Soil Drainage Classification and Hydric Soil Indicators

EAS/CSS 260 - Intro Soil Science

Cornell University

Drainage classification of soils refers to the frequency and duration of periods when the soil is saturated with water. **Hydric soils** , loosely corresponding to poorly and very poorly drainage designations and to aquic moisture regimes in soil taxonomy, are water-saturated for sufficient duration when plants and soil microbes are active (soil temp > ~5 C) to produce a reduced matrix (e.g. anaerobic environment) and also support hydrophilic vegetation. Collectively referred to as **hydric soil indicators** , mineral and organic soil features created under these conditions are utilized in conjunction with vegetation cues to infer the presence of hydric soils and to assist the wetland delineation process.

Soil drainage characterization is essential for taxonomic classification and determining suitability for various potential uses. For instance, constructing a sceptic field on a poorly-drained soil would be a particularly odious investment! Wetland determinations commonly carry the weight of federal, state, and (occasionally) local laws. Among many environmental services, wetlands provide important habitat for wildlife, reduce the intensity and duration of flood events, and act as natural filters for surface water resources. Consequently, wetlands are regulated differently than non-hydric land units. In New York State, the Department of Environmental Conservation (NYSDEC) enforces the Freshwater Wetlands Act of 1975 which restricts certain types of development on wetland parcels larger than 5 hectares (NYSDEC Freshwater Wetlands Program). The economic consequences of wetland delineation can be tremendous for landowners and would-be developers. Hence, many resources are dedicated to wetland delineation both in the public and private sectors.

Soil Drainage Classes in USDA's Soil Taxonomy (Soil Survey Staff, 1993):

Very Poorly Drained - Water is at or near the soil surface during much of the growing season. Internal free-water is shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Commonly, the soil occupies a depression or is level. If rainfall is persistent or high, the soil can be sloping.

Poorly Drained - The soil is wet at shallow depths periodically during the growing season or remains wet for long periods. Internal free-water is shallow or very shallow and common or persistent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soil, however, is not continuously wet directly below plow depth. The water table is commonly the result of low or very low saturated hydraulic conductivity class or persistent rainfall, or a combination of both factors.

Somewhat Poorly Drained - The soil is wet at a shallow depth for significant periods during the growing season. Internal free-water is commonly shallow to moderately deep and transitory to permanent. Unless the soil is artificially drained, the growth of most mesophytic plants is markedly restricted. The soil commonly has a low or very low saturated hydraulic conductivity class, or a high water table, or receives water from lateral flow, or persistent rainfall, or some combination of these factors.

Moderately Well Drained - Water moves through the soil slowly during some periods of the year. Internal free water commonly is moderately deep and may be transitory or permanent. The soil is wet for only a short time within the rooting depth during the growing season. The soil commonly has a moderately low, or lower, saturated hydraulic conductivity class within 1 meter of the surface, or periodically receives high rainfall, or both.

Well Drained - Water moves through the soil readily, but not rapidly. Internal free-water commonly is deep or very deep; annual duration is not specified. Water is available to plants in humid regions during much of the growing season. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soil is deep to, or lacks redoximorphic features.

Somewhat Excessively Drained - Water moves through the soil rapidly. Internal free water commonly is very rare or very deep. The soils are commonly coarse-textured, have high saturated hydraulic conductivity, and lack redoximorphic features.

