Soils of Rhode Island Landscapes

William R. Wright
Edward H. Sautter

University of Rhode Island Agricultural Experiment Station Bulletin 429

Soils of
Rhode Island Landscapes

William R. Wright
Edward H. Sautter

University of Rhode Island Agricultural Experiment Station in cooperation with the United States Department of Agriculture, Soil Conservation Service. Agricultural Experiment Station Bulletin No.492

1/88/2M **January 1988**

Authors

William R. Wright is Associate Professor of Soil Science at the University of Rhode Island. Edward H. Sautter is State Soil Scientist, Soil Conservation Service, U.S. Department of Agriculture.

Bulletin 429 is Contribution No. 1869 of the Rhode Island Agricultural Experiment Station, University of Rhode Island, Kingston, Rhode Island, 02881.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Preface

The soil is one of our most valuable natural re sources. It either directly or indirectly provides us with the food, clothing, shelter, and fuel needed in everyday living. Soil serves as a medium for the disposal of wastes and provides the foundation for the homes we live in and the roads we drive on. Soil also provides the base for recreational facilities and is a determining factor in our aesthetic surroundings. This means that everyone should have some knowledge of the soil and its suitability for various uses.

Before the soil can be used efficiently, it needs to be identified and characterized. Soil scientists of the Soil Conservation Service and the Agricultural Experiment Stations have been examining the soils for many years recording their properties, and interpreting them for agricultural and other uses. This bulletin and the soil map it contains have been prepared for persons who want a picture of the soil resources of Rhode Island.

If the information desired is for individual farm planning or for small parcels of residential land, the detailed Soil Survey of Rhode Island should be consulted. For general information about the soils of larger areas, however, this bulletin and the enclosed map may be more useful than detailed maps and reports. In order to use the map and soil information more effectively, one needs to know something of the state as a whole — its geology, climate, and vegetation. It is also important to know what kinds of soils are in the state and how they are associated one with another on the landscape. The first part of the bulletin reviews these briefly. The remainder of the bulletin describes the soil areas outlined on the map and interprets the soil properties in terms of their limitations for agricultural, urban, and other uses.

Finally, and perhaps most importantly, it is hoped that this publication will arouse public interest in soils and make people more aware of the importance of this valuable natural resource.

Acknowledgements

The authors gratefully acknowledge the work of the many field soil scientists of the Soil Conservation Service who participated in the detailed soil survey of Rhode Island. Without their dedicated efforts in completing the soil survey, this bulletin would not have been possible. Special appreciation is also extended to Dr. Eliot Roberts, Professor of Soil Science at the University of Rhode Island and Mr. Everett Stuart, Soil Resource Specialist for Rhode Island, USDA Soil Conservation Service, for their many valuable comments and suggestions during the preparation of this bulletin.

SOILS OF RHODE ISLAND LANDSCAPES

Introduction

Many changes have taken place in agricultural land use in Rhode Island. The number of farms and the acres in farms has been steadily decreasing for over a century. In 1850, over 81 percent of the total land area in the state was classified as farmland (17), however by 1974, only about 9 percent of the land was being farmed (21). In addition, the growing population has put demands on the use of land for residential, industrial, highway, recreational and other non- farm purposes. Although Rhode Island's growth rate has generally been less than the United States average, many consider Rhode Island to be the first truly urban state. Even as early as 1900, nearly 90 percent of the state's population was urban compared with only 40 percent for the United States as a whole (4). This pressure on farmland results in more intense and varied uses of land by farmers. Statistics show that the production of dairy, poultry, and other animal products and most agronomic crops has been steadily de creasing during the past few decades, whereas high cash value crops such as fruits, vegetables, turfgrass, and ornamental shrubs have held their own or in creased in production during recent years (21).

The loss of farmland is only one of the consequences of urbanization. Serious health, safety, and pollution problems have been created by failure to consider the capabilities and limitations of soils during planning and design stages of rural or urban development projects. Such problems include malfunctioning septic tank sewage disposal systems, surface and groundwater pollution, flood damage, foundation failures, soil erosion, and stream and lake sedimentation.

Many of the properties of soils which determine their capabilities for various uses are readily apparent to the soil scientist, In surveying soils, the soil scientist takes into account the thickness and arrangement of each layer to a depth of four or five feet. Each layer is examined to determine its color, texture, structure, consistence, and stoniness. Qualitative information is also gained on the relative compaction of each layer, its stability, the tenacity with which water is held, and the ease with which water may move through the soil profile. The result of this investigation forms the basis for a decision on proper identification of a soil. Using their knowledge about soils, the soil scientists classify the different kinds of soils and record their boundaries on aerial photographs.

A uniform system of soil classification is followed in the United States so that each map unit delineates an individual soil or soils possessing a defined range of characteristics which determine the usefulness of that soil. Since each kind of soil has a unique set of properties, the results of research on, and experience with, a particular soil in one place can be used to predict the behavior and suitability of the same soil elsewhere. This, for example, is how suitability for septic tank filter fields or sanitary landfills can be predicted from one area to another.

The National Cooperative Soil Survey program is a joint venture of various federal and state agencies. Most of the work is conducted by soil scientists employed by the Soil Conservation Service and the state Agricultural Experiment Stations. The objectives of the soil survey program are to define and delineate various kinds of soils, determine their physical, chemical, mineralogical and morphological properties, and to interpret these soil characteristics for the public sector. Such information is useful to soil conservationists, agricultural extension agents, vocational agricultural teachers, farmers, highway engineers, planners, land appraisers, tax assessors, public health personnel, building contractors, and any one else who works with the soil.

This publication presents: (1) a background discussion of soil-forming factors in Rhode Island; (2) a detailed discussion of the important properties of soils; (3) a discussion of how soil surveys are made and how they can be used; and (4) specific information on the identification and classification of Rhode Island soils as delineated on the general soil map.

Urban encroachment on prime farmland in Newport County.

SOIL DEFINITION

The definition of soil is dependent upon the point of view of the user. Engineers and geologists commonly refer to all unconsolidated material above bedrock as soil, and many agricultural specialists define soil as the biochemically weathered portion of the earth's surface. Perhaps the most common definition, used by farmers and homeowners, is that soil is simply a natural medium for the growth of plants. All of these definitions are accurate, yet quite limited in scope. A prime prerequisite for learning more about soil is to have a common concept of what it is. This concept must encompass the diverse viewpoints of the engineer, the geologist, the farmer, and the homeowner. Since one cannot distinguish accurately under all conditions between what is and what is not soil, a short, precise definition is perhaps impossible. Nevertheless, some things are common to all soils.

Most soil scientists consider soil to be a dynamic three-dimensional unit of the landscape and would define it as:

the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors. Its upper limit is air or shallow water. At its margins it grades to deep water or to barren areas of rock or ice. Its lower limit, to the not-soil beneath, is perhaps the most difficult to define. Soil includes the horizons near the surface that differ from the underlying rock material as a result of interactions, through time, of climate, living organisms, parent materials, and relief. In the few places where it contains thin cemented horizons that are impermeable to roots, soil is as deep as the deepest horizon. More commonly soil grades at its lower margin to hard rock or to earthy materials virtually devoid of roots, animals, or marks of other biologic activity. The lower limit of soil, therefore, is normally the lower limit of biologic activity, which generally coincides with the common rooting depth of native perennial plants (20).

Nearly all soils are similar in that they consist of mineral and organic matter, water, and air. The proportions vary, but the major components remain the same. The soil scientist's concept of soil, however, is not that of a mere mass of inorganic and organic material; rather each soil has its own set of unique properties. Every soil occupies space. As a small segment of the earth, it extends down into the planet as well as over its surface, It has length, breadth, and depth (Figure 1).

A vertical cross section of soil, as seen in an exposed road cut or pit, is called a soil profile. A soil profile consists of two or more layers lying one below the other and approximately parallel to the land

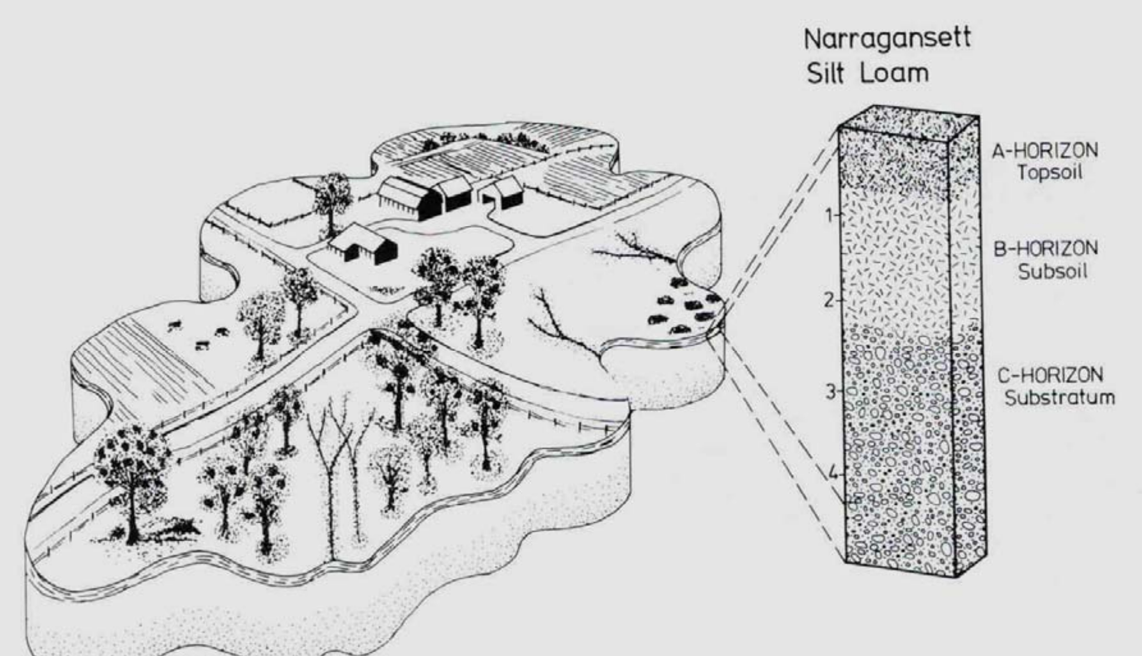


Figure 1. Schematic diagram illustrating the three-dimensional nature of soils.

surface. These layers are called horizons and differ from adjacent horizons in one or more properties such as color, texture, structure, consistence, porosity, or reaction.

Each soil has a unique profile that varies in kind and number of horizons. These horizons usually merge gradually over a vertical distance of several inches and cannot be observed without close examination. Occasionally, however, the boundaries between horizons are sharp and easily seen.

In order to describe, study, and classify soils, it is necessary to assign symbols to the different horizons. Each symbol is a genetic designation and has definite implications. Thus, horizons within a soil profile are not merely given sequential letters or numbers.

The capital letters 0, A, B, C, and R are used to denote master horizons and indicate the dominant kinds of departures from the parent material. These master horizons may be subdivided by placing an Arabic numeral after the capital letter. Thus, symbols such as 01, 02, Al, A2, A3, B1, B2, and B3 are obtained which imply definite genetic characteristics. Lower case letters may also be used as suffixes to these symbols to indicate selected subordinate departures from the parent material. For example, B2g would indicate a subsurface horizon that was gleyed or gray in color resulting from high water tables, and Cx would indicate an extremely dense, brittle subsurface horizon called a fragipan. Roman numerals which are pre fixed to master horizons indicate lithologic discontinuities or changes in parent materials which are characterized by abrupt changes in texture and/or mineralogy. Thus, the horizon symbol 11B2 would suggest that it was formed from different materials than the horizons above it. Figure 2 is a hypothetical soil profile showing most of the commonly used horizon symbols.

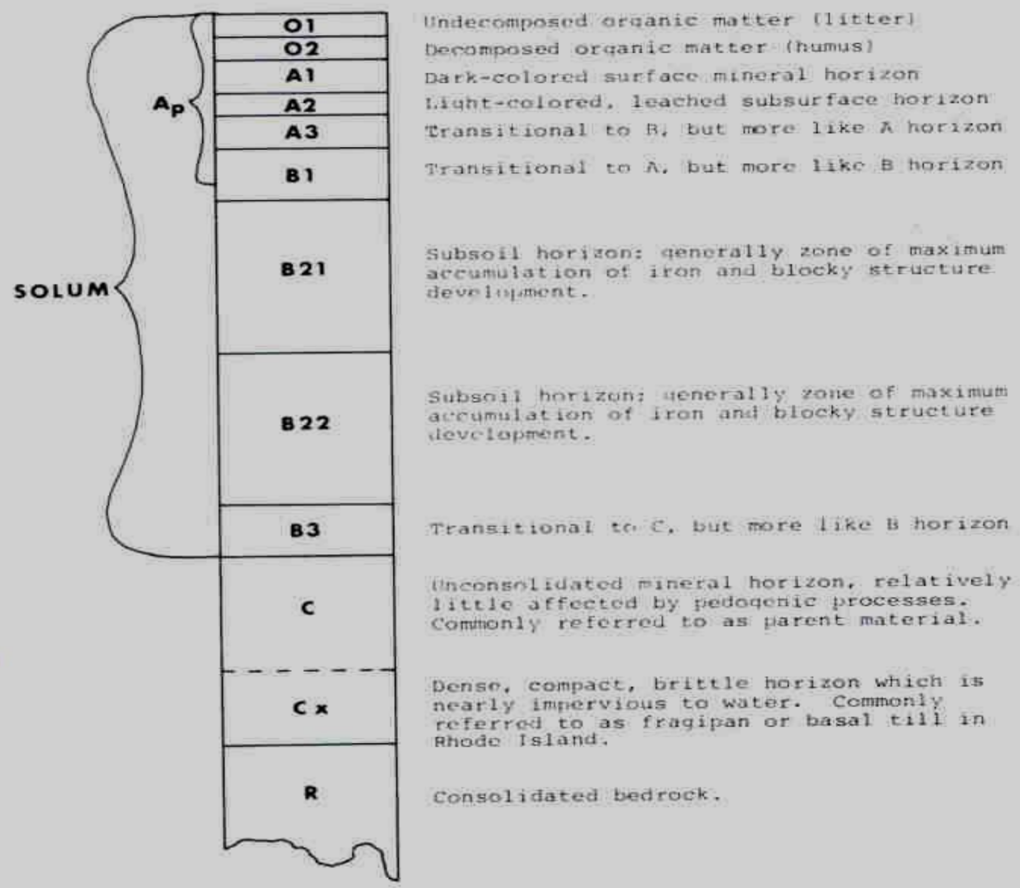


Figure 2. Hypothetical soil profile illustrating principal horizons.

O Horizon

The O horizons were formed from organic litter derived from plants and animals and overlie mineral surfaces. The uppermost part of this organic layer which is called the 01 horizon is unaltered except for some leaching of soluble constituents and discoloration. Most of the material in this horizon can be identified with the naked eye. The lower portion of the organic layer, which is called the 02 horizon, is composed or decomposed plant and animal remains and is commonly referred to as humus. These organic horizons are present in the forested regions of Rhode Island, but may be destroyed by burning, erosion, pasturing, or cultivation. The horizons of organic soils, however, are described as Oi (fibric). Oe (hemic), or Oa (sapric) which indicates whether the organic materials are undecomposed, moderately decomposed, or highly decomposed.

