Best Management Practices

Subsidence

Organic soils are a unique resource that have developed over a long period of time. These valuable soils play a significant role in vegetable production. However, they are also fragile and subject to degradation particularly once used for agricultural purposes.

This factsheet looks at the soil processes that lead to subsidence, the impact on the productivity and environment and explores options for reducing subsidence through management practices such as controlled drainage, reduced tillage and cover crops.

THE ROLE OF HEALTHY SOIL IN A CHANGING CLIMATE

Agriculture and climate are directly linked – anything that has a significant effect on our climate will influence farm production. Greenhouse gas (GHG) emissions and climate change are global concerns, and agriculture can be part of the solution.

BMPs that improve soil health can also help lower GHG emissions, reduce phosphorus loss from fields to surface water and improve resilience to drought or excessively wet conditions. Healthy soil – an essential component of a healthy environment – is the foundation upon which a sustainable agriculture production system is built.

Ontario

What is subsidence?

Subsidence is the permanent lowering of the surface elevation of organic soil by a set of soil degradation processes following the subsurface drainage and cultivation of organic soils.

Organic soils are often referred to as muck or peat soils. They develop in level or depressional areas, usually wetlands, where persistently high-water tables have prevented the biological oxidation of dead plant materials. Historically, both peat and muck soils have been cleared, drained and used to grow high-value vegetable crops. Subsidence starts immediately after drainage.

Field lowering and light-coloured mineral subsoil at the surface are visual evidence of subsidence.

High water tables enable plant residue to accumulate and develop into organic soils. It is estimated that it takes approximately 500 years to create 30 cm of organic soil if the water table is undisturbed.

Subsidence and soil health

Muck or peat soils are valuable for specialized vegetable production of crops like carrots, onions, celery, radish and leafy greens like lettuce. The soil is limited in acreage and highly fragile. Subsidence occurs from a combination of a number of forms of soil degradation. Subsidence puts muck soils at risk of:

- further degradation
- lower fertility
- limited rooting medium
- soil erosion

RISKS OF FURTHER DEGRADATION. Wind and water erosion are part of the process of soil loss and degradation and help to drive subsidence in organic soils.

LOWER FERTILITY. Fertility management is important in organic soils with high value vegetable production. With subsidence, organic soils become shallower and start to mix with mineral subsoils below. This affects soil pH and nutrient availability as well as plant available moisture.

POORER ROOTING MEDIUM. Over time, tillage brings up soil material from a greater and greater depth like this relatively untouched fibrous material. Eventually the subsoil starts to be incorporated. Reduced soil depth means less exploitable rooting soil volume for crops and less water and nutrient holding capacity.

RISK OF SOIL EROSION. Traditionally, the high value of muck soils has discouraged the use of buffer strips or other conservation measures, often resulting in cropping adjacent to ditches and soil movement into waterways.

Subsidence: the basics

Subsidence is unique to organic soils or the organic layer in peat covered mineral soils. Organic soils contain >30% organic matter by weight and are at least 40 cm deep over mineral subsoils or bedrock. These soils develop in level or depressional areas, usually wetlands, where persistently high-water tables have prevented the biological oxidation of dead plant materials.

Organic soils are classified according to their depth and degree of decomposition. Highly decomposed organic soils are often referred to as muck soils. Whereas, organic soils where the original woody or plant material remains visible, are often referred to as peat soils.

