HYDROLOGIC ROLE OF SHALLOW ORGANIC SOILS IN COLD CLIMATES

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INTRODUCTION

Subarctic landscapes such as the Yukon-Tanana Uplands of central Alaska are commonly characterized by a fairly predictable mosaic of vegetation and soil cover. At the high latitudes of central Alaska (64° to 67° N), slope exposure is a major determinant of annual solar energy input, and consequently of growing conditions, organic matter accumulation and decomposition, and soil temperature. Relatively shallow organic soils comprise an important hydrologic variable in the soil-plant-water system. This paper addresses the hydrologic significance of such organic soils in generating runoff.

The strong dependence on slope exposure allows a convenient, if somewhat idealized, characterization of naturally occurring vegetation, and (by inference) of occurrence of permafrost and associated organic soils. On permafrost-underlain sites, which typically include north-facing slopes and valley floors, lower annual soil temperatures result in reduced rates of decomposition of plant debris. The consequent buildup of litter and organic material on such cold sites provides favored habitat for moss and moss-lichen plant communities, often with a black spruce/ blueberry/ labrador tea-dominated overstory. A thick, dense ground cover (moss, lichens, vascular plant roots, and litter) effectively insulates the mineral soil, lowering soil temperatures and furthering development of what has come to be referred to as "organic soil", or an organic mat overlying mineral soil. In contrast to thicker "peat" deposits found in many parts of the world, the organic soils with which we are concerned here are relatively shallow---20 to 50+ cm in general. Non-permafrost sites also have a thin veneer of organic material; however, the depth of this layer seldom exceeds 15 cm.

Two soil conditions prevail in this zone of discontinuous permafrost. Where permafrost is present, the underlying mineral soil tends to be poorly drained and have high moisture content. If the mineral soil is coarse, and if the slopes are steep, the active layer is generally deeper and better drained; these conditions are not common. Non-permafrost sites are well drained. The importance of the moisture content lies in the influence on hydraulic conductivity in the spring. If high moisture contents exist in the fall, the hydraulic conductivity of this soil is substantially reduced by ice occupying the pores. Where the mineral soils are relatively dry, the pores are not completely filled with ice, and infiltration of water occurs.

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The hydrologic significance of these relatively shallow organic soils stems from their influence on disposition of rainfall or snowmelt water received at the soil surface. When essentially impermeable permafrost underlies the organic material, as is common, saturated conditions may develop in the organic layer; consequently, water moves downslope through the relatively porous organic material much more rapidly than through the frozen mineral soil. Where permafrost is absent, water infiltrates into the organic layer, satisfying the water retention properties of this layer. If additional water is available, infiltration into the mineral soil will proceed. If the infiltration capacity for that soil is exceeded, water will again start to saturate the organic mat.

In the first case, water moving downslope can contribute significantly to surface runoff. This can often be observed on permafrost-underlain slopes during spring snowmelt, when large quantities of water are available. The high hydraulic conductivity of this material ensures that overland flow (at the organic soil surface) will not occur and that essentially all available water will infiltrate into this shallow organic system. Whether water continues downward into the mineral soil depends upon two factors: the hydraulic properties of the mineral layer, and the rate of infiltration into the organic layer.