarily tied up by microbial breakdown of the carbon material. This is known as nitrogen immobilization and it will prevent nitrogen from reaching your plants, preventing them from growing. We have set the carbon to nitrogen limits at 25:1 since this is the limit for compost manufacture in Nova Scotia and composts are commonly blended with soils. However, if the carbon to

[1] Patriquin, D.G., D.A. Reid, and B.D. Walsh. 1996. *The Oaks Experiments on Organic Management of Turf. Final Industry Report.* Published by Edmonds Landscape and Construction Services Ltd., Halifax, Nova Scotia, Canada.

nitrogen ratio of your soil is greater than 15:1 you may need to address a potential nitrogen immobilization problem, or avoid adding any further high carbon amendments.

Phosphorus
This nutrient is also required in relatively large quantities by plants, since it is found in every plant tissue. Phosphorus is usually abundant in soils, but phosphorus is bound very tightly by the soil so most available phosphorus is taken up by microorganisms, and only small amounts are available to plants. The advantage is that phosphorus does not leach from the soil very readily, and in fertilized soils it tends to build up over time. The main goal is to create the conditions for it to be released by the soil and microorganisms so plants can benefit from the phosphorus that is already there. The availability of phosphorus is increased by the following; aeration helps break down organic matter to release phosphorus; moisture helps release phosphorus as long as there is not so much that it inhibits break down of organic matter, sandy soils are less able to bind phosphorus so it will be more available but may also be lost through leaching; higher temperatures help release phosphorus through breakdown of organic matter, and the total amount of organic matter and mineral phosphorus in the soil largely determines how much is available.

Potassium
Potassium is important for growth, regulation of plant processes, drought resistance, disease and pest resistance, protection against extreme temperatures, deep rooting and tolerance to traffic. A lot of potassium may be held very tightly in the soil but it is mostly unavailable to plants. About 0.1-2% of the total potassium will be available to plants; the only exception is in sandy soils where it is more available but more easily lost through leaching. The available form of potassium is held at the surface of soil particles and in soil organic matter. The availability depends on soil texture, the total amount of potassium in your soil, and how it is balanced with three other elements (calcium, magnesium, and hydrogen). A heavier silt or clay soil will hold more available potassium than sandy soils, in what is called a cation exchange complex (measured as cation exchange capacity or CEC). Therefore you need enough potassium for your soil, but it must also be in balance with calcium, magnesium and hydrogen. A rule of thumb states that your cation exchange complex should contain 2-7% potassium (K), 10-15% magnesium (Mg), 65-75% calcium (Ca), and the remainder would be 10-20% hydrogen. This means that you may have lots of potassium, but plants will not take it up unless you also have the right amount of the other elements in your soil as well.

Important factors
In addition to the factors mentioned for each nutrient above, the following factors will influence overall nutrient availability.

Soil water is important for dissolving nutrients in a soil solution that plants can absorb through their roots. There must also be enough water to support a flow of water to the roots and through the plants to satisfy water loss through the leaves. Without this supply, the plant will not function properly in order to take in and use nutrients.

Soil temperature is important for microorganisms that help decompose organic matter and release nutrients into the soil. Plants also prefer certain temperatures, and the spring and fall temperatures in Atlantic Canada (5-15°C) are when plants function well and take up nutrients for growth.

Soil organic matter has a significant role in nutrient availability since it contains nutrients and will support the activities of microorganisms that help make nutrients available to plants.

Soil pH will partly determine how tightly phosphorus and trace elements are held by your soil. The ideal ranges are different for each element, but most are available between pH 6 and 7. This is the basis for the pH measures in the guidelines, except in the "soil for planting areas and planters" where you may wish to grow a wide variety of plants. In that case you may ask about the soil pH that is suited to your particular plants. Raising the pH is commonly the first step to improving soils in Atlantic Canada. Most soils in this area need maintenance amounts of limestone every few years once a desirable pH has been reached. Typical maintenance amounts would be 25 kg per 100 square meters. Pelletized and powdered lime is equally effective, and although pelletized lime is more expensive it is easy to apply using a drop spreader. Lime does not change your soil pH immediately; it may take 6 months or a season to influence soil pH unless you are able to incorporate it deep in your soil.

Fertilizers

After everything has been done to build up your soil reserves of nutrients and the right conditions have been set for microorganisms to help release those nutrients to your plants, you may still need additional nutrients. As mentioned above, various fertilizers are available for specific soil and plant needs, and they are indeed a major part of the landscape trades industry. Their benefits are widely known, so it is important here to present some tips in order to avoid unexpected problems.

First, be aware that adding fertilizer in large amounts can "burn" your plants, not because they set fires, but because they leave salt residues in the soil. Fertilizer salts react in the soil to increase acidity, and this acid will "burn" the roots of your plants. This will also be a problem for many small fertilizer additions over the long term; you will have to include lime with your fertilizer program, especially on sandy soils that have very little ability to resist pH changes.

You should also be aware that inorganic nitrogen, the form of nitrogen taken up by plants, is not held tightly in the soil and it is estimated that up to 30% of your fertilizer nitrogen can be lost from the soil if the plants do not immediately take it up. Not only is this a loss of your investment, but nitrogen will leach from the soil and harm nearby waters. This has been a significant concern for landscaping around lakes and rivers, but also with respect to wells for drinking water. To prevent these problems you may look for slow release fertilizers and organic fertilizers that more effectively release nutrients in coordination with plant needs.

Lastly, excessive fertilizer use has been associated with decreased resistance to pests and disease. This is sometimes due to the attraction of pests to lush growth, but it is also related to the unnatural growth response to the addition of nitrogen fertilizer. Nitrogen is generally used for shoot growth (the part of your plant that you see above ground), and sometimes fertilization will boost shoot growth at the expense of resources for root development. This may put your plants in a weakened state for tough weather conditions, pests and disease.

You can improve fertilizer effectiveness and minimize negative impacts by fertilizing only when your plants will take up the nutrients. This means spring and fall growth periods are good times for fertilization and sometimes a late fall application will lie dormant over the winter and be ready for uptake in the spring. Take care with all types of fertilizers to ensure they are not applied to hard surfaces such as driveways or frozen soil. This will minimize losses from being washed away by the rain. In all cases, follow the directions for use on product labels and abide by applicable laws in your area.

Keep in mind that there are two ways to influence nutrient availability for your plants, you can feed nutrients directly to the plants, or you can feed the organisms in your soil that will make stored nutrients available to your plants. With the development of fertilizers, there has been a tendency to feed the plants directly, bypassing natural processes; however the other approach has historically been the common way to improve fertility. The approach of feeding the soil organisms is regaining support, and we will describe this more in the next section on biological elements.

BIOLOGICAL COMPONENTS

Unfortunately it is difficult to measure biological activity of a soil at the installation stage. There is also far more information on the biology of soils, so this only highlights some topics. This will hopefully ensure that you start with a soil that will be a good home for soil organisms, even if it may take some time to build up these components. There are ways of monitoring soil biological activity over time and eventually we may even be able to better assess the biological outcomes of a particular soil at the installation stage.

Just because it is difficult to measure does not mean that it is not important. Soil is alive and teaming with organisms and they do a tremendous amount of beneficial work for free. They help make nutrients available to plants when they grow, and help breakdown plants into organic matter when they die. This is a very close-knit cycling of energy and nutrients and it is the most effective and efficient means of supporting plant growth on a sustained basis. This section will help you understand how to take care of this hidden work-force in your soils.

Soil organisms are responsible for the decomposition of organic matter, the release of nutrients for plant uptake, turning nitrogen from the air into plant available forms, the creation of soil aggregates, improved soil tilth, and defense against many pests and diseases.

Macro-organisms
The groups of large soil organisms or macro organisms include earthworms, beetles, ants, centipedes and many others. These are the first to tackle the leaf and plant debris on the surface of the soil. They incorporate this into the soil as they digest it and create food for other organisms. Many of them are also beneficial predators of plant pests.

Earthworms are one of the best-known macro-organisms, given their benefits to soil and plant health. As earthworms burrow through the soil they help form soil aggregates, aerate the soil, improve water infiltration and breakdown organic matter into forms usable by plants. Studies have shown that earthworms can increase the availability of soil calcium by 59%, potassium by 19%, magnesium by 39%, and phosphorus by 165%. Earthworms particularly enjoy the turf environment where they feed on dead grasses. Earthworms do not live at the extreme ends of the soil texture range; they prefer a loam over a sand or clay soil.

Many other soil macro organisms perform specialized tasks that help each other and the plants that depend on them. Plants will benefit from nutrient release, improved soil structure and tilth, regulation of gases and water infiltration rates. They will also help prevent pests and disease since beneficial organisms will out-compete intruders or even consume them directly.

Micro-organisms
Smaller organisms such as bacteria, fungi, protozoans, and algae continue the work of macro organisms by further decomposing materials and releasing nutrients for plant growth. Although they cannot be seen without a microscope, one teaspoon of soil can contain a billion bacteria, a million fungi, and several thousand algae.

Bacteria are largely responsible for the conversion of nitrogen in the air to usable forms for plants. Higher plants and animals would cease to exist if bacteria disappeared. Bacteria may do this freely in the soil or by living directly in the roots of legume plants. The roots give the bacteria a home in exchange for their ability to provide nitrogen. Through this relationship, they can supply up to half of the nitrogen requirements for a turf and legume blended lawn or garden.

Important factors
Populations of soil organisms rise and fall as the conditions change in soils over time and depending on use and maintenance of the landscape. Balanced soil texture, organic matter, suitable pH, climate and microclimate conditions, moisture, aeration, recycling of plant material and fertility factors can all improve the health of your soil organisms. Among other things, salt residues, acidity, excess nutrients, and pesticides may inhibit or kill beneficial organisms. This may lead to reduced plant health or additional costs to replace the services that these organisms provided.

ORGANIC MATTER

Organic matter has been discussed in many ways throughout each section so far, and it actually deserves its own section. Organic matter is central to so many physical, chemical, and biological properties of soils that it could be the keystone of your soil management program. Indeed the promotion of organic matter as a basic soil amendment has been greeted with widespread acceptance by many gardeners and landscapers.

Organic matter is any dead plant or animal material that alive or moving through various stages of decomposition. When organic matter has fully decomposed and the original plant or animal material is no longer recognizable, it is called humus. About 90% of humus by weight is carbon, hydrogen and oxygen. Humus particles are smaller than clay therefore they have incredible capacity for nutrient exchange, moisture retention, and binding of soil particles to form pore spaces and reduce erosion. Any dead plant or animal material mixed with the right microorganisms will eventually turn to humus under appropriate conditions. This is a natural process that is essential for returning nutrients and energy to soils.

