Building Your Soil

A Guide to Building Sustainable Garden Soil in the Northwest Territories

Ecology North
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Building Your Soil: A Guide to Building Sustainable Garden Soil in the Northwest Territories

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The information presented in this document is meant to encourage sustainable community and backyard gardening in communities of the Northwest Territories. It is meant to be a guide and a reference document, to be used along with the Soil Recipes Booklet to create garden soil from locally sourced materials.

This is by no means a comprehensive guide. For more information on building soil, soil health and management, and gardening, contact Ecology North, or refer to the end of this report for some helpful suggested reading and a list of resources that were used in compiling this information.
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Introduction

Most communities in the NWT require some amendment to their soil in order to grow productive crops. Remote communities trying to grow food in community and backyard gardens are faced with the problem of having very limited access to good quality soil. This is especially the case in the Tlicho communities in the Canadian Shield geologic region, where soil is particularly thin and low in essential nutrients. Importing large quantities of soil for gardening is an expensive and inefficient solution. Building on the existing soil in a way that promotes soil fertility and soil life can allow us to grow good food and reduce dependencies on outside resources. Some communities have even started creating soil in larger batches to share within the community. We want to encourage this, and to work toward finding easy, sustainable alternatives to importing soil into our gardens.

The information presented in this report is meant to serve as a guide for building your own soil in the NWT.

(1) Community garden in Gameti, NT.

Northern gardening is a challenge that often takes a community effort. Making healthy soil can also be done as a community.
Addressing the Problem:

Transporting soil from the south is often the main approach used to address poor soil conditions in the North. However, while simple, this solution has several problems associated with it. Transporting small bags of garden soil north can be very expensive. Some remote communities have to wait until winter to bring in large amounts of soil on winter roads. Transporting unsterilized soil may also introduce foreign pests and diseases to the North. At the very least, this could mean we will have a living soil community that is not suited to the specific environmental situation that we move it into – not ideally suited to live in a northern garden. It could also mean introducing bacterial and fungal diseases, insect pests, chemical contaminants, and causing more problems for food producers in the North.

At best, transporting garden soil is an expensive, energy-intensive fix.

At worst, it could be detrimental to local ecosystems.

At any rate, it is not very sustainable.

(2) Weledeh School Garden, Yellowknife.

Growing good food starts with the soil.

➡️ Sustainable Soil Practices ➡️

Sourcing materials locally has a number of benefits.

- Nutrients in the food you grow come from the materials you put in your soil, and keeping that cycle close to home is good practice from a sustainability perspective.
- Microbial communities can be very specifically adapted to small geographic areas, especially in the North where changes in latitude result in substantial variation in climate conditions.
- If all material comes from nearby, it helps to ensure the microbiology of the soil is well suited to the micro-environmental conditions of your garden.
- While many areas of the NWT have very little soil, the raw materials needed are all here. By tapping into local resources, we can build healthy soil for the northern garden. If the materials are harvested responsibly, we can do this sustainably.
Soils in the NWT:

Soils in the NWT are generally poor quality soil for growing food crops. Many of the plants that grow naturally here are adapted to harsh winters, short growing seasons, and thin, acidic soil. Soil development is a slow process and in the NWT this process has been slowed further by the cold northern climate. Most soil deposits have only been developing since the retreat of the glaciers at the end of the last ice age (about 10,000 years ago). Despite this, there are actually a fair variety of soil types on the regional scale in the NWT.

Generally, the best soil for agriculture is located in southern areas of the Taiga Plains ecoregion, where permafrost is discontinuous and more well-developed soil types like greysols and luvisols are more common. In the Mackenzie Valley, up through the northern Taiga Plains region, common soil types include brunisols (well-drained, poorly developed soils), greysols (soil periodically saturated during formation), fibrisols (relatively undecomposed organic material), and mesisols (partly decomposed organic material), all subject to permafrost to some extent. Sand, gravel and fine glacial till are common and there are also large deposits of organic soil, mostly associated with river floodplains. Areas with acidic clayey soils tend to be low in many essential nutrients, but many areas in the Mackenzie River basin are rich in both calcium and phosphorus, which are both incredibly important for plants.

Taiga Shield soils are mostly brunisols formed on sandy glacial till deposits, and bedrock is often close to the surface. North of Yellowknife all soil types are subject to permafrost. Common soil types include organic soils and clay-based soils formed in association with peatlands and lakes. In most areas of the NWT, permafrost and soil acidity make it very difficult to grow classic vegetable and fruit garden crops.
Building Your Soil

Building your garden soil is like baking a cake; you just need the right ingredients together in the right proportions. Getting the right mix is the first crucial step.

Soil is made up of four main components:
- Mineral Material,
- Organic Material,
- Air and
- Water.

