Soils

Soil is the mixture of rock and mineral particles, organic matter, and water that covers the surface of the earth. It makes the cultivation of food crops possible, supports building foundations, filters groundwater resources and waste materials, and sustains vegetation and wildlife habitats. An understanding of soil properties and limitations contributes to the intelligent use and preservation of all natural resources.

Composition of an Average Soil

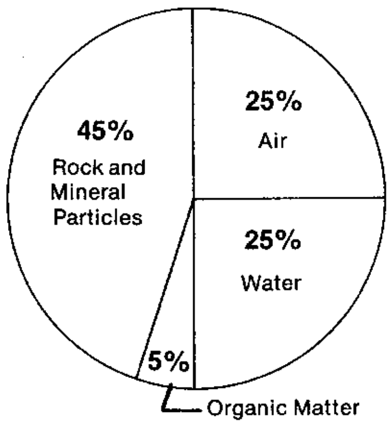


Figure 5.1

As depicted in Figure 5.1, an average soil consists of 45 percent rock and mineral fragments, 25 percent air, 25 percent water, and 5 percent organic matter. Few real soils actually match this description. The composition and proportions of soil components vary from place to place and give rise to differences in color, depth, texture, and the types of vegetation that the soil can support. Factors contributing to these differences include:

- parent material
- climate
- organic matter
- topography
- time

Parent material is the mixture of rock and organic matter from which soil is formed. Its structure, texture, and chemical and mineral composition determine many of the characteristics of soils derived from it.

Soil parent materials are often formed from the underlying bedrock. Over time, daily and seasonal temperature changes and water weather this rock into fragments that form the basis of the soil. In many instances, however, the parent material is derived from bedrock found far away. As described in the Geology chapter, many of the surficial deposits in Dutchess County were left here by glaciers, which deposited them hundreds of miles from their places of origin. Wind and water are also capable of carrying soil-building materials over long distances.

Dutchess County soils are derived primarily from glacial till, glacial outwash, organic matter, and lacustrine and alluvium sediments. These are briefly defined below, and more fully discussed in the Geology chapter.

- Glacial till consists of unstratified, mixed deposits of clay, silt, sand, and rock fragments deposited by glacial ice.

- Glacial outwash is material swept out, sorted, and deposited beyond the ice front by streams of glacial meltwaters. These deposits are usually stratified and made up of sands and gravels.

- Organic matter such as decomposed plant and animal residue forms the basis of muck soils. Many of these soils are the direct result of glaciation, which, by impeding drainage, caused wetlands to form. Wetland vegetation flourished as the climate became warmer, resulting in the accumulation of vegetative materials that ultimately became organic or muck soils.

- Alluvium sediments consist of material moved and redeposited by streams. They can appear in terraces well above normal stream beds or in the normally flooded bottoms of existing streams.

- Lacustrine sediments consist of very fine sands, silts, and clays that have settled out of the still water of lakes.

The nature of parent material has a profound effect on soil characteristics. For example, the different mixtures of source materials left in Dutchess County by the various glacial processes have produced soils with textures ranging from fine-grained clay to coarse sand. These textures, in turn, are responsible for such characteristics as water-holding capacity, fertility, and strength in supporting foundations.

Many interrelationships are apparent among the factors that shape soils. Climate, especially temperature and precipitation, contributes to soil formation through constant weathering and periodic glaciation. Plants and animals also affect the physical and chemical characteristics of soils. Their activities mix, aerate, and enrich the soil, while the organic matter they produce combines with weathered parent material to build the soil gradually. Topography is important because it can modify climate, determine drainage patterns, affect rates of erosion, and influence the location and type of vegetative cover. Time is another critical variable in the process of soil formation. Soil depth, for example, can be directly related to the amount of time bedrock is subjected to the forces of weathering. It can take thousands of years for a well-developed soil to form.

Soil forms layers, called horizons, over time. A typical soil contains four horizons, illustrated in Figure 5.2: organic layer, topsoil, subsoil, and parent material. The thickness and composition of each horizon vary with location, time, and disturbance.