Physical components of your soil are the first to benefit from addition of organic matter. Organic matter will increase water holding capacity on a sandy soil or improve drainage on a clay soil. Organic matter will also improve soil aggregation helping to aerate soils and prevent soil erosion. Organic matter will bring physical benefits regardless of soil texture. Although, it should be noted that organic matter will break down more rapidly in a sandy soil therefore some of the benefits will not last as long.

Chemical components will also benefit from increased organic matter. Organic matter can influence pH and bind nutrients just like smaller soil particles. Many biological and chemical processes occur on the surface of organic matter particles. Organic matter stores and releases many important nutrients as your plant needs them. While fertilizers provide a large amount of selected nutrients, organic amendments provide smaller amounts of many nutrients.

Biological components of soils will respond to the physical and chemical improvements that result from additional organic matter. It also provides carbon, a basic building block and energy source for living organisms. Many sources of organic matter, such as compost, will even add organisms to the soil to help build soil processes.

For these reasons, organic matter is a valuable component of soil amendments, as discussed in the next section.

SOIL AMENDMENTS

Soil improvement is a continual process, and it often takes 5-10 years to make a productive garden soil. There are many things that we can use to amend the soil in order to create better conditions for plants and organisms. Many soil amendments focus on the addition of organic matter to soils.

Properties of some soil amendments

Amendment	Permeability	Water Retention
Coarse Peat	low-medium	very high
Wood chips	medium	low-medium
Softwood bark	high	medium
Seaweed	high	medium
Compost	low-medium	medium-high
Aged manure	low-medium	medium
Vermiculite	high	high
Perlite	high	low

Some of these are very good amendments but may be derived from non-sustainable practices, when compared with manure or compost for example. Compost is perhaps the best organic amendment since it is renewable and can be purchased or made easily on-site by composting yard prunings and clippings.

Be aware that organic amendments can be sources of weed seeds. To avoid weed introductions, use only well composted materials and keep them covered if they are to be stored for any length of time.

Before planting lawns, trees and shrubs, add organic materials to the soil. Where perennial and annual plantings like flowers and vegetables are grown, the soil can be amended every year.

Fall is an excellent time for the addition of these materials, giving them time to work into the soil over winter, and time for soil organisms to help incorporate the amendment into soil processes. Mulches in garden areas of chopped fallen leaves or other soil amendments will add to soil organic matter levels and site conditions.

SOIL TESTING

All of the measures in the guidelines can be determined through soil tests. You can ask your local garden center for more information about test kits or where lab testing can be done. We have provided contact information for several labs in Nova Scotia (Appendix D**).** Since soil tests are very simple and cheap, they are recommended before you make any major maintenance or renovation decisions. If you have problems with your plants, a soil test is an excellent starting point for determining corrective measures. Laboratories will supply recommendations if you specify what plants you are trying to grow.

Many plants, both "weed" and desired species, can also be helpful in pointing out certain soil conditions.[2] This can be useful to someone who is attempting to diagnose and correct turf/garden problems. You will need to arm yourself with a guidebook on weeds of Nova Scotia or a similar resource from your local bookstore, garden centre, or the Internet. When using plants as indicators keep in mind the following considerations:

- There are limitations to using plants as indicators of soil conditions. Many plants are very adaptable across a wide range of conditions. Therefore, it is advisable to also use other diagnostic tools such as soil testing.
- Do not use single plants to judge a condition, use plant communities. If possible, rely on more than one species to confirm a soil condition.
- Use the healthiest plants as indicators since stunted and weak plants may be growing on the edge of their preferred conditions.
- Perennials are the most reliable since they must live longer in one place. Annuals may be useful but since they often disperse seed over a wide area, they are likely to appear over a wider range of conditions.

Turf / soil conditions and plants that may be useful indicators [3]:

Droughty conditions:	Silvery cinquefoil, rabbit foot clover, wild mustard, prostrate pigweed, common speedwell, leafy spurge
Excess moisture:	Creeping buttercups, corn chamomile, coltsfoot, cudweed, docks, goldenrod, lady's thumb, ox-eye daisy, plantains, mosses
Low pH:	Eastern bracken, silvery cinquefoil, hop clover, rabbit foot clover, coltsfoot, English daisy, ox-eye daisy, dandelion, docks, hawkweeds, knawel, prostrate knotweed, lady's thumb, common mullein, nettles, wild pansy, plantains, radish, sheep sorrel, wild strawberry
High pH:	Bladder campion, wild carrot, corn chamomile, mustard, sow thistle, nodding thistle
General low fertility:	Wild carrot, common mullein, wild parsnip, wild radish
Low nitrogen:	Clover species, black medic, vetch species
Low phosphorus:	Eastern bracken
Low potassium:	Eastern bracken, corn chamomile, yarrow
Compaction:	Wild carrot, pineapple weed, broadleaf plantain
Mowing too low:	Annual bluegrass, chickweeds, speedwell, moss, creeping bentgrass
Not enough sunlight:	Moss, mouse-ear chickweed, common chickweed, creeping speedwell

WORKING WITH SOILS

These guidelines began with the view that initial soil and compost selection should be mindful of your intended use and maintenance, so this is an opportunity to briefly tie in some ideas on maintenance. There are many

[2] Willison, M. 2001. *HRM Sustainable Gardening and Landscape Maintenance*. Prepared for Halifax Regional Municipality. 65 pp.
[3] Hill, S.B., and J. Ramsay. 1977. *Weeds as indicators of soil conditions*. Macdonald J. 38(6):8-12.

maintenance practices for your lawn or garden, but these are the main ones specific to soils and building a healthy soil and plant system. These practices are only suggestions since local landscape knowledge and different landscape uses may determine particular maintenance needs. The maintenance practices presented here are also geared toward lawns since the maintenance of garden beds and planting areas will be specific to your plants.

Onsite recycling

Save as much energy and material on your site by recycling local resources. Recycling can take on many forms, the main ones are mulch mowing to return lawn clippings, composting prunings, and mulching or composting other leaf and yard "waste". Recycling these into your landscape will improve soil health in the following ways.

- Increased soil fertility
- Increased organic matter
- Improved soil structure
- Improved water retention or drainage depending on soil type

If you have identified such things as compacted soil, weak or thin turf, excessive thatch development, or poor fertility then you can take some steps to build your soil and eventually reduce these problems. Improving soil fertility, loosening the soil, and adding organic matter are often best addressed in the fall for lawns and many perennial landscapes.

Organic mulches and topdressings

We have discussed fertilizer, lime, and organic topdressings in the sections above, but we can also consider some other mulches and topdressings here. Some materials that are also suitable as surface mulches or topdressings include bark, wood residues, and chopped leaves. Often they contribute to soil humus levels over the longer term, perhaps in three to five years. In the short-term these mulches often suppress weed growth and prevent weed seeds from germinating. The most effective mulches for this purpose are often coarse materials such as bark and wood chips. Other mulches, such as chopped leaves may be less effective in weed suppression but may help stimulate organisms in the soil that will help desirable plants grow. Mulches applied to the surface of the soil may also reduce temperature fluctuations or increase the winter survival of some plants.

Mowing practices

Proper mowing is essential to the health and appearance of your lawn, and it also influences several soil properties. Even though it seems to be a basic cultural practice, mowing is often the primary cause for decline in lawn quality and appearance. Mowing your lawn improperly will severely reduce turf vigor and increase susceptibility to weeds, insects and diseases.

Height of mowing can have an effect on soils since the depth of rooting is related to the height of the turf shoots. Higher shoots will generally lead to deeper roots, and deep rooting will help loosen deeper soils, bringing water and air deeper in the soil, and bringing nutrients up to the surface. Raising the height will also help shade your soil to keep it cool and retain more moisture. While this can be practiced any time of the year, the fall is the period of greatest root growth for turfgrasses so it is important to let the turf grow during this period so that turf energy can be put into root development. A closely mowed lawn may appear to be attractive but results in a turf less tolerant to environmental stresses and one that is slower to recover from pest problems. Intensively maintained turf, such as golf course fairways, are able to withstand a lower mowing height because of more intense management practices. Unless you have specific landscape uses, the healthiest mowing height for a blended lawn is 5-7.5cm (2"-3"). It is important that cutting height be measured and adjusted carefully since the actual height of cut may lower as mower wheels compress and settle into the lawn. The height may be lowered to 4.25-5cm (1-3/4"-2") for the first mowing of the year to remove debris and promote spring green-tip, and also at the end of the season for over wintering.

Frequency of mowing should be determined by the growth rate of the turf. Lawn mowing should be frequent enough to ensure that no more than 1/3 of the grass leaf blade is clipped off in a single mowing. Removing more than 1/3 of the leaf blade will make it more difficult for soil processes to break down the clippings, and large cuts cause stress to the turf plants. Cutting a very small amount will also lead to problems since mowing does stress the turf plants. When turf is cut, it will lose more water and will be more susceptible to certain diseases. The "1/3 guide" is especially important during periods of midsummer stress; so let turf grow to 10cm (4") then cut to a finished height of about 7cm (2-2/3").

Clippings do not need to be collected when the "1/3 guide" of mowing frequency and proper mowing height is practiced. If excessive growth has occurred, raise the mowing height and gradually establish the 5-7.5cm (2"-3") mowing height. Collecting lawn clippings removes the valuable nutrients from decomposing grass material. Leaving clippings does not increase thatch build-up; the primary contributors to thatch accumulation are the roots and belowground stems.

Mower blades should be kept sharp, this will make a clean, even cut whereas a dull blade tears the ends of the grass, leaving ragged or shredded tips. Mowing with a dull blade gives your lawn a brown look and makes it more susceptible to a variety of diseases. It is important to note that not all new mowers have sharp blades. Dull blades have also been shown to increase gasoline consumption by 22%, and to increase watering requirements.

Cultural practices to avoid include; mowing faster than a normal walking pace (prevents a clean cut), mowing when grass is wet (prevents a clean cut and helps spread many fungal diseases), mowing when the engine is not running properly (prevents a clean cut), and mowing in the same pattern or direction (increases soil compaction and ruts in the lawn).

Alleviating Soil Compaction

Healthy soil requires pore spaces for air exchange to occur. This is easier to maintain in a garden where you have better access to the soil and there are less traffic problems. Lawns however are often subject to pedestrian traffic and sometimes-even vehicles. Excessive pressure on soils will force the air and water out of the soil pore spaces and will compress the soil to a higher bulk density. Compaction creates difficulties for air and water to move through soil, and this will result in reduced biological activity in the soil and poor plant growth.

Mechanical aeration is a method for correcting soil compaction by pulling cores out of soil, or by slicing the soil to create openings. Your lawn will benefit from mechanical aeration in the following ways:

Soil compaction will be relieved by creating holes that loosen the soil, providing growth conditions, which favor turf rather than weeds. Aeration allows the air in the soil to exchange with the atmosphere, stimulating root growth and increasing shoot growth.