A Horizon

The A horizon is commonly referred to as the topsoil or surface soil. It is the uppermost layer of the mineral soil profile and contains the most organic material of any mineral horizon. The A horizon is also the most active biologically. Plant roots, bacteria, fungi, insects, and small animals are more common in the topsoil that in any other major horizon.

Because it lies at the surface, the A horizon is affected the most by falling rain. Some of the rainwater percolates directly into the soil and may remove or leach some of the soluble bases present. This results in quite acidic (low pH) surface soils; therefore, lime and fertilizer are required to maintain a soil pH and fertility conductive to optimum plant growth. This is particularly true in Rhode Island soils. Not al of the rain falling on the soil surface percolates down through the soil profile. During severe rainstorms, runoff from sloping areas can result in erosion of the topsoil.

Most of the soils in Rhode Island have developed under forest vegetation, thus the A horizon on most well drained soils in only one or two inches thick. If the soil is very poorly drained, the thickness of the A horizon might be eight or ten inches.

If a soil has been cultivated, the O horizon, A horizon, E horizon, and some of the B horizons may have been destroyed. The resulting plow layer is called an Ap horizon. These plow layers are evident in many forested regions of Rhode Island which indicate that they were cultivated at one time.

E Horizon

The E horizon is commonly referred to as the zone of evaluation or leaching. This horizon has been leached out of organic matter, iron, and aluminum oxides, and other soluble constitutes, and has a corresponding concentration of resistance minerals such as quartz. This lighter-colored layer, which occurs directly beneath the A horizon in some soils is frequently destroyed by plowing and, therefore, is rarely present in Rhode Island soils.

B Horizon

The B horizon is commonly referred to as the subsoil and usually occurs immediately below the Ap horizon in Rhode Island soils. In well-drained soils the B horizon is commonly yellowish-brown to reddish-brown in color. These brighter colors have resulted from the accumulation (illuviation) of iron oxides which were leached from the A horizon. The B horizon is generally referred to as the zone of maximum illuviation. In addition to iron, there may also be an accumulation of such constituents as aluminum, manganese, calcium, and clay in the sub surface horizons of some soils. The B horizons of soils classified as poorly or very poorly drained are usually gray because the lack of oxygen prevents the oxidation of iron to a red color.

The properties of the B horizon are important to agriculture and urban development because of their influence on root growth and water movement. Knowledge of the characteristics of this subsurface horizon is critical for the appropriate design of tile drain systems, sanitary landfills, on-site sewage disposal systems, and highway construction.

In soil profile descriptions, the B horizon may be subdivided into B1, B2, and B3 horizons. The symbols B1 and B3 designate the upper and lower portions of the B horizon, respectively, which are transitional to the A horizon above and the C horizon below. The B2 horizon is the subsurface horizon with the maximum expression of B horizon properties such as reddish-brown color and blocky structure.

The soil solum is that portion of the soil profile which has developed by soil-forming processes and includes the A and B horizons collectively.

C Horizon

The C horizon is a layer of unconsolidated material underlying the solum (A and B horizons). This horizon is outside the zone of major biological activity and has been influenced only slightly by soil forming processes. However, sufficient physical and chemical weathering have occurred to distinguish this material from the consolidated bedrock below. The C horizon material may have accumulated in place by the breakdown of bedrock, or it may have been moved to its present location by the action of water, wind, or ice. If the C horizon material is similar in chemical, physical, and mineralogical properties to the material from which the A and B horizons have developed, the C horizon has been commonly referred to as the parent material.

In many soils in Rhode Island the C horizon consists of materials differing from those in the solum. An example is where the solum has developed in windblown silt (loess) and the C horizon consists of stratified sand and gravel. The presence of two or more different geologic materials in the same soil profile is referred to as a lithologic discontinuity. In profile descriptions these differences in geologic materials are designated by Arabic numerals such as 2C.

R Horizon

The underlying consolidated bedrock, such as granite, gneiss, or shale, is designated as the R horizon. If the bedrock is unlike the overlying soil material, the R is preceded by an Arabic numeral as 2R. Although bedrock can be observed in many areas of Rhode Island, none of the soils in the state was formed in place from this material.

Additional Symbols

In describing soil profiles, additional symbols may appear as a suffix to master horizons to denote special features. For example, a gray subsurface horizon resulting from the reduction of iron (B2g), plowing of a surface soil (Ap), and fragipans or firm, dense, brittle subsurface layers (Cx).

SOIL FORMATION

The characteristics of a soil profile are the result of various physical, chemical, and biological reactions. These reactions may be grouped into four broad soil-forming processes which contribute to the differentiation of horizons. These soil-forming processes include additions, removals, transfers, and transformations (16). Additions of organic matter from decaying vegetation are an early step in soil formation. In addition, accumulations of various elements and particles from rainwater or wind occur in most soils. During soil formation there is also a relatively constant removal of soil constituents. Many soluble elements are leached through the soil profile by percolating rainwater, and water running over the soil surface may remove soil particles by erosion. Water percolating through a soil profile may not actually remove elements from the soil completely, but may simply transfer these compounds from one horizon to another. This transfer process may involve the movement of such soil constituents as clay, organic matter, iron, calcium, and magnesium from the A horizon to the B horizon. Transformations or chemical and biological changes of various soil components are continually occurring in soils. Organic matter is readily broken down in most soils and is present in various stages of decomposition. Upon decay it releases numerous humic acids. The inorganic or mineral components of soils are also undergoing continuous change. Although relatively long periods of time are required, primary minerals such as feldspars and micas are transformed to clay type minerals during the weathering process.

It is generally accepted that the soil-forming processes of additions, removals, transfers, and transformations proceed in most, if not all, soils. The relative importance of the various processes, however, differs from one soil to another. The combinations of these processes, as dictated by various factors of soil formation, give rise to specific and unique soils. The five soil-forming factors commonly recognized among soil scientists as controlling the relative importance of the various processes of soil formation and thus the kind of soil that ultimately develops are: parent material, climate, living organisms, topography or relief, and time (7).

These factors work interdependently in producing a particular soil. Differences or similarities between soils are due to differences or similarities in one or more of the soil forming factors. Each factor also modifies, or is modified by, other soil forming, factors. For example, topography modifies the effects of rainfall, a climatic factor, by influencing the distribution of water. On steep slopes a greater percent age of the rainwater runs off the soil surface and less of this water percolates through the soil. Conversely, depressions in the landscape not only receive water directly as rainfall, but as runoff from higher positions on the landscape. Climatic differences, primarily rainfall and temperature, also influence the type of vegetation present in an area. Therefore, not only does the difference in climate produce a change in soil characteristics, but a change in vegetation, as a result of the climatic change, may result in a different balance of soil-forming processes. It is necessary to study the various factors of soil formation so that variations in soil properties can be explained, as well as predicted, from one place to another. These factors will be discussed in subsequent sections in greater detail as they relate to Rhode Island soils.

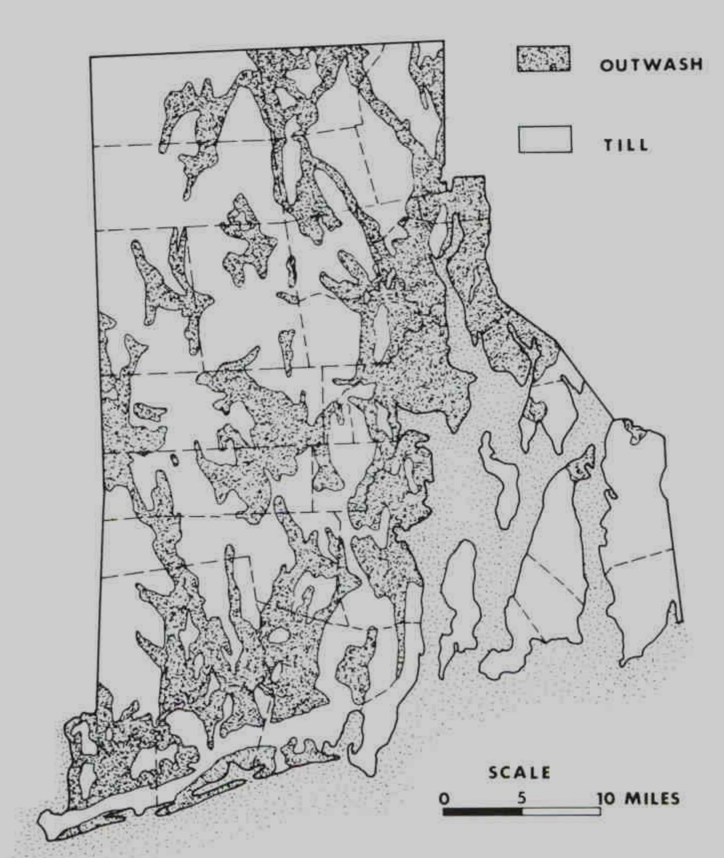


Figure 3. Generalized map showing major areas of glacial till and outwash in Rhode Island (adapted from Quinn, 1976).

Parent Material

The initial step in the development of a soil profile is the formation of soil parent material. The unconsolidated residue resulting from the physical and chemical weathering of various types of bedrock is called parent material. Some soils have formed from the weathering of bedrock in place; however, most of the soils in Rhode Island have formed from material that was transported from the site of the parent rock and redeposited at the new location through the action of ice, water, wind, or gravity.

Glacial ice was particularly important in transporting and depositing the parent materials from which Rhode Island soils developed. During the Pleistocene or Ice Age, a very large mass of glacial ice moved down from Canada and covered the entire state. The ice moved like a giant bulldozer across the landscape and pushed along pre-glacial soil, plucked boulders out of the bedrock, and ground rocks into smaller particles. Hills were leveled and streamlined in the direction of the ice movement and some valleys were deepened. Approximately 10,000 years ago the climate warmed and the ice melted, filling many of the valleys with glacial debris. Subsequently, winds blowing across the nonvegetated glacial sediments picked up silt and fine sand particles and redeposited them elsewhere on the landscape to form what is called loess.

The parent material not only provides a framework for the soil, but influences to a great degree the physical, chemical, mineralogical, and morphological characteristics of the soil. The principal parent materials of Rhode Island are glacial till and glacial outwash. A small percentage of the soils in Rhode Island have also developed from organic deposits or loess-covered glacial drift.

Approximately 65 percent of the soils in Rhode Island have developed from glacial till. Glacial till is the unsorted mixture of clay, silt, sand, gravel, and boulders which was directly deposited by the ice sheet. The glacial tills from which Rhode Island soils were formed are primarily loamy sand and sandy loam of acid crystalline rock origin. Thus most of the soils are medium to coarse textured. The area of glacial till located east of Narragansett Bay and along a narrow strip on the west side of the Bay originated from carboniferous slates and shales. The soils de rived from these carboniferous deposits are, for the most part, dark colored and silt loam in texture. Most of the glacial till in Rhode Island is located on gently sloping and rolling uplands and drumlins. The landscape is characterized by numerous boulders and stone walls. Because of limitations for farming most of these areas remain forested.

Approximately 20 percent of the soils in Rhode Island have developed in glacial outwash deposits. As the ice sheet melted during warm periods, melt water flowed from the margins of the glacier and carried with it a large amount of sediment. This sediment became sorted and was redeposited as stratified layers of gravel, sand, and silt. Most of the outwash in Rhode Island is in broad valleys which are called outwash plains. These areas are relatively fiat and free of stones and boulders and are generally considered to be some of the best soils for farming in the state.

Loess is a silty, wind-deposited material which makes up approximately ten percent of the land area in Rhode Island. Loess deposits originated from materials laid down on outwash plains as a result of glacial melt water. After drying, they were picked up by the wind and redeposited over the landscape. The thick ness of loess deposits in Rhode Island ranges from 6 inches to more than 4 feet and averages about 30 inches. These deposits of loess overlie both glacial outwash and glacial till. They have high water holding capacities and relatively few stones or boulders and make excellent soils for agricultural use.

Organic deposits form the parent materials for peat and muck soils which occupy approximately five percent of the land area in Rhode Island. These organic deposits generally occur in small, very poorly drained depressions. The wet environment has retarded the decay of organic matter which has accumulated over time. The thickness of the organic deposits ranges from less than one foot to more than 20 feet. Most of the salt marshes, which occur along the coast, have less than 16 inches of organic material over sand. They occupy only about one percent of the land area in Rhode Island.

Climate

Climate, through its component elements (precipitation, temperature, humidity, and seasonal variability), directly and indirectly influences soil development. Direct effects include the influence of temperature and precipitation upon the weathering of rocks and minerals. High temperatures and high rainfall encourage rapid weathering of soil parent materials. In areas of low rainfall or low temperatures, however, the weathering processes are very slow and the soils have little development.

Climate also plays an indirect role in the formation of soils through its effect upon plant growth and adaptation. These influences are more pronounced on a world-wide or nation-wide basis where climate dictates to a great degree whether the dominant vegetation is grassland, deciduous or conifer forest.

Although Rhode Island is small in total land area, the weather varies widely between localities (5]. Rhode Island’s climate is humid and temperate, and the growing season generally ranges from about 130 to 180 days. Because of the proximity of the ocean and of Narragansett Bay. The climate is modified and warmed in winter and correspondingly cooled in summer. The effect of these maritime air masses is particularly evident on Block Island which has a frost-free period exceeding 200 days a year.

The average annual temperature in Kingston, RI., is 49.1°F (9). On the average there are only about four days a year with a high temperature of over 90°F, though there is a great deal of variation from year to year. During the winter months, the daily maximum is usually well above freezing and there are, on the average, only 20 days a year without significant after noon thawing. While the daily minimum is below freezing on all but 12 days during the average winter, below zero readings occur only four days a year. The normal maximum, mean and minimum temperatures at Kingston, RI., during the year are presented in (figure 4). Precipitation is highly variable from year to year and the probability of any one year being four or more inches below normal is about one in four. In addition, the range in precipitation between measuring stations in Rhode Island is reported as a little over 9 inches (5). Seasonal snowfall averages 32.6 inches and most of it occurs during the months of December through March. The average annual rainfall at Kingston, RI., is 48.07 inches (9). The monthly

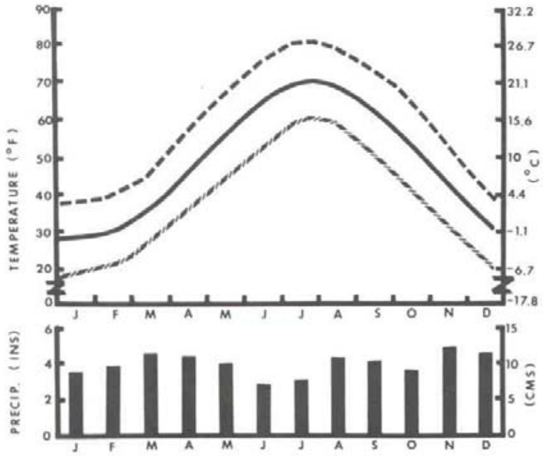


Figure 4. Average daily maximum and minimum temperatures, and average monthly temperature and rainfall for Kingston, Rhode Island (1951-1973).

distribution of rainfall in Rhode Island is fairly uniform; however, June and July are the driest months. Figure 4 shows the monthly distribution of rainfall at Kingston.