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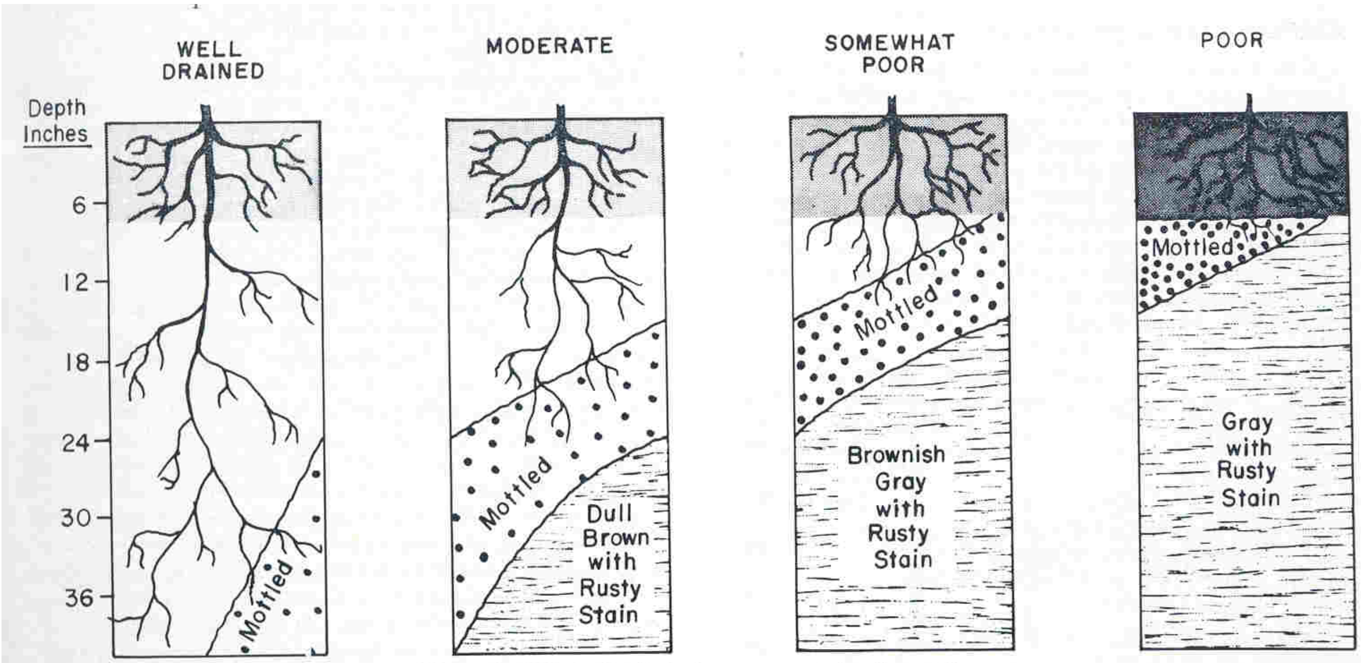


Figure 5.—Effect of soil drainage on root development.

Drainage classes recognized in the Tompkins County Soil Survey. Note the depth to redox features.

Hydric Soil Chemistry

Soil microbes oxidize carbon compounds to obtain energy (i.e. respiration) and require chemical elements to act as terminal electron acceptors in these reactions. In aerobic environments, oxygen serves as the primary electron acceptor, forming water as the respiratory by-product . When microbes are active under saturated or near-saturated condition, pools of oxygen in the soil air and dissolved O_2 in soil water are rapidly depleted. Suites of facultative and obligate anaerobic microbes become ascendant, utilizing oxidized forms of nitrogen, manganese, iron, sulfur, and carbon (primarily in this order) as terminal electron acceptors. In strongly anoxic environments, the reduced forms of these elements predominate (i.e. N_2, Mn^{2+}, Fe^{2+}, S^{2-}, CH_4). The soil signatures employed to identify hydric environments are directly and indirectly formed by anaerobic consumption of organic matter:

Carbon Anaerobic decomposition of organic matter is less efficient (i.e. rapid) than aerobic decomposition. All other factors being equal, hydric soils tend to accumulate more organic matter than their better drained counterparts.

Iron In oxidized form (Fe^{3+}), iron pigmentation ranges from orange to dark red. Soils with large amounts of reduced iron (Fe^{2+}) are typically gray to blue-green (termed "gleyed").

Sulfur Under extremely reduced conditions, sulfate ions (SO_4^{-2}) are reduced to sulfide (S^{2-}). Some of these sulfide ions combine with hydrogen to form the memorably-pungent hydrogen sulfide "swamp" gas (H2S).