Typical Soil Profile

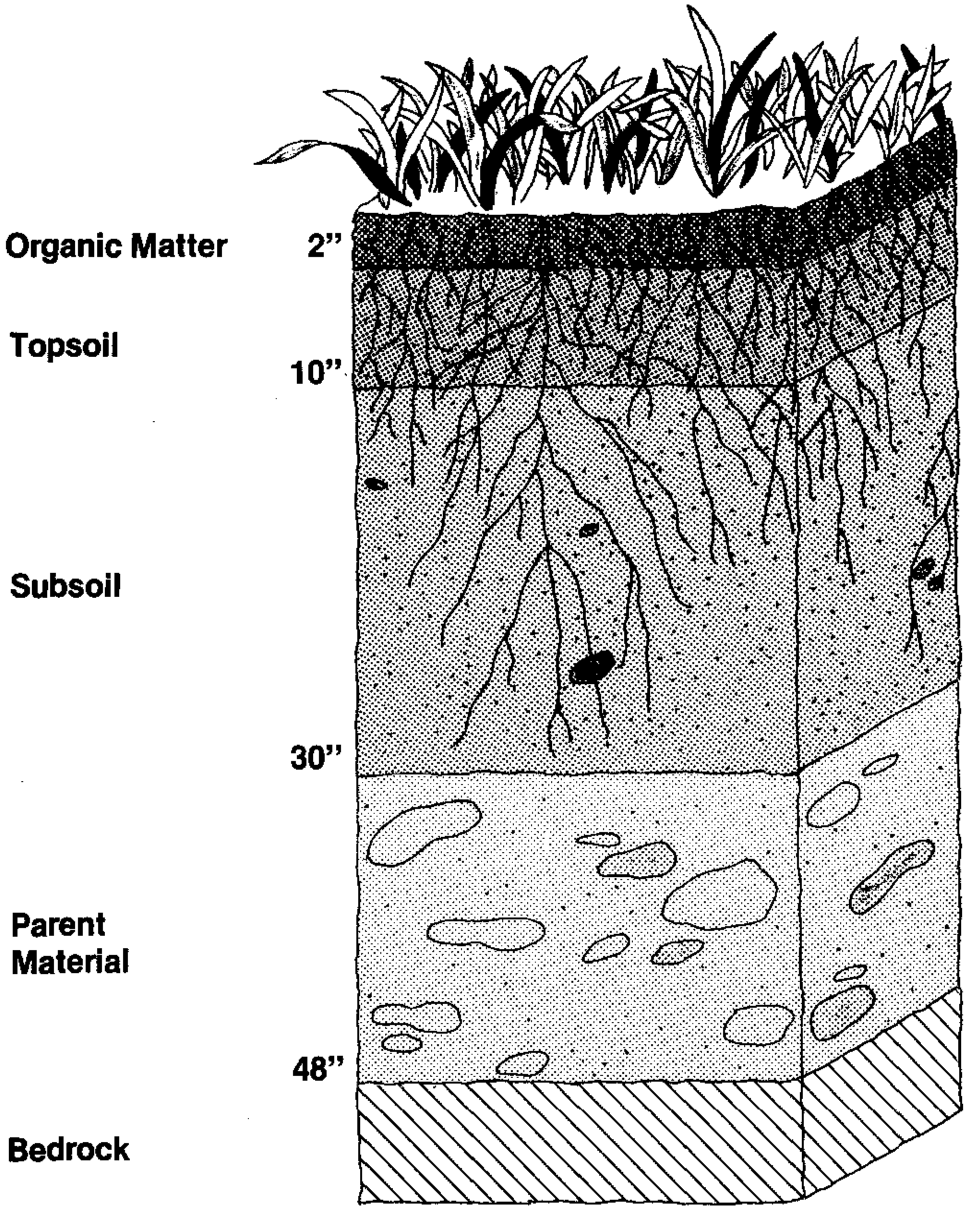


Figure 5.2

Redrawn from USDA Soil Conservation Service, Conserving Soil.

Surveys

Soil surveys are inventories used to interpret the best uses for the particular soil series that occur in a given area. Each series consists of all soil types whose layers or horizons have nearly the same characteristics, thickness, and arrangement. Soil texture is usually the only feature that can vary considerably within one series.

The Soil Survey of Dutchess County, prepared in 1955 and updated in 1972, lists, describes, and maps 134 different soil series, each with distinct characteristics and qualities. No single soil series covers more than three percent of the county.

Dutchess County soils vary greatly. Silt loam textures dominate, although textures vary from gravelly, sandy loam to fine, silty clay. Most of the soils that have been cultivated are moderately eroded, except in certain nearly level areas. More than 70 percent of county soils are well-drained, but small areas of poorly- and very poorly-drained soil can be found in complex associations that limit the use of the well-drained soils.