Living Organisms

The role of living organisms (flora and fauna) in soil formation is extremely important. Although microorganisms and other soil fauna play a major role in the decomposition of organic matter and availability of nutrients, the importance of vegetation is perhaps more evident in soil genesis. The type of vegetation growing in an area is determined primarily by the climate, soil parent material, relief, drainage, and age of soil or landscape. There are approximately 423,000 acres of uncleared forest land in Rhode Island, which makes up about 7 percent of the total land area in the state (8). The state's most important forest land category in terms of area is hardwoods. The hardwoods, located on well-drained upland sites, generally include black oak, red oak, white oak, scarlet oak, and red maple. Less common trees in hardwood stands are American beech, chestnut oak, and various species of birch, cherry, aspen, and ash. Hardwood forests associated with poorly and very poorly drained sites consist mainly of red maple, red ash, and swamp white oak. These sites usually have a dense shrub layer that includes species such as laurel, azalea, sweet pepperbush, spice bush, and wetland herbs such as hellebore and skunk cabbage.

Softwood forests make up only about three per cent of the total land area of the state (8). In upland sites the common tree species are white pine and pitch pine. In the more poorly drained areas and swamps, black spruce and Atlantic white cedar are present along with some hemlock.

The tidal marshes and freshwater marshes comprise about 5 percent of the land area in the state. Some plants characteristic of salt marshes are cordgrass, saltgrass, and various sedges and rushes. The plant composition of freshwater marshes is strongly influenced by water depth. The shoreline of marshes is characterized by cattail, pickerel weed, and burreed while in water three to four feet deep, pond weed, bladderwort, and coontail are common.

Microorganisms also play an important role in soil formation. They are a source of organic matter and aid in the decomposition of fallen leaves and dead organisms. These oxidized or decomposed organic materials are called humus. Only small amounts of humus are needed to influence the character of a soil. An average mineral soil in Rhode Island contains about four to six percent organic matter in the A horizon, but this small amount greatly influences such soil properties as nutrient content, aggregation, and water holding capacity.

The type of vegetation not only determines the amount of organic matter in the soil, but modifies many of the soil's chemical, physical and morphological properties. Nearly all of the nitrogen and a large portion of the phosphorus and sulfur are contained in organic fractions. In addition, soils formed under deciduous vegetation are usually not as acid as those formed under conifers. The residue of deciduous plants generally contains larger amounts of basic elements, such as calcium and potassium, than residue from conifers, and therefore, there is a greater degree of nutrient cycling. Soils developed under deciduous plants also tend to have thicker A1 horizons and greater microbial populations.

Human activity also greatly influences soil development. Although we may improve some soils through various practices such as liming, fertilizing, and drainage; most of our activities are destructive in terms of soil formation.

Topography

Topography, or relief, generally denotes the configuration of the land surface. It affects the formation of soils primarily by altering the distribution and movement of water. Topographic position also affects soil temperature, parent material character, and type of vegetation. A number of soil properties are related to relief or landscape position and include such things as thickness of solum, thickness and organic matter content of the A horizon, soil color, reaction, soluble salt content, degree of horizon differentiation, and presence or absence of dense, compact layers.

One of the most obvious relationships of topography to a soil property is that nearly level soils tend to have thicker sola than those on slopes. This can usually be attributed to slow erosion of the soil material on slopes and its subsequent deposition in depressions. As a result of this increased runoff on slopes, there is also less percolating water to weather the parent material and form soil. Both of these processes are perhaps important in considering the relationships between solum thickness and relief.

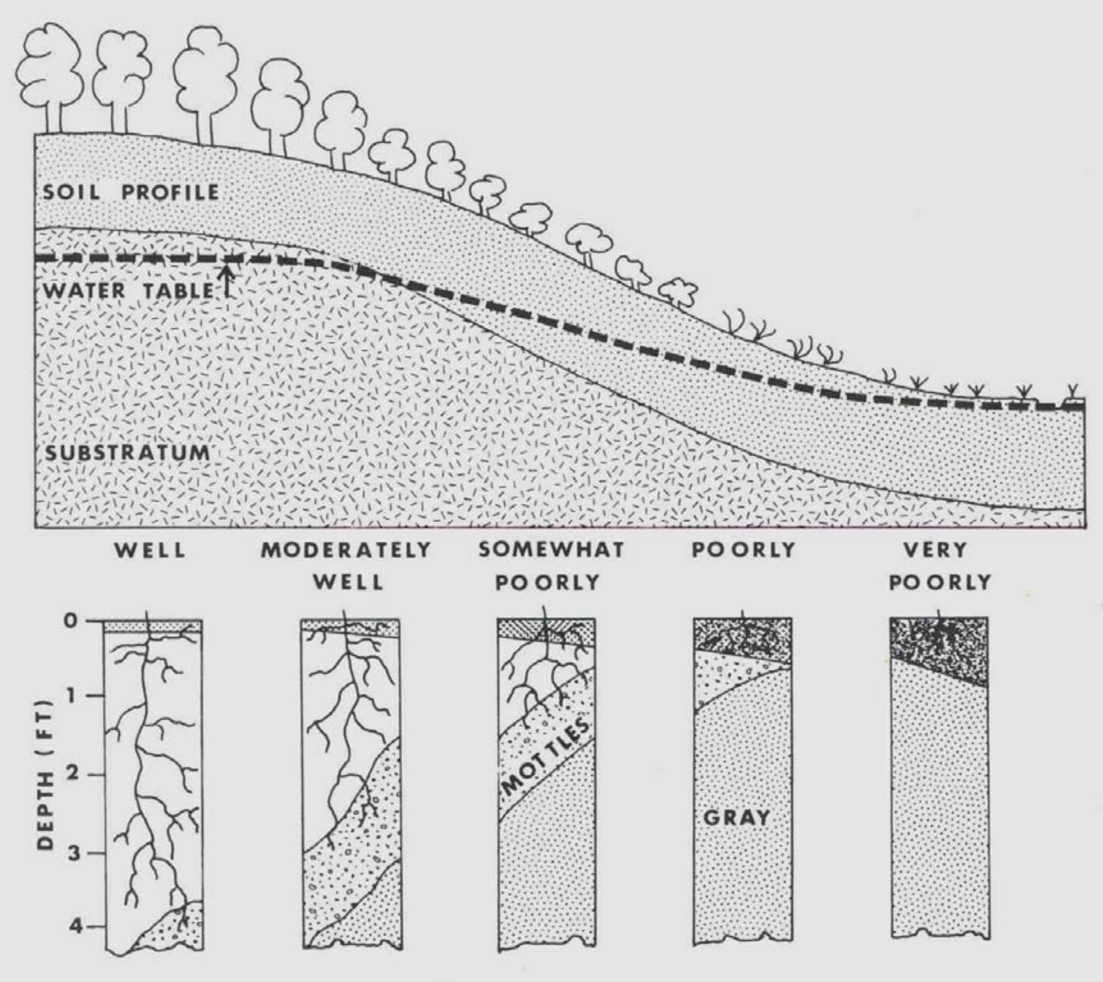


Figure 5. Schematic representation of a soil toposequence or catena.

Not only is the degree of slope important in soil genesis, but also the slope aspect. In the temperate regions of the world, south-facing slopes are generally drier and warmer than north-facing slopes. Thus, soils on south-facing slopes are generally lower in organic matter, contain fewer microorganisms, and have more mature profiles. In addition, the vegetation on south-facing slopes consists of species adapted to drier and warmer environments.

The relationship of topographic position to type of parent material is an important and obvious association in Rhode Island. The broad, flat valleys, termed outwash plains, are composed primarily of water-worked, stratified sand and gravel. These outwash deposits are essentially stone-free and are commonly capped with a windblown silt deposit called loess. Most of these areas are being farmed. The more rolling topography associated with most of the Rhode Island landscape is composed of glacial till. Boulders are generally quite prevalent in these areas and the dominant land use is forestry.

Perhaps the most important soil-landscape relationship in Rhode Island is that associated with water tables or internal soil drainage. As illustrated in Figure 5, soil profiles are more strongly developed and deepest on the higher portions of the landscape. The more poorly drained soils, which are at lower positions or in depressions on the landscape, generally have thick, dark surface-horizons and the subsoils are speckled or mottled with gray colors. These poorly and very poorly drained soils are saturated with water for much of the year and are slower to warm up in the spring. The cool temperatures and low oxygen supplies associated with these wet conditions retard microbial activity, thus resulting in a buildup of organic materials. These low-lying wet soils also tend to have higher base saturations, as nutrients have ac cumulated from runoff water from higher positions on the landscape.

Although the soil toposequence illustrated in Figure 5 is the classical example, it is not uncommon to find wet, poorly drained soils in upland positions on the landscape. Many of Rhode Island's soils on uplands, are underlain by dense, compact glacial till which can result in perched water tables.

Relief is perhaps the single most dominant factor influencing the different kinds of soils in Rhode Island. A knowledgeable, well-trained soil scientist can readily identify soil-landscape relationship. These concepts are perhaps the most valuable in preparing accurate, useful soil maps.

Time

The degree of profile differentiation is dependent not only on the intensity of the soil-forming processes, but also on the duration of these processes. The amount of time may vary from a few days for fresh alluvial deposits to several hundreds of thousands of years for old stable landscapes. In terms of soil formation, the soils of Rhode Island are relatively young. The ages of the soils in Rhode Island are mainly related to the ages of the glacial deposits. Most of the glacial drift in southern New England has been correlated with the Wisconsin glacial period (13). The maximum advance of the ice sheet occurred approximately 20,000 years ago. Nearly 5,000 years elapsed during the retreat of the ice sheet which was followed by a periglacial climate in which a great deal of wind-blown silt was deposited on the landscape. Therefore, it is generally agreed that the oldest soils in Rhode Island are in the neighborhood of 10,000 to 15,000 years old.

It is more reasonable, however, to speak of the age of soils in terms of their state of maturity, rather than in years. The terms "young," "mature," and "old age" which were originally developed for the description and identification of landscapes have been applied to soils. The estimate of relative age or degree of maturity of soils is universally based on horizon differentiation. In practice, it is accepted that the larger the number of horizons and the greater their thickness and expression, the more mature the soil.

The comparatively young soils in Rhode Island have horizons that are weakly developed except for the addition of organic matter to topsoils and the development of color in B horizons. The soils of recent alluvial origin are even less mature than those formed in glacial drift. Many of these soils continue to receive sediment which has been eroded from the surrounding uplands and their morphological properties are not unlike the parent material, since soil- forming processes have not had time to alter this fresh material.

Mature soils are those which have attained maximum horizon differentiation and are in equilibrium with their environment. As a result of the relatively young glacial landscapes in Rhode Island, the soils have not yet reached this degree of maturity. Although the processes of soil formation are extremely slow, it is possible that the soils of Rhode Island could change drastically over the centuries as they approach equilibrium with their environment.

Summary

Soil thinly mantles the earth's surface and is a dynamic natural body. It has been produced by numerous physical and chemical processes acting upon geologic materials. Soil formation is a continuing process and the nature of the soil formed is dependent upon the parent material, climate, living organisms, relief, and time of weathering. None of these factors acts independently, but each modifies the effects of the others. It is the interaction of these five factors of soil formation that has resulted in the formation of the more than 100 types of soil in Rhode Island.

****PROPERTIES OF SOILS**

An experienced pedologist (soil scientist) can read a great deal from the morphology of a soil seen in the field. Many of the soil properties, such as color, structure, consistence, and sequence of horizons, are readily observable and the soil scientist can make many interpretations based on these properties. However, some soils may look alike but may have entirely different chemical and physical properties which could cause them to react quite differently to various uses. Thus, for modern soil science, quantitative field and laboratory data on the composition of soils are needed in order to make accurate interpretations related to the response of soils to different uses. In addition, modern soil classification systems place a great deal of emphasis on the quantitative composition of soils.

Color

Color is perhaps the most obvious and easily determined soil characteristic. This physical property has little effect on soil behavior beyond influencing the gain and loss of radiant energy; however, color is particularly useful for making a number of meaningful predictions about the soil. It is an indirect measure of such things as the intensity of mineral weathering, the amount and distribution of organic matter in the soil, and the state or degree of soil aeration.

The two dominant coloring agents of soils are organic matter and iron oxides. The effects of organic compounds are most prevalent in surface horizons and give them their dark colors. Although organic matter is not the only coloring agent, and all organic matter is not the same color, there is generally a darkening of soils with increased organic content. The relationship between soil color and organic matter content may be somewhat obscured by the type of organic matter and its stage of decomposition. Raw peat is generally brown in color, whereas highly de composed organic materials, such as those found in muck soils, are black or nearly so. The amount of organic matter and thus the color of the soil are correlated quite well with the soil drainage class. As illustrated in Figure 5, as a soil becomes more poorly drained the Al horizon becomes thicker, the organic matter content increases, and the color becomes darker.

Subsoil or B horizon colors can range from
gray to yellowish brown to reddish red. These color differences can generally be attributed to the amount and type of iron compounds. Although the parent material may influence the color of some soils, particularly young soils, most subsoil colors are related to the intensity of weathering or the amount of oxidation which is controlled by drainage. Usually the reddish soils are found in warm humid climates where the intensity of weathering has been high, as in the southeastern parts of the United States or in tropical areas. Some well-drained soils which have apparently undergone extensive weathering may be yellow rather than red. Laboratory analyses often reveal that these soils are just as high in iron as the red soils, but the iron occurs in a different form. A number of studies have suggested that red soils are occupied by unhydrated forms of iron oxides such as hematite, whereas the yellow soils are composed primarily of hydrated iron oxides such as goethite. The dominant subsoil colors in Rhode Island range from gray to yellowish brown.

The soils of Rhode Island are greatly influenced by the interrelationships between color and aeration which generally reflect the obstruction of water or air flow through the soil. Poor aeration results when soil pores remain filled with water for prolonged periods. When aeration is poor, iron assumes a chemically reduced form, referred to as ferrous iron that imparts grayish to bluish hues to the soil body. In addition, ferrous forms of iron are quite soluble in water and are readily leached from the soil and the uncoated mineral grains dictate the color of poorly and very poorly drained soils. The Leicester, Mansfield, Matunuck, Raypol, Ridgebury, Rumney, Scarboro, Stissing. Walpole and Whitman series are examples of soils with gray subsoil colors.

The depth to water tables fluctuates from season to season in Rhode Island soils. During the winter and spring, water tables are generally quite high resulting in a reduction of iron compounds to the ferrous form which imparts a gray color to the soil. Water tables generally drop during the summer months resulting in oxidizing conditions. This alternate reducing and oxidizing environment causes a mobilization and redeposition of iron compounds resulting in the formation of mottles in the soil. These rust-colored mottles are generally indicative of seasonally high water tables. The Birchwood, Deerfield, Ninigret, Pittstown, Podunk, Rainbow, Scio, Sudbury, Sutton, Tisbury, Wapping, and Woodbridge series are examples of moderately well drained soils in Rhode Island which exhibit rust-colored mottles.