The following pages contain information on the factors that should be considered when building your soil:

- **Environmental Factors**
- **The Living Component**
- **The Mineral Component**
- **The Organic Component**

There is also a list of some materials available locally in many areas of the NWT that can be incorporated into local garden soil recipes.

*Example soil recipes can be found in our Soil Recipes booklet.*
Environmental Factors – Air, Water, Temperature, and pH

The physical environment of your soil greatly affects the activity of soil microorganisms. It also affects the decomposition of organic material, as well as nutrient uptake and growth of plants. Keeping your soil loose and aerated, keeping it moist, feeding it organic material, and protecting it from the cold in the winter by insulating your garden with mulch and snow – these are all good ways to manage the physical factors affecting your soil.

Air:

Soil needs to have lots of airspaces. Many helpful microbes in the soil need oxygen to survive and your plant roots need air as well. Soil with good texture and lots of organic matter will naturally have lots space for air, unless it is heavily compacted. Avoid walking unnecessarily on the garden to avoid compacting the soil.

Water:

Plants need a lot of water in the soil. It is necessary for growth and energy production, and also for taking in nutrients through their roots. Microbes in the soil also need water, so even before the soil is put into the garden it needs to be kept moist. However, overwatering can flush nutrients, especially nitrogen, out of the soil.

Temperature:

Soil temperature in the North can be difficult to manage due the cold winters, however you can grow food here. Many insect pests aren’t able to survive the winter in the NWT, which is good for the northern gardener. Also, the long day length partly makes up for short growing seasons. Soil microbes go dormant in the winter and then become active when the soil warms up in the spring. Soil heats up when the organic matter starts to decompose. If you make soil in large batches, you can maintain higher temperatures within large piles or windrows than in small backyard composter batches, and the soil will be more likely to continue “working” through the winter.
pH:

pH is a measure of the acidity or alkalinity in your soil. It is a scale from 0 (very acidic) to 14 (very alkaline or basic), with 7 being neutral (neither acidic or basic). pH essentially tells you what the chemical environment is like in your soil, and this affects a variety of things in the soil and in the plants. Bacteria and fungi are the living components of the soil that break down complex chemical compounds in organic matter into elements that plants can use. These organisms all have a range of pH in which they can function properly. Not surprisingly, the range at which these organisms can thrive, about 5.5 – 7, tends to line up with the pH range ideal for plant growth.

Testing pH:

pH can vary with moisture, temperature, and biological activity over the course of a season. It can also change through the years as you build up the organic component of your soil. It is good to know whether you have very acidic or basic soil. A laboratory test or do-it-yourself test kit will tell you the pH of your soil with accuracy. There are also a variety of tests you can do very quickly to give you an idea of the approximate pH of your soil.

Red cabbage test: Boiled red cabbage juice has a neutral pH and will change colour if its pH changes. Add a few spoonfuls of soil to a cup of red cabbage juice;

- If it does not change colour, the soil is likely near neutral.
- If it turns bright pink, the soil is likely very basic.
- If it turns blue or green, the soil is likely very acidic.

Fizz test: Take two cups of soil from your garden in separate containers. In the first container, add distilled water to make the soil muddy, and then add some baking soda. Then pour some vinegar into the dry sample. Very acidic soil (less than pH 5.0) will fizz if you sprinkle baking soda on it, because baking soda is very basic. Very basic soil (greater than pH 7.5) will fizz if you pour some vinegar on it, because vinegar is very acidic.

Adjusting Soil pH:

Soil that is rich in organic matter will slowly shift toward a neutral pH over time. The short term solution to very high or very low pH is just to add materials that raise or lower pH:

↑ Wood ash will raise soil pH if soil is acidic.
↓ Sulphur will lower soil pH if soil is basic.

Adding too much of these materials can drastically change your pH and can be very stressful on the life in your soil. Use sparingly if at all – start with small amounts of wood ash or sulphur and monitor your soil pH carefully throughout the process.
The Living Soil

Healthy soil is required for growing good, healthy, nutrient rich food. A healthy soil is very much alive, and needs all the things that living things need: air, water, warmth, and food. The organisms living in your garden, the bacteria, the fungi, the tiny nematode worms, these are what nurture and support your plants. These are the microscopic creatures responsible for giving your plants access to the nutrients in the soil, for aerating the soil so your plant roots can breathe, for repelling pests and staving off diseases. These are the creatures that build soil. Building healthy garden soil is as much about creating good habitat for a billion microbes as it is about adding the correct amount of nutrients and water. Maintaining the soil you make should focus on maintaining your living soil.

What Do Microbes Need?

Water – All soil organisms need water, keep your soil moist. This means paying attention to your soil, feeling it with your hands and adding water as needed, whether it is sitting in a pile or spread out in the garden.

Organic material – Microbes need to eat. Feed them by adding organic material (like compost) to the top 10-15cm of your garden once or twice a year. Organic material also helps create air spaces, hold water, and resist compaction. Very important. A little bit of ground oatmeal, bran, dried fish, or molasses can also be added to soil to boost fungal and bacterial growth.