Major Soil Areas

The Generalized Soils Map presents an overview of soil types in Dutchess County. The eight soil areas shown are general groupings of the more numerous and detailed soil series listed in the county soil survey. Large areas of land are usually dominated by two to five soil series that differ in drainage capacity but are derived from the same type of parent material. Such groups of soil series are called catenas.

On the Generalized Soils Map, a map unit that contains one dominant catena, such as the Nellis area, is named for the soil series that covers the largest portion of that unit. If two catenas are major components, the names of the most extensive series in each catena are combined to produce the map unit name, as in Bernardston and Nassau. In all cases, other minor soil groups are also present in the map units.

Each soil area is associated with certain characteristic landscapes. As a result, each map unit indicates something about the drainage and landscape character of a particular portion of the county. Table 5.1 summarizes the differences among the map units by indicating the percentages of each soil area that are steep, wet, very stony, and shallow. Any of these characteristics can severely limit the use of land.

Soils in the lowland and valley portions of the county tend to have the most favorable topography and the highest potential for intensive uses. These areas are also usually the best for agricultural purposes. The highland areas contain poorer soils and, consequently, are more conducive to sparse development and less intensive agricultural uses. Descriptions of each soil area are given below. More detailed information about the series within each map unit is available in the Dutchess

County Soil Survey, prepared in 1955, and the Manual of Soil Survey Interpretations of Soils in New York State, published in 1972.

Table 5.1 Interpretation of Generalized Soils Map

Dutchess County, N.Y.

Map Unit	Percentage: Steep	Wet	Very Stony	Shallow	Use Restrictions
Nellis	0-25	5-30	0-10	0-20	--
Hollis	35-85	1- 5	20-95	50-85	Slope and depth limit use
Nassau	10-45	2-15	0-15	35-80	Depth limits use
Bernardston-Nassau	10-25	5-15	0-10	10-35	--
Bernardston-Hoosic	5-40	5-30	0-20	5-15	--
Hoosic	0- 5	0-35	0- 5	0- 5	Droughtiness limits use
Hudson	15-50	20-40	0	0	Wetness and slope limit use
Rock outcrop, steep	45-95	0-20	0-95	40-95	Depth and slope limit use

Nellis

Nellis areas occur in the eastern and southern parts of the county, where they make up the till-mantled, lower portions of valley sides. Nellis and Amenia groupings, which overlie limestone and are derived from glacial till, cover 40 to 55 percent of most of these areas. Elsewhere within this unit in the eastern part of the county, Copake or Stockbridge groups appear instead of the Nellis-Amenia soils. The Copake group overlies stratified sand and gravel and is derived from glacial outwash. The Stockbridge group overlies slate and is derived from glacial till.

More than 75 percent of the Nellis unit has deep, gently sloping, moderately stony soils. These are usually moist and have only moderately or slowly permeable subsoils, which restricts their value for uses requiring rapid internal drainage. Dairy farming is prevalent on many of the Nellis areas.

Hollis

The Hollis unit occupies hilly or steep, mostly wooded areas in eastern Dutchess County. Shallow Hollis soils make up 50 to 85 percent of the unit. Deeper Charlton and Paxton soils occupy 5 to 25 percent of each Hollis area. Thirty to 85 percent of this unit is steep, and 20 to 95 percent is stony. Rock outcrops are common on the steep slopes. Soils in this unit are most suited to recreational, wildlife, and forestry uses.

