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Organic Matter: Does it matter?

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Highlights

- Organic matter is a key pool of available nutrients and should be appropriately managed for the next tree generation during harvesting and site preparation.
- Humus type can be a rough indicator for site fertility; mull humus sites tend to be more fertile than sites with mor humus.
- Minimizing forest floor disturbance on sites with coarse soils and thin forest floors will reduce the impact on nutrient availability.
- Slash left on site will help to maintain organic matter in nutrient-poor soils.
- Forest floor removal in black spruce peatlands (i.e. thick organic horizons) can enhance nutrient availability by increasing decomposition.

Organic matter, humus, forest floor and carbon – all these terms come up frequently in discussions of forest and forestry practices. There are good reasons to focus on the organic layer in forests. This note gives an overview of exactly what organic matter is, clarifies some of the jargon, discusses the importance of organic matter in forest ecosystems and looks at some of the effects of forest practices on organic matter and, in turn, forest growth.

Organic matter, carbon, humus and humus forms

Organic matter refers to a wide variety of materials that originated primarily from plant residues and grades from relatively fresh, undecomposed material at one end to humus, a very stable, highly decomposed substance at the other. Organic matter represents a significant part of the forest floor and a much lesser part of the mineral soil below. This is why we often talk about the forest floor and the organic horizon (and although not entirely correctly, humus) interchangeably. In the context of this note, organic matter is used with respect to the forest floor. Where does organic carbon (C) fit in? Organic matter is largely composed (between 35 – 50%, depending on the site) of C. Carbon is key as it can limit how rapidly or slowly organic material decomposes.

The forest floor can be subdivided into L (freshly fallen litter), F (partly decomposed) and H (relatively homogeneous, well-decomposed humus) layers. The humus found in the lowest forest floor layer is made up of the recalcitrant (hard to break down) products of decomposition that yield few available nutrients.

One broad classification of forest floor is by humus forms: mull, mor and moder. Mor humus has matted forest floor layers held firmly by fungal hyphae and is often, but not exclusively, associated with coniferous forests. Mull humus consists of thin H layers underlain by an Ah horizon (mineral soil mixed with humus) that has been mixed as a result of animal activity and is generally found under deciduous forests. Mixedwoods, as well as some deciduous and some coniferous forests, have a moder type of humus, which is distinct from either mor and mull humus but incorporates characteristics of the two – an intermediate of sorts.

Knowledge of humus type can tell you something about the nutrition. Mor humus, for instance, is associated with the accumulation of organic matter, lower rates of decomposition and, hence, lower nutrient availability. Mull humus, on the other hand, is often associated with higher rates of decomposition and, hence, enhanced nutrient availability.

Organic matter has important functions in the forest ecosystem

Organic matter is a source of nutrients

The organic matter in the forest floor provides many of the nutrients used by plants for growth and maintenance. The availability of nitrogen (N), sulphur (S) and phosphorus (P), depends on the release of these nutrients from soil organic matter through decomposition by the soil biota. As decomposition proceeds these nutrients are released (mineralized) or tied-up and unavailable (immobilized) depending on the C content of the organic matter. Early phase decomposition (when soluble C and cellulose-C are 'taken apart') tends to result in immobilization while later phase (when lignin-C is decomposed) results in mineralization.

Organic matter, specifically the forest floor, is the main source of nutrients for plant growth in forests. Sure, there are other sources of nutrients – in precipitation and atmospheric deposition for instance, but when it comes to nitrogen and phosphorus in particular, organic matter rules. Not only is organic matter key to plant nutrition, but it also plays a role in water holding capacity, microclimate and soil physical structure.

Nutrient availability

Whether or not nutrients are mineralized or immobilized is key to plant nutrition. This is where the C:N (carbon to nitrogen) ratio comes into play. The C:N ratio refers to the relative concentrations of C and N in any given material. Generally, nutrients are made available once the C:N ratio is below 30. In the decomposition phases described above, the C:N ratio shifts from about 60:1 to 30:1. When micro-organisms decompose materials with a high C content such as logging residues (e.g. slash) they need a good supply of N as well as P in order to live and grow. As the micro-organisms use up these nutrients, they become tied up in microbial biomass and unavailable to plants. In a nutrient poor soil, this immobilization could lead to temporary tree nutrition problems, at least until the first phase of decomposition is over. On the other hand, when organic matter with a relatively low C:N ratio is abundant (i.e. relatively more N for microbial growth), there is the potential to deliver nutrients to plants much more readily with less immobilization by decomposers.

Organic matter helps retain nutrients

Availability of potassium (K), calcium (Ca), magnesium (Mg) and many micronutrients, depends on these nutrient ions being held by negatively charged sites on soil particles, such as the organic matter in the forest floor. This leads to one of the essential features of soil organic matter (specifically humus)-- its ability to hold positively charged ions (otherwise known as cation exchange capacity). Combine this capacity with a large surface area, and organic matter offers excellent nutrient holding advantages. Thus, nutrients that might otherwise be washed into the subsoil where they are inaccessible to plant roots can be retained by organic matter in the forest floor or in the upper mineral soil. A soil with low organic matter or a site where organic matter has been displaced during site preparation, for instance, is likely to have a limited capacity to hold nutrients especially if the mineral soil below is coarse-textured.