Warmth – If left to their own devices, plants naturally create a layer of mulch that insulates the soil and helps to retain water. Adding a layer of mulch to your garden in the fall will help it to retain moisture and avoid washing out in the spring. This also promotes microbes in the soil. Mounding soil in a large heap allows the microbes to heat up the soil and work more efficiently to break down organic material. The pile should be turned or mixed every 2 – 4 weeks in the summer to prevent it from overheating.

Minimal disturbance – Avoid compacting the soil, and also avoid excessive tilling. Roots, soil animals, and decaying organic matter naturally create great soil structure, and tilling up the garden only slows down this process. If you have a pile, don’t turn it too frequently; let the microbes heat up the soil and do their work.
What Lives in Healthy Soil?

**Bacteria and Archaea:**
Bacteria and archaea are very simple, single-celled organisms that live in all but the deadest of soils. They are extremely diverse in form and function. Some live in the top 10-15 cm of soil. These are aerobic species, which means they need air to survive. Some do not need air and these are called anaerobes. They can live further down in the soil. Some bacteria fix nitrogen, which means they take nitrogen from the atmosphere and convert it to a soluble form that plants can then use. Many consume organic matter and when they die, contribute to it. While some species can be detrimental to crops, the vast majority are crucial to maintaining healthy plants.

**Fungi:**
Fungi in soil are a strange and fascinating group of organisms that include lichens, moulds, and networks of fibres in the soil. Fungi are very important to soil for several reasons. In healthy soil they create vast networks of hyphae ("root" strands) through the soil, weaving through organic matter, breaking minerals free from rocks, and connecting the roots of plants. Fungi are responsible for releasing minerals like phosphorus from rock that would otherwise be inaccessible to plants. They provide structural support for the soil, compete with disease causing organisms, and help to break down decaying organic matter. Fungi are needed to break down tough woody materials that other soil microbes have difficulty digesting. The fungi that form networks between the plant roots provide those plants with minerals, nitrogen, and water. The plants connected through the network can essentially share nutrients and communicate, warning each other of threats like pests and disease so that other plants can prepare defences. Maintaining these networks can help keep your plants healthy, which is why it is important not to over-till your garden.

**Protists, Microscopic Animals, and Insects:**
These are the larger, more mechanical components of the soil community. Insects, like ants and beetle larvae, and other animals like sow bugs, worms and nematodes break down organic material by basically chewing it up, which greatly speeds up the decomposition process. They also help to aerate the soil as they dig their way through the soil and leaf litter creating air spaces. Protists are single-celled microbes that act more like miniature animals than bacteria, archaea or fungi. They feed on bacteria and help to digest the nutrients that the bacteria gather from organic matter and make it available for uptake by plants.
Microbes and Nutrients:

Bacteria, archaea, and fungi are useful in breaking down the minerals and nutrients out of the organic material, out of the mineral soil and rock, and locking these nutrients up inside their bodies. This is called nutrient immobilization. When protists and other animals eat the bacteria, archaea, and fungi, they release these stored nutrients back into the root zone for plants to use. This is called nutrient mineralization. Both of these processes are important for healthy garden soil. It is important to build soil that supports a diversity of organisms, so that the processes that feed your plants and maintain their health are all in place.

Natural Controls:

Some bacteria, fungi, insects and protists can cause diseases in plants or are notorious garden pests. The most effective natural control of these hazards is not in the plants themselves but in the living soil, and the organisms that eat and compete with the pests. These are the organisms that also support the health of your plants and allow them to resist succumbing to these threats. Sustaining a diverse community of soil organisms is a great way to ensure that the natural controls of pests and disease are present in your garden.
The Mineral Component

Soil is mostly made up of minerals. This is what makes up most of the structure of the soil. Ideally, the mineral component of a well-developed soil should make up about 90% of the solid portion of your soil. The rest should be made up of organic material. Structure and texture of soil is very important – plants prefer about half of soil to be air and water. Smaller groupings of soil particles are preferable to large hard clumps or clods, because nutrients and water are more accessible to plant roots in loose, fine-grained soil.

Testing Your Texture:

Mineral soil is classified by its texture by comparing the amount of soil grains of different sizes. NWT soils range from nearly pure sand to sandy loam to clay to pure organic soils. The best way to learn what type of soil you have is to go out and feel it between your fingers. There are two simple tests you can do with just your hands to tell what type of soil you have: the grain test and the squeeze test.

- **Clays are very fine grains (less than 0.002mm – invisible to the naked eye).**
  - Grain Test: If you pick up pure clay and rub it between your fingers, you should not be able to feel any individual grains, and it may stain your skin as well. It also tends to be sticky when wet.
  - Squeeze Test: Pick up a moist handful and squeeze it between your fingers. If it squeezes out between your fingers in ribbons that do not crumble, there is likely a lot of clay in your soil.