Water savings may result since core aeration reduces surface water runoff and allows better penetration of water into the soil.

Thatch can be reduced to acceptable levels by aeration. A small layer of thatch ($^1/_4$" to $^3/_4$") is acceptable and even beneficial. This thin layer of thatch acts as a cushion to the crown of the turf plants and also shades the soil and roots of the turf from intense summer sun. If your thatch is 3/4" or more, this accumulation can harbor turf-damaging insects and diseases as well as reduce the vigor of the turf. Aeration helps to keep your thatch layer at a desirable level.

Timing and frequency of aeration is important for the health of your lawn and soil. For most lawns, aeration once a year will correct soil compaction, thatch build-up, and associated problems. Aeration can be done during most of the growing season, as long as your soil is moist enough to ensure deep penetration. If the coring is done late in the fall, the holes should be filled to prevent winter injuries. Do not over-aerate your lawn since excessive aeration may stimulate weed growth either by exposing soil to weed seeds that travel to your area, or by bringing weed seeds up to the surface where they find the right conditions for germination. To help avoid these problems, it might be helpful to overseed and/or topdress with compost after aeration so desired species or materials are likely to fill in those spaces before weeds do.

While compaction can be alleviated with cultivation practices, keep in mind that increasing the soil organic matter levels will reduce the ability of the soil to become compacted in the first place. The organic matter helps to maintain space through improved aggregation and conditions for soil and plant organisms to help reduce compaction through their growth and activity.

Overseeding

Many people establish lawn cover by sodding since this is the most rapid way to achieve full cover in a new area. However, this is expensive and sometimes there is no need to establish immediate cover or full cover, therefore seeding and overseeding are still common practices. Overseeding is an opportunity to influence what plants dominate your landscape and to promote a more suitable balance of ground cover species. For lawn areas, we want mixes that compete well in the local conditions and meet the functional and aesthetic requirements of the landscape. Some species are more adapted to certain light, temperature, or soil conditions. A functional requirement may be to have a thick hardy ground cover that will help cushion the impact of traffic and reduce soil compaction. Also, a deeper root system will help to bring nutrients to the surface where they will start to cycle in the upper soil layers. Some plants, namely legumes will even bring nitrogen into the soil system. We can choose seeds to meet these goals, and there are several things you can do to improve the success of your overseeding efforts.

Thatch is the thin layer of decomposing plant material on top of your soil, the top spongy material in a soil core. If thatch levels are less than 7mm (¼") then light dethatch followed by overseeding, topdressing, and a diligent watering regime may be sufficient. Too much thatch will prevent seed-soil contact, so if thatch level is over 7mm (¼") then you should prepare the soil first.

Soil Preparation with a power dethatch or vigorous hand-raking in the worst areas will remove excess thatch and expose soil for better seed contact with the soil. You may also aerate depending on soil conditions and use the power dethatch to break up cores on the soil surface. Top dress with 1.25cm - 2.5cm (½-1") of soil or compost depending on soil conditions.

Seed selection is the starting point for successful overseeding where seed should match your site conditions. Your local seed distributor will have suggestions; however some general information is available here. Where heavy traffic is anticipated, such as for sportsfields or playgrounds, select a 50% ryegrass mixture with some aggressive bluegrass seed and decreased fine fescue. For areas under shade increase the fine fescue content and shade tolerant ryegrasses and bluegrasses. For open sunny areas consider higher bluegrass content, but maintain some other turf types for a competitive blend. All seed mixes should have low weed seed content and high germination rates. For clover overseeding to improve soil nitrogen levels, Dutch White Clover has worked well.

Seed distribution with a drop or broadcast spreader, should be done at the appropriate rate for your site. If seeding to fill in a thin turf, use approximately 5-6lbs/1000 sq ft, and if using clover, apply ¼ lb/1000 sq ft. It is preferable to mechanically mix seed into the prepared soil; do not use a fan rake to incorporate seed as this leaves bare areas in some places. If an area cannot be treated mechanically due to terrain or other considerations, use a hard rake pushing in one direction only to avoid leaving bare areas. Roll the entire area to ensure seed-soil contact. If you are seeding in dry conditions or wind and sun exposed areas, you may want to hydro seed or hydro mulch after overseeding. The next critical step is maintaining adequate water for successful germination and seedling survival.

Watering is the most critical activity following seed application. You will want to maintain moisture for the next three weeks. Do not miss a day of watering during this period unless there has been sufficient rain on that particular day. The best time to water is in the morning before sunrise, if your schedule does not permit this, or you do not have a sprinkler with a timer, this may be difficult some mornings. Late afternoon is the second best time for watering and it would even be necessary to water both times on hot days or in areas that need more water. Watering in the evening must be avoided because this leaves the lawn moist all night, making it easier for fungal diseases to establish. Aim for frequent light watering, especially on hot or windy days, and especially in areas of the lawn that are sloped or highly exposed to the sun. It is best to monitor the soil surface and water when the soil begins to dry out. From the third to sixth weeks after seeding, and when the seeded areas begin to fill in with new growth, you may reduce the watering to just 2 or 3 times per week, but water more thoroughly each time. In all this is a 5-6 week process to ensure that your investment grows.

Mowing can begin when you switch to watering only 2-3 times per week. The new areas will grow high and you can begin mowing, initially with a bag mower so that grass clippings do not smother new growth. At this point you may also want to spot-seed any remaining bare or thin patches to ensure that all areas grow in evenly. When the turf fills in to the same thickness as the rest of the lawn, you can stop bag mowing and regain all the benefits of grass clippings being recycled back to the lawn.

Watering

Many important soil processes require water, and plants need for water for a variety of functions. Water helps to dissolve nutrients and trace elements into a soil-water solution so they become available to soil organisms and plants. Once your lawn or garden is established, it may still be occasionally necessary to water the soil for these purposes. Also, plants require water for gas exchange through their leaves, for maintaining plant structure, and for many internal processes. During growth periods and dry periods, plants water needs can be very large. When you water, it is better to water less often but deeply rather than regular small amounts. Thorough watering deep into the soil will encourage deep rooting of plants so they will be more tolerant of drought periods. Deep roots will also tap into deeper soil nutrients and help bring them to the surface where they can begin to cycle in the soil-plant system.

As mentioned in the overseeding section above, it is best to water first thing in the morning when it is cool, rather than lose a large portion of your water during the heat of the day. Early in the morning, the water will soak into the soil and any excess left on leaf tissue will dry off during the day, leaving fewer opportunities for fungal diseases to establish. If you cannot water first thing in the morning, wait until it has cooled somewhat at the end of the day, but do not wait until late evening. Fungal diseases will develop on leaves that are left wet all through the night and over time this may cause problems.

Pest and disease control

From a soil perspective and ultimately a plant health perspective, you want to use least toxic methods of pest and disease control. We will not go into any great detail here, since there are many excellent resources on this subject. If you have done an excellent job of building up soil texture and structure, organic matter and nutrients, and productive soil organisms, you will likely have a very healthy and resilient turf. This will reduce your need for pest and disease control measures. But if you do encounter a problem, seek out the best practices that will not harm the beneficial elements of your soil system that you have worked hard to build up.

General Compost Information

INTRODUCTION

Our understanding of compost is growing quickly, and it is growing very quickly in Nova Scotia. Since Nova Scotia was one of the first state or provincial jurisdictions in North America to ban organics from landfills, we are one of the first to see the use of these products. This is not to say that composting is new, agriculture has used compost for ages, but opportunities now exist that were not there before. Large quantities of organic matter were once buried in landfills or flushed into waterways, and they are now being turned into resources. Simply the availability of compost in such large quantities opens new possibilities for use, and expands the possibilities for traditional uses.

We hope that as you follow the text in this section, you will understand what compost is, how it is made, what the benefits of compost are, how it compares to other products, how to identify a good compost, and how to use that compost to get the results you want.

What is compost?
Compost is the product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material from which it originated. Compost is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer.

The current working definition of compost for the Canadian Council of Ministers of the Environment is: "A solid mature product resulting from composting, which is a managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic stage."

What is composting?
Composting decomposes and transforms organic material into a soil-like product called humus. The composting process uses microorganisms such as bacteria and fungi to break down the organic materials. Composting is a managed version of the natural breakdown of organic materials that occurs in natural soils, so that we can compost certain materials and accelerate the outcome.

The organisms that help produce compost require oxygen, moisture, and food in order to grow and multiply. When these resources are maintained at optimal levels, the natural decomposition process is greatly accelerated. Microbes generate heat, water vapor, and carbon dioxide as they transform raw materials into a stable form of organic matter, meaning it will not tend to breakdown any further. Composting is typically characterized by a high-temperature phase that sanitizes the product and allows a high rate of decomposition, followed by a lower-temperature phase that allows the product to stabilize while decomposing at a slower rate.

For the process to work best, it is important that the microorganisms have a continuous supply of organics (food), water, and oxygen. Managing the temperature of the composting material is also important to make the process work well. It is important to give the microorganisms a “balanced diet” of organics. Although most organic materials provide all of the nutrients for the microorganisms to grow, they grow best particularly with certain levels of carbon (C) and nitrogen (N). Excellent results have been achieved with C:N ratios of 25:1 or 30:1, but they can be as high as 40:1. Higher levels will significantly slow the process or lead to an immature product; lower ratios may result in lower nitrogen in the finished product. Paper, leaves and wood are high in carbon while grass clippings and vegetable scraps are high in nitrogen. Combining the correct “mix” of carbon and nitrogen materials in the composting “recipe” helps to get the best results.

Compost feedstocks
Quality composts are being produced from many different materials or *feedstocks*. Typical feedstocks include agricultural by-products, yard trimmings, biosolids (sludge), food by-products, industrial by-products, and

municipal solid waste. Some of these feedstocks, such as biosolids must be blended with wood chips, sawdust, paper, biodegradable packaging, etc. to enhance the composting process. The majority of composters in North America use agricultural by-products, yard trimmings, or biosolids. If prepared properly, composts produced from various feedstocks will be somewhat similar in nature and function. There are some exceptions where certain feedstocks lead to compost with some unique characteristics.

It should be understood that the qualities of a particular compost are not indicative of the quality and characteristics of all products produced from that same feedstock. For instance, if you use a yard trimmings compost that is not fully stabilized and immobilizes available nitrogen in the soil, you should not assume that all yard trimmings-based composts would have the same effect. As far as quality and usefulness of compost are concerned, it is typically more an issue of the quality of composting than it is an issue of feedstock.