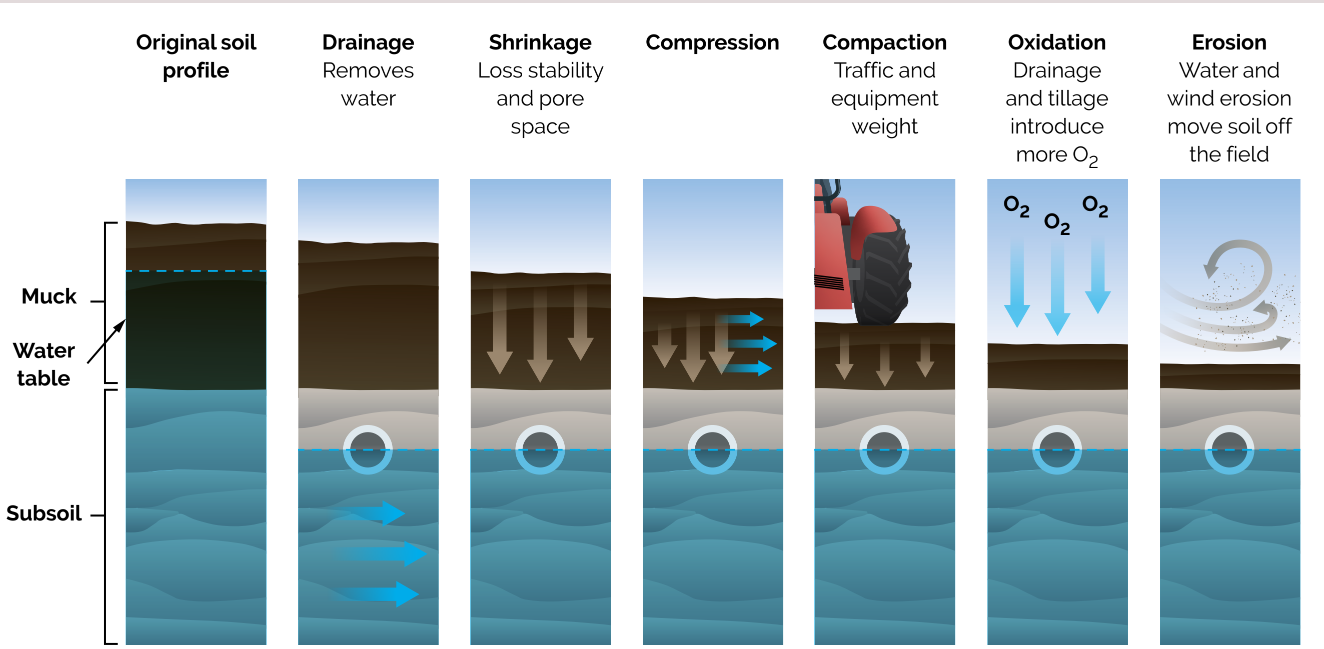
Organic soils begin the process of subsidence with clearing of the land, drainage and the start of cultivation.

Most organic soils were developed in wetlands.

SUBSIDENCE PROCESSES

Subsidence consists of several processes:

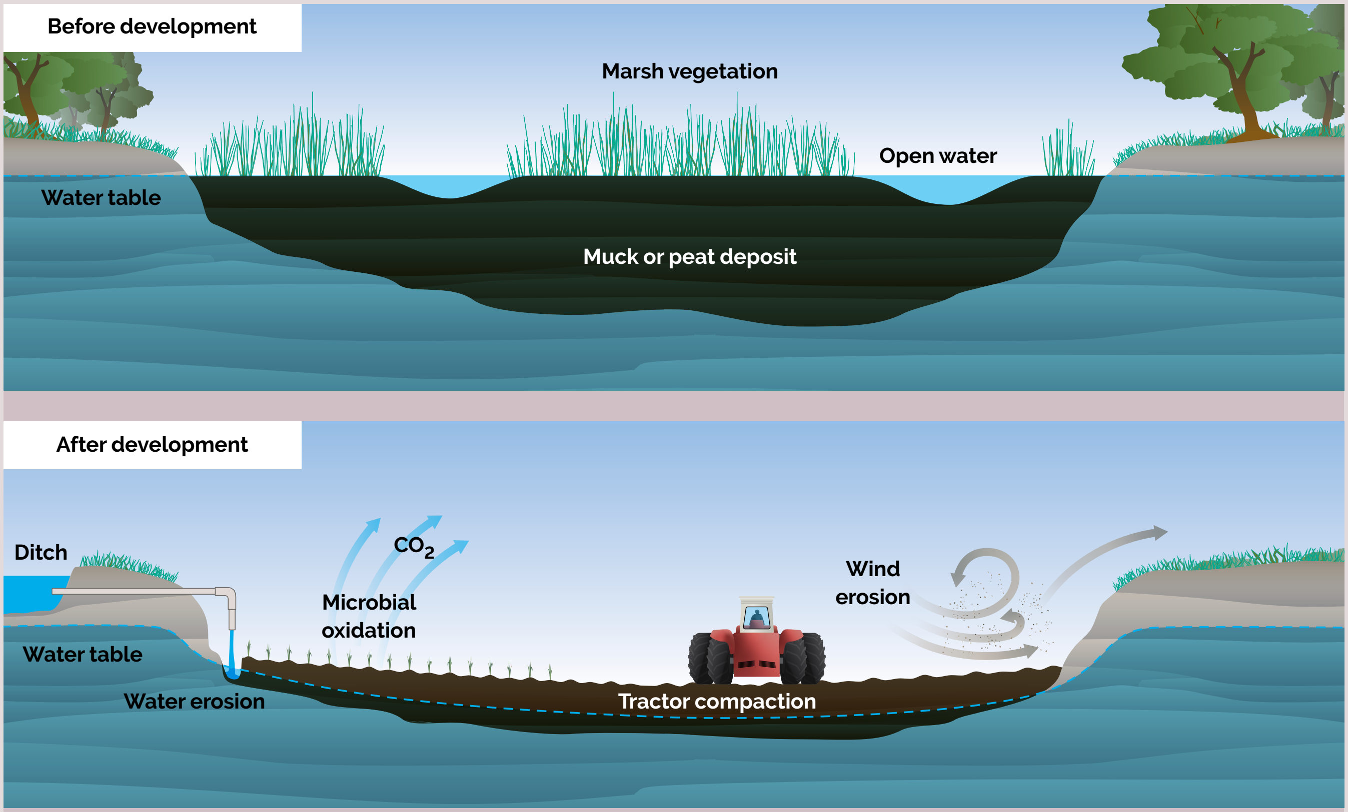
- **Shrinkage –** loss of volume due to the removal of water
- **Consolidation or compression –** densification of the peat due to the loss of buoyancy from the lowering of the water table
- **Compaction –** in-filling of the macropores with humic and mineral particles combined with wheel and weight-based pressure
- **Oxidation –** microbial decomposition of well-aerated organic soil substrate



