Part II

Drainage of Organic Soils

Sacramento-San Joaquin Delta

Florida Everglades

Cultivated peat soils in the Sacramento-San Joaquin Delta

(California Department of Water Resources)

In the U.S. system of soil taxonomy, organic soils or histosols are one of 10 soil orders. They are formally defined as having more than 50 percent organic matter in the upper 30 inches, but may be of lesser thickness if they overlie fragmental rock permeated by organic remains. Organic soil is commonly termed "peat," if fibrous plant remains are still visible, or "muck" where plant remains are more fully decomposed. Other common names for accumulations of organic soil include "bog," "fen," "moor," and "muskeg."

Organic soils generally form in wetland areas where plant litter (roots, stems, leaves) accumulates faster than it can fully decompose. Fibrous peats typically include the remains of sedges and reeds that grew in shallow water. "Woody" peats form in swamp forests. In northerly latitudes with cool, moist climates, many peats are composed mainly of sphagnum moss and associated species. The total area of organic soils in the United States is about 80,000 square miles, about half of which is "moss peat" located in Alaska (Lucas, 1982). About 70 percent of the organic-soil area in the contiguous 48 States occurs in northerly, formerly glaciated areas, where moss peats are also common (Stephens and others, 1984).

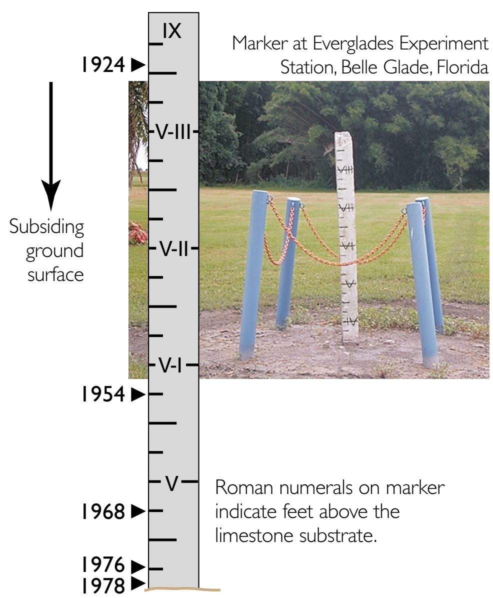
Most organic soils occur in the northern contiguous 48 States and Alaska.

Land subsidence invariably occurs when organic soils are drained for agriculture or other purposes. There are a number of causes, including compaction, desiccation, erosion by wind and water, and, in some cases, prescribed or accidental burning. The effects of compaction and desiccation after initial draining can be dramatic, because organic soils have extremely low density and high porosity or saturated water content (up to 80 to 90 percent).

DRAINED ORGANIC SOILS WILL LITERALLY DISAPPEAR

The most important cause of organic-soil subsidence, however, is a process commonly termed "oxidation." The balance between accumulation and decomposition of organic material shifts dramatically when peat wetlands are drained. Under undrained conditions, anaerobic microbial decomposition of plant litter—that is, decomposition in the absence of free oxygen—cannot keep pace with the rate of accumulation. One reason is that lignin, an important cell-wall component of all vascular plants, is much more vulnerable to decomposition under aerobic conditions. Oxidation under aerobic conditions converts the organic carbon in the plant tissue to carbon dioxide gas and water. Aerobic decomposition under drained conditions is much more efficient.

Evidence of subsidence in the Everglades is shown on a concrete marker that has been driven through the organic soil into the underlying limestone substrate.



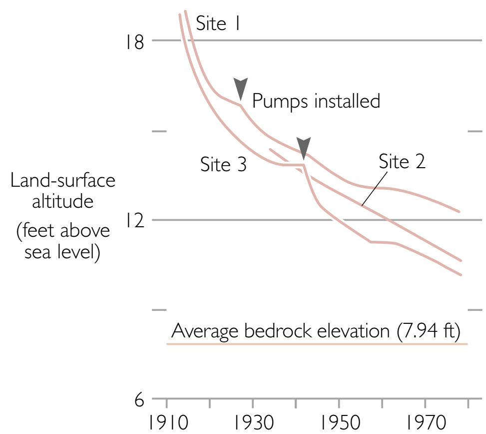
The biochemical origin of much organic-soil subsidence was established by 1930 through laboratory experiments with Florida peat that balanced the loss of dry soil weight with rates of carbon-dioxide production (Waksman and Stevens, 1929; Waksman and Purvis, 1932). This early laboratory work also suggested optimal temperature ranges and moisture contents for microbial decomposition. Later field studies and observations have confirmed "oxidation" as the dominant subsidence process in many instances. For example, in the Florida Everglades, sod fields and residential areas—where causal mechanisms such as erosion, burning, and compaction are minimized or absent—have sunk as rapidly as the cultivated land (Stephens and others, 1984). It is believed that oxidation-related soil loss can be halted only by complete resaturation of the soil or complete consumption of its organic carbon content (Wosten and others, 1997).

Whereas natural rates of accumulation of organic soil are on the order of a few inches per 100 years, the rate of loss of drained organic soil can be 100 times greater, up to a few inches per year in extreme cases. Thus, deposits that have accumulated over many millennia can disappear over time scales that are very relevant to human activity.

SOME ORGANIC SOILS CAN BE CULTIVATED FOR CENTURIES

Human experience with subsiding organic soils dates back nearly 1,000 years in The Netherlands and several hundred years in the English fen country. The old polders in the western Netherlands were reclaimed for agriculture between the 9th and 14th centuries, and by the 16th century the land had subsided to such an extent that windmills were needed to discharge water artificially to the sea (Shothorst, 1977). Because ground-water levels beneath the polders were still relatively high, the rate of subsidence was relatively low—less than 5 feet total, or 0.06 inches per year, over a roughly 1,000-year period in which progressively more sophisticated drainage systems were developed (Nieuwenhuis and Schokking, 1997). Greatly improved drainage in the 20th century increased the thickness of the drained zone above the water table. As a result, subsidence rates rose to about 0.2 inches per year between the late 1920s and late 1960s, and current rates are more than 0.3 inches per year.

Long-term subsidence rates in the Everglades show cycles. Subsidence slows during periods of poor drainage and accelerates when pumps are installed to improve drainage.



(Stephens and others, 1984)

The organic-soil subsidence rates in The Netherlands are still unusually low in a global context. This is due in part to the relatively cool climate, where temperatures are generally below the optimal range for microbial decomposition, and in part to a thin layer of marine clay that caps much of the peat. Larger average rates have been observed elsewhere: up to 3 inches per year over the last 100 years in the Sacramento-San Joaquin Delta, California; about 1 inch per year over the past 100 years in the English fens; and about 1 inch per year for the last 70 years in the Florida Everglades.

Both in the English fens and the Everglades, long-term subsidence rates have been monitored using stone or concrete columns driven into the underlying solid substrate. The history of both areas has been marked by alternate cycles of improved drainage followed by accelerated subsidence and, consequently, inadequate drainage (Stephens and others, 1984), so that the achievements of one generation become the problems of the next (Darby, 1956).