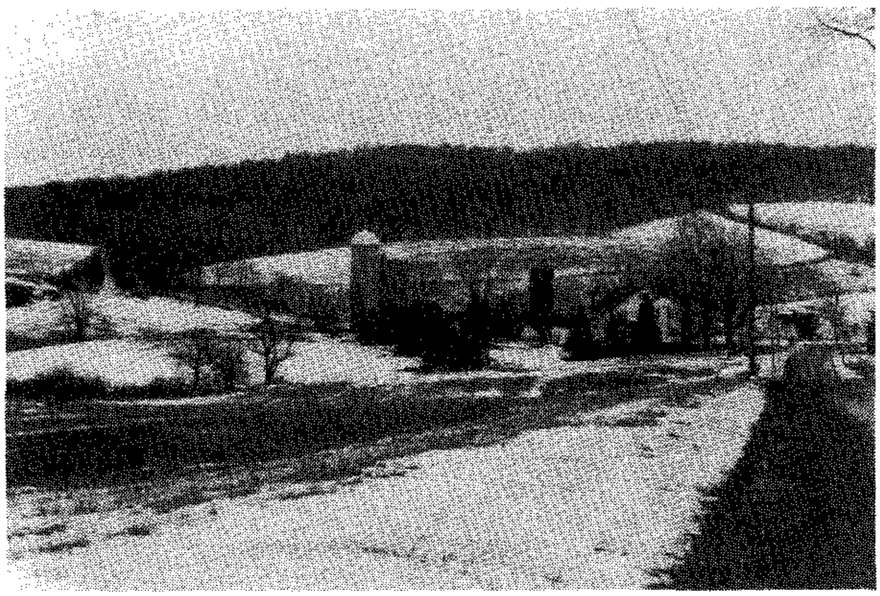
Nassau

The Nassau unit contains large tracts of shallow Nassau soils (50 to 80 percent) intermingled with smaller areas of deeper soils, such as the Bernardston-Pittstown group (20 to 40 percent). The unit can be found in the northwestern and central regions of the county. The Nassau soils have many rock outcrops. The deeper soils usually occur in tracts of a few hundred to several thousand acres in size and can support viable farm units. Steep and shallow areas account for 25 to 40 percent of the unit. Fragipans (hard, slowly permeable layers) in some of the deeper soils make them poorly suited to septic systems and other uses that require the internal disposal of water.

Bernardston - Nassau

The Bernardston-Nassau unit covers large parts of the Hudson Valley uplands. In Dutchess County it forms a wide band extending from the town of Northeast to the city of Beacon, and contains a mixture of two highly contrasting soil associations. Drumlins, which are cigar-shaped hills formed by glaciers, often dominate the Bernardston-Nassau landscape. They have deep soils that are usually farmed, and are chiefly composed of Bernardston soils (50 to 70 percent) with small areas of Pittstown. Around the drumlins are idle lands, forests, or pastures with surface irregularities that indicate the presence of slate bedrock at shallow depths. Shallow Nassau soils dominate these areas, accounting for 10 to 35 percent of the total acreage. Wet Stissing and droughty Hoosic soils may make up another 5 to 15 percent.

The Bernardston-Pittstown portions of this unit are particularly good for dairy farming. Parts of these areas have moderately steep slopes that present tillage and erosion control problems. The shallow Nassau portions are untillable. Fragipans limit drainage in some Bernardston areas, but drainage is less restricting here than in areas where wetter soils dominate.



Bernardston - Hoosic

The Bernardston-Hoosic unit, in the northwest corner of the county, includes two contrasting soil associations. The Bernardston and Pittstown soil association accounts for 40 to 55 percent of the total acreage. Glacial outwash terraces, dominated by moderately droughty Hoosic soils and interspersed among the Bernardston-Pittstown areas, account for another 20 percent. In Dutchess County, the Bernardston portion is an undulating glacial till plain with low drumlins. The Hoosic areas are interspersed, and appear in relatively flat outwash terraces. Approximately 5 to 10 percent of the acreage in this unit is steep.

Most of the areas in this unit are farmed or used for housing, with orchards especially important on the Hoosic soils. Only 10 to 40 percent of the acreage is affected by steep, wet, very stony, or shallow soil conditions. Bernardston areas have fragipans, which may cause problems for uses requiring rapid internal drainage.

Hoosic

Hoosic areas are found east of Wappingers Falls and in the northwestern corner of the town of Milan. This unit is nearly level to undulating, and includes moderately broad glacial outwash plains and narrower outwash terraces in valleys. Soils derived from coarse glacial outwash comprise 45 to 90 percent of the Hoosic unit, with Hoosic as the dominant series. Hamlin, Tioga, and related alluvial soils appear on floodplains and comprise 5 to 30 percent of the unit. Bernardston and Nassau soils on till, and Rhinebeck or Hudson soils derived from lake sediments occupy up to 10 percent of any Hoosic areas.

On 50 to 90 percent of the land in the Hoosic unit a low water-holding capacity causes droughtiness. The dry soil makes it difficult for many annual crops to thrive; perennial plants with deeper roots fare better. Although the rapid permeability is considered an asset for non-farm uses, it has the potential for readily transmitting groundwater pollution from areas used for waste disposal. Only in small areas is hilly, wet, very stony, or very shallow soil a problem.

Hudson

Hudson soils are concentrated along the Hudson River in the northwestern quarter of the county. They include landscapes where glacial lakes deposited clayey sediments on what are now valley walls. In some places streams have cut channels into the underlying bedrock, and now flow down through these channels to the Hudson River. Close to the Hudson, narrow remnants of the original surface are interspersed among these stream valleys. The original gently-sloping surface, largely uncut by streams, is found farther inland at the higher elevations.

