

### 20-3.2 Grassland Soils in Humid Tropics and Subtropics

Vertisols are the most abundant grassland soils in humid tropical areas. The 2,340,000 ha or 1.8% of the land surface of the earth that they occupy is mostly in tropical or subtropical areas with wet and dry seasons. They commonly occur where the annual rainfall is 600 to 1000 mm—enough to support forest vegetation on other soils, but the Vertisols grow grasses. Two factors favor the grasses—the high base saturation and the high content of montmorillonite clay (at least 30% clay to a depth of 50 cm) that gives Vertisols their self-swallowing action. The shrink-swell potential of the montmorillonite causes deep cracks to open in these soils during dry seasons, as shown in Figure 20-4. Granular surface soil falls into these cracks and causes the soil to shift and “churn” when it gets wet. The churning action distributes organic matter throughout the soil and produces a deep, dark-colored soil. It also can break deep roots of perennial plants and the foundations of buildings.

Traditional crop culture on Vertisols in Ethiopia includes cotton, grain sorghum, and sesame in a shifting cultivation that involves burning the soil. Only Vertisols are burned—never the adjoining red

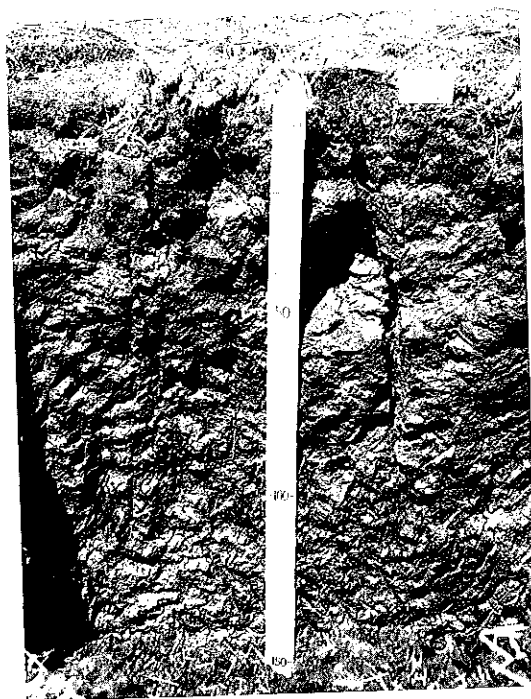


Figure 20-4 A Vertisol in northwestern Ethiopia. This soil developed on high-lime materials, is dark colored, has a high percentage of montmorillonite clay, and has wide deep cracks for at least ninety consecutive days a year. (Courtesy Roy L. Donahue.)

clay soils. The native tall-grass prairie is plowed with a village-made, tongue-type plow pulled by oxen (bullocks). The plowed rows are crooked, and the seedbed is always cloddy and full of large sod pieces with soil attached. The farmer gathers these sod pieces, puts them in piles, and adds cattle manure in the center of each pile, as shown in Figure 20-5. When the soil and sod pieces have dried, each pile is set on fire and may smolder for several days. Upon cooling, the residues from each burned pile are spread over the field. The soil has improved tilth after burning. After further plowings, seeds of cotton, grain sorghum, or sesame are sown. Field crops are then grown for a period of three to five years, after which the land is abandoned. During abandonment, weeds, annual grasses, and finally perennial native grasses grow over a fallow period of ten to twenty years until the burning and cropping cycle is repeated.

During the cropping cycle, the soil becomes weedy, insect and disease populations build up, and soil tilth decreases. Soil fertility is decreased by crop removal; soil crust formation becomes more serious; and sheet and gully erosion are increased. By contrast, during the fallow cycle, the grasses improve the physical condition of the soil, pests decrease, fertility increases by weathering of minerals, and erosion is controlled. The native grasses help to develop a fine crumb structure that makes a desirable physical, chemical, and biological seedbed. Burning the black clay soil inside each pile of sod pieces destroys pests, eliminates cloddiness, and transforms the montmorillonitic clay into nonswelling particles that resemble brick dust. The surface soil that was a clay loam now tests a loamy sand. The burning also increases soil pH, available phosphorus, and total carbonates, but decreases organic carbon (Donahue, 1972).

Shifting cultivation on burned Vertisols supporting native grasses is a soil conserving practice but is an inefficient land use that will not support rising populations with their increasing demand for land. Replacement of this traditional system awaits field research solutions. Perhaps a solution will be found that is comparable to that for forested areas using minimum tillage, organic surface-residue management, pesticides, and chemical fertilizers. In the meantime, Ethiopian farmers are using a system with no modern inputs that maintains yields and stabilizes the soil against excessive erosion.

#### 20-4 EROSION AND ITS CONTROL IN THE TROPICS

In the tropics, soil erosion increases with increasing annual rainfall up to about 1000 mm, but usually decreases at higher rainfalls be-



a



b

Figure 20-5 Traditional shifting cultivation on Vertisols in Ethiopia involves (a) plowing the grassland several times with a village-made plow and then (b) gathering sod pieces into piles. Cattle manure is added to the piles and they are allowed to dry; then they are burned and spread back over the field. (Courtesy Roy L. Donahue.)

cause trees are the usual vegetation in the higher-rainfall areas, and they are more protective than grasses that thrive under lower rainfall. Rains usually come with greater intensity in the tropics than in temperate regions, and high rates of erosion are common on cleared land. Lal (1974) measured soil erosion losses in the tropics on bare slopes varying from 1% to 15%. The rates were 3, 37, 50, and 115 mt/ha on 1%, 5%, 10% and 15% slopes, respectively.

Many sloping soils are used in shifting cultivation, and changes in soil characteristics during the cropping cycle are often catastrophic. Two years after cutting the trees, for example, as much as 30% of the soil organic matter and 70% of the soil nitrogen may be gone.