Although color itself has little influence on the nature of soils, it is a property which soil scientists use to interpret and predict soil conditions and responses. Because soil colors reflect seasonally high water tables they are a valuable tool in determining the suitability of soils for such uses as on-site sewage disposal systems, sanitary landfills, homesites, and other structures affected by wet soils,

Texture

Soils, as they occur in the field, are mixtures of mineral particles of different sizes ranging from stones and gravel to microscopic clay. While stones and gravel, when present, give certain characteristics to a soil, from a biological and nutritional standpoint, the important fraction is the fine earth (C 2 mm). Table I lists limits of various particle size fractions as established by the United States Department of Agriculture (18). Sand grains are easily seen with the naked eye and feel gritty. Silt and clay particles, how ever, cannot be felt individually but they do have characteristics that permit their identification. Visually, silt particles fall within the range of an ordinary microscope. They are very smooth when moist and have the consistency of face powder or flour when dry. Clays, on the other hand, are too small to be observed with an ordinary microscope and are extremely sticky and plastic when wet and form hard clods when dry.

Few soils consist of a single particle size and most of Rhode Island soils contain varying proportions of sand, silt and clay. Some variation in texture can occur without causing a major change in the general character of the soil. Because of this, it is convenient to group soils into a limited number of textural classes, each representing a fairly narrow range in particle size composition and properties. Twelve textural classes are recognized in the United States and are listed by name on the textural triangle in figure 6. The most common soil textures found in Rhode Island is presented in Table 2.

The textural class of a soil is determined by analyzing the particle size. Accurate measurements of particle size distributions are made in a laboratory, however, an experienced soil scientist can estimate texture fairly accurately by rubbing a small portion of moist soil between the thumb and forefinger. Soil texture classes can be determined by using the following descriptions.

Table 1. U.S.D.A> size limits of coarse fragments and soil particles.

Name of Component	Diameter
Stones	Above 10 inches
Cobbles	3-10 inches
Gravel	2 mm - 3 inches
Very coarse sand	1.0- 2.0mm
Coarse sand	0.5 - 1.0 mm
Medium sand	0.25 - 0.5 mm
Fine sand	0.1 - 0.25 mm
Very fine sand	0.05 - 0.1 mm
Coarse silt	0.02 -0.05 mm
Fine silt	0.002 - 0.02 mm

Coarse clay ------------------------0.0002 - 0.002 mm
Fine clay --------------------------Below 0.0002 mm

Sand. Soil consisting mostly of coarse and fine sand, and containing so little clay that it is loose when dry and not sticky when wet. When rubbed it leaves no film on the fingers.

Loamy Sand. Consisting mostly of sand, but with sufficient clay and silt to give the soil slight cohesion when very moist. Leaves a slight film of fine materials on the fingers when rubbed.

Sandy Loam. Soil in which the sand fraction is still quite obvious, it molds readily when sufficiently moist, but in most cases does not stick appreciably to the fingers. Threads do not form easily.

Loam. Soil in which the fractions are so blended that it molds readily when sufficiently moist, and sticks to the fingers to some extent. It can, with difficulty, be molded into threads.

Silt Loam. Soil that is moderately plastic without being very sticky and in which the smooth, soapy feel of the silt is the most noticeable feature

Silt. Soil in which the smooth, soapy feel of silt is dominant.

Sandy Clay Loam. Soils containing sufficient clay to be distinctly sticky when moist, but in which the sand fraction is still an obvious feature

Clay Loam. The soil is distinctly sticky when sufficiently moist, and the presence of sand fractions can only be detected with care.

Silty Clay Loam. The soil contains quite subordinate amounts of sand, but sufficient silt to confer some thing of a smooth, soapy feel. It is less sticky than silty clay or clay loam.

Sandy Clay. The soil is plastic and sticky when moistened sufficiently, but the sand fraction is still an obvious feature. Clay and sand are dominant, and the intermediate grades of silt and very fine sand are less apparent.

Silty Clay. Soil which is composed almost entirely of very fine material, but in which the smooth, soapy feel of the silt fraction modifies to some extent the stickiness of the clay.

Clay. The soil is plastic and sticky when moistened sufficiently and gives a polished surface on rubbing. When moist, the soil can be rolled into threads. It is capable of being molded into any shape and takes clear fingerprints.

Table 2. Selected physical and chemical properties of six Rhode Island soils.

	Texture %			Organic		CEC
Horizon	%Sand	%Silt	%Clay	Matter	pH	meq./100 g.
Paxton fine sandy loom						
Ap	62	33	5	3.2	4.8	12.9
B22	57	38	5	0.6	4.8	6.8
Woodbridge fine sandy loam						
Ap	50	45	5	6.6	4.8	24.3
B22	49	50	1	0.9	4.7	6.9
Bridgehampton silt loam						
Ap	19	75	6	9.0	5.5	25.0
B22	23	74	3	0.7	4.8	7.9
Stissing silt loam						
Al	30	69	1	7.1	5.5	28.2
B22	45	50	5	0.3	6.6	8.4
Mansfield silt loam						
All	28	68	4	17.2	6.1	33.2
B2	20	75	5	0.5	6.0	6.2
Agawam fine sandy loam						
Ap	65	27	8	3.4	5.1	12.9
822	56	30	14	0.4	5.6	6.5

Because of its usefulness in predicting many things about soil behavior, texture is one of the most important soil characteristics. If the texture of a soil is known, some judgment maybe made concerning the ease with which it can be worked in the field, the rate at which water moves through it, and its ability to hold water and nutrients for plant use. These judgments are not quantitative by any means, but they are often useful in the general characterization of a soil when other, more precise, information is not available.

Coarse-textured soils, such as sands, loamy sands, and coarse sandy loams, are highly permeable and water moves through them rapidly. These types of soils warm up quickly in the spring and can be tilled soon after a rain. However, water-holding and plant-nutrient-supplying capacities of coarse- textured soils are low. They tend to be droughty and nutrients can be lost by leaching. In addition, if waste disposal, such as landfills, septic systems, or the spreading of sewage sludge is carried on in these highly permeable soils, shallow wells may become contaminated. The Gloucester, Hinckley, Merrimac, Quonset, and Windsor series are examples of soils found in Rhode Island that are particularly susceptible to groundwater pollution.

Fine-textured soils, which contain large quantities of clay, may pose severe problems for both agricultural and urban uses. These soils generally have slow permeabilities and compact readily when wet. Plant roots may be restricted and sewage systems are often short-lived or fail completely when installed in such soils. These dense, clayey soils are essentially nonexistent in Rhode Island.

The most productive soils generally have textures such as silt loam, loam, or fine sandy loam. These soils contain sufficient quantities of silt and clay to store nutrients and water for plants, but also contain enough sand to provide good aeration and adequate oxygen. These medium-textured soils pro vide a very favorable environment for root growth and are also well suited for most non-agricultural purposes.

Texture is a relatively permanent soil feature and will ordinarily not change during a lifetime. Nonetheless, losses through erosion or additions by water and wind can alter the texture of the surface soil. These changes in surface texture can influence the physical and chemical properties of a soil. Therefore, good conservation and management practices are essential in preserving our agricultural soils.

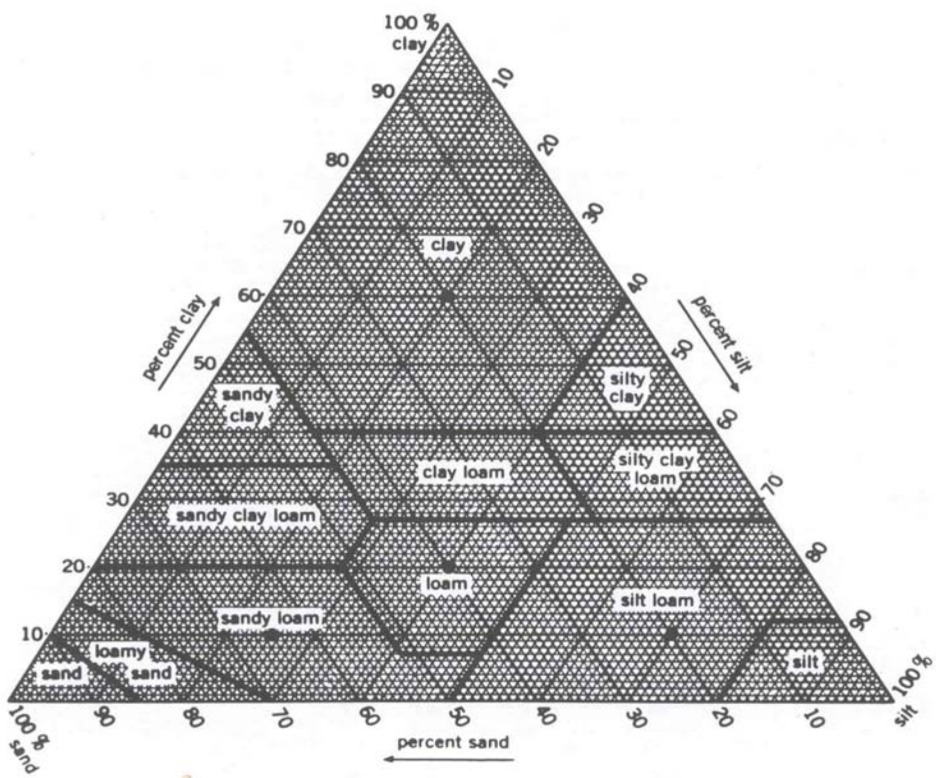


Figure 6. Textural triangle illustrating the 12 major textural classifications.

Structure

Soil structure refers to the arrangement or grouping of individual soil particles into aggregates or clusters called peds. These are naturally occurring units with specific shape and size which are the result of the soil forming processes of wetting and drying, freezing and thawing, and other physical and chemical changes. These processes have created planes of weakness in the soil which form the surface of peds.

Organic matter, clay, and other cementing agents, such as iron oxides, may act as forces of attraction in stabilizing structural peds.

Soils too stony for cultivation are often used for pasture or forest production.

Soil scientists describe structure in terms of its shape, size and distinctness. The four primary structural types are granular, platy, blocky, and prismatic (Figure 7). Granular structure is spheroidal and particles are arranged around a central point bounded by rounded or curved surfaces. This type of structure is common in surface horizons of Rhode Island soils.

Platy structure results when particles are arranged along a horizontal plane approximately parallel to the soil surface. This type of structure resembles thick sheets of paper and is common in Cx horizons of Rhode Island soils.

Blocky structure is composed of particles arranged around a point and bounded by flat or slightly rounded surfaces. These cube-like peds are the dominant structural units found in subsurface B horizons of Rhode Island soils.

Prismatic structure results when particles are arranged around a vertical line and bounded by relatively flat vertical surfaces. This type of structure is common in many subsoils but is rare in Rhode Island soils.

An important function of structure is to modify soil properties that are otherwise controlled by the texture. Benefits derived from structure are generally related to the size of the pores in the soil. For example, fine-textured soils would ordinarily have very small pores, but the formation of structure results in larger pores and therefore increased movement of both water and air. Practices designed to increase the organic matter content of the soil generally result in
better structure. These practices would also improve air and water relationships in the soil which would benefit the development of plant roots. Plowing when soils are too wet may have the opposite effect by breaking down their structure and impairing drain age and tilth.

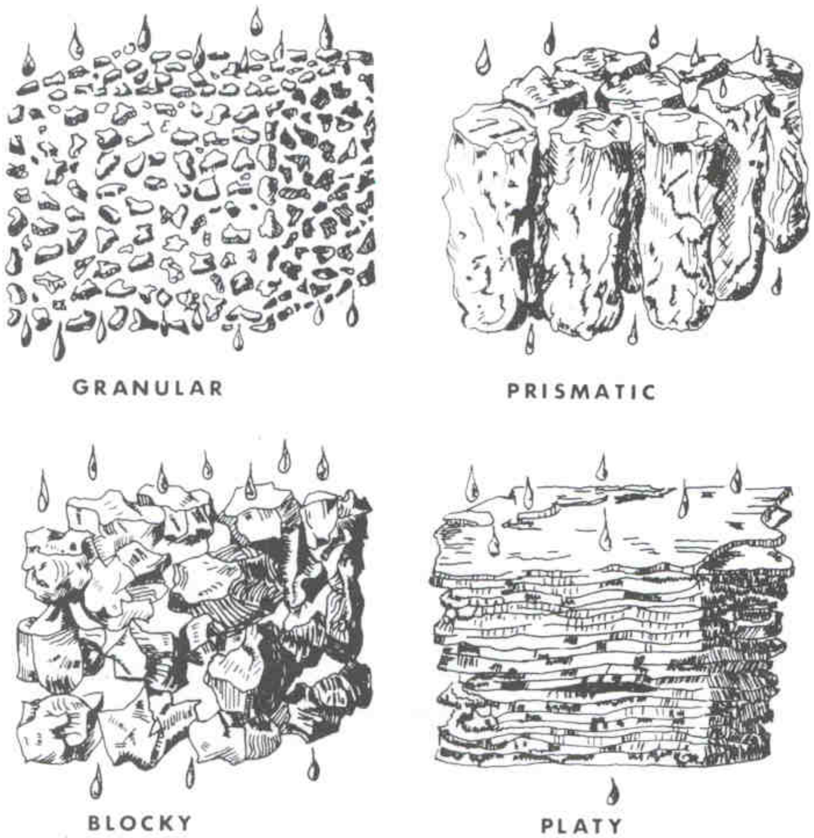


Figure 7. Schematic illustration of the four major types of soil structure.

Consistence

Soil consistence refers to the resistance of soil peds to deformation or rupture. Consistence proper ties are manifested by cohesion, or the attraction of soil particles to each other, and adhesion, the ability of particles to cling to other objects. Thus, the consistence of a soil is dependent upon such factors as clay, organic matter, and iron oxide content.

For any particular soil, consistence varies with the water content. For example, moistening a hard, dry clod may soften it by reducing the attraction between particles. With increasing water content, the soil will approach a plastic state and may even be come sticky. For this reason, soil scientists describe consistence under three moisture conditions — dry, moist, and wet.

Terms such as loose, soft, and hard are used to describe the consistence of air-dry soil. Loose consistence applies to sandy materials. Soft suggests that the soil would crush to powder if worked in a dry condition, and cultivation of a dry soil with hard consistence would leave the surface rough and cloddy. If soils are wet, consistence is expressed in terms of plasticity and stickiness which is an indication of the amount of clay.

The consistence of most soils is determined under a field-moist condition. It is intended to represent a soil in a condition suitable for plowing. Consistence terms used at this moisture content are loose, friable, and firm. A loose consistence generally refers to non-coherent, coarse-textured soils. Friable soils are in aggregate form, but they crumble readily under gentle pressure. These soils are desirable in the preparation of a seedbed prior to planting. Soils described as firm when moist are usually relatively dense. This may be the result of compaction or cementation. These types of soils are generally difficult to work, and roots, air, or water may have difficulty moving through the soil. Degrees of moist consistence are determined by attempting to crush a piece of soil and are defined in the Soil Survey Manual (18) as:

1. Loose: Non-coherent
2. Very friable: Soil material crushes easily under gentle pressure between thumb and forefinger.
3. Friable: Soil material crushes easily under moderate pressure between thumb and forefinger.
4. Firm: Soil material crushes under moderate pressure, hut resistance is distinctly notice able.
5. Very firm: Soil material crushes under strong pressure; barely crushable between thumb and forefinger.
6. Extremely firm: Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger.