Thanks to its large nutrient holding capacity, organic matter can also buffer against an increase in soil acidity (i.e. acid rain) and tie-up heavy metals (e.g. mercury, lead) thus reducing their toxicity and restricting their transfer to more sensitive aquatic systems.

Organic matter increases water availability to plants

Just as organic matter retains nutrients, it also retains water for use by plants. This is important in shallow and sandy soils, which are notably dry. Organic matter can ameliorate droughty situations to some extent – holding water longer than sand or silt for plant root uptake. In fact, organic matter can hold enough water to create boggy, saturated conditions, as found in black spruce bogs across the boreal zone. Water is essential to biological life since most of the soil bacteria, fungi and other flora and fauna either move in water and /or require it for their survival. On the other hand, too much water or too little can cause biological life and thus, decomposition and nutrient cycling, to slow down enough for subsequent consequences to tree productivity.

Organic matter affects micro-climate

Organic matter is also implicated in microclimate – the climate on a small scale as experienced, for instance, by tree seedlings or soil organisms. In general, an undisturbed forest floor with its cover of litter and vegetation has significant insulative value, which moderates temperatures for tree roots and nutrient cycling. However, disturbance can have a similar effect on nutrient cycling. Exposed humus and burned forest floor, both unreflective, absorb solar energy and can promote decomposition and nutrient cycling. In contrast to this are very thick organic layers, which often remain quite cool and can cause the process of decomposition to slow down sufficiently to impact nutrient cycling.

Plant rooting patterns and depth are affected by the amount of organic matter in the forest floor. The presence of organic matter in the soil can ameliorate the negative effects of compaction often observed as a result of harvesting, and thus, retain air space for roots. Roots can grow deeper and further laterally, and explore the soil better for nutrients and water. In compacted soils, seedlings often have difficulty rooting, and nutrients and water are not likely to reach the roots.

Organic matter is affected by forest management

Given the importance of organic matter (and, thus, the forest floor) to the supply and retention of plant nutrients, forest practices that affect it will, in turn, affect tree growth and nutrition. Forest floor displacement through harvesting and site preparation can result in either significant or minimal loss of site nutrient capital in forests depending on the nature of the stand and the harvesting/site preparation method. One could make the broad generalization that sites with thin forest floor are vulnerable to nutrient losses after full-tree harvest and benefit from minimal disturbance. On the other hand, on sites where forest floor has accumulated (as in peaty-phase black spruce stands), forestry practices that reduce this organic layer or 'activate' it via enhanced decomposition could be beneficial to regeneration. In such cases, full-tree harvest may not impact the next crop of trees and site preparation is recommended.

Harvesting, be it full or tree- length has the immediate effect of reducing organic matter input, which in turn impacts the nutrient cycle. In some forest systems, the effect of harvesting on forest floor nutrients is minimal and disappears with the establishment of pioneer species and the next crop of trees. This can be especially true when slash is left on-site. In lowland black spruce stands, however, complete tree removal may have serious impacts on nutrient availability. By removing the source of organic matter input from an often thin, upper organic layer that is not waterlogged and where decomposition takes place, this type of harvest could disrupt the entire nutrient flow. A discussion of the effects of harvesting and subsequent site management on nutrient pools introduces the concept of nutrient replacement times and ecological rotation. In terms of site nutrient capital management (removal vs. returns), the length of the recovery period (return to pre-harvest levels) is a function of: 1) the degree of site depletion accompanying the harvest treatment, 2) the rate of input, and 3) the ability of the regenerating forest to retain these inputs.

Fire and organic matter

While fire (both wild and prescribed) consumes organic matter, it can also aid in its decomposition and release of nutrients in some ecosystems. Many studies in black spruce and jack pine boreal forests have found initial post-wildfire increases in N, P, and Ca in the forest floor. These increases are followed by decreases but subsequent increases in these nutrients in lower soil layers. At the same time fire can lead to nutrient losses due to leaching and erosion, which can significantly lower nutrient concentration in the forest floor.

Summary

Organic matter is an essential component of the forest floor which, in an undisturbed forest, generally acts as a nutrient reservoir. Where the forest floor is very thick, the forest floor may act more like a nutrient sink, especially for N, with low rates of decomposition. Humus forms can provide a rough guide to site fertility. Natural disturbance, such as wildfire, often results in a flush of nutrients from the forest floor. While forest floor management is generally site-specific, sites with thin forest floors are often considered vulnerable to nutrient losses. Here, forest floor should be minimally disturbed with benefits to slash left on site. On lowland black spruce sites with thick forest floors, its disturbance may be beneficial to nutrient cycling, at least in the short term, by promoting decomposition.

Suggested Readings

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