An association of Hudson and Rhinebeck soils, dominated by Hudson soils, covers 30 to 70 percent of the unit. Rhinebeck soils occur primarily on the higher elevations that have not been disturbed by streams. Large tracts of the Rhinebeck soils are often used for crops that can tolerate wetness. Varysburg and Arkport soils that overlie sand or gravel glacial deltas account for 5 to 25 percent of most areas in the Hudson unit. Glacial till soils and rock outcrops cover another 5 to 20 percent, particularly where erosion has removed the Hudson sediments.

Steep slopes restrict the use of 20 to 40 percent of the unit. Wetness and slow permeability cause problems on an additional 20 to 40 percent. The sand and gravel delta areas have few limitations. Moderately steep and steep

Hudson soils are often pastured. These soils are subject to landslides, and for that reason alone are not suitable for many uses.

Rock Outcrops

Rock outcrop areas are common at high elevations in the southern and eastern portions of the county. Two types of rock outcrops can be found. A Hollis rock outcrop-Charlton soil association occurs in the southern part of the Hudson Valley. Exposed rock and shallow Hollis soils cover 50 to 90 percent of this portion of the unit. Deep charlton soils and others cover 5 to 40 percent of it. The second type of outcrop is an association of Nassau outcrop areas and Bernardston soils. Rock and shallow Nassau soils cover 65 to 85 percent of this association, and Bernardston accounts for 5 to 20 percent. Most rock outcrop areas are forested and are uniquely suited to recreational uses and wildlife. Between 45 and 90 percent of them are hilly or steep. Many of the deep soils around rock outcrops contain stones or boulders.

Depth and Permeability

Permeability

Permeability rates, which are usually given in inches per hour, measure the ease with which water flows downward through the soil layers. Septic fields, farming, and other uses requiring good internal soil drainage may not function properly in slowly permeable areas. This characteristic can also place severe restrictions on development densities in areas not served by central water and sewer systems.

The Soil Permeability Map indicates where soils with relatively poor internal drainage occur in the county. The permeability rates of these soils are generally less than 0.63 inches per hour, which is the level considered by the Dutchess County Soil Survey a severe limitation on the soil's suitability for septic tanks. Such soils are extensive, covering most of the western half of the county. However, in many of these areas, septic systems have been functioning adequately for years. Local variations in soil or slope features, the use of fill in creating septic fields, and the non-intensive use of the waste disposal systems enable these septic systems to operate properly.

Rapidly permeable soils can also limit the suitability of land for development, because they allow pollutants to move quickly into groundwater supplies.

The Relationship Between Soil Texture and Water Runoff

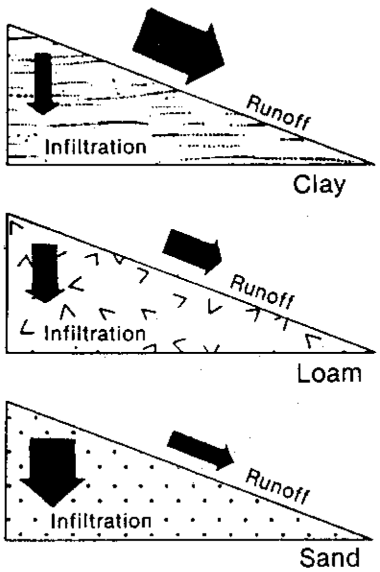


Figure 5.3

This characteristic is of particular concern in siting landfills and other facilities that generate potentially harmful wastes.

Soil texture influences permeability. Soils with a high concentration of sand or gravel particles and organic matter tend to drain more rapidly than soils with a high clay content. Clay particles, defined as particles smaller than 0.002 millimeters in diameter, cannot be seen with the naked eye. They pack together so tightly that there is little room for air or water to filter through the microscopic pore spaces around them. Sand, on the other hand, ranges from .05 to 2 millimeters in diameter, up to 10,000 times the size of the clay. The pore spaces around the sand, gravel, and stones found in permeable soils allow water and air to pass through more freely. The relationship between such variations in soil texture and the absorption of rainfall is illustrated in Figure 5.3.

Depth

Depth to bedrock is another characteristic that can affect the development suitability of soils. Shallow soils limit the placement of wells, septic systems, foundations, and agricultural uses. Because they are often found on steep slopes, such soils can also be highly vulnerable to erosion. Pollutants can pass quickly through shallow soils and contaminate groundwater supplies.