Drainage

Soil drainage, in a dynamic sense, refers to the rapidity with which excess water is removed from the soil by surface runoff or internal percolation. In addition, soil drainage indicates the frequency and duration of time when the soil is free of saturation. Accurate appraisal of the drainage conditions of soils is necessary for both soil descriptions and interpretations. The problem is far more complicated than it may first appear. Certain direct evidences of drainage, such as saturated soil at various times after rains, or pools of surface water, are useful. In addition, soil drainage can be related by inference to differences in soil color and patterns of soil color. Mottling, the gray colors that accompany gleying and the organic-rich materials characteristic of wet soils are all good evidences of the extent of soil drainage. Other characteristics, such as the slope of the landscape, the texture and structure of the soil horizons, and type of vegetative cover are all useful in predicting the permeability of the soil and drainage conditions. Thus, the assessment of drainage is partly a matter of direct observation and measurement, and partly a matter of inference from a group of observations.

Table 3. Surface water runoff classes.

	Surface Soil Texture		
Slope Class	Coarse	Medium*	Fine
Nearly level (0-3%)	Very slow	to	Slow
Gently Sloping (3-8%)	Slow	to	Medium
Moderately sloping (8-15%)	Medium	to	Rapid
Strongly sloping to moderately steep (15-35%)	Rapid	to	Very Rapid
Steep (>35%)	Very Rapid	Very Rapid	Very Rapid
Ponded (depressional areas with no runoff)			

*Where there is good vegetative cover, use the slower class and if the soil surface is bare or there is poor vegetative cover, use the more rapid class.

Runoff. Surface runoff, or external soil drainage, refers to the relative rate at which water is removed by flow over the surface of the soil. Slope is usually the dominant factor in determining the amount of runoff, and erosion generally increases as the length and steepness of the slope increases. However, soil texture, structure, vegetative cover, and climate also affect the amount of runoff and subsequent erosion. The six classes of runoff are: ponded, very slow, slow, medium, rapid, and very rapid. Table 3 illustrates the relationships between slope, soil texture, and runoff classes.

Permeability. Soil permeability is that characteristic of the soil that enables it to transmit water or air. It can be measured quantitatively in terms of rate of flow of water through a cross-section of saturated soil in a unit of time under specified temperature and hydraulic conditions. The soil's permeability is generally expressed in inches per hour.

The permeability is dependent upon various soil properties such as texture, structure, and density or compaction. Therefore, in the absence of precise measurements, soils may be placed into relative per meability classes based on their physical properties. Coarse-textured soils such as sands, loamy sands, and coarse sandy loams commonly have rapid permeabilities, exceeding 6 inches of water per hour. Medium-textured soils, which include loams, silt loams, and fine sandy loams, have permeabilities ranging from 0.2 to 6 inches per hour and are broadly classified as moderate. If the water movement is less than 0.2 inches per hour, the permeability class is slow and it includes clayey soils or soils with dense sub surface horizons, such as fragipans, which are common in Rhode Island.

The percolation test is a common procedure for determining the suitability of soils for on-site sewage disposal systems. The "perc" test is an approximate measure of the soil's permeability; however, the methods are not nearly as accurate as those used to assess permeability. Percolation rates are expressed in minutes per inch of water dropping in an uncased hole in the ground.

Internal Soil Drainage. Internal soil drainage is the capacity of a soil to permit the downward flow of excess water through it. Internal drainage is related to the frequency with which the soil is saturated with water. Factors involved in influencing internal drain age are similar to those for permeability: texture, structure, and density of soil layers. However, the height of the water table, either permanent or perched, also plays a major role in the internal drain age characteristics of a soil. For example, a sandy soil may have a rapid permeability, but as a result of a high water table may have poor internal drainage.

Although the height and duration of water tables can be measured in a pipe over a long period of time, observations of the soils morphology can be a very accurate indirect method of assessing the soil's internal drainage characteristics. The soil's natural internal drainage can be estimated by the color and thick ness of the topsoil and particularly by the color of the subsoil. As indicated in the section on soil color, soils with restricted drainage tend to have darker and thicker surface layers than well-drained soils. In addition, the presence of mottles or gray colors in subsoils. generally indicates poor internal soil drainage.

Soil Drainage Classes. On the basis of the observations and inferences used to obtain classes of runoff, soil permeability, and internal drainage, relative soil drainage classes can be defined. Seven natural soil drainage classes are recognized and are described briefly as follows.

Excessively drained soils exhibit bright colors and are usually coarse-textured. The soils have rapid permeabilities, very low water-holding capacities, and the subsoils are free of mottling. The Hinckley and Quonset series are examples of Rhode Island soils which fall in this class.

Somewhat excessively drained soils have bright colors and are rather sandy. These soils also have rapid permeabilities, low water-holding capacities, and the subsoils are free of mottles. The Gloucester and Merrimac soils are examples of this class which occur in Rhode Island.

Well-drained soils drain excess water readily, but contain sufficient fine material to provide adequate moisture for plant growth. The subsoils are free of mottles to a depth of at least three feet and the colors are generally bright yellow, red, or brown. Examples of this drainage class in Rhode Island include the Agawam, Bridgehampton, Enfield, and Narragansett, Newport, and Paxton soils.

Moderately well drained soils may have any texture but their internal drainage is restricted to some degree. Mottles are common in the lower part of the subsoil, generally at a depth of 18 to 36 inches. These soils may remain wet and cold later in the spring, but are generally suited for agricultural use. Because they have high water tables during certain periods of the year, caution must be exercised in using these soils for some non-agricultural purposes. The Pittstown, Scio, Sudhury, Tisbury, and Woodbridge series are examples of Rhode Island soils which fall in this class.

Somewhat poorly drained soils remain wet for long periods of time due to slow removal of water. These soils generally have a slowly permeable layer within the profile or a high water table. Mottles are common in the subsoil at a depth of 8 to 18 inches and artificial drainage is needed before these soils can be used extensively for agricultural production. As a result of high water tables these soils are poorly suited for most non-agricultural purposes. This drainage class is not applied in Rhode Island

Poorly drained soils have water tables at or near the surface during a considerable part of the year. Dark, thick, surface horizons are commonly associated with these soils and gray colors usually dominate the subsoils. Mottles are frequently found within eight inches of the soil surface. These soils exhibit severe limitations for most uses, and structures like highways and septic systems frequently fail or require expensive modifications to overcome water-related problems. The Ridgebury, Stissing, Leicester, and Walpole soils are examples of this class found in Rhode Island.

Very poorly drained soils are saturated by a high water table most of the year. These soils generally have thick black surface horizons and gray subsoils. Topographically, soils of this drainage class usually occupy level or depressed sites and are frequently ponded with water. These soils have a poor potential for most agricultural and urban uses and are best suited for wildlife habitats, flood control, or aesthetic purposes. Examples of this drainage class in Rhode Island include the Whitman, Mansfield, and Scarboro soils.

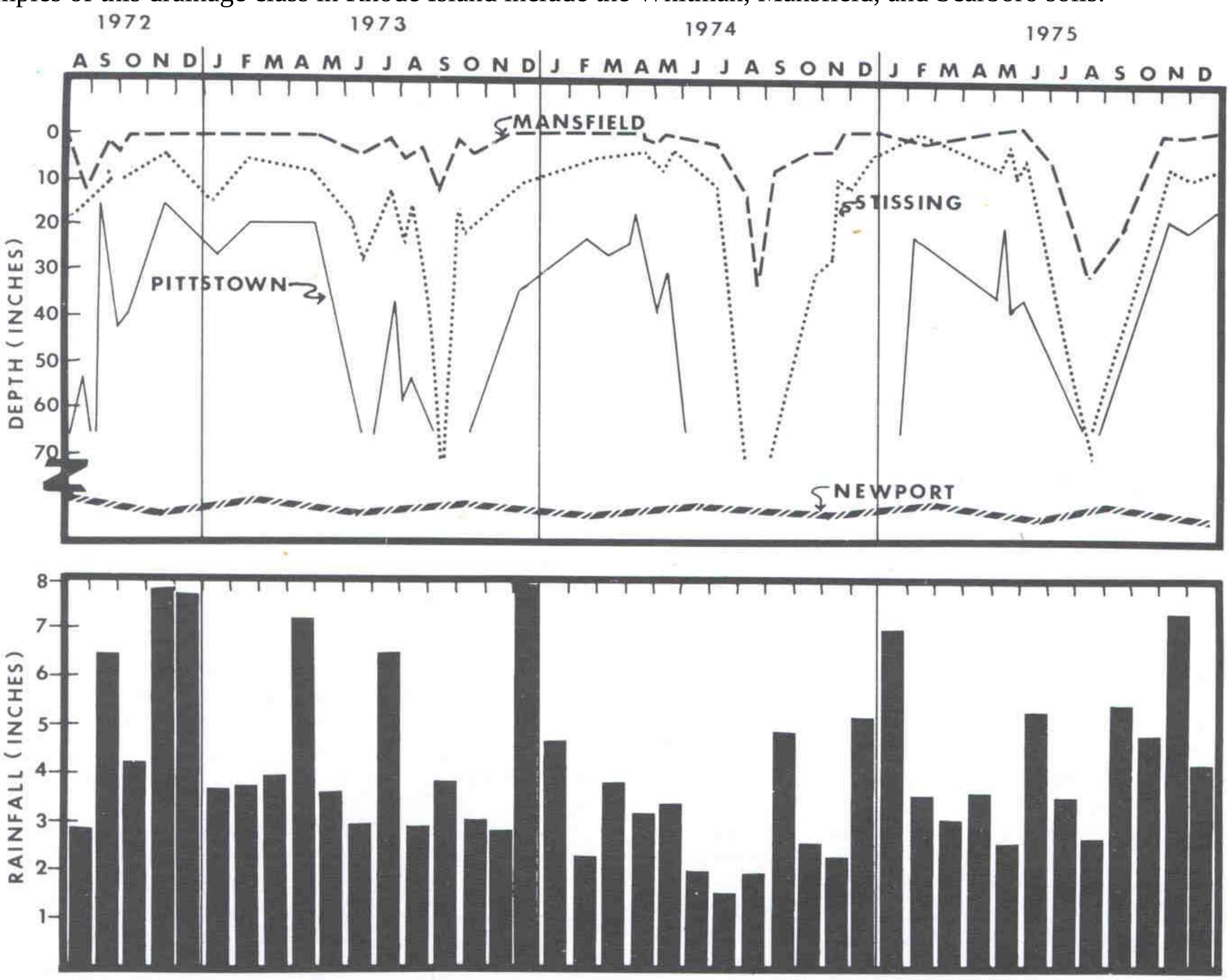


Figure 8. Water table fluctuations in soils of the Newport catena.

The morphological characteristics used in placing soils into drainage classes are generally related to the height and duration of seasonally high water tables. Data obtained by the RI. Agricultural Experiment Station on water-table fluctuations in soils of the Newport catena are presented in Figure 8. These data are similar to those observed in other soils of comparable drainage classes in Rhode Island,

Although soil drainage classes are indicative of seasonal water table elevations, they are also related to the landscape position on which the soil occurs. A sequence of soils which is similar in all properties except for drainage is referred to as a "catena" or "toposequence" (Figure 5). The grouping of soils into catenas is helpful in understanding the soils that blanket the landscape of Rhode Island. Table 4 illustrates the relationships among soil series, parent material, and drainage class. Each numbered group consists of soils formed from similar parent materials, but differing in drainage as they extend across relief positions. Each group is referred to as a catena which is named after the well-drained soil. For example, the soils in group four make up the Paxton catena or toposequence and consist of the Paxton, Woodbridge, Ridgebury, and Whitman soils.

Available Water Capacity

The capacity of a soil to hold water is of fundamental importance to soil productivity. Water is held in the soil by mutual attraction between soil particles and water. Stored water is distributed through the pore system of the soil and over the surfaces of the soil particles. Since water drains first from larger pores, fine-textured soils usually hold the greatest amount of water and coarse-textured soils, high in sand, the least.

Not all of the water held in the soil is available to plants. Most plants die when soils are saturated for prolonged periods and this excess water is generally not considered to be available for plant use. The upper limit of useable water is called 'field capacity" and refers to the amount of water held in the soil against the forces of gravity. In some cases, soils may contain moisture but plants will wilt and die because the water is held very tightly in small pores and the plants are unable to extract it. This lower limit of available water is called the permanent wilting point. Thus, the available water capacity of a soil is the difference in moisture content between field capacity (1/3 atmosphere*) and the permanent wilting point (15 atmospheres).

A sandy soil has large pores and most of the water drains out by gravity. Thus, coarse-textured sandy soils cannot sustain crop growth for long periods without rain or supplemental irrigation. These soils generally have very low to low available water capacities (< 4 inches of available water to a depth of 36 inches).

**Unit of measure of pressure equal to air at sea level (14.7 lbs. per sq. in.)*

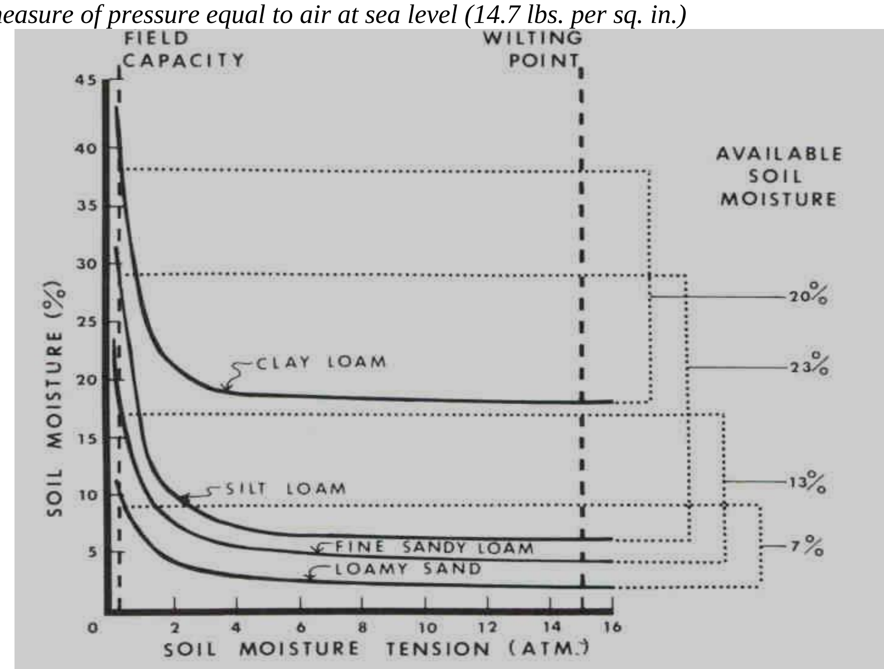


Figure 9. Relationship between soil texture and moisture availability.

Although fine-textured clayey soils hold large quantities of water, most of the water is held very tightly within the small pores. Because most of the water is held at tensions greater than the permanent wilting point, plants are unable to use it. Thus, these fine-textured soils are generally classified as having medium available water capacities (4-6 inches of available water to a depth of 36 inches).