- **Silt is a slightly larger grain (0.002-0.05mm).**
  - Grain Test: You should be able to feel the grains and the grittiness of silt when you run it between your fingers. If you know what sand feels like in your fingers that helps because silt is less gritty than sand. The squeeze test is a better test of the silt content of your soil.
  - Squeeze Test: Just like clay, silt will come out from between your fingers in ribbons, but the ribbons will crumble away and won’t hold their shape.

- **Sand grains are easily visible to the naked eye (0.05-2mm) – anything that could be called a grain that is larger than 2mm in diameter is classified as gravel. Gravely soil either experiences a lot of disturbance or is under developed.**
  - Grain Test: Very gritty and individual grains can be separated easily.
  - Squeeze Test: Sand will crumble out from between your fingers without forming ribbons.

If your soil contains a lot of organic material already, it can be difficult to judge your soil texture based on these simple tests. A settling test can be done fairly simply as well and it can give you a more accurate breakdown of the different parts of your soil.
The Settling Test (from Nauta 2012)

You’ll need:

- A flat-bottomed jar, with a lid
- Water
- Dish soap
- Soil

1. First, you’ll need some soil from your garden, dig down about 15cm, and scoop up enough to fill the jar to about 1/3 full.

2. Remove any sticks or rocks and break up clods.

3. Add some dish soap and fill the rest of the jar with water, leaving a few centimetres of open space at the top.

4. Cover and shake well for at least 10 minutes.

5. Set it down carefully some place where it can sit undisturbed for the next 24 hours. In that time all the different parts of the soil should settle out in layers – first the sand, then silt, then clay, and lastly the organic matter.

6. Now you should be able to see what your soil is made of, and the relative proportions of sand, silt, clay and organic matter it contains. You can even measure them on the side of the jar to calculate percentages and classify your soil using this triangle chart.

(8) Using the soil texture triangle - If you want to classify your soil using the triangle, take the percentages of solid material taken up by sand, silt and clay, and multiply them by 1.19 (sand), 0.87 (silt), and 0.94 (clay), respectively. This will give you the relative weight of the different parts of your soil, and you can use these in the triangle.
Getting the Right Mix:

A well-balanced soil has a fairly even mix of sand, silt and clay. Loam is a mix of sand, clay and silt – plants love loam. It is helpful to know what you are starting out with but don’t get too hung up on whether or not you have sandy loam or loamy sand. If your mineral soil is mostly clay or mostly sand, it is going to take more effort and more time to build it into a healthy, productive soil, and that is good to know.

The important thing is that you have a good amount of base material on which to build. Your main goal from this point on should be to get some life into your soil, and that is where the organic component comes into play.

When collecting sand, clay and silt for your soil, try to find areas where there is already some dark organic material already mixed in, as it will save you some of the hassle of creating that yourself. Even in regions with very little soil, stream banks and the shores of shallow lakes are good places to look.

Clay in the Dirt:

Many areas of the NWT have soils that are low in clay. Clays are important for retaining mineral nutrients in the soil, but if what you have is sand, use sand. A good mix of clay and sand is best but use what is available to you. Humus is organic material that has been broken down to the point where it is very resistant to degrading further. It also happens to be good for retaining water and trapping nutrients. If your soil is low in clay you may want to add more materials that contain humus to your mix, like peat.

Sustainable Soil Practices

Take care when working around water.

- Digging or dredging in stream channels or lake bottoms will negatively affect the immediate aquatic ecosystem, and effects can easily spread to downstream ecosystems.
- Avoid taking too much material from any one place, and if you are collecting material near a stream or lake try to avoid spilling sediment into the water.
The Organic Component

Qualities of Soil Components:

<table>
<thead>
<tr>
<th>Material</th>
<th>Water Infiltration</th>
<th>Drainage</th>
<th>Water and Nutrient Retention</th>
<th>Aeration</th>
<th>Compaction Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Clay</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Despite making up a fairly small portion of the finished soil, organic matter is perhaps the most important part. Organic matter is really where the life of your soil comes from. Anything that was once alive, or came from something alive is organic matter. This is how most of the nutrients that your plants need get into the soil. It is also an important part of the structure of a good soil. It binds grains of soil together creating loose but cohesive soil, full of spaces for water, air, and soil microbes. If your mineral component is sandy, organic matter will help to hold water and nutrients, and keep them from draining and leaching out of the garden. If your mineral component is clayey, adding organic matter will help to loosen the soil and promote aeration, water infiltration, and drainage.

It really does it all.

“Ideal” Soil Composition:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Organic</th>
<th>Water</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-45%</td>
<td>5-10%</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

These are guidelines for a healthy, productive soil and they work well as general goals for the soil composition.