Subsidence is usually considered to be a combination of up to 4 processes – shrinkage, compression, compaction and oxidation. Soil erosion also plays a role in the loss of soil depth.

Shrinkage

- Shrinkage is due to physical processes.
- The withdrawal of moisture from the surface layers by lower water tables (subsurface drainage) and increased evapotranspiration rates (from cropping and tillage practices) may cause high moisture tensions in the root zone resulting in a decrease in water volume of those layers (above the phreatic surface where the soil is saturated).



Subsidence starts as soon as the water is removed by lowering water tables through drainage. The other processes further deplete the organic soil layer over time.

Consolidation or Compression

- Consolidation or compression is a mechanical process.
- When the water table is lowered, the soil is no longer supported by the buoyant force of gravitational water. Most compression happens in the first few years of cultivation following clearing and drainage.
- Compression of the pore spaces is worse when the soil is wet due to the lack of structure in a wet or permanently saturated soil.
- As an organic soil compresses, the deeper layers have to bear an increased weight of 1 g/cm^2/cm of draw-down of the groundwater table. This causes compression of the soil layers in the saturated zone.

Compaction

- Compaction in organic soils is somewhat similar to the process of compaction in mineral soils. Soil compresses from the weight of vehicles and implements on the surface when subsoils are moist to wet, which reduces the size of macropores through compression and the filling of macropores with smaller humic particles.
- The rate of compaction increases with a decreasing depth of organic soil over mineral soil as mineral particles can contribute to the in-filling of macropores.

Oxidation

- Organic soils develop under anaerobic (waterlogged) conditions. When the water is drained from the soil, biological oxidation or mineralization of the organic matter starts. As the organic matter breaks down, the amount of peat shrinks and the soil level lowers (subsides).
- The rate of oxidation is accelerated when the drained organic soils are cultivated. Tillage physically breaks down the soil particles and adds air to the soil to feed the microbes that are breaking down the organic matter.

Tillage can accelerate the oxidation processes and leave soil open to wind and water erosion.

Interactions with other forms of degradation

While soil structure in organic soils is more subtle and fragile, tillage destroys any soil structure that might have been present. Loss of soil structure affects a number of physical properties, including ease of drainage or other water movement within the soil profile. Once aggregates have been destroyed, the associated particles that originally made up the aggregate now have considerably more surface area and are more susceptible to microbial degradation, enhancing subsidence and carbon loss.

Wind and water erosion can lead to a loss of peat material. Runoff on peat soils is common since the water holding capacity is often above field capacity. If the peat is not waterlogged (during a growing season), it is light and fluffy and easily blown by wind, if not covered, or detached and moved off site with runoff.