The Soil Depth Map shows where bedrock lies within three feet of the surface, placing a severe constraint on the suitability of the soil for streets, buildings, and septic systems. The largest concentrations of such shallow soils are in upland areas in the county's higher elevations.

Erosion and Sedimentation

Erosion studies conducted in 1974 revealed that an average of 1.34 tons per acre of soil were lost every year from watersheds totally or partly within Dutchess County. As summarized in Table 5.2, the rate of erosion was greatest in the Roeliff Jansen Kill watershed that extends into Columbia County, and least within the Wappinger Creek basin and the small portions of the Upper Housatonic River watershed that reach into Dutchess County near the Connecticut state line.

Since 1974, federal and county soil conservation programs have made significant progress in reducing erosion from croplands in Dutchess County, particularly within the Tenmile River, Roeliff Jansen Kill, Crum Elbow-Hudson River, and Hunns Lake watersheds where agricultural uses are concentrated. How much cropland erosion rates have been reduced has not yet been determined. Considerable erosion problems are known to persist, however, on construction sites and croplands where no soil conservation measures are in place.

Table 5.2 Erosion in Dutchess County Watersheds, 1974

Watershed Name	Erosion rate (tons/acre/year)	Watershed size (acres)	Total soil loss tons/year
Croton river	.96	232,699	223,172
Crum Elbow Creek-Hudson River	1.01	109,314	110,541
Fishkill Creek	1.30	129,671	168,705
Hunns Lake	1.61	5,681	9,173
Jansen Kill	2.54	145,716	370,258
Tenmile River	1.70	98,071	166,585
Wappinger Creek	0.84	128,329	107,849
Upper Housatonic River	0.51	1,199	616

Source: USDA Soil Conservation Service, Erosion and Sediment Inventory, New York, 1974.

Soil loss remains a significant threat to the quality of the county's land and water resources. By stripping topsoil from the land, erosion robs the land of valuable natural nutrients and washes soil, pesticides, and fertilizers into waterways. It also undermines soils and structures and chokes streams, lakes, rivers, and drainage systems with sediment.

The rate of soil loss varies dramatically with land use. In New York State, erosion rates from construction sites are as many as 25 times those from cropland, and as many as 75 times those from pastures and woodlands. Proper conservation procedures can drastically reduce these rates. The average erosion rates observed in New York State for several different land uses are listed in Table 5.3. Erosion rates for eight major Dutchess County watersheds are listed by land use in the appendix.

Table 5.3 Erosion Rates for Major Land Uses

	Average Soil Loss (tons/acre/year)	
Land Use	New York State	Dutchess County
Construction sites	31.58	9.61
Cropland without conservation measures	7.38	11.88
Orchards, vineyards, bush fruits	3.28	1.21
Urban land	1.69	0.59
Cropland with conservation measures	1.26	0.74
Pasture	0.99	0.79
Woodland	0.43	0.48
Streambanks (tons/bank-mile/yr.)	73.10	6.54
Roadbanks " "	29.25	31.80

Source: USDA Soil Conservation Service, Erosion and Sediment Inventory, New York, 1974, and USDA Soil Conservation Service, Dutchess County Office.

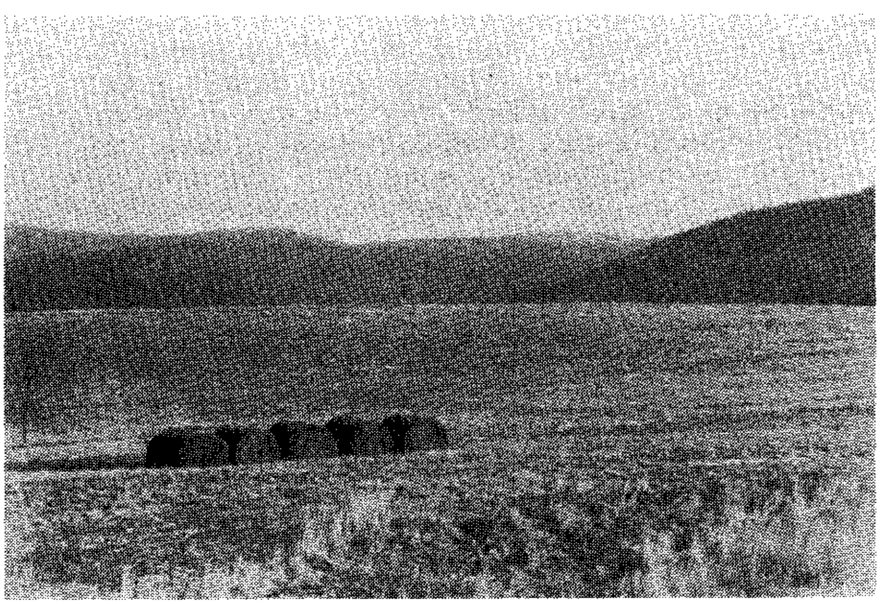
The figures given in Table 5.3 are approximate. Actual soil loss rates vary considerably from site to site, depending on such characteristics as slope, soil type, vegetation density, and rainfall. The scale of the differences among the erosion rates is, however, an accurate indication of the relationship between soil loss and land use.