However, when you are just starting out and building your soil from scratch, you may consider exceeding the recommended 5-10% organic matter, in order to ensure there is adequate food for your plants.
The Compost:

Making the organic component of your soil is the same as mixing up good compost. Then you can add this into the mineral component of your soil. You will need to balance the carbon sources (“browns”) with the nitrogen sources (“greens”) in order to have a good starting ratio that the microbes in your soil can work with.

Carbon and Nitrogen:

The ratio most sources recommend is 20-40 parts carbon to 1 part nitrogen (20-40:1). The simplest way to keep your compost within this range is: whenever you add “greens”, add some “browns” as well. The table below gives the approximate carbon/nitrogen ratios of selected compost ingredients to help you create a mix with the materials available to you.

<table>
<thead>
<tr>
<th>Material</th>
<th>C:N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper</td>
<td>400-900:1</td>
</tr>
<tr>
<td>Woodchips</td>
<td>200-1300:1*</td>
</tr>
<tr>
<td>Sawdust</td>
<td>200-750:1*</td>
</tr>
<tr>
<td>Pine Needles</td>
<td>66:1*</td>
</tr>
<tr>
<td>Birch Leaves</td>
<td>50:1*</td>
</tr>
<tr>
<td>Spruce Needles</td>
<td>26-48:1*</td>
</tr>
<tr>
<td>Wood Ash</td>
<td>25:1</td>
</tr>
<tr>
<td>Peat</td>
<td>22:1</td>
</tr>
<tr>
<td>Green Yard/Garden Waste</td>
<td>20-25:1*</td>
</tr>
<tr>
<td>Seaweed</td>
<td>19-24:1*</td>
</tr>
<tr>
<td>Alder Leaves</td>
<td>16-80:1*</td>
</tr>
<tr>
<td>Household Food Compost</td>
<td>15-35:1*</td>
</tr>
<tr>
<td>Manure</td>
<td>10-50:1</td>
</tr>
<tr>
<td>Fish By-Products</td>
<td>5-9:1*</td>
</tr>
<tr>
<td>Animal Hair</td>
<td>3-10:1*</td>
</tr>
</tbody>
</table>

*Tip!

Let these organic materials sit and compost for a growing season, before adding them to the mineral component of your soil. This will help to ensure that more of the nutrients from the organic materials actually make it into your plants.

Table adapted from RDN Environmental Services 2001, with reference to several other sources listed at the end of this report. *C:N range derived from multiple sources.
Sourcing Organics in the NWT

The following section contains information on a variety of organic materials that can be included into compost for your soil, including some suggestions of ways to collect these materials sustainably.

Woodchips, Bark, Twigs, and Sawdust:

Woodchips, twigs, bark, and sawdust are all readily available carbon sources in the NWT. There is a wide range of nutrient content in woodchips, but they all have relatively low levels of nitrogen, phosphorus and potassium, and are slower to break down than other carbon sources. Avoid using woodchips or sawdust from treated wood/lumber, as harmful chemicals could leach out into the soil.

Dry leaves make the best mulch and carbon source for soil. Sawdust, woodchips, and even shredded paper can also serve as a carbon source, but these are not good sources of other nutrients.

Putting shredded paper and cardboard in the soil is a great way to recycle these materials and keep them out of the landfill.

Keep it Wet:

The moisture content of your compost is also important to manage. Wet materials like fruit and vegetable waste should be balanced with dry materials like dry leaves or shredded paper. Compost works best at about 50% moisture.
Deciduous Forest Litter:

Birch, poplar, willow and alder are deciduous tree and shrub species, meaning they lose their leaves in the fall. Leaves vary in nutrient content depending on the species. Alder leaves can be very high in nitrogen. Alder also fixes nitrogen in the soil, so soil gathered near alder stands would likely make a good base material for garden soil. Deciduous forest litter is a good carbon source that will also serve as a source of nitrogen and calcium. Deciduous leaves are moderately acidic (pH 5.1-5.6).

Coniferous Forest Litter:

White spruce, black spruce, jack pine and tamarack are conifer trees that are common throughout most of the NWT. Spruce needles vary in nitrogen content; white spruce have higher nitrogen compared to black spruce. A coniferous forest floor typically has a C:N of around 32:1, and a pH in the range of 4.0-4.8.

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**→ Sustainable Soil Practices →**

**Collecting in Forests:**

When collecting litter from the forest floor, keep in mind that the leaves and needles are doing a job there. The litter in the forest holds in moisture and facilitates fungi and soil animals that keep the soil healthy and the trees healthy. Especially in coniferous forests, this layer of litter can take a long time to build up. Avoid stripping the forest floor down to bare ground, and keep both your garden and the forest healthy.