As mentioned, compost can be produced from almost any organic feedstock but there are some limitations. Do not include meat, fish or bones (except in certain composting systems with regulatory approval), plastics, metals, glass, fats and oils, dairy products, pet waste, cheese, or sauces.

Agricultural by-products can include manure and bedding from various animals, animal mortalities, crop residues, cull fruits and vegetables, and processing/packaging by-products. Composts produced from agricultural by-products, especially manures, are known for generally possessing higher nutrient concentrations as well as elevated salinity levels. They are typically low in contaminants and are commonly available in both bulk and bagged form.

Yard trimmings compost consists of grass clippings, leaves, weeds, twigs, brush, tree and shrub pruning, Christmas trees, and other vegetative matter from land clearing activities and from residential, commercial, and institutional properties. The compost generated may contain one or all of these source materials. Yard trimmings composts are also referred to as "yard waste", "yard debris", or "green waste" composts. Yard trimmings composts are typically lower in nutrients and contaminants. The soluble salt concentration is typically low, but may be elevated where the feedstock is collected in areas where road salts are commonly used.

Biosolids (sewage sludges) are the organic solid residue derived from residential, commercial, or pre-treated industrial wastewater processing. Biosolids are treated to reduce pathogens and contain only minimal levels of heavy metals and organic contaminants. Biosolids composts are fairly rich in plant nutrients and typically possess a pH between 6.0 and 7.5. Some biosolids used to produce compost have been treated with liming agents that can affect pH, buffering capacity, and soluble salts level, thus limiting their horticultural use to a degree.

Food by-products can be obtained from various sources, including food processors and restaurants or institutions, which separate the food by-products from the general waste stream. Although food by-product composting is increasing in popularity, it is currently only a small percentage of the composting industry. Food by-products that are commonly composted included culled or damaged fruits and vegetables, coffee grounds, eggshells, fish residues, bakery items, among others. Composts produced from food by-products are typically rich in plant nutrients, but may also possess elevated salinity levels.

Industrial by-products come from businesses that produce organic residues that have begun recycling materials through composting. Industrial by-products may include wood processing by-products, paper goods, biodegradable packaging materials, pharmaceutical by-products, paper mill sludges, forestry by-products, brewery residuals, and so forth. These materials are typically unique in nature and may possess some excellent properties for plant growth or environmental improvement.

Municipal solid waste (MSW) is typically considered to be mixed residential or commercial refuse that has not been source-separated for the removal of specific recyclable items such as paper, glass, plastics, and so forth. However, in most cases, mixed municipal solid waste that is intended for composting will be processed after collection to have recyclables and household hazardous wastes removed by mechanical or hand separation. MSW composts, especially those containing significant quantities of paper, possess a lower quantity of nutrients and higher pH (7.5-8.0). Because MSW tends to be rich in paper, its compost often has a higher water holding capacity. Communities that source-separate residential wastes usually have lower contaminants and the compost has a higher plant nutrient content.

As composting grows and becomes a better understood science, more and more organic by-products will be used as feedstocks. Although end users will have their own personal preferences regarding the type of product they utilize, it is important to stress that high-quality compost products have been produced from all of the feedstocks described. Not all feedstocks are available in Nova Scotia therefore composts from these materials may not have been produced. As new products are developed, we encourage you to try different types of composts to better determine which product you prefer, based on performance, and which products may be best suited for a specific use.

Composting methods

There are three basic methods for composting, the in-vessel, aerated static pile, and the windrow method. For the in-vessel method, the organic material is composted inside a drum, silo, agitated bed, covered or open channel, batch container or other structure. The process conditions are closely monitored and controlled and the material is aerated and mechanically turned or agitated. The aerated static pile method involves forming compostable materials into large piles, which are aerated by drawing air through the pile or forcing air out through the pile. The pile is not turned. In the windrow method, compostable material is formed into elongated piles, known as windrows, which are turned mechanically on a regular basis.

The length of the process depends on the degree of decomposition desired in the finished product. Typically, an immature compost can be produced in about a month, while a mature compost may be allowed to cure for six months to a year. This choice may depend on how the finished compost will be used and what benefits we might want to capture.

PHYSICAL BENEFITS

This is the first of three broad benefits of using compost, including physical, chemical, and biological benefits. Physical benefits related to the use of compost in your landscape, include the following:

1. Improved soil structure, porosity, and density, thus creating a better plant root environment.
2. Increased infiltration and permeability of clay soils, thus reducing erosion and runoff.
3. Improved water holding capacity, thus reducing water loss and leaching in sandy soils.

Improved structure

Compost can greatly enhance the physical structure of soil. In fine-textured (clay, clay loam) soils, the addition of compost will reduce bulk density, improve friability (workability) and porosity, and increase its gas and water permeability. When used in sufficient quantities, the addition of compost has both an immediate and long-term positive impact on soil structure. It resists compaction in fine-textured soils and increases water-holding capacity and improves soil aggregation in coarse-textured (sandy) soils. The soil-binding properties of compost are due to its humus content. As mentioned above, humus is a stable residue resulting from a high degree of organic matter decomposition. The constituents of the humus act as a soil 'glue,' holding soil particles together, making them more resistant to erosion and improving the soil's ability to hold moisture.

Erosion control

In addition to the binding properties of humus that will create more stable soil structure just described, coarser composts have been used with great success as a mulch for erosion control. Compost mulches have been successfully used on sites where conventional erosion control methods have not performed well. In Europe, fine compost has even been mixed with water and sprayed onto slopes to control erosion.

Moisture management

The addition of compost may provide greater drought resistance and more efficient water utilization. Therefore, the frequency and intensity of irrigation may be reduced. Recent research also suggests that the addition of compost in sandy soils can facilitate moisture dispersion by allowing water to more readily move laterally from its point of application.

CHEMICAL BENEFITS

There are several chemical benefits related to the use of compost in your landscape, including the following:

1. Supply of a variety of macro and micronutrients
2. Phytotoxins to suppress weeds (immature composts)
3. Improved cation exchange capacity (CEC) of growing medium, improved nutrient holding
4. Improved and stabilized soil pH
5. Binding of specific pollutants

Nutrients
Compost products contain a considerable variety of macro and micronutrients. Although often seen as a good source of nitrogen, phosphorous, and potassium, compost also contains micronutrients essential for plant growth. Since compost contains relatively stable sources of organic matter, these nutrients are supplied in a slow-release form. On a pound-by-pound basis, large quantities of nutrients are not typical of compost in comparison to most commercial fertilizers. However, compost is usually applied at much greater rates; therefore, a typical application can have a significant effect on soil nutrient availability. Compost also acts more like high-end fertilizers and organic fertilizers since it provides slow, biologically released forms of nutrients. This is best over the long term because the nutrients are more likely to be released when plants need them most. This will reduce the loss of nutrients due to leaching, saving you money and reducing the related impacts on nearby waters. In some cases, combined compost and fertilizer applications have shown that the compost makes the fertilizer programs more effective.

Phytotoxins
Some composts, often immature composts, possess substances detrimental to plant growth (phytotoxins), and they are used to suppress some weeds. A coarse and immature compost may be applied as a mulch for moisture conservation and moderation of soil temperatures, and could have the added benefit of phytotoxins acting as mild herbicides to suppress weeds.

Increased cation exchange capacity
Compost will also improve the cation exchange capacity of soils, enabling them to retain more nutrients and better hold them in the soil. It will also allow crops to more effectively utilize nutrients, while reducing nutrient loss by leaching. For this reason, the fertility of soils is often tied to organic matter levels.

Improved and stabilized pH
The addition of compost to soil may modify the pH of the final mix. Depending on the pH of the compost and of the native soil, compost addition may raise or lower the growing medium pH. The incorporation of compost also has the ability to buffer or stabilize soil pH, whereby it will more effectively resist pH change.

Binding pollutants
Compost has the ability to bind heavy metals and other pollutants, reducing both their leachability and absorption by plants. Sites contaminated with various pollutants may often be improved by amending the soil with compost. The same binding effect allows compost to be used as a filter media for storm water treatment and has been shown to minimize leaching of pesticides in soil systems.

BIOLOGICAL BENEFITS

There are several biological benefits related to the use of compost in your landscape, including the following:

1. Supply of beneficial microorganisms.
2. Control or suppression of certain soil-borne plant pathogens.
3. Degradation of pollutants.

Provides soil biota
The activity of soil organisms is essential in productive soils and for healthy plants. Their activity is largely based on the presence of organic matter. Soil microorganisms include bacteria, protozoa, actinomycetes, and fungi. They are not only found within compost, but proliferate within soil media. Microorganisms play an important role in organic matter decomposition, which, in turn, leads to humus formation and nutrient availability. Microorganisms can also promote root activity as specific fungi work symbiotically with plant roots, assisting them in the extraction of nutrients from soils and the air. Sufficient levels of organic matter also encourage the growth of earthworms and other insects that help increase water infiltration and aeration.

Suppresses plant diseases
Disease incidence on many plants may be influenced by the level and type of organic matter and microorganisms present in soils. Research has shown that increased populations of certain microorganisms may suppress specific plant diseases such as pythium and fusarium as well as nematodes. Efforts are being made to optimize the composting process in order to increase the populations of beneficial organisms.

Degrades pollutants
The organisms found in compost are also able to degrade some toxic organic compounds, including petroleum (hydrocarbons). This is one of the reasons why compost is being used in the bioremediation of petroleum contaminated soils.

COMPOST VERSUS OTHER AMENDMENTS

Comparing compost to other horticultural/agricultural products is not an easy task. The variability of the particular compost and the need to compare effectiveness in a specific application makes comparisons difficult. Within this section is a discussion of various horticultural and agricultural products that are used in conjunction with or instead of compost. This section is included for reference purposes only and as a means to compare the general characteristics of compost to these materials. Following are descriptions of other horticultural/agricultural products.

Peat moss
Peat moss is derived from Sphagnum that grows in bogs and becomes covered with water when it dies. Because of the cold wet climate in which it grows, peat moss accumulates to great depths undergoing partial anaerobic decomposition. Over the years, peat moss has changed both physically and chemically due to harvesting methods and location. Coarse chunky peat with a pH above 5.0 is the best, but often these are not available and finer material is harvested with a pH between 3.3-3.5. This finer peat moss shrinks rapidly and requires two or three times more limestone to neutralize the acidity. Although peat moss initially starts with a high cation exchange capacity, it decreases with time, thus reducing its ability to hold nutrients as the aging process continues. Although peat moss is very consistent and provides high organic matter content, compost may be as good or better for many applications.