Prime and Important Agricultural Soils

The best, most potentially productive soils are called prime soils. Classified by the U.S. Soil Conservation Service (SCS), they are suited to a wide variety of farm crops with relatively few limitations, and represent an irreplaceable agricultural resource. Prime soils tend to be well-drained, nearly level, fertile, stable, and deep. These characteristics make them both ideal for farming and easy to develop.

Prime soils once covered 15 percent of Dutchess County. Significant concentrations occurred along the major stream valleys and throughout the towns of Red Hook and Rhinebeck, as well as major portions of Clinton and Pleasant Valley. High quality soils also used to be abundant in the southwestern quarter of the county. In the last 40 years, however, this area has become the county's urban core as a result of sustained development activity. How much prime agricultural land remains is unknown, but it has been estimated that as much as 50 percent of the county's best soil acreage has been developed for residential, commercial, or industrial use.

"Important" soils usually support good crop fields, but unlike prime soils they have limitations that require special conservation measures and are suited to a smaller variety of crops. According to SCS inventories, they once covered 32 percent of the county, and can still be found near the remaining prime agricultural soils and throughout Stanford, Washington, and Hyde Park. Smaller tracts of important soils are found in much of the county. Important and prime soils are noticeably absent from the Hudson Highlands, the ridges along the Harlem Valley, and other steeply sloping uplands where soils are characteristically shallow.



Resource Management Implications

Soil is a fundamental resource that is often taken for granted because of its abundance, low cash value, utilitarian functions, and lack of aesthetic charm. Soil makes it possible to use and live on the land. Without ample supplies of good, arable soil, food production would be vastly more difficult.

Soils have several characteristics, such as permeability, depth, erodibility, and wetness, that limit the land uses they can support. All of these limiting characteristics should be considered during the land use decision-making process. Development proposals and local land use controls should be well-matched to soil features to ensure that the type, density, location, intensity, and design of all land uses are appropriate to the soils and other natural resources that must sustain them.

Permeability

Soil permeability is an important measure of the development potential of land. Highly permeable soils drain well and rapidly transmit rainwater into groundwater supplies. Soils with permeability rates of 0.63 inches per hour or less are considered to have poor internal drainage, and are usually not suitable for septic systems or other uses that depend on water infiltration. They also are less valuable for groundwater recharge than more permeable soils are, because rainwater travels down through them so slowly.

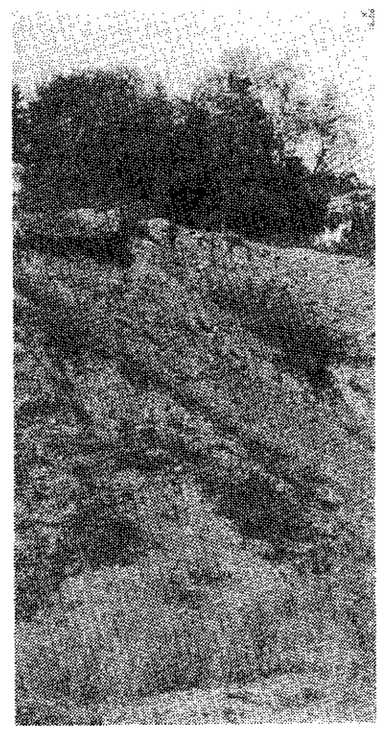
Development densities and waste management practices should reflect the severely limited ability of impermeable soils to absorb and filter wastes. Otherwise, intensive development without central sewage treatment facilities will saturate soils with wastes, causing untreated wastes to spread into nearby surface waters and groundwater supplies. In areas where such contamination occurs, expensive construction of central sewage and water treatment facilities and pipelines may be the only remedy.