Redox Features Together with organic matter, iron and manganese are primarily responsible for imparting color to soils. When Fe and Mn are reduced they become mobile, diffusing towards oxidized zones in the soil. Over time this results in areas of concentration and removal, creating a pattern of high pigmentation mottles in a gray, low-chroma matrix. Unlike with gleyed soils or the presence of swamp gas, redimorphic mottles do not necessarily indicate the current redox of the soil, but rather the long term conditions that predominate at the site.

Care must exercised when making inferences based on the presence or absence of hydric soil signatures. Chemical transformations depend on redox potential, rates of biological activity, and the basic mineralogical composition of the soil. For example, visible mottles may not be present in poorly-drained soils formed on red parent materials in coastal regions of the southern USA.

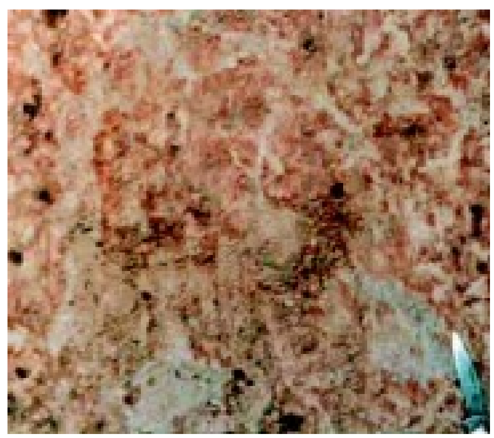
Generic Hydric Soil Indicators:

(1) Histosols and soils with histic epipedons (**organic accumulation**). O horizon >= 8 in thickness.

(2) Sulfidic material (H_2S, "rotten eggs") present within 12 inches of the soil surface (**reduced sulfur**).

(3) Gleyed, low chroma (i.e. chroma <=1) soil colors within 12 inches of the soil surface **(reduced iron**). Refer to the gley pages of the Munsell color book. Color of gleyed soil changes when iron is oxidized to Fe^{3+} (i.e. if the soil is drained).

(4) In the presence of redox concentrations (accumulations of red-orange iron and/or black manganese), colors in the mineral matrix with chromas <= 2 (**mottles**) close to the soil surface. Low chroma regions are commonly referred to as redox depletions.



Hydric soil phenomena are dependent on parent material, vegetation, and climatic factors. Detailed indicators for specific regions of the US are compiled by the Natural Resources Conservation Service (Field Indicators of Hydric Soils in the United States, v 5.0 2002). *Photos courtesy of NRCS.*

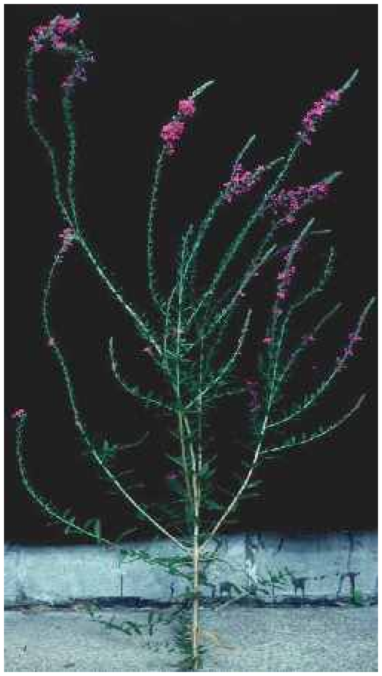
Typical New York Wetland Vegetation

Cyperus spp. **- (sedges)**

Phalaris arundinacea **- (reedcanary grass)**

Populus deltoides
(cottonwood)

Polypodiaceae
(fern family)



Lythrum salicaria
(purple loosestrife)

Thousands of plant species have been designated as hydrophytes in the USA. View a compilation of common northeastern wetland flora. *Photos courtesy of USGS*.

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