Sedge peat or native peat
These amendments consist mostly of sedges and grasses that grow in bogs. When these grasses and sedges die, their tops sink into the water and undergo partial anaerobic decomposition. Since these plants are high in cellulose and contain little lignin, they decompose more rapidly than peat moss and contain few fibers. Although sedge peat and native peat can be used as a substitute for peat moss, they are generally not as satisfactory in nursery applications. Also, they are highly variable from bog to bog and can be equally as acidic as peat moss. The cation exchange capacity of sedge peat and native peat is similar to peat moss.

Softwood bark
This product has become a major source of organic matter for the ornamental horticultural industry. Products including pine, fir, hemlock, redwood, and cypress barks are used throughout different regions of North America. Because they are low in cellulose and high in lignins, they can be used either fresh or can be composted but do not decompose rapidly. Some sawdust is also low in cellulose and can be used in much the same way. However, only coniferous barks with less than 10% cellulose can be used fresh. Coniferous bark with 10% or more cellulose must be composted. For optimum growth, when used as a soil amendment or growing media component, the bark

products should be milled to particle sizes no larger than 5cm (1/2") in diameter. Unlike peat moss, sedge peat, or native peat, the cation exchange capacity of bark improves with age. However, not all barks are the same and their availability is diminishing in certain regions. The landscaping industry not only uses ground coniferous bark as a soil amendment but coarser materials are popular as decorative mulches.

Hardwood bark, sawdust, shavings, or wood chips

These products should never be used in blending potting media unless they have been thoroughly composted. These materials are high in cellulose and high in lignins; therefore, they will deprive plants of available nitrogen. The competition for nitrogen may not be effectively offset by supplying additional nitrogen in a fertilizer program. It is important to note that the use of these materials in field applications should be limited to areas where planting will not occur for several months. Using a fine-textured and well-aged or composted hardwood bark will minimize negative effects.

Topsoil

Topsoil is usually considered the surface or upper part of the soil profile. As in these guidelines, topsoil is often defined by sand, silt, clay, organic matter, trace amounts of nutrients, and other inerts capable of supporting plant growth. However many of the soils purchased as topsoil and used for horticultural applications are not true topsoils. Commonly we manufacture topsoils using mineral soils obtained from below the true topsoil layer. These subsoils are often devoid of organic matter and essential plant nutrients and do not possess the physical structure required for optimum plant growth. These materials are typically processed to remove debris before marketing. In some areas, sand and muck-type materials are sold as topsoils. Neither of these materials possess all of the properties essential for optimum plant growth. Most topsoils that can be purchased today contain less than 2% organic matter, and should be amended over time to improve soil and plant requirements for organic matter.

Manures

Manures from a variety of livestock have been used as a source of nutrients and organic matter on agricultural soils for centuries. Typically these materials have been applied in a fresh form, but are currently available for agricultural and horticultural usage in aged, dehydrated, or stabilized form. Common manure feedstocks include beef and dairy cattle, chicken, turkey, and horse manures. Raw manures are typically more odorous than composted manures, and may still contain viable pathogens and weed seeds. When raw manures are applied, it is suggested that planting be delayed two-to-four weeks after application and incorporation to allow for stabilization. Since raw manure has not been stabilized, the nitrogen is often readily available and subject to leaching. Its organic matter is also subject to more rapid degradation. Composted manures will contain a more stable form of nitrogen and a lower content of organic matter than raw manures.

General comparison of compost to other products

	Compost	Canadian Peat	Native Peat	Mineral Topsoil	Fresh Manure	Ground Pine Bark
Macronutrients	med-high	very low	very low	low	high	low
Micronutrients	med-high	very low	very low	low-med	med-high	low
Soluble Salts	low-med	very low	very low	low	high	low
pH	medium	low-very low	low-very low	medium	medium	low
Bulk Density	medium	low	low	high	high	low
Moisture Holding Capacity	medium	very high	high	low	low-med	low
Organic Matter Content	med-high	very high	high	low	med-high	med-high
Stability in Soil	very good	excellent	excellent	N/A	low-med	good
Microbial Population	very good	poor	poor	poor-good	good	very good

*Note: These are general guidelines and individual products may vary.
N/A = not applicable

Specific comparison of compost to other products

	Compost[1]	Organic Soil[2]	Native Peat[3]	Canadian Peat[4]	Aged Chicken Manure
Organic Matter (%)	46.00	12.00	74.00	97.00	43.00
pH	7.40	7.50	5.20	4.20	---
Soluble Salts (mmhos/cm)	2.23	0.64	0.31	0.07	15.10
Bulk Density (lbs/ft^3)	32.16	70.22	14.26	6.98	39.32
Moisture-Holding Capacity (%)	227.00	53.00	428.00	1,307.00	166.00
Cation Exchange Capacity (meg/100g)	17.30	13.60	4.00	3.10	---

1 = represents a biosolids/yard trimmings compost
2 = represents an organic muck soil
3 = represents a reed sedge peat
4 = represents a Canadian Sphagnum peat moss

Typical characteristics of municipal composts*

Parameter	Typical Range	Preferred Range for Various Applications under Average Field Conditions
pH	5.0 - 8.5	6.0 - 7.5
Soluble Salts	1 - 10 dS (mmhos/cm)	5 dS (mmhos/cm) or below
Nutrient Content (dry weight basis)	N 0.5 - 2.5%	N 1% or above
Water Holding Capacity (dry weight	75 - 200%	100% or above
Bulk Density (dry weight basis)	700 - 1,200 lbs/yd^3	800 - 1,000 lbs/yd^3
Moisture Content (fresh weight basis)	30 - 60%	30 - 50 %
Organic Matter Content (loss on ignition)	30 - 70%	40 - 70%
Particle Size	--	Pass through 5cm (1") screen
Trace Elements/Heavy Metals	--	Meet CCME Guidelines
Growth Screening	--	Meet CCME Guidelines
Stability	--	Meet CCME Guidelines

* Municipal composts are primarily derived from yard trimmings, biosolids, municipal solid waste, or food by-products, or a combination of one or more of these feedstocks.

COMPOST TESTING

In all there are twelve compost parameters that should be routinely provided to compost users to help ensure successful compost use and overall satisfaction. Not all of these are included in the guidelines since some of them are related to the logistics of use rather than quality or performance. These measures are pH, soluble salts, nutrients, water holding capacity, bulk density, moisture, organic matter, particle size, foreign materials, trace element and heavy metal concentration, phytotoxicity, and maturity or stability. In the future, more may be added such as biological activity or even presence and absence of certain organisms that are desirable for particular uses.

pH
This is the numerical measure of the acidity (or alkalinity) of a material. The pH scale ranges from 0-14, with a pH of 7.0 indicating neutrality. Compost typically possesses a pH between 5.0 and 8.5. Specific plant species can flourish when grown within a specific pH range, and based on typical compost application rates, it is understood

that the addition of compost can help influence the pH of soil and growing media. Therefore, to estimate the effect, which in turn will affect maintenance practices or system management, pH is a necessary parameter.

Liming agents are sometimes used in the production of compost. Although the addition of lime in the composting process may not dramatically affect the compost's pH, it will have a pronounced effect on calcium levels. Therefore, pH adjustment of these composts is much more difficult due to the compost's higher buffering capacity, and for that reason may not be appropriate for specific applications.

Soluble salts
Soluble salts concentration is the concentration of soluble ions in a solution, which is measured by the ability of a medium to conduct an electric current. Excess soluble salts can be phytotoxic (damaging) to plants, yet many nutrients are supplied to plants in salt form. Some soluble salts, such as sodium and chloride, are more detrimental to plants than others. Most plant species have a salinity tolerance rating and maximum tolerable quantities are known. Soluble salts are measured in dS or mmhos/cm. Compost may contribute to, or dilute, the cumulative soluble salts concentration of a growing medium or soil. Manure compost tends to be higher in soluble salts, while soluble salt concentrations in biosolids and yard trimmings composts are more variable. Reduction in soluble salts concentration can sometimes be achieved through heavy watering (leaching). However, management practices for leaching will be dependent on the salinity of the irrigation water. Most composts produced from municipal feedstocks possess a soluble salt concentration of 10 dS (mmhos/cm) or below.

Nutrients
Nitrogen (N), phosphorous (P), and potassium (K) are the three nutrients used by plants in the greatest quantities (macronutrients), and are the nutrients most often applied through commercial fertilizers. These nutrients are measured and expressed on a dry weight basis as a percent (%). The percent of plant available phosphorous and potassium are expressed as P_2O_5 and K_2O, respectively. Nitrogen in compost is predominantly in the organic form and must be mineralized to available forms (NO_3 and NH_4) for use by plants. Nitrate and ammonium levels in stable compost are generally low. The total nitrogen content should be expressed and the amount of water soluble (NO_3 and NH_4) and insoluble nitrogen forms should be known. The content of these nutrients, as well as magnesium and calcium, should be known to allow users to make correct decisions regarding supplemental nutrition and pH adjustment. Calcium (Ca) and Magnesium (Mg) may be applied through fertilization application or pH adjustment (e.g. lime, gypsum). Providing data relative to the content of other nutrients can also be helpful, and may be necessary for specific applications or crops.

Water holding capacity
Water holding capacity is the ability of a compost to hold water. Water holding capacity is measured as a percent of dry weight. Water holding capacity measures the potential benefit of reducing the required frequency of irrigation, as well as gross water requirements for the crop. The water holding capacity should be known to allow users to monitor, or estimate, the compost's effect on their watering regime. Most composts produced from municipal feedstocks possess a water holding capacity of 75%-200% of their dry weight.

Bulk density
Bulk Density is the weight per unit volume of compost. Bulk density is used to convert compost application rates from tonnage to cubic yards. In a field application, cubic yards per acre would subsequently be extrapolated to express an application rate represented as a depth in inches (e.g., 2.5cm or 1 inch application rate). Bulk density is also used to determine the volume of compost that may be transported on a given vehicle. Bulk density is typically measured in grams per cubic centimeter, and then converted to pounds per cubic yard since this is the measure used by many producers and landscapers. Most composts possess a bulk density of 700-1,200 pounds per cubic yard.

Moisture
Moisture content is simply the amount of water in a compost product, expressed as a percent of the total weight. The moisture content of compost affects its bulk density and, therefore, will affect transportation costs. Moisture content is also relevant because it affects product handling. Compost that is dry (35% moisture or below) can be dusty and irritating to work with, while compost that is wet can become heavy and clumpy, making its application more difficult and delivery more expensive. Most composts possess a moisture content of 30%-60%, and 40%-50% is generally preferred for product handling.

Organic matter
Organic matter content is the measure of carbon-based materials in a compost. Organic matter content is typically expressed as a percent of dry weight. Being aware of a product's organic matter content may be necessary for determining compost application rates on specific for specific uses, such as turf establishment. Most composts possess an organic matter content of 30%-70%, with 50%-60% being preferred.