Peat soils are typically low in fertility and in particular micronutrients. When fertilizers are added to grow crops, the microbial community changes and rates of decomposition are accelerated.

Over just a few years of cultivation, the levels of the organic soil can drastically drop due to these processes. These soils do not regenerate quickly enough when cropped which means that eventually they will become mineral soils with high organic matter rather than muck soils. Note the lower field level versus the fencerow area.

Conditions where subsidence is likely

SOIL CHARACTERISTICS

- **Humus content of the peat –** humus is more resistant to decomposition as it is by nature well-decomposed
- **Mineral content of the peat –** higher mineral content (which occurs over time) leads to less subsidence
- **Thickness of the original organic layer –** deeper deposits will subside more

WATER TABLE AND TILE CHARACTERISTICS

- **Water table fluctuations –** fluctuating high water tables that saturate more of the soil may reduce the rate of subsidence if it keeps the soil saturated
- **Tile or surface drain depth and spacing –** closer and deeper tiles lead to accelerated subsidence if the water table is kept very low and soil is well drained

CLIMATE CONDITIONS

- **Wet and dry cycles –** rainfall and soil moisture levels affect the rate of subsidence
- **Temperature –** oxidation rates (a result of microbial activity) increase with temperature

PAST AND PRESENT MANAGEMENT

- poor management of water table levels resulting in excessive drainage
- deepening of drainage ditches when conducting maintenance
- short crop rotations and continuous cropping
- tillage to incorporate fertilizers or lime to correct low pH
- intense production operations (e.g., tillage, planting, spraying and harvesting) leading to compression, compaction and soil erosion
- bare soils over winter leading to erosion
- harvesting of peat for gardening or soilless mixes

Subsurface drainage contributes to an increased rate of subsidence. However, by managing the water table outside of the crop production time, subsidence can be slowed.

Bare soil over winter contributes to the rate of subsidence in Ontario organic cropland soils.

Diagnostics for subsidence

FIELD OBSERVATIONS

Organic soils can subside at a rate of 25 m/year.

- field soil surface is noticeably lower than the soil surface in adjoining areas or field edges
- spotty areas of poor drainage or areas that dry out sooner than the rest of the field
- soil wind erosion visible during windy days
- loss of eroded soil visible, especially in the spring

CROP OBSERVATIONS

- shortened rooting depth due to less soil volume for rooting area
- more irrigation is required to avoid crop stress
- varied crop development and yields across a field (e.g., crops on knolls stressed before rest of field)

While the loss of soil depth and mixing of topsoil and subsoil will have an impact on the crop roots over time, losses due to wind erosion can have a significant impact in one season. Here onion sets have been exposed shortly after planting in spring.

SOIL OBSERVATIONS:

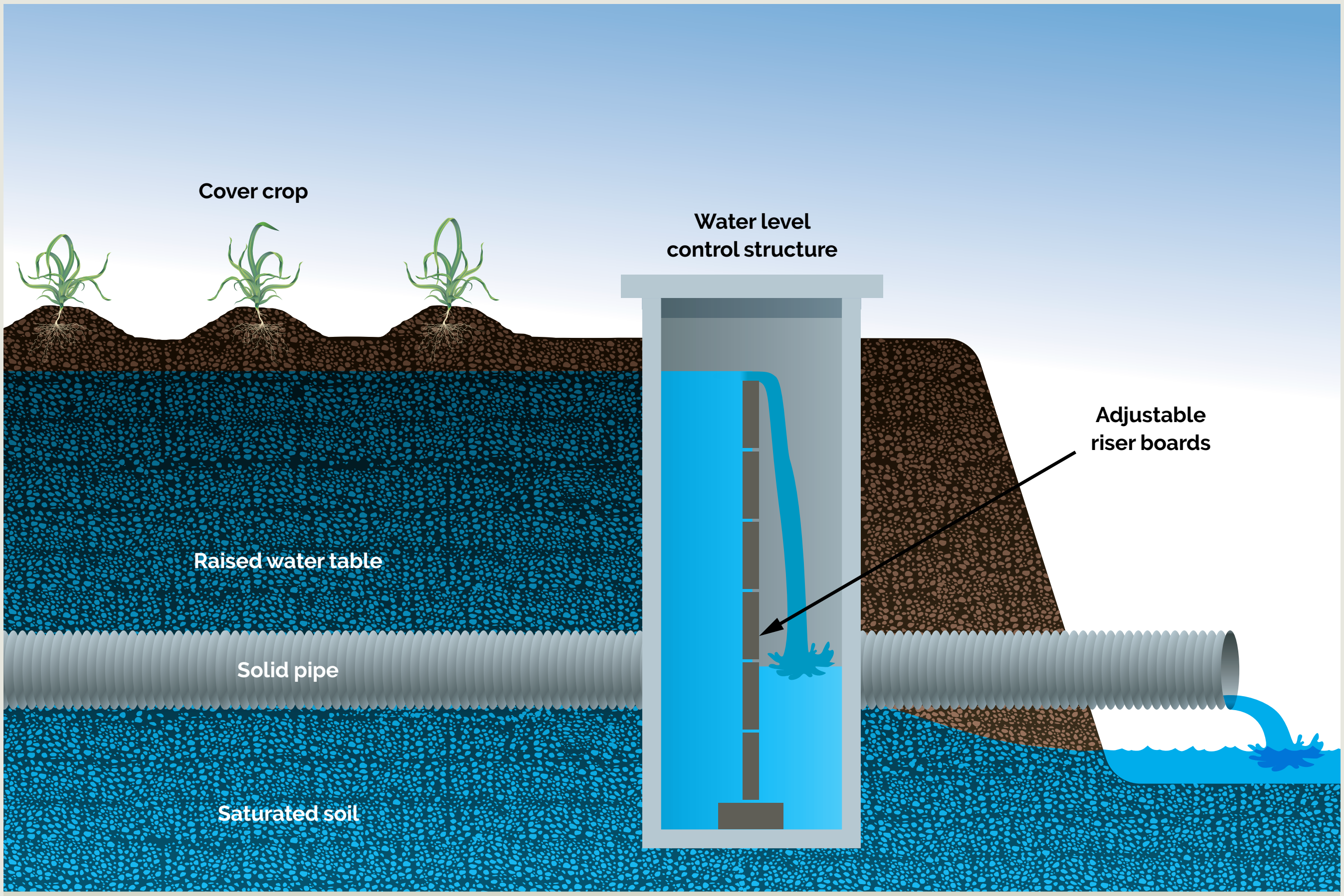
- cracking of dry soils from water removal
- slow to re-wet due to lowered permeability from compression and compaction
- lighter coloured mineral soil mixed into the dark organic soils indicating mixing of the mineral subsoil with the organic topsoil.

Subsided soils will crack when dry.

A soil probe can give quick information about the depth of the muck soil and the degree of mixing with lighter coloured mineral subsoil. This probe is 30 cm in length.

Best management practices

- use water table control structures to keep subsoils saturated
- reduce tillage operations, especially in saturated soils
- implement residue management to have the surface covered to avoid evaporation and slow oxidation of organic material
- plant windbreak/nurse crops, use quick emerging grains early in the season to prevent wind erosion and protect young vegetable seedlings
- plant cover crops as the green manure returns organic matter to the soil



Water table level control devices are used to keep subsoils saturated and reduce the rate of oxidation and other forms of subsidence during winter and other non cropping time periods.

Fast growing small grains can protect both the soil and the vegetable seedlings from spring winds.

Crop rotation and cover crops can protect organic soils and add organic matter.

For more information

ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Many sources of supplementary information are available.

Most can be found online at Ontario.ca or ordered through Service Ontario.

- *Soil Fertility Handbook* Pub 611
- *Agronomy Guide for Field Crops* Pub 811
- OMAFRA factsheet, *Soil Erosion – Causes and Effects*
- OMAFRA factsheet, *Management of Organic Soils*

Best Management Practices Series

- *Controlling Soil Erosion on the Farm*
- *Horticultural Crops*
- *Soil Management*

Ontario Crop IPM Soil Diagnostics
http://www.omafra.gov.on.ca/IPM/english/soil-diagnostics/index.html

Specialty Cropportunites General Agronomics
http://www.omafra.gov.on.ca/CropOp/en/general_agronomics/index.html

Environmental Farm Plan (4th ed.) and EFP Infosheets

- Worksheet #15, *Soil Management*

Inquiries to the Ontario Ministry of Agriculture, Food and Rural Affairs

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