**Leaf Mould:**

One effective method of making a good soil amendment is piling deciduous leaves and keeping them moist through the summer. This will create a leaf mould that is high in bacterial life that can add complexity, porosity and moisture retention to the soil.
Fish Waste:

Fish guts, tails, and heads are a fantastic source of nitrogen in compost and also provide fairly high levels of phosphorus, potassium, calcium and trace amounts of other minerals. The best way to give your plants the benefit of these nutrients is to compost the fish waste prior to mixing it into your garden. In Alaska, fisheries waste is mixed with peat to create large quantities of high quality compost. Burying the fish remains under at least 30cm of peat helps to discourage animals from pillaging your compost pile. It also helps with the smell. When fish decompose, part of what you can smell is the volatilization of nitrogen, leaving the fish material as ammonia gas. Surrounding the fish remains with moist humic material like peat or organic soil helps to stop the nitrogen from entering into the atmosphere where your plants cannot access it. If you mix it directly into your soil, you may lose some of the nutrients and run the risk of attracting animal, but the material will still be an excellent amendment to your garden soil.

Hair:

Human hair and pet hair are excellent nitrogen sources, and provided they have not been overly treated with chemicals, can make a great addition to your garden soil. Caribou fur and the fur of other fur-bearing animals can also be used. Animal hair and fur is high in nitrogen and calcium. As a mulch, it can also be an effective moisture barrier and pest deterrent.

Sustainable Soil Practices

Collecting from Animals:

Traditional practices around giving back to the land, and returning what you do not use are important to uphold. Fish remains should be treated respectfully whether they are returned to the water or used in garden soil. Ask a local elder if there is any question about whether incorporating fish remains, or other animal-based materials like caribou hair, into garden soil is appropriate.

(14) Fish guts are high in nitrogen and many other nutrients that plants need.

(15) Hair stripped from animal hides during the tanning process makes a great addition to garden soil.
Household Compost:

A wide range of food scraps can be included in household compost. Vegetable waste has a C:N around 15:1, fruit waste is closer to 35:1 or higher. Coffee grounds are at 20:1. “Woodier” bits likely have a higher carbon content; corn cobs are in the range of 50-100:1. The more broken up the material is, the more available the nutrients will be to your plants.

(16) In Yellowknife, a Centralized Composting system is in place to turn household food waste into rich finished compost that makes an excellent fertilizer and structural amendment to garden soil. You can also do this on a smaller scale in your backyard or in your community.

Garden/Yard Waste:

Grass clippings, garden trimmings and weeds are all great sources of nitrogen. Green grass clippings have a C:N of about 20:1; vegetable scraps can be as low as 10:1 (low is good!). Weeds should not be included in soil if they have already gone to seed. Putting weeds in your compost heap is essentially planting them in your garden. Most weed seeds are sterilized at between 71°C and 82°C, some can remain viable at temperatures approaching 100°C; compost in your garden soil or backyard composter typically does not get that hot.
Seaweed and Aquatic Plants:

Seaweed and freshwater plants are an excellent source of nitrogen, potassium, and calcium for your soil. It also has a near neutral pH meaning you do not have to worry that adding too much will lower your soil pH. Collecting it once it has washed up on shore is best – raking it directly out of the water damages aquatic habitat. Marine seaweed can be high in salt, which can be damaging to plants at high concentrations in the soil. It should be used sparingly and rinsed with fresh water before being added to the soil.

Wood Ash:

Wood ash is a potential carbon source and potent liming agent for your garden. Wood ash is also a good source of potassium. It should not be considered unless the pH of your soil is very acidic (less than pH 5.0) – high pH can be just as harmful to plants as low pH. If your organic mix is composed largely of acidic materials like peat and boreal forest litter, you may consider adding some wood ash. As a lime it is about 25-50% as effective as crushed limestone, but is reportedly fairly potent and mixing it into compost is preferable to sprinkling it directly onto the soil. Spreading wood ash directly onto the garden can be damaging to seedlings. Wood ash can also contain trace amounts of heavy metals and other contaminants, so its use in the garden should be limited. Wood ash from pellet stoves in the NWT can contain boron at levels far exceeding those recommended for use in the garden, and so it is not recommended that pellet stove ash be used without testing it first.

(17) In areas where aquatic plants wash up on the beach often, these can be a great organic material to include in your garden soil.

(18) Save your wood ashes over the winter to mix into your soil in the spring. Wood ash can help to balance out the pH of more acidic materials in your soil, like forest litter and peat. Be careful not to add too much into your mix.
Manure:

Well-cured or well-composted animal manure from livestock makes an excellent organic fertilizer and addition to garden soil. It is a good source of nitrogen, phosphorus, potassium and micronutrients for your plants. Bison manure, theoretically would be similar to cow manure and an effective source of manure if locally available. Chicken, bison, sheep, goat, horse, and reindeer manure all make great fertilizer for your garden as long as they are allowed time to cure. This means it must be piled so it can reach temperatures of 55°C or higher for at least 15 days before it is used as a soil amendment. Fresh manure can contain pathogens like E. coli, and when spread on the garden these pathogens can be transferred to fruit and vegetables that come in contact with the manure.