Particle size
The specificity in which compost particle size is measured should be based on the product's intended use or other customer requirements. For most applications, merely specifying the product's maximum particle size or the screen size through which the compost passes is sufficient. However, for specific applications, such as a component of potting media, a full particle size distribution may be required. A compost's particle size distribution will affect the porosity of the media to which it is added. Particle size distribution measures the amount of compost meeting a range of specific sizes. Particle size distribution figures are expressed as the percent of material retained per sieve size. A compost product's particle size may also determine its usability in specific applications. For example, a yard trimmings compost screened through a 7mm (1/4") screen would probably not be appropriate for use as a mulch, whereas the same product screened through a 2.5cm (1") screen could be acceptable.

Foreign materials
In large quantities, foreign materials may inhibit plant growth, but these are mainly a safety and aesthetic concern. If you will continue to work with the compost in soils or be in close contact with the receiving landscape then metals, glass, and sharp plastics should be minimized. Foreign material content is regulated under the CCME guidelines (Appendix C) but you may have particular needs for your landscape project and will want to have the supplier give you more details about their compost product.

Trace elements and heavy metals
Heavy metals are also regulated according to the CCME guidelines. Heavy metals are trace elements whose concentration is regulated due to the potential for toxicity to humans, animals, or plants. The quantity of these elements are measured on a dry weight basis and expressed in parts per million (ppm) or milligrams per kilogram (mg/kg). Trace elements include arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. The mere presence of these elements does not mean that the product is unsafe. Rather, some of these elements are essential in the diets of plants, animals, and humans. Therefore, measuring the concentration of these elements, as well as other plant nutrients, will provide valuable management data relevant to the nutrient requirements of plants, and subsequent fertilizer application rates. Certain heavy metals and trace elements are known to cause phytotoxic effects in plants, and some plant species are more sensitive than others. Although detrimental quantities of these elements are not typically found in compost, some can accumulate in the root zone over time. To avoid potential plant damage, these elements should be monitored.

Phytotoxicity
A growth-screening test is an indicator of the absence or presence of phytotoxic substances, including volatile fatty acids, alcohol, soluble salts, heavy metals, or ammonia. Any of these substances may cause delayed seed germination, seed or seedling damage, plant damage, or death. The growth screening test is not intended to identify the growth inhibiting compounds, but serves as a general measure of toxicity. The CCME guidelines include a growth-screening test where a compost fails if it shows any signs of phytotoxicity compared to controls. Growth screening tests include germination, root elongation, and pot tests. It is important to note that compost passing initial growth screening tests may fail a similar test later if stored improperly. This is because specific growth inhibitors, such as volatile fatty acids and alcohol, may form in compost stored under anaerobic conditions.

Maturity or stability
Stability is the level of biological activity in a moist, warm, and aerated compost pile. Unstable compost consumes nitrogen and oxygen in significant quantities to support biological activity and generates heat, CO_2, and water vapor. Stable compost may consume little nitrogen and oxygen and generates little CO_2 or heat. Depending

on feedstocks, unstable and active compost may demand nitrogen when applied to soil and growing media. This can cause nitrogen deficiency and be detrimental to plant growth, even causing death to plants in some cases. If stored improperly without aeration, unstable compost can become anaerobic and give rise to nuisance odors.

Until industry standards are developed, it is important that growth screening and stability tests be performed and used for process control and to qualify these parameters. Once we standardize test methods for maturity and stability, we can develop a measurable understanding of their effects on specific crops and in specific situations.

Compost selection

Compost produced from different feedstocks and with different levels of processing may have different uses. For example, compost produced from municipal solid waste will generally possess a greater water holding capacity than other composts because the feedstock from which it is produced typically contains paper and paper products. Therefore this compost may be more suitable to use in areas where drought conditions exist (e.g., sandy soils) or low maintenance occurs (e.g., roadsides), or perhaps in erosion control.

No two composts or applications are exactly the same but one product may be versatile enough to use for a number of different applications. In selecting a compost, it is important that you purchase from firms who test regularly and supply data to their customers. Aside from working with a company that manufactures a compost, which meets your requirements and provides characterization data, you must be assured that they are capable of producing a consistent product. Only the production and use of a consistent product can assure uniform results. Even a compost product that is mediocre in quality, but is consistent in nature, can be used successfully as long as all parties understand its attributes and limitations.

As more compost is produced and marketed, users will have the task of evaluating suppliers. Increased competition for compost should improve the quality and variety of available compost, stabilize prices, and improve customer satisfaction.

Selecting a compost supplier

Keep in mind the following important attributes of compost suppliers when selecting your compost. Does your supplier:

1. Produce compost that meets these guidelines or your specific project?
2. Provide a consistent product?
3. Perform on-going quality assurance or quality control testing?
4. Make test results available to quantify and qualify their product's attributes?
5. Provide good customer service?
6. Assure prompt and reliable delivery?
7. Possess adequate storage to ensure availability?
8. Provide technical assistance regarding end use?

Laboratory testing

The most accurate way to obtain data for the pH and nutritional status of a compost is by having it analyzed at a reputable laboratory. If you are ordering large amounts of compost or need to know the specific content of the batch of compost you are working with, then we recommend having tests done. If you test your soil at the same time, you can compare the soil fertilizer recommendations from the laboratory with the compost nutrients using Appendix B. More information on this will be discussed in the next section on working with composts.

WORKING WITH COMPOSTS

The method in which compost is applied is typically based on the compost's characteristics, type of application, the size of the project, and field conditions. For small planting or mulching projects, compost may be obtained in bags and spread by hand using a rake. For larger projects, compost may be obtained in bulk, transported to the site in a dump truck or wheelbarrow and spread by hand or by using tractor drawn equipment. Where slopes are being mulched for decorative purposes or erosion control, or compost is being applied to sites that are difficult to access, blower-type units have been used to propel the compost up to 60 metres (200 ft). Smaller blower-type units have also been developed which propel the compost through a wide hose that can be directed around plants and other objects. A more common method to apply compost for various applications is with a manure spreader or topdressing unit. A manure spreader uses rotating flails (paddles) to project the compost into the air, whereas a topdressing unit uses a rotating, cylindrical brush to project the compost down towards the soil surface. Both units may be calibrated to apply 0.75cm - 1.25cm layers (1/4 - 1/2") or larger 2.5cm (1") layers of compost; however, the application of higher rates is slow and may take more than one pass over the area. Often, when rates of 2.5cm (1") or more are applied to exposed soil, piles of compost are strategically placed throughout the site and a grading blade, York rake, or front-end loader/bulldozer blade is used to spread the compost. With experience and care, accurate application rates are achievable. The agricultural community and companies marketing compost have developed efficient methods of applying compost. Side discharge manure spreaders have been used to apply compost inside planting rows and tractor-trailers have been fitted with flails to allow large volumes to be spread.

Continued innovations in compost application equipment will increase compost usage. For that reason, equipment is now available for purchase or rental to allow users to more efficiently apply compost. It is important to note that the moisture content and particle size of the compost will affect its spreadability. Standard "box spreaders" and agricultural or commercial fertilizer/lime spreaders often have difficulty spreading coarse or wet compost.

Some calculations are available in Appendix B to help determine your compost needs for a given area and depth of application.

Fertility application

As discussed in earlier sections, although compost is not typically considered a fertilizer; it can supply a variety of macro- and micronutrients. The quantity and availability of these nutrients is based on the soil type, climate, compost's constituents, its feedstocks, as well as its stability. Source-separated food by-products, biosolids, and manure composts are known for being richer in nitrogen than are yard trimmings and municipal solid waste composts. When incorporated into the soil or a growing medium, composts that are carbon-rich or less stable (less thoroughly composted) may cause nitrogen depletion for a period of time or consume its own supply of available nitrogen. Because all composts contain different quantities of nutrients and plant-available nutrients, it is important to obtain current soil test data. The total nitrogen content should be known, as should the content of water-soluble (NO_3 and NH_4) and insoluble nitrogen forms. Plant available forms of nitrogen, phosphorous, and potassium are expressed as NO_3, P_2O_5, and K_2O, respectively. Performing a soil test is also important to allow for proper fertilization application, as well as data regarding the plant nutrient requirements. Completing a soil test a week or so following compost incorporation will allow for more accurate soil test results.

All fertilizer programs should be designed to meet the requirements of the plant species being grown and complement the nutritional content of the compost being used. Performing a soil test on amended soil will aid in determining more appropriate fertilizer application rates and will help reduce potential over-fertilization and pollution. Where the plant-available nitrogen, phosphorus, and potassium in the compost are adequate, pre-plant fertilizers incorporated into the soil, raised bed, or growing media may be eliminated or reduced. Often supplemental nutrition, primarily nitrogen, is necessary during spring and fall season because nitrogen in the compost may not be available (mineralized) at rates sufficient to meet immediate crop requirements. Research has shown, however, that it is possible to meet the nitrogen requirements of many plant species by applying compost in successive years, since the quantity of available nitrogen is cumulative (see Appendix B). Marginal or low-quality soils are likely to need greater fertilizer applications unless high rates of stable compost are used. The addition of compost at prescribed rates will supply nutrients after the first year of application. It is estimated that the nitrogen content of compost is released for five or more years following application, with quantities of available nutrients declining each subsequent year. Therefore, compost's slow feeding nature will allow end users to reduce fertilizer application to some degree.

Since nutrients are supplied to plants in the form of salts, a good rule of thumb is to apply only half of the recommended fertilizer rate specified when compost is used on known salt-sensitive plant species. However, completing a soil test is the most accurate method to determine nutritional requirements or soluble salts concentration.

Where stable biosolids composts are used at prescribed rates, as a component to growing media, nitrogen fertilizers should not be applied during the first 2-3 weeks of plant growth, and the addition of micronutrients to the mix should not be necessary. Composts produced from feedstocks other than biosolids and considered stable typically do not need nitrogen fertilizers during the week or two following potting. The need to apply micronutrients will likely be eliminated when using compost at suggested rates.

Composts that are immature, regardless of the feedstock, will need supplemental nutrition, especially nitrogen and phosphorus. If unstable compost is used in field applications, it should be allowed to age in the field before any planting takes place to avoid stunting, potential plant damage, or reduced crop yields. Depending on the compost's degree of instability and time of year, field aging could take a few weeks, a few months or longer. Alternatively, or in conjunction with field aging, fertilizer may be added to help compensate for any nitrogen immobilization. Stunted growth or yellowing vegetation is a symptom of nitrogen immobilization.

pH adjustments

All plants possess a specific pH range in which they prefer to grow and flourish. Knowing this, we adjust the pH of our soils or growing media to meet the requirements of the specific plants. pH is typically increased with lime and decreased with sulphur-based products. Growing plants in their desired pH range allows for optimal growth and proper plant nutrition. A list of desired pH ranges for various plant species can be obtained from agricultural specialists or agricultural/horticultural reference literature.