Medium-textured soils are usually considered the most desirable for most agricultural crops. They have sufficient amounts of clay and small enough pores to hold large quantities of water and yet provide enough large pores for good drainage and aeration. These soils generally have high available water capacities (> 6 inches of available water to a depth of 36 inches).The relationships between soil tension and moisture content for various textures are presented in Figure 9 above.

All soils do not have the same texture throughout their profiles. For example, many of the soils of Rhode Island have two feet of medium-textured silts overlying a coarse-textured, loamy sand substratum. It thus becomes necessary to calculate the available water capacity of the soil. A general guide for calculating available water capacity is given below.

Textural Class	Inches Available Water per Inch of Soil
Sand	0.04
Loamy sand	0.07
Sandy loam	0.12
Loam	0.13
Silt loam, silt	0.18
Sandy clay loam, sandy clay	0.10
Silty clay loam, clay loam	0.14
Silty clay, clay	0.11

Thus, for the example given above; 24 inches of silt x 0.18 inches of water per inch of soil plus 12 inches of loamy sand x 0.07 inches of water per inch of soil yields 5.16 inches of available water to a depth of 36 inches. Therefore, this soil would be classified as having a medium available water capacity.

Table 4. Groups of soil series as they relate to parent material and drainage class

	Drainage Class					
Soil Parent Material	Excessively Drained	Somewhat Excessively Drained	Well Drained	Moderately Well Drained	Poorly Drained	Very Poorly Drained
Glacial Till						
1. Sandy from crystalline rocks, friable		Gloucester*				
2. Loamy-skeletal from crystalline rocks, friable		Lippitt				
3. Loamy from crystalline rocks, friable			Charlton Canton	Sutton	Leicester	
4. Loamy from crystalline rocks,			Paxton	Woodbridge	Ridgebury	Whitman

compact						
5. Loamy from dark sedimentary or crystalline rocks, compact			Newport	Pittstown	Stissing	Mansfield
6. Sandy mantled from sedimentary or crystalline rocks, compact			Poquonock	Birchwood		
7. Sandy from crystalline rocks	Windsor			Deerfield		Scarboro
8. Very gravelly from crystalline rocks	Hinckley	Merrimac		Sudbury	Walpole	
9. Very gravelly from dark sedimentary or crystalline rocks	Quonset					
10. Loamy from crystalline rocks			Agawam	Ninigret		
Eolian Deposits						
11. Moderately thick loess over compact till			Broadbrook	Rainbow		
12. Moderately thick loess over friable till			Narragansett	Wapping		
13. Thick loess over glacial outwash or friable till			Bridge-hampton	Scio		
14. Moderately thick loess over glacial outwash			Enfield	Tisbury	Raypol	
Freshwater Organic Material						
15. Thick, highly decomposed						Carlisle
16. Moderately thick, highly decomposed, over sands						Adrian
Recent Alluvium						
17. Loamy from crystalline rocks				Podunk	Rumney	
Tidal Marsh Sediments						
18. Organic materials						Ipswich
Sandy from						Matunuck

crystalline rocks						

**Those soil series in italics are of major extent and are found on the general soil map. Source:Rector (11)*

Soil Reaction

Soil reaction refers to the acidity or alkalinity of a soil solution and is expressed in pH units. Soil acidity or alkalinity is measured on a scale of 0 to 14 with a pH of 7.0 considered neutral and values above or below this figure as alkaline or acid, respectively. The terms commonly expressing the ranges of pH are:

Extremely acid ....Below 4.5
Very strongly acid......................4.5 – 5.0
Strongly acid ....5.1 – 5.5
Medium acid...............................5.6 – 6.0
Slightly acid ....6.1 – 6.5
Neutra...l6.6 – 7.3
Mildly alkaline ....7.4 – 7.8
Moderately alkaline....................7.9 – 8.4
Strongly alkaline ....8.5 – 9.0
Very strongly alkaline................Above 9.0

Most of the soils in Rhode Island are classified as very strongly acid or strongly acid unless they have been limed. The pH of representative soils in Rhode Island is presented in Table 2. In general, the primary reasons for such low pH values include the following:

• The parent material, which is primarily granitic in nature, is inherently low in basic elements and high in hydrogen giving rise to acid conditions.
• Plant roots give off hydrogen as a metabolic product of respiration.
• Decomposition of plant remains generates organic. acids.
• Leaching has removed most of the basic plant nutrients from the soil leaving a hydrogen enriched environment.

Hydrogen causes acidity and makes many elements such as aluminum, zinc, nickel, and lead more soluble. These elements may become toxic to some plants and retard their growth or kill them. The solubility and availability of most nutrient elements are influenced by the soil's pH. Most crops perform best under neutral or only slightly acid conditions. The nutrients needed by plants are soluble enough at this pH to promote good growth, and toxic com pounds are only slightly soluble so that they are not harmful to plants. Crops such as alfalfa, red clover, barley, Kentucky bluegrass, and most vegetables are very sensitive to acid conditions, and pH values above 6.0 are required for optimum production. How ever, some crops such as blueberries, potatoes, and rye, and many ornamental plants such as rhododendrons and azaleas are quite tolerant of acid conditions. Because most of Rhode Island's soils are quite acid a good soil testing program is important in making wise management decisions.

Cation Exchange Capacity

The cation exchange capacity (CEC) or buffer capacity is the ability of soils to hold nutrients for plant use. As a result of various chemical processes, clays and organic matter develop negative charges on their surfaces called exchange sites. These exchange sites act like magnets and attract positively charged elements (cations) such as calcium, magnesium, and potassium. If it were not for the exchange properties of soils, most nutrients would leach readily through the soil into groundwaters. This would necessitate more frequent applications of fertilizer and lime.

The purpose of fertilizing and liming soils is to saturate the exchange sites with basic elements. Sandy soils, low in organic matter, have very few negatively charged particles, therefore, applications of fertilizer and lime need to be made more frequently and there are greater losses due to leaching. However, finer-textured soils, particularly those high in organic matter have the capacity to retain large amounts of plant nutrients and leaching losses are not nearly as costly in these soils.

The unit used to express the magnitude of the cation exchange capacity is called a milliequivalent (meq.). This unit is designed to put all elements on an equal chemical basis. This allows one to compare the reactive potential and concentrations of elements in stead of their size or weight. The result is that one meq. of any element is required to displace one meq. of any other element from the exchange sites on clay or organic matter particles. It is standard practice in soil science to express the soils cation exchange capacity in terms of the number of milliequivalents for a 100-gram sample (meq./100 g). Some typical cation exchange capacity values of Rhode Island soils are given in Table 2.

Summary of Soil Properties

Soil behavior, like soil formation, is dependent upon a variety of soil properties. To suggest that the physical characteristics of a soil are dependent solely on texture or structure would be erroneous. Such soil properties as mineralogy, consistence, exchangeable cations, pH and organic matter content contribute significantly to the behavior or response of Rhode Island soils. Problems encountered with crop production, sewage disposal systems, pipeline maintenance, erosion, and other activities can usually be corrected or minimized by altering one or more of the soil's properties. The importance of any single soil characteristic is dependent upon the intended use. For example, a soil with a dense, compact substratum, such as Paxton, would have severe limitations for on-site sewage disposal systems, but would be desirable for a sanitary landfill facility.

It has been common practice in the past for many people dealing with soils to use and treat them indiscriminately. Only recently have we recognized that soils respond differently to different uses. There is a need to understand the properties and limitations of our soils so that we may prevent unnecessary economic, physical, or environmental loss and insure their efficient and wise use.

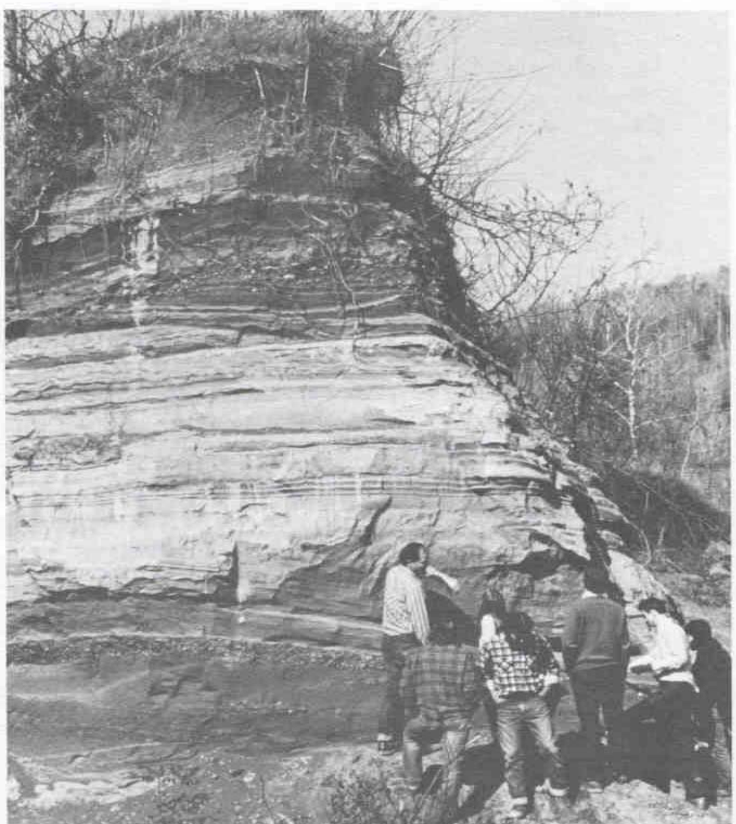
KINDS OF SOILS IN RHODE ISLAND

There is a natural tendency among people to sort out and classify the objects in their environment. As stated in a 1938 classical treatise on soil classification: Man has a passion for classifying everything. There is a reason for this; the world is so complex that we could not understand it at all unless we classified like things together Just as plants, insects, birds, minerals, and thousands of other things are classified, so are soils" (1).

The purpose of any classification system is to organize our knowledge so that the properties of objects may be remembered and their relationships understood. Soil science is no exception. The soil is a more or less continuous body covering that portion of the land surface of the earth upon which plants grow. There are literally thousands of different kinds of individual soils in the world. Without some sort of a systematic classification system it would be impossible for anyone to comprehend all the various proper ties of these soils and to interpret these properties for various purposes.

There have been several different types of classification systems used in soil science. Most of the earlier systems were interpretive classifications in which soils were grouped according to a particular use or purpose. For example, soils were classified as to their suitability for corn production or waste disposal. These types of classification systems are valuable; however, they are only applicable for the use for which they were designed. The classification system presently in use in the United States is a natural or taxonomic system. The differentiating characteristics used to classify soils are naturally occurring soil properties. The soil properties which are considered in classification include texture, structure, color, drainage, parent material. slope, number of horizons, sequence of horizons, reaction, stoniness, and soil depth.

Approximately 64 percent of the soils in Rhode Island have developed from glacial till.



About 21 percent of Rhode Island soils have developed from glacial outwash deposits laid down in successive layers and visible here.

Soils are so complex that a single grouping process (using a single differentiating characteristic) to produce classes of individuals with similar proper ties does not bring out all the relationships among soils nor produce a useful or satisfactory classification system. Therefore, it is necessary to have a multiple-category or hierarchical system of soil classification. In one sense, taxonomy is simply a sorting out process. In the highest category of this system, one sorts all kinds of soils into a small number of classes. The number of classes is small enough to permit one to comprehend and remember them and to understand the distinctions between them. Obviously, when all soils are sorted into a very few classes, each group is very heterogeneous with respect to those properties not used as the differentiating characteristic. Therefore, to reduce this heterogeneity, all soils are sorted again into the next lower category. Additional soil properties are used in this sorting process and this results in groups or classes of individual soils which are more similar. As the sorting process proceeds to lower and lower categories, the soils within classes become more homogeneous and can be treated essentially as similar soils. Collectively, the thousands of soil series found in the United States are far beyond our powers of comprehension, but we seldom need to try to comprehend more than a few of them at any one time. Several levels of generalization have been established, and soils are placed in common groups only if there is evidence of similar diagnostic features. At the highest level or category, only a few similarities are present. In the lowest categories, there is relatively complete homogeneity in both soil features and their genesis. The criteria for separation of the various classes and a general description of each category are summarized below (20).

Order

All soils are grouped into ten orders. They are differentiated by common diagnostic features indicating differences in the degree and kind of soil- forming processes that have gone on. Classification at the order level is extremely broad, and is only useful when comparing gross soil properties to various factors of soil formation, and then only on a national or world-wide basis. The soil orders common to Rhode Island include Histosols, Inceptisols, and Entisols.

Suborder

Forty-seven suborders are currently recognized in the classification system of which seven occur in Rhode Island. The differentiating characteristics used to separate most of the classes include those proper ties that influence soil genesis and that are important to plant growth. Subdivisions are generally made ac cording to the presence or absence of properties associated with wetness, soil moisture regime, soil temperature regime, and parent materials. The dominant suborders found in Rhode Island are Ochrepts and Aquepts (11).

Great Group

Approximately 185 great groups are currently known to occur in the United States and 11 are recognized in Rhode Island. Soils within each category are similar in kind, arrangement, and degree of expression of horizons. The soils also have similar moisture and temperature regimes and similarities in base status. The dominant great groups found in Rhode Island are Dystrochrepts, Fragiochrepts, and Fragiaquepts (11).

Subgroup

About 970 subgroups are currently recognized in the United States of which 16 occur in Rhode Island. The differenting characteristics used in categorizing subgroups are not necessarily different from those used at the higher levels of classification. They may essentially be subordinate or modifying characteristics bought about by other sets of soil-forming processes.Three kinds of subgroups are recognized in the classification scheme: 1) the central concept of the great group, 2) the intergrades or transitional forms to other orders, suborders, or great groups, and 3) extragrades, or transitions to unknown kinds of soils or to “not-soil” such as permafrost or bedrock. The dominant subgroups found in Rhode Island are Typic Dystrochrepts. Typic Fragiochrepts, and Aquic Dystrochrepts (11).

Table 5. Classification of Rhode Island soils (11).