(19) Chicken manure is often high in calcium, which is a nutrient that can be naturally low in acidic NWT soils. Use where it is available.

→ Sustainable Soil Practices →

Covering the Garden in Winter:

Avoid mounding manure in large piles on top of the soil in the winter as this can protect insects that normally die off during the winter from the cold. This die off is a natural process and allowing it to occur can help prevent the spread of southern agricultural pests northward.

But, Don’t Compost...

Dogs, and cats do not produce good garden manure. Animals that eat meat can harbour diseases and parasites that are best kept out of the garden. This includes human manure (“humanure”), which must be properly composted to kill potential pathogens and tested before it is safe to use in the garden. Cat litter can contain harmful chemicals and is also not recommended as a soil amendment.
Peat:

Peat is the result of Sphagnum moss and other plants building up layers of organic matter under waterlogged, low oxygen conditions. It can be found under the live layer of growing mosses and sedges in fens and bogs. It is excellent at holding moisture, and improving the texture of soil. It has a pH of less than 4.0, often closer to 3.0 (very acidic). Peat is generally not a good source of essential nutrients, but it can serve as an excellent source of carbon for your mix, and it has the added benefit of trapping nutrients as they are released from other decomposing organic material; nutrients like nitrogen that can easily be lost to leaching or evaporation. Collecting peat for use in garden soil has many potential negative implications for local environments, especially if carried out on a large scale, and this should come into consideration when deciding which carbon sources to include in your soil.

**Sustainable Soil Practices**

**Collecting in Peatlands:**

Overharvesting peat essentially destroys the existing ecosystem, and changes it into something new. If peat is extensively harvested from a bog or fen, the conditions that created the peat are destroyed, and production of peat stops. It takes thousands of years to form peat, and therefore peat is a non-renewable resource. However, peat makes an excellent amendment to garden soil, and in some areas, may be one of few resources available for building soil. While removing peat in any quantity will affect the ecosystem, harvesting peat in small quantities could be done with minimal effect on the surrounding hydrology and plant life. Creating small, shallow depressions or pools can actually increase the variety of habitat on the peatland, and if done carefully on the scale necessary for backyard or community gardens, this would be much less detrimental than systematic harvest of peat. Peatlands are very susceptible to compaction, and thus care is needed when extracting large quantities with heavy equipment.
Importance of Peatlands:

Peatlands are a common feature of the landscape in the NWT. They are sensitive wetlands, where saturated organic material has built up over time. Peatlands vary in appearance – they can be open expanses of mossy hummocks, pools and low shrubs, or they can be drier and spongy areas sparsely forested with black spruce.

- These areas provide habitat for a wide variety of animals and plants.
- They are also used for hunting and for gathering traditional foods and medicines.
- They help to prevent flooding and filter groundwater.
- They can also act as important seed sources following forest fires.
- Northern peatlands also store an immense amount of carbon, and it is important that they continue to do so.

At the heart of these important ecosystems is a plant that supports all of the rest: Sphagnum moss. Harvesting peat moss from peatlands is very disruptive to these ecosystems. However, if it is harvested carefully, locally and minimally, it can be a great ingredient for soil recipes where there is not much else available.

(21) Peatlands are used by humans as a source of food and medicine. Many other animals, including caribou, use peatlands to find food.

(22) This illustration shows the difference between a bog and a fen. Both contain peat, but a bog is cut off from water running over the surrounding rocks, whereas a fen receives both water and nutrients from the surrounding landscape – so bogs have lower nutrients and minerals than fens.
Putting It All Together

Once you have all the ingredients of the mineral and organic components, it’s time to bake the cake! You will get the most out of your ingredients if you have time to let them bake. Mix well with air and water and let it all compost over the course of a growing season. This will allow more of the nutrients to be released from the organic matter before you plant your crops in the soil.

Healthy soil has a good mix of mineral and organic components, but it also has proper moisture, aeration, nutrients and pH. These factors need to be managed to keep the microorganisms healthy, and they should all be considered when you are mixing up your soil.

There are many other organic materials that can be incorporated into your soil. Try to balance the moisture and nutrients in your soil with what you have available.

**Scale:**

Soil can be made in small quantities in the backyard, or in larger piles or windrows through the efforts of a community. Larger piles will cure faster than soil made in a backyard composter, and allow animal attractants like fish remains to be buried deeper in the pile.