The addition of compost at recommended rates will usually affect the pH of soils and growing media. The extent to which the pH is influenced depends on the pH of the soil being treated, the pH of the compost, the quantity of compost applied, and the soil type. In most field situations, the addition of compost will increase the pH of soil or growing medium, except when the soil is already alkaline by nature. In alkaline soils, pH may increase gradually with repeat applications if the compost pH is greater than that of the soil. Since most finished composts possess a pH of 6.0-7.5, the use of compost does not typically raise soil/media pH above 6.5. Some municipal composts may be rich in cellulose materials and will possess an elevated pH. If they are not fully mature and stable, this will cause a short-term rise in soil/medium pH until the compost stabilizes, then the pH will decrease again. Compost also improves the cation exchange capacity (CEC) of soils, thereby improving its buffering capacity, making it more resistant to pH change. Therefore, the addition of compost can have a long-term effect on stabilizing pH. Keep in mind that it is easier to alter the pH of sandier soils than clay or organic soils because sandy soils possess a very low CEC.

An interesting phenomenon occurs in relation to organic matter content and soil pH. It has been shown that as the organic matter of soil increases, the importance of meeting the plants' preferred pH range becomes less relevant. This is because organic matter, and the humic acid it contains, more effectively binds and releases nutrients, making them more available to plants. One of the main reasons for maintaining a desirable pH is to ensure that roots are capable of obtaining optimal nutrient quantities. This phenomenon has been well illustrated in the production of excellent-quality acid loving rhododendrons in soil with a pH of above 6.0 where compost has been used as an amendment.

Although it is impossible at this point to estimate what effect a particular compost product will have on a particular soil, several general statements can be made:

Rules of thumb

1. In most acidic soils, most composts will increase soil pH.
2. The greater the calcium and magnesium and CEC of the compost, the more it will influence soil pH.
3. Increasing a soil's pH from 5.5-6.0 can be achieved through the addition of compost at typical rates.
4. Where a greater rise in pH is required, compost should be used in conjunction with a liming agent.
5. Where a reduced pH is required, adjust the soil pH with sulphur to the desired level, and then add the compost (the compost will modify the pH slightly upward).

Health and environmental issues
Concerns over potential health and environmental related issues have peaked since we began the use of municipally generated compost feedstocks (e.g., biosolids, and municipal solid waste). These concerns are understandable and have been addressed through research and regulations enforced by the Nova Scotia Department of Environment and Labour (See Appendix D).

Pathogens are found in certain compost ingredients or feedstocks such as biosolids, septage, municipal solid waste, yard trimmings, food by-products, and animal manures. However, specific processes and management techniques have been developed to effectively destroy these pathogens. These processes and techniques are based on a known *time-temperature relationship*. Simply, all living organisms can be killed when exposed to a specific temperature for a specific length of time. The greater the temperature, the shorter the exposure time necessary. The time-temperature criteria for controlling potentially harmful pathogens in biosolids were first identified and verified in the 1970's by the United States Department of Agriculture (USDA) and the United States Environmental Protection Agency (US EPA) when they began biosolids composting research. The time-temperature criteria are also valid for destroying pathogens in other feedstocks, and are effective in destroying other organisms and weed seeds. Since the 1970's, over 250 biosolids and municipal solid waste composting facilities have been in operation, and there has never been a documented case of disease or illness caused by the use of these products. The composting process is very effective for disinfection or pasteurization.

Heavy metals can be found in certain municipal (e.g., biosolids and municipal solid waste) and industrial compost feedstocks. In order to guarantee public safety, a tremendous amount of research has been performed on heavy metals. Heavy metals, so called because of their location on the Periodic Table of the Elements, are trace elements whose concentrations are regulated due to potential toxicity to humans, animals, and/or plants. These trace elements are inherently found in almost everything and are only deemed a health risk when we are exposed to them in relatively large quantities. Keep in mind that many of the trace elements referred to as heavy metals are purchased by the horticultural industry as micronutrients and applied to their crops because they are necessary for plant growth. Many of these elements are also found in typical fertilizers in greater quantities than they are found in composts.

Nutrient loading from over-use of nitrogen and phosphorus, and their effect on the environment has been a growing concern with improper use of nitrogen and phosphorus fertilizer. These have caused runoff and leaching concerns, which are a serious threat to our water and aquatic resources. The composting industry takes these concerns seriously. To ensure that over-fertilization does not occur, maximum compost application rates should be based on the plant's annual plant nutrient requirements. Plant requirements for different species are known values and are obtainable through agricultural and horticultural specialists. Keep in mind that plant-available nutrient content is different from the total nutrient content. For example, nitrogen content for compost is generally considered to be between 5%-15% available during the first growing season. The quantity of nitrogen available to plants on an annual basis from compost is also influenced by climatic and soil conditions. We recommend that you use the calculations in Appendix B to determine the amount of nitrogen released from your compost and make sure that this does not exceed the requirements of your plant. This will prevent nitrogen from leaching out of the soil causing contamination to nearby waters and waste of your investment.

Foreign materials or man-made materials can be found in compost. For this reason, regulations restrict the size and quantity of foreign materials allowed in compost. The content of these foreign materials is not considered a major hazard but your compost supplier should be able to describe this aspect of their products. Also, if the compost is excessively dry when applied (like lime and other agricultural/horticultural products), dust may be produced that can be irritating to eyes and respiratory tract. If you have certain sensitivities or concerns, protective eyewear and dust masks should eliminate these problems.

Major References

The Soil and Compost Use Guidelines are primarily based on input from a wide range of local landscapers, soil manufacturers, government staff, and academic researchers. In addition, the following documents were helpful references for gathering general soil and compost use information, and some of these were specifically referenced in sections of the Guidelines.

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Appendix A: Measurement conversion factors

See one of the following websites for conversion calculators or use the following table:
http://www.onlineconversion.com/ http://www.convert-me.com/en/
http://www.convertit.com/Go/ConvertIt/

	To change . .	into . .	do this . .
Volume	pints (UK)	litres	x 0.5683
	pints (UK)	pints (US liquid)	x 1.201
	pints (US liquid)	litres	x 0.4732
	pints (US liquid)	pints (UK)	x 0.8327
	cubic cm	cubic inches	x 0.06102
	cubic cm	litres	/ 1000
	cubic cm	millilitres	x 1
	cubic feet	cubic inches	x 1728
	cubic feet	cubic metres	x 0.0283
	cubic feet	cubic yards	/ 27
	cubic feet	gallons (UK)	x 6.229
	cubic feet	gallons (US)	x 7.481
	cubic feet	litres	x 28.32
	cubic inches	cubic cm	x 16.39
	cubic inches	litres	x 0.01639
	cubic metres	cubic feet	x 35.31
	fl.ounces (UK)	fl.ounces (US)	x 0.961
	fl.ounces (UK)	millilitres	x 28.41
	fl.ounces (US)	fl.ounces (UK)	x 1.041
	fl.ounces (US)	millilitres	x 29.57
	gallons	pints	x 8
	gallons (UK)	cubic feet	x 0.1605
	gallons (UK)	gallons (US)	x 1.2009
	gallons (UK)	litres	x 4.54609
	gallons (US)	gallons (UK)	x 0.8327
	gallons (US)	litres	x 3.785
Distance	feet	centimetres	x 30.48
	feet	metres	x 0.3048
	feet	yards	/ 3
	yards	metres	x 0.9144
	centimetres	feet	/ 30.48
	centimetres	inches	/ 2.54
	centimetres	metres	/ 100
	centimetres	millimetres	x 10
	kilometres	metres	x 1000
	kilometres	miles	x 0.6214
	litres	cu.inches	x 61.02
	litres	gallons (UK)	x 0.2200
	litres	gallons (US)	x 0.2642
	litres	pints (UK)	x 1.760
	litres	pints (US liquid)	x 2.113
	metres	yards	/ 0.9144
	metres	centimetres	x 100

	To change . .	into . .	do this . .
Weight	kilograms	ounces	x 35.3
	kilograms	pounds	x 2.2046
	kilograms	tonnes	/ 1000
	kilograms	tons (UK/long)	/ 1016
	kilograms	tons (US/short)	/ 907
	pounds	kilograms	x 0.4536
	pounds	ounces	x 16
	tonnes	kilograms	x 1000
	tonnes	tons (UK/long)	x 0.9842
	tonnes	tons (US/short)	x 1.1023
	tons (UK/long)	kilograms	x 1016
	tons (UK/long)	tonnes	x 1.016
	tons (US/short)	kilograms	x 907.2
	tons (US/short)	tonnes	x 0.9072
	grams	kilograms	/ 1000
	grams	ounces	/ 28.35
	ounces	grams	x 28.35
Area	hectares	acres	x 2.471
	hectares	square km	/ 100
	hectares	square metres	x 10000
	hectares	square miles	/ 259
	hectares	square yards	x 11 960
	inches	centimetres	x 2.54
	inches	feet	/ 12
	square feet	sq. inches	x 144
	square feet	sq. metres	x 0.0929
	square inches	square cm	x 6.4516
	square inches	square feet	/ 144
	square km	acres	x 247
	square km	hectares	x 100
	square km	square miles	x 0.3861
	square metres	acres	/ 4047
	square metres	hectares	/ 10 000
	square metres	square feet	x 10.76
	square metres	square yards	x 1.196
	square miles	acres	x 640
	square miles	hectares	x 259
	square miles	square km	x 2.590
	square yards	square metres	/ 1.196
	acres	hectares	x 0.4047
	acres	sq. kilometres	/ 247
	acres	sq. metres	x 4047
	acres	sq. miles	/ 640

Appendix B: Compost use calculations

The information here will help you calculate the amount of compost you need to spread over a field, or to fill planting pots. You will also find the information you need to estimate the nutrient release from a given amount of compost. Since compost is commonly sold by the cubic yard, imperial measures are used here.

Estimating compost requirements

Follow this simple formula to determine the number of cubic yards of compost you need. You will only need to measure the area you want to cover with compost and decide what depth of compost you would like to have.

Multiply the area to cover (square feet) by the depth of compost desired (inches), then multiply the result by 0.0031 and you will have the number of cubic yards of compost to order.