Series	*Family*
*Adrian**	Sandy or sandy-skeletal, mixed, euic, mesic Terric Medisaprists
Agawam	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Typic Dystrochrepts
Birchwood	Sandy, mixed, mesic Typic Fragiochrepts
Bridgehampton	Coarse-silty, mixed, mesic Typic Dystrochrepts
Broadbrook	Coarse-loamy, mixed, mesic Typic Fragiochrepts
Canton	Coarse-loamy over sandy or sandy skeletal, mixed, mesic Typic Dystrochrepts
Carlisle	Euic, mesic Typic Medisaprists
Charlton	Coarse-loamy, mixed, mesic Typic Dystrochrepts
Deerfield	Mixed, mesic Aquic Udipsamments
Enfield	Coarse-silty over sandy or sandy-skeletal, mixed, mesic Typic Dystrochrepts
Gloucester	Sandy-skeletal, mixed mesic Typic Dystrochrepts
Hinckley	Sandy-skeletal, mixed, mesic Typic Udorthents
Ipswich	Euic, mesic, Typic Sulfihemists
Leicester	Coarse-loamy, mixed, acid, mesic Aeric Haplaquepts
Lippitt	Loamy-skeletal, mixed, mesic Typic Dystrochrepts
Mansfield	Coarse-loamy, mixed, mesic Humic Fragiaquepts
Matunuck	Sandy, mixed, mesic Typic Sulfaquents
Merrimac	Sandy, mixed, mesic Typic Dystrochrepts
Narragansett	Coarse-loamy, mixed, mesic Typic Dystrochrepts
Newport	Coarse-loamy, mixed, mesic Typic Fragiochrepts
Ninigret	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Dystrochrepts
Paxton	Coarse-loamy, mixed, mesic Typic Fragiochrepts
Pittstown	Coarse-loamy, mixed, mesic Typic Fragiochrepts
Podunk	Coarse-loamy, mixed, mesic Fluvaquentic Dystrochrepts
Poquonock	Sandy, mixed, mesic Typic Fragiochrepts
Quonset	Sandy-skeletal, mixed, mesic Typic Udorthents
Rainbow	Coarse-loamy, mixed, mesic Typic Fragiochrepts
Raypol	Coarse-loamy over sandy or sandy-skeletal, mixed, acid, mesic Aeric Haplaquepts
Ridgebury	Coarse-loamy, mixed, mesic Aeric Fragiaquepts
Rumney	Coarse-loamy, mixed, nonacid, mesic Aeric Fluvaquents
Scarboro	Sandy, mixed, mesic Histic Humaquepts
Scio	Coarse-silty, mixed, mesic Aquic Dystrochrepts
Stissing	Coarse-loamy, mixed, mesic Aeric Fragiaquepts
Sudbury	Sandy, mixed, mesic Aquic Dystrochrepts
Sutton	Coarse-loamy, mixed, mesic Aquic Dystrochrepts
Tisbury	Coarse-silty over sandy or sandy-skeletal, mixed, mesic Aquic Dystrochrepts
Walpole	Sandy, mixed, mesic Aeric Haplaquepts
Wapping	Coarse-loamy, mixed, mesic Aquic Dystrochrepts
Whitman	Coarse-loamy, mixed, mesic Humic Fragiaquepts
Windsor	Mixed, mesic Typic Udipsamments
Woodbridge	Coarse-loamy, mixed, mesic Typic Fragiochrepts

**Soils of major extent which occur on the General Soil Map of Rhode Island are printed in italics.*

Family

About 4,500 soil families are currently recognized in the United States. The differentiating characteristics used in this category have no direct relationship to soil-forming processes. However, soils within a family have similar physical and chemical proper ties that affect their responses to management and manipulation. The soil properties used are important to the movement and retention of water and to aeration, both of which affect soil use for production of plants or for engineering purposes. The dominant differentiating characteristics used in grouping soils within families include: ii particle-size distribution in horizons of major biological activity below plow depth, 2) mineralogy of horizons of major biological activity below plow depth, 3) temperature regime, and 4) thickness of the soil penetrated by roots. There are 28 different soil families recognized in Rhode Island and the most abundant is coarse-loamy, mixed, mesic Typic Fragiochrept (Table 5).

Series

The series is the lowest category used in this classification system and comprises about 10,500 soils in the United States. A soil series is a group of soils which have developed from the same combination of genetic processes. Their horizons have similar characteristics and arrangement in the soil profile and have developed from the same parent material. All soils within a series have similar physical, chemical, and morphological characteristics such as texture, structure, pH, base saturation, organic matter content, drainage, color, and horizon thickness, type, and arrangement.

Soil series are named for geographical places or features such as towns or rivers which are located near the area where the soil was first described and defined. Thus, names such as Narragansett, Newport, Quonset, and Matunuck are series names for soils described first in Rhode Island. These soils are not limited to Rhode Island, however, and many soils recognized and mapped in Rhode Island such as the Paxton, Merrimac, Windsor, and Char series are from other states. Forty-one soil series are recognized and mapped in Rhode Island (Table 5].

Phase

Although the lowest category in the comprehensive soil classification system used in the United States is the series, many soils are subdivided further at the local level to identify variations in soil characteristics which have definite land use implications. The most important characteristics differentiating soil phases are surface soil texture, stoniness, rockiness, slope, soil depth, and degree of accelerated erosion. For example, the Newport soil series has been identified and mapped as the Newport silt loam where few surface stones exist, and as the Newport very stony silt loam, where many stones cover the soil surface.

Summary

The classification system presently used in the United States is a hierarchical or multiple-category system. The level of classification dictates the homogeneity of the soils within each class. If the intended used is very broad, a grouping of soils at the order level is perhaps justified. However, for detailed land use planning and interpretation at the local level, a grouping of soils at a lower category, such as series or even phases of soil series, is perhaps necessary. The classification of the soils found in Rhode Island is given in Table 5. The major soils are printed in italics and are found on the General Soil Map.

SOIL MAPS

History of Soil Surveys

A soil survey is a field investigation, supported by information from other sources, resulting in a soil map showing the geographic distribution of different kinds of soils. The map is generally accompanied with a text that describes, defines, and classifies the different kinds of soil and interprets their properties for a variety of uses. Soil surveys are made to collect soil information that is useful in developing land use plans, resource management systems, and to evaluate and predict effects of continuing or changing land uses. They permit knowledge about soils in one area to he transferred to other areas having the same or similar soils. Fundamentally, soil surveys contribute to the knowledge and understanding of our land and related resources.

Authorization for the making of soil surveys by the United States Department of Agriculture was part of the Agriculture Appropriation Act of 1896 in response to the recognized need of farmers for soil in formation. A soil mapping program was initiated and Rhode Island was one of the first states to have a completed soil survey which was published in 1905 (3). These initial surveys were quite general and had only limited usefulness. The Soil Conservation Act of 1935 promoted the use of new and better ideas and methods for making soil surveys. Rhode Island was remapped, using improved standards and more de tail, and by 1943 published soil surveys were avail able for the entire state (12, 14, 15).

Most of the earlier soil surveys were agriculturally oriented and served a useful purpose at the time. With the increased demand on soil resources, particularly for non-agricultural purposes, it became evident that these earlier surveys were inadequate. Responsibility for the national soil survey program of the United States Department of Agriculture was as signed to the Soil Conservation Service by the Secretary of Agriculture in 1952. The Soil Conservation Service in cooperation with the state Agricultural Experiment Stations initiated what is referred to as a modern, detailed soil survey. Soil mapping units were redefined, classification parameters were narrowed, the mapping scale was increased, and all soil maps were published with an aerial photographic base. Using these new refined methods, Rhode Island was remapped during the 1970s. Field work was completed during the summer of 1977 and the published soil survey for the state will be available in 1980(11). As a result of the more refined methods of classifying and mapping soils and the increase in the availability of basic research data, these modern de tailed soil surveys are extremely valuable in making interpretations and predictions of soil responses to a wide variety of agricultural and urban manipulations.

How Detailed Soil Maps are Made

In making detailed soil maps, soil scientists walk over the land, observing soils, vegetation, and other landscape features. Using their knowledge about soils they classify the different kinds of soil and re cord the boundaries on aerial photographs. In surveying soils, scientists take into account the thickness and arrangement of each horizon to a depth of about five feet. Each layer is examined to determine its color, texture, structure, mineral composition, and stoniness. Qualitative information is also obtained on the relative compaction of each layer, its stability, the tenacity with which water is held, and the readiness with which water can move through the soil profile. This is just a partial list of the soil properties studied in determining the kind of soil. But what the soil scientist records on the map are kinds of soils defined by certain combinations of these properties. Thus, a soil map shows the drainage condition, parent material, slope, and other profile characteristics associated with a particular soil and identified by a symbol. This symbol represents the mapping unit or phases of soil series. One hundred and eleven mapping units are used in the detailed Soil Survey of Rhode Island (11).

How General Soil Maps are Made

In order to see the broad geographic relationships among soils, small-scale general soil maps have been developed. These maps have been prepared through an orderly abstraction of the detailed soil survey field sheets. Several mapping units from the detailed soil survey have been combined into larger units, resulting in a map of less detail, which illustrates broad groups of soils. Some of these mapping units may contain soils of quite contrasting properties; how ever. an attempt has been made to combine soils of similar characteristics on the Rhode Island general soil map. It must be remembered, that as a result of smaller scale and less detail, the usefulness of these maps is limited to broad planning. If more detail is required for a specific parcel of land, the detailed soil survey of Rhode Island should be used (11).

USE OF SOIL MAPS

Serious health, safety, pollution, and economic problems have been created by failure to consider the capabilities and limitations of soils during planning and design stages of rural and urban development projects. The problems include malfunctioning sep tic tank sewage disposal systems, surface and groundwater pollution, flood damage, footing and foundation failures, soil erosion, and stream and lake sedimentation, to name but a few. All result in added construction and maintenance costs to overcome the soil's limitations for the desired use. Information concerning soils, particularly their ability to support various types of activities, can help to avoid such problems.

Many otherwise knowledgeable persons look upon soil as merely unconsolidated earth material and do not recognize that different kinds of soil exist. Such thinking has led to many unfortunate results through ignorance or misuse of specific soil characteristics in suburban areas. Nevertheless, large numbers of regional and urban planners, engineers, and developers are making effective use of the soil information that has been amassed by the United States Department of Agriculture Soil Conservation Service and the state Agricultural Experiment Stations. Soil maps have been one of the most effective means of making soil information available for use.

The following sections present examples of how soil maps can be used. It must be kept in mind, how ever, that the intended use determines whether de tailed or genera! soil maps should be referenced. The examples presented generally refer to detailed soil surveys, but for state-wide or regional broad-based planning purposes, these ideas can be projected to the general soil map of Rhode Island.

Agriculture

Detailed soil surveys may be interpreted for many purposes, and they are still extremely valuable in terms of crop production estimates and erosion control practices. Ratings for land that could be used for agriculture are based on the value of the soils for the production of either general or specific crops and for livestock production. Major consideration is given to drainage problems, drought problems, crop adapt ability, stoniness, erosion hazards, and potential productivity. This grouping of soils according to hazards or limitations for various agricultural uses is known as the Land Capability Classification. All soils are placed in eight categories in this system, and the degree of limitation for agricultural use increases from Class I through Class VIII. Class I land is considered our best prime agricultural soil with few or no potential hazards. Only the first four capability classes are considered suitable for crops.

A brief description of the soils in each capability class follows.

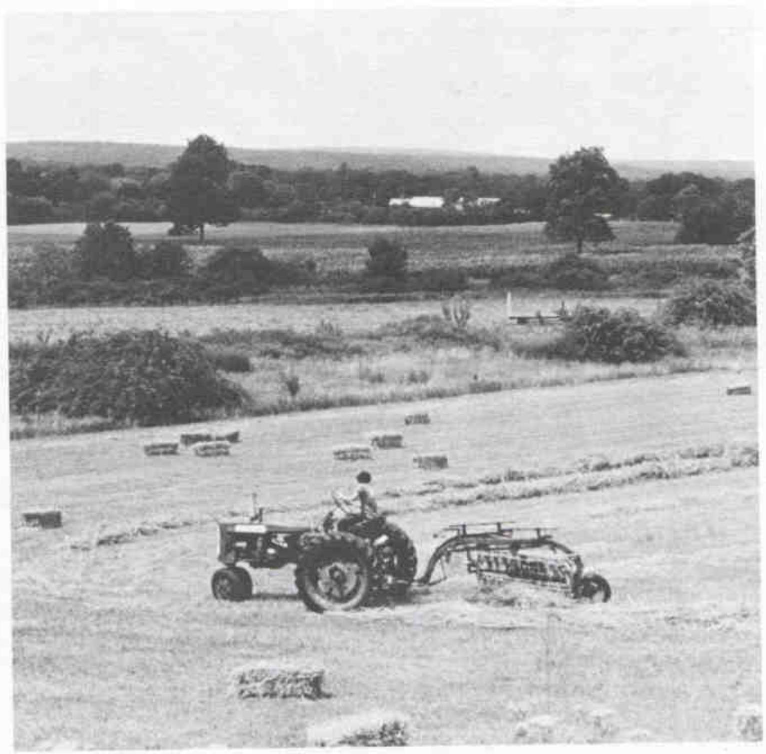
Class I. Soils in this class have few limitations that restrict their use. These soils are deep, well-drained, medium-textured, and non-stony; have high avail able water capacities, and are nearly level.

Class II. Soils in this class have some limitations that reduce the choice of plants or that require moderate conservation practices. These soils may have one or more of the following properties: moderate soil depth, moderately well drained, coarse or fine textures, medium available water capacities, or gentle slopes.

Class III. Soils in this class have severe limitations that reduce the choice of plants or require special conservation practices or both. These soils may have one or more of the following properties: shallow soil depth, somewhat poor drainage, coarse or fine textures, low available water capacities, or moderate slopes.

Class IV. Soils in this class have very severe limitations that restrict the choice of plants or require very careful management, or both. These soils are generally poorly drained or are strongly sloping.

Class V. Soils in this class are nearly level and are not subject to erosion, but because they are either very poorly drained, ponded, or subject to frequent flooding, they are not suited for cultivation.



Class II Paxton and Woodbridge soils are well suited to general farming.

Class VI. Soils in this class have severe limitations that make them unsuitable for cultivation. These soils may have one or more of the following properties: shallowness to bedrock, many stones, excessive wet ness or flooding, very low available water capacity, or occur on slopes greater than 25 percent. These soils are largely limited to pasture, woodland, or wildlife .food and cover.

Class VII. Soils in this class have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to grazing, woodland, or wildlife. These soils have properties similar to those for Glass VI soils, but more severe.

Class VIII. Soils and landforms in this class have limitations that preclude their use for commercial production of plants and restrict their use to recreation, water supply, wildlife, or esthetic purposes. This class includes such areas as tidal marshes, borrow pits, sandy beaches, steep rocky slopes and ledges, and barren mine dumps.

The distribution of the soils of Rhode Island into capability classes is presented in Figure 10. In addition to classifying soils according to agricultural potential, most soil surveys also give estimates, for each soil, of the yield that can be expected of the principal crops under various levels of management.

Recreation

Soil survey information is being used increasingly in the selection and development of recreational areas. Soil properties which should be considered in determining the suitability for recreational use include: wetness, slope, texture, stoniness, depth to bedrock, permeability, and tendency to flooding. Many recreational facilities such as camp sites, picnic areas, playgrounds, and golf fairways are subject to heavy foot traffic. Therefore, the best soils for these areas are firm when wet, not dusty when dry, not subject to flooding during the

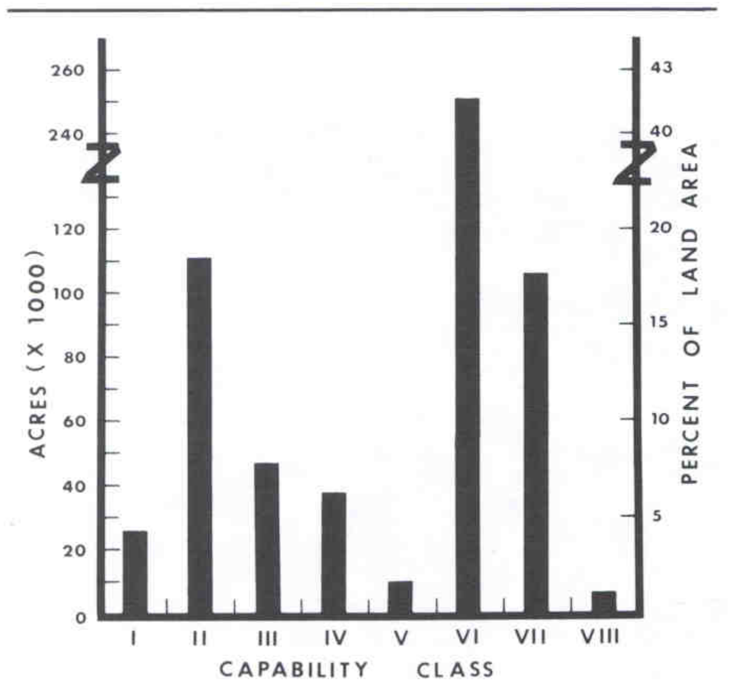


Figure 10. Distribution of capability classes in Rhode Island.

period of use, stone free, and relatively level. In addition to these soil properties, but important in evaluating a site, are location and accessibility of the area, size and slope of the area and its scenic quality, the ability of the soil to support vegetation, access to water, availability of potential water impoundment sites, and either access to public sewer lines or capacity of the soil to absorb septic tank effluent.