(23) Aerating and wetting a windrow, Yellowknife Centralized Compost.
Nutrients:

Nutrients are the elements that plants take from the environment in order to carry out all the important functions that allow them to survive. Nitrogen (N) is needed to make proteins and chlorophyll so the plants can get energy through photosynthesis; phosphorus (P) helps with the development of roots and stems; potassium (K) is involved in photosynthesis and water uptake, as well as a number of other cellular processes. Calcium (Ca) is very important as a structural component of plants and assists with the uptake of other nutrients. There are dozens of other nutrients that are necessary for plants to grow and be productive. Carbon, hydrogen and oxygen are taken in through the leaves from the atmosphere. All of the rest are taken up through the roots from the soil.

Testing Your Soil:

Not all nutrients are needed in equal amounts, and keeping the balance is important. Most are only needed in very small amounts and plants are not usually lacking them as long as the soil is rich in organic matter. Others may need to be added to the soil via fertilizers, and the best way to do this accurately is by testing your soil first. You can get a full soil test done by sending a sample in to a soil lab, and it will give you all the information you need to make the necessary adjustments to your nutrients. There are also very inexpensive methods (like Rapitest Soil Test Kits) that will allow you to quickly assess the N, P and K (three essential nutrients that are found in the greatest quantities in soil), as well as the pH of your soil.

(24) In a new garden, you may want to add fertilizers like bone meal to your soil to bring the nutrients up to an acceptable level, especially in the first few years before the soil life begins to flourish. Try to minimize your use of fertilizers, even organic ones; even these have an environmental impact. You should be able to get all the nutrients you need from local materials.

There are many nutrients necessary for plant growth. Some are needed in greater quantities than others.
Fertilizing:

Fertilizing your soil is not as simple as dumping nutrients into it until your plants grow better. Here are some things to consider:

**N-P-K:**
Most chemical and organic fertilizers list the relative content of nitrogen, available phosphate and soluble potash (N-P-K). These N-P-K values are useful for knowing what you are adding to your soil. Bone meal is a source of phosphorus, and is not a great source of nitrogen or potassium. It has N-P-K values of around 2-15-0. It is also a good source of calcium but the N-P-K values do not tell you everything that is in the fertilizer. A good livestock manure may be around 2-0.8-1, which seems low compared to values on a bottle of chemical fertilizer, but that is because the values show what is immediately available to plants. Much of the nutrients in manure, as well as in other organic materials, are released slowly and will become available to plants over the course of several growing seasons.

**Too Much or Too Little?**
Plants need a balance of nutrients. Adding lots of nitrogen will not save your soil if it is low in calcium. Adding too much of one nutrient can impact the balance of another. This is why it is good to test your soil to find out exactly what it is you need more of, and how much.

**Calcium:**
NWT soils are often low in calcium, especially where soil is very acidic. Wood ash is an excellent source of calcium but be careful not to add this if your soil has a high pH. Other good sources of calcium include:
- Bone meal
- Crushed limestone dust,
- Crushed eggshells,
- Fish bones,
- Animal hair,
- Spruce needles.

**Avoid Chemicals:**
N-P-K values do not tell you everything that is in a fertilizer. Many chemical fertilizers include many filler materials not listed on the packaging that will not help your garden in the long run.

In fact, chemical nitrogen fertilizers like ammonium sulphate and ammonium nitrate can actually contribute to soil acidification, and can have negative impacts on microbial communities in the soil.

**Organic Fertilizers:**
Some good organic fertilizers to use include: (good source of)
- Compost (N)
- Manure (N, P, K)
- Wood ash (P, K) *raises pH
- Rock phosphate (P)
- Granite dust (K)
- Bone meal (P)
- Blood meal (N)
Summary

*What does good soil look like?*

- Loose and dark
- Lots of organic matter
- Mix of sand, clay, and silt
- Well mixed, with few large clumps
- 25% moisture
- pH ~5.5-7.0

Building local garden soil is really about growing food, and moving toward sustainable local food systems in the NWT. Community gardens and backyard gardens can produce healthy food using transparent, healthy techniques. They can encourage people to become active in the community, and they can encourage people to take control of their food choices, and make informed decisions about their nutrition.

Harvest materials responsibly, experiment and find a mix that works for you.

Growing good food in the NWT is possible. We can provide affordable, nutritious alternatives to imported fruits and vegetables, and good soil is the key to making this a reality.

*It all starts with the soil.*
Suggested Reading

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Jeanne Burke and Debbie Abbot, Yukon Agriculture Branch, 2005.
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Soils in the NWT:

EcoDynamics Consulting Inc. Northwest Territories soil survey enhancement project – final report (draft). Department of Industry, Tourism and Investment (ITI), Government of the Northwest Territories, Yellowknife, NT. 36 pp. + appendices.

Nutrients and pH:


Living Soil:


Composting:


Woodchips, Sawdust, and Forest Litter:


Fish Waste:


Wood Ash:


Hair:


Manure:


Peat:


Fertilizing:


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(1) Ecology North
(2) Ecology North
(3) Map adapted from: Ecological regions of the Northwest Territories, Department of Environment and Natural Resources, GNWT, 2010
(4) Ecology North
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