Formula: area (ft^2) x depth of compost (inches) x 0.0031 = volume of compost to order (yd^3)

Example: 5,000 ft^2 x 0.5 inches of compost x 0.0031 = 7.75 yd^3

Some common scenarios are presented here for quick reference:

Cubic yards of compost required to cover 1,000 square feet:

¼ -inch layer (0.75cm) ∧ approximately 0.75 cubic yards
½ -inch layer (1.25cm) ∧ approximately 1.5 cubic yards
1-inch layer (2.5cm) ∧ approximately 3.0 cubic yards
1½-inch layer (3.75cm) ∧ approximately 4.5 cubic yards
2-inch layer (5cm) ∧ approximately 6.0 cubic yards
2½-inch layer (6.25cm) ∧ approximately 7.5 cubic yards
3-inch layer (7.5cm) ∧ approximately 9.0 cubic yards

Cubic yards of compost required to cover one acre:

¼ -inch layer (0.75cm) ∧ approximately 34 cubic yards
½ -inch layer (1.25cm) ∧ approximately 67 cubic yards
1-inch layer (2.5cm) ∧ approximately 134 cubic yards
1½-inch layer (3.75cm) ∧ approximately 201 cubic yards
2-inch layer (5cm) ∧ approximately 269 cubic yards
2½-inch layer (6.25cm) ∧ approximately 335 cubic yards
3-inch layer (7.5cm) ∧ approximately 402 cubic yards

Pots filled by one cubic yard of compost amended media:

4 inch pot (10cm or 2 litre) ∧ 1,210 pots
6 inch pot (15cm or 4 litre) ∧ 225 pots
8 inch pot (20 cm or 8 litre) ∧ 120 pots
10 inch pot (25cm or 12 litre) ∧ 80 pots
14 inch pot (35cm or 28 litre) ∧ 38 pots
17 inch pot (45cm or 60 litre) ∧ 14 pots

Estimating nutrient loading

The following information is provided to estimate the amount of macronutrients found in a specific quantity of compost. By determining the quantity of macronutrients, you can adjust your fertilizer applications and minimize environmental impacts and waste. The example is for nitrogen but you could also use the same formulas with information for other nutrients and trace elements in compost. Research is continuing to determine the release rates of nutrients from different composts, the following should be used as a guide and your compost supplier should be contacted for specific values needed in these calculations.

Steps/formulas:

1. Use the formula to determine the volume of compost to order for your area.
Formula: area (ft^2) x depth of compost (inches) x 0.0031 = volume of compost to order (yd^3)

2. Convert compost volume from cubic yards to pounds.
Formula: compost volume (yd^3) x compost bulk density (lbs/cubic yard) = lbs of compost

3. Determine compost application rate on a dry-weight basis.
Formula: application rate (lbs) x 1- percent moisture of compost = lbs of dry compost applied

3. Determine nutrient loading rate.
Formula: lbs of dry compost applied x percent content of a specific nutrient = lbs of nutrient applied

Example: Estimate the amount of total nitrogen applied for a 1,000 ft^2 area.
Application rate for a 1,000 ft^2 area at $^1/_2$ inch depth
If analysis shows compost has a bulk density of 900 lbs. per yd^3
If analysis shows compost is 55% dry solids (45% moisture)
If analysis shows compost has 1% total nitrogen…

1. 1000 ft^2 x $^1/_2$ inch depth x 0.0031 = 1.55 yd^3
2. 1.55 yd^3 x 900 lbs per yd^3 = 1395 lbs of fresh compost
3. 1395 lbs x (1-0.45) = 767 lbs of dry compost
4. 767 lbs x 0.01 = 7.67 lbs of nitrogen for the 1000 ft^2

Note: This figure does not represent plant available nitrogen, only total nitrogen which is slowly released or mineralized over time. The mineralization rate of nitrogen in compost is based on soil type, climactic conditions, and the stability of the compost; contact your compost supplier for details.

Rules of thumb

1. Nitrogen mineralization rates (availability) of stable composts are greatest in the first year following application, and rates reduce each year until they reach background levels. Rapid mineralization occurs in the first 4-8 months following application, then it decreases and drops to a more constant level.
2. Nitrogen mineralization rates are greater in coarse-textured (sandy) soils and less in fine-textured (clay, clay loam) soils.
3. Nitrogen mineralization rates are increased as ambient temperatures and humidity increase; rates may be greater inland than in coastal areas.
4. Stable composts contain more plant-available nitrogen.
5. Unstable composts can cause nitrogen immobilization, and some of its nitrogen content may be lost through volatilization of ammonia.

Although compost nitrogen mineralization rates have been studied for many years, they are difficult to estimate because they are site and compost specific. With this in mind, research suggests that the nitrogen mineralization rate of stable composts during the first year following application is 5%-15% for the Nova Scotia, based on soil type and climatic conditions. In the second year following application, the mineralization rate should be estimated as half of the first season rate, and the mineralization rate in the third year will be half again.

A typical example might be 10% in the first year, 5% the next and 2.5% in the third. But if a compost has a mineralization rate of 10% the first year and compost is reapplied the next year, the total mineralization rate of the compost in the second year will be 15% because the two applications are added together.

Appendix C: Regulations for compost quality and use

Compost categories
In this province, the Nova Scotia Department of Environment and Labour (NSDEL) regulate the manufacturing and use of compost products. The Canadian Council for Ministers of the Environment (CCME) has provided guidelines that the Province uses to distinguish category A and B composts. The Province only restricts the use of category B compost, which cannot be used on soils for growing food crops. These regulations are for health and environmental criteria, and do not make distinctions for horticultural uses as in the Soil and Compost Use Guidelines. Contact the NSDEL for the most current information, the table and information below shows the CCME requirements currently in use for category A and B composts.

Nova Scotia Department of Environment and Labour
Environmental Monitoring and Compliance Division
P.O. Box 697
5151 Terminal Road, 5th Floor
Halifax NS
B3J 2T8
(902) 424-5300
http://www.gov.ns.ca/enla/emc/wasteman/

Canadian Council for Ministers of the Environment
CCME Documents, c/o Manitoba Statutory Publications
200 Vaughn Street
Winnipeg, Manitoba R3C 1T5
Ph: (204) 945 4664
www.ccme.ca

Concentrations of trace elements in compost*

	Category A	Category B
Trace Elements	Maximum Concentration Within Product (mg/kg dry weight)	Maximum Concentration Within Product (mg/kg dry weight)
Arsenic	13	75
Cadmium	3	20
Cobalt	34	150
Chromium	210	1060**
Copper	100	760**
Mercury	0.8	5
Molybdenum	5	20
Nickel	62	180
Lead	150	500
Selenium	2	14
Zinc	500	1850

*See table below for maximum cumulative additions to soils
**See CCME Guidelines for further description of these values

Maximum cumulative trace element additions to soil* (kg/ha)

Arsenic (As)	15
Cadmium (Cd)	4
Chromium (Cr)	**
Copper (Cu)	**
Mercury (Hg)	1
Molybdenum (Mo)	4
Nickel (Ni)	36
Lead (Pb)	100
Selenium (Se)	2.8
Zinc (Zn)	370

*Other elements, such as boron, manganese, aluminum and iron, may eventually be regulated in certain provinces to accommodate regional and national concerns.

**Limits for copper and chromium are not established in the Fertilizers Act., Agriculture and Agri-Food Canada will be conducting a consultation process for adopting limits for chromium and copper. The CCME will re-evaluate these parameters when this process is complete.

The Province has determined that category A compost is appropriate for all uses, but that use of category B compost should consider the feedstocks used to produce the compost, the quality of the compost, and the sensitivity of the environment where it will be applied. The province currently prohibits the application of category B compost for growing food crops.

Both category A and B compost must meet all of the following maturity, foreign matter, and pathogen requirements.

Maturity
Two of the following criteria must be met:

- A C/N ratio < 25;
- An oxygen uptake < 150 mg O_2/kg volatile solids per hour; and
- A germination and growth test using cress (*lepidum sativum*) seeds and radish (*Raphanus sativus*) seeds, which demonstrates an absence of phytotoxic effects.

OR

- Compost will not reheat upon standing to greater than 20 degrees C above ambient temperature; and
- Compost must be allowed to mature for at least 21 days after the thermophilic phase is completed.

OR

- Reduction of organic matter must be 60 percent by weight; and
- Compost must be allowed to mature for at least 21 days after the thermophilic phase is completed.

OR

If no other determination of maturity is made, the compost must be cured for a six-month period. The state of the curing pile must be conducive to aerobic biological activity. The curing stage begins when the pathogen reduction process is complete and the compost no longer re-heats to thermophilic temperatures.

Foreign matter
In the guidelines prepared by the CCME, mineral soils, sand, rocks and wood are not considered to be foreign matter. Both Category A and Category B compost must be virtually free of foreign matter that may cause nuisance, damage or injury to humans, plants or animals, during or resulting from intended use. The compost must not contain any sharp foreign matter measuring over 3mm in any dimension or any foreign matter greater than 25mm in any dimension.

Pathogenic organisms
When a compost does not contain feedstock known to be high in human pathogens, the following criteria shall be met:

- The compost shall undergo the following treatment or other process recognized as equivalent by the relevant authority.
- Using the in-vessel composting method, the solid waste shall be maintained at operating conditions of 55 degrees C or greater for three days.
- Using the windrow composting method, the solid waste shall attain a temperature of 55 degrees C or greater for at least 15 days during the composting period. Also, during high temperature period, the windrow shall be turned at least five times.
- Using the aerated static pile composting method, the solid waste will be maintained at operating temperatures of 55 degrees C or greater for three days. The preferable practice is to cover the pile with an insulating layer of material, such as cured compost or wood chips, to ensure that all areas of the feed material are exposed to the required temperature.

OR

Organisms shall not exceed the following:

- Faecal coliforms <1000 most probable number (MPN)/g of total solids calculated on a dry weight basis, and
- Salmonella sp. <3 (MPN)/4g total solids calculated on a dry weight basis.

Appendix D: Contacts

Project Partners

Landscape Nova Scotia Horticultural Trades Association
65 Celtic Drive
Dartmouth, Nova Scotia
Canada
B2Y 3G5
(902) 463-0519
http://www.landscapenovascotia.ca

Halifax Regional Municipality Environmental Management Services Department
P.O. Box 1749
Halifax, Nova Scotia
B3J 3A5
(902) 490-4000 or 1-800-835-6428 (toll free in Nova Scotia)
http://www.region.halifax.ns.ca/environment/ems_index.html

Resource Recovery Fund Board of Nova Scotia
14 Court Street, Suite 305
Truro, Nova Scotia
B2N 3H7
(902) 895-7732 or 1-877-313-7732 (toll free in Nova Scotia)
www.rrfb.com

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Quality Evaluation Division, Laboratory Services
http://www.gov.ns.ca/nsaf/qe/analytical/soilsamp.htm
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A&L Canada Laboratories Inc.
http://www.al-labs-can.com/
2136 JetStream Rd.
London, ON
N5V 3P5
Phone: (519) 457-2575
Fax: (519) 457-2664
Email:aginfo@alcanada.com