Highly permeable soils should also be used carefully, because of their ability to transmit hazardous materials into groundwater supplies. Landfills, petroleum storage tank farms, chemical manufacturers, and other facilities that handle such materials should not be located on top of the most permeable soils.

Depth

Like permeability, depth-to-bedrock affects the development suitability of soils and should be considered when development proposals and land use policies are reviewed. Shallow soils limit the placement of wells, septic systems, foundations, agricultural uses, roads, and utilities. Expensive blasting is often needed for construction on shallow soils, and the likelihood of erosion and septic failures is much greater than in areas with deeper soil. At the same time, shallow soils with bedrock outcrops on steep slopes often offer spectacular views, making them tempting sites for recreational developments and homes. They are ideal sites for natural recreation areas such as hiking trails, forest preserves, and open space.

To prevent costly mistakes, local governments should use soil features such as permeability and depth to determine allowable land uses and development densities, and to prepare central utility plans. Intensive development should not be encouraged on shallow soils without central sewage systems and stringent erosion control measures.



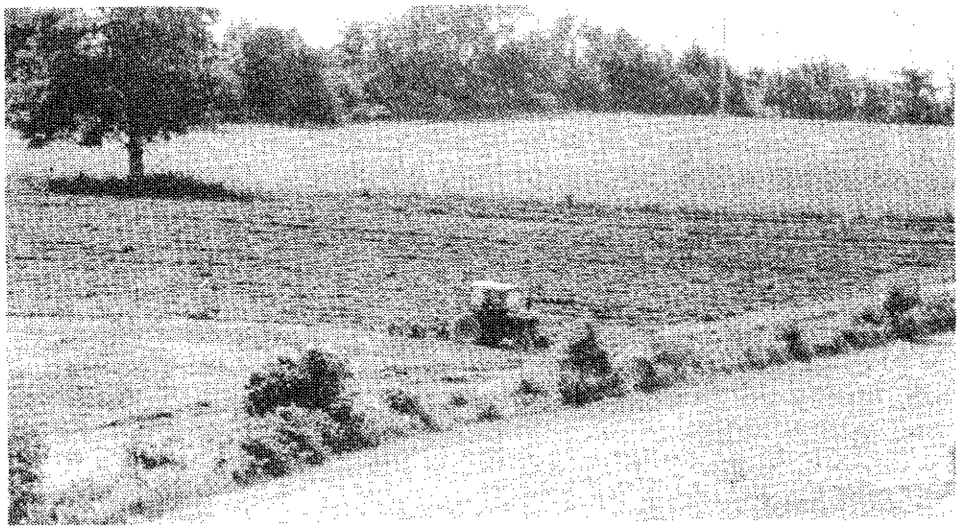
Erosion and Sedimentation

Although federal and county soil conservation programs have helped reduce cropland erosion significantly since the mid-1970s, erosion continues to damage the county's soil and water resources. Erosion rates are especially severe on construction sites, roadbanks, and croplands that are not using erosion control methods.

Erosion not only destroys an irreplaceable resource; it also adds to the public costs of maintaining drainage systems, roads, and waterways. Soil eroded from poorly managed construction sites, for example, chokes drainage culverts and sediment traps, which must be cleaned frequently at public expense. Local governments should develop and enforce effective erosion control standards for construction sites, roads, and croplands and should support county and federal programs that help landowners reduce soil loss.

Prime and Important Soils

Much of Dutchess County's prime and important soil acreage has been developed since World War II, and is no longer available for agricultural or open space use. The best remaining soils, located mainly outside the southwestern core area, form a critical resource on which Dutchess County's current agricultural industry and its future food producing capability depend.



Agriculture is a significant and highly valued component of Dutchess County's economy and visual identity. Prime and important soils support active farms throughout the northern and eastern communities, as well as a handful of farming operations within the urban area. Many of these farms are under intense development pressures which threaten their continued viability. It is necessary, therefore, to devise ways to preserve the county's best soils even where farming activity declines.

If land uses that can function satisfactorily on less valuable soils are allowed to continue to consume the best soils in Dutchess County, the county's agricultural community will weaken and its ability to respond to future changes in the nation's food production system will be severely impaired. The loss of agricultural open land also threatens one of the most traditional and aesthetically pleasing contributors to the county's high quality of life.

Aggressive measures are needed to protect the soil resource. Communities must find equitable, effective ways to divert development to less valuable sites, to encourage open space preservation, to support agricultural activities, and to institute effective erosion control measures.