Wildlife Habitat

Biologists realize that the number and kind of wildlife that inhabit an area will vary with the kind of soil. The distribution of wildlife varies with the species and the environmental conditions. Soil directly affects the kind and amount of vegetation that is available to wildlife as food and cover, and it affects the construction of water impoundments. The kind and abundance of wildlife that populates an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, inadequate, or inaccessible, wildlife is scarce or does not inhabit an area. A soil's ability to produce food and cover can be interpreted as an indication of the wildlife-carrying capacity of that soil. If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by encouraging the natural establishment of desirable plants. Most soil surveys rate soils according to their potential to support the main kinds of wildlife habitat. This information can be used in the selection and planning of parks, wildlife refuges, nature study areas, and other developments for wildlife habitat.

Barrier beaches like this in southern Rhode Island are suitable for wildlife habitat and recreation.

Woodland Production

The use of soil surveys as an aid in woodland management and production is invaluable, particularly in a state such as Rhode Island which is approximately 70 percent forested. Soil properties such as wetness, stoniness, slope, and texture are used to evaluate a site with respect to erosion hazard, equipment limitations, seedling mortality, wind-throw hazard, and potential productivity. The estimated productivity of a soil is expressed as a site index. This index is the average height, in feet, that a particular species of tree can attain in 50 years. This kind of information is useful for commercial wood production, making possible the planning of the species of trees that are best suited to the soils.

Because about 70 percent of Rhode Island is forested, the potential for wood production is high.

Large areas of land are required for interstate highways and, where bedrock is near the surface, construction costs are high.

Engineering

Soil surveys can be useful in conjunction with detailed engineering surveys. The soil properties pertinent to engineering uses identified in most soil survey reports include: grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, soil wetness, depth to seasonally high water table, slope, likelihood of flooding, density, and geologic origin of the soil material. On the basis of these data, estimates can be made of the soil's erodibility, permeability, corrosivity, shrink-swell potential, avail able water capacity, shear strength, compressibility, and other factors important for engineering uses. These factors of soil behavior affect construction and maintenance of roads, airports, pipelines, foundations of homes, drainage systems, small dams, and other engineering works.

Soils high in silt are subject to frost heaving and may result in pavement or foundation failures, High electrical conductivities may result in an accelerated rate of corrosion of pipelines. Soils with high water tables may result in flooded basements or pavement failures. These are but a few of the possible consequences of building on unsuitable soils. Soil surveys are not only useful for identifying problem soils, but often prove invaluable in locating suitable sand and gravel resources for fill material or as subgrade material for highways.

In general, the possible uses of soil surveys for engineering purposes include: 1) selection of potential residential, commercial, or industrial sites; 2) evaluation of alternative routes for highways, pipelines, or underground cables; 3) preliminary estimates of soil limitations pertinent to construction techniques; 4) design of farm drainage systems, irrigation systems, ponds and terraces, and 5) location of sources of gravel, sand, clay and topsoil. The use of soil surveys does not eliminate the need for on-site sampling and testing, but can serve as a guide for helping engineers, planners, and others to avoid potential trouble areas

.

Sanitary Facilities

Favorable soil properties and site characteristics are needed for properly functioning septic tank absorption fields, sewage lagoons, and sanitary land fills, The nature of the soil is important in selecting sites for these facilities and in identifying the limiting soil properties and site features to be considered in design and installation. In addition, such features as boulders, bedrock, and steep slopes, which affect ease of excavation or installation of these facilities are of interest to contractors.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Properties that affect absorption of the effluent and survival of the system include permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. The presence of stones and boulders may also interfere with installation, and excessive slope may cause lateral seepage and surfacing of the effluent. Although relatively high permeabilities are desired for absorption fields, coarse-textured sandy or gravelly soils may not adequately filter the effluent, and groundwater in the area may become contaminated.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Aerobic lagoons are generally two to five feet deep with nearly impervious soil material for the sides and bottom to minimize seepage and contamination of groundwater. In addition to permeability, other soil features to consider in sewage lagoons include stoniness, slope, depth to bedrock, susceptibility to flooding, depth to seasonal high- water table, and shear strength.

Sanitary landfill is a method of disposing of solid wastes by placing refuse in successive layers either in excavated trenches or on the surface of the soil. The waste is spread, compacted, and covered daily with a layer of soil. Risk of polluting groundwater and ability to accommodate traffic influence the suitability of a soil for this use. The best soils have a silty texture, have moderate to slow permeability, have a deep water table, and are not subject to flooding. Clayey soils are sticky and difficult to spread, whereas sandy or gravelly soils generally have rapid permeability which might allow pollutants to contaminate groundwater. The soil material used for the daily cover should be easy to excavate and spread over the compacted waste during either wet or dry periods. Soils should be silty and free of large stones for this purpose. In addition, medium-textured topsoil should be used for the final cover as it has the best potential for growing plants when the landfill site is abandoned.

Economic Evaluation

Soil surveys have been used throughout the United States as a basis for evaluating land for such purposes as equitable tax assessment, loan value, and potential sale value. Most of these evaluations have dealt with the soil’s management capability, yield potential, and adaptability for various crops as they relate to agricultural production. For example, a farm with 100 acres of soil unsuited for agricultural use should not be taxed as much as a 100-acre farm with fertile soils highly suited to a variety of agricultural crops. Thus, in rural areas, soil surveys can be valuable in bringing about an equitable tax assessment of agricultural land. It is also possible to tax forest land or potential residential land equitably by evaluating the soils with respect to site index or suitability for homes and on-site sewage disposal systems.

Land Use Planning

Land use planning is an expression which is being heard more frequently every day. As the population increases, the demands upon land and soil resources become more competitive. Good agricultural land is under increasing pressure from urban growth and expanding public facilities such as high ways and airports. In addition, with the larger areas of soil being devoted to housing, factories, highways, and the like, there is an increasing danger of costly mistakes in locating structures on soils ill-suited to the particular purpose. In many communities this has focused attention on matching soil characteristics to the requirements for specific uses. Soil surveys should and have become integral parts of sound municipal and regional planning programs (2). Soil characteristics such as permeability, bearing strength, slope, depth to bedrock, depth to seasonal high water tables, and flooding hazard are detectable through the use of soil surveys. This information is invaluable when planning for subdivisions, shop ping centers, industrial sites, roads, and sewage systems. The use of soil surveys in the planning process does not preclude detailed on-site investigations. However, soil surveys have played important roles in developing comprehensive regional land use plans, urban plans, subdivision designs, and in the planning and construction of highways (2).

SOIL INTERPRETATIONS

The increased demand for soil resources in the United States in recent years has put some land to uses for which it is poorly suited. This is evidenced by the increasing number of cracked foundations, flooded basements, broken pavements, failing septic systems, and polluted water supplies. Many of these situations could have been predicted and avoided if soil information had been considered prior to the land use decision.

The usefulness of soil surveys has long been recognized in agriculture. In addition, the increased use of soils information by engineers, planning commissions, health departments, tax assessors, realtors, developers, contractors, loan agencies, banks, utility companies, zoning boards, and prospective home owners indicates an increased awareness of the importance of soils in formulating many land use decisions.

Various agricultural and non-agricultural interpretations of the general soil map units are presented in Table 6. These units are rather broad and in some cases include soils of somewhat diverse proper ties. Therefore, these interpretations should be used only for very broad or regional type planning and detailed on-site investigations should be conducted prior to any specific site decision. For additional in formation, users should consult the detailed soil survey of Rhode Island (11). Furthermore, although a soil may be designated as having moderate or severe limitations for a particular use, this does not imply that the soil cannot successfully be put to that use. The rating simply indicates that as a result of various soil characteristics, additional precautions, engineering design, or construction techniques must be used to overcome the limitations.

The data presented in Table 6 can be used to compare the limitations and suitability of large areas for broad planning purposes. Ratings are given for seven specified uses. The overall rating for each map unit is based on the rating for the dominant soil or soils, if more than one soil has the same rating.

Limitation Ratings

Slight. Soils with this rating have few limitations for the use indicated.

Moderate. Soils with this rating have one or more features that limit their use. The natural limitations of these soils are more difficult and costly to overcome.

Severe. Soils with this rating have one or more features that seriously limit their use. Using soils with a severe limitation will increase the probability of failure and add to development difficulty and costs.

Suitability Ratings

Good. Soils with this rating are relatively free of restrictive features and are generally well suited for the specified use.

Fair. Soils with this rating have one or more restrictive features and have intermediate suitability for the use specified.

Poor. Soils with this rating have one or more restrictive features that place extreme limits on their suitability for use.

Restrictive Features

DR - Depth to Rock	PS- Percs slowly
DY – Droughty	SL- Slope
EF - Excess fines	SS-Small stones

EH - Excess humus	TS- Too sandy
FL – Floods	WT- Wetness
LS - Large stones	

Column Headings

Column 1. Map Unit and Component Soils. Map units are in numerical order. The map unit name is listed first along with percentage of the state covered by the unit. The component soils of the unit are listed last. "Others' represents minor soils in the map unit.

Column 2. Percent of Map Unit. The percentage of each map unit component is given in this column.

Columns 3, 4, and 5. Soil Limitations. Ratings for sanitary facilities, building site development, and recreational development are given in these columns for the map unit and for each named soil of the unit. Restrictive features are listed for soils with moderate and severe limitations. The ratings for sanitary facilities are based on use for septic tank absorption fields, those for building site development are based on use for dwellings with basements, and those for recreational development are based on use for camp areas,

Columns 6, 7, 8, and 9. Soil Suitability. Ratings for construction materials, cropland, woodland, and wildlife habitat are given in these columns for the map unit and for each named soil of the unit. Restrictive features are listed for soils with fair and poor suitabilities. The ratings for construction materials are based on use as a source of sand and/or gravel. Ratings for cropland are based on use for growing cultivated crops common to the area. The ratings for woodland are based on use for commercial production of wood crops. Wildlife habitat ratings are based on use for producing woodland wildlife habitat.

Table 6. Interpretations for the General Soil Map of Rhode Island.

		Soil Limitations			Soil Suitability			
Map Unit and Component Soils (1)	*Percent of Map Unit (2)*	*Sanitary Facilities (3)*	*Building Site Development (4)*	*Recreational Development (5)*	*Construction Material (6)*	*Cropland (7)*	*Woodland (8)*	*Wildlife Habitat (9)*
1. Canton-Charlton-Sutton (21%)		Moderate	Moderate	Moderate	Poor	Poor	Good	Good
Canton	35	Moderate: LS	Moderate: LS	Moderate: LS	Poor: EF	Poor: LS	Fair: DY	Good
Charlton	30	Moderate: LS	Moderate: LS	Moderate: LS	Poor: EF	Poor: LS	Good	Good
Sutton	15	Severe: WT	Severe: WT	Moderate: LS	Poor: EF	Poor: LS	Good	Good
Others	20							
2. Charlton-Rock Outcrop (12%)		Moderate	Moderate	Moderate	Poor	Poor	Good	Good
Charlton	50	Moderate: SL, LS	Moderate: SL, LS	Moderate: SL, LS	Poor: EF	Poor: LS	Good	Good
Rock Outcrop	15	Severe: DR	Severe: DR	Severe: DR	Poor: DR	Poor: DR	Poor: DR	Poor: DR
Others	35							
3. Gloucester-Hinckley (2%)		Moderate*	Moderate	Moderate	Poor	Poor	Fair	Poor
Gloucester	55	Moderate: SL, LS	Moderate: LS, SL	Moderate: SL, LS	Poor: EF	Poor: LS	Fair: DY	Poor: DY
Hinckley	20	Moderate: SL	Moderate: SL	Moderate: SL, SS, TS	Good	Fair: SL, DY	Poor: DY	Poor: DY
Others	25							
4. Narragansett-Bridgehampton-Wapping (6%)		Moderate	Moderate	Moderate	Poor	Poor	Good	Good
Narragansett	40	Moderate: LS	Moderate: LS	Moderate: LS	Poor: EF	Poor: LS	Good	Good
Bridgehampton	25	Moderate: LS	Moderate: LS	Moderate: LS	Poor: EF	Poor: LS	Good	Good
Wapping	15	Severe: WT	Severe: WT	Moderate: WT, LS	Poor: EF	Poor: LS	Good	Good
Others	20							
5. Newport-Pittstown (6%)		Severe	Slight	Slight	Poor	Good	Good	Good
Newport	60	Severe: PS	Slight	Slight	Poor: EF	Good	Good	Good
Pittstown	25	Severe: WT, PS	Severe: WT	Moderate: PS	Poor: EF	Good	Good	Good
Others	15							
6. Paxton-Woodbridge (13%)		Severe	Moderate	Moderate	Poor	Poor	Good	Good
Paxton	40	Severe: PS	Moderate: LS	Moderate: LS, PS	Poor: EF	Poor: LS	Good	Good
Woodbridge	40	Severe: WT, PS	Severe: WT	Moderate: LS, PS	Poor: EF	Poor: LS	Good	Good
Others	20							

7. Ridgebury-Whitman-Leicester (8%)		Severe	Severe	Severe	Poor	Poor	Fair	Fair
Ridgebury	40	Severe: WT, PS, LS	Severe: WT, LS	Severe: WT, LS	Poor: EF	Poor: LS	Fair: WT, LS	Fair: WT, LS
Whitman	20	Severe: WT, PS, LS	Severe: WT, LS	Severe: WT, LS	Poor: EF	Poor: WT, LS	Poor: WT, LS	Poor: WT, LS
Leicester	20	Severe: WT, LS	Severe: WT, LS	Severe: WT, LS	Poor: EF	Poor: LS	Fair: WT, LS	Fair: WT, LS
Others	20							
8. Stissing-Mansfield (2%)		Severe	Severe	Severe	Poor	Fair	Fair	Fair
Stissing	45	Severe: WT, PS	Severe: WT	Severe: WT	Poor: EF	Fair: WT	Fair: WT	Fair: WT
Mansfield	35	Severe: WT, PS	Severe: WT	Severe: WT	Poor: EF	Poor: WT	Poor: WT	Poor: WT
Others	20							
9. Enfield-Bridgehampton-Agawam (5%)		Slight*	Slight	Slight	Good	Good	Good	Good
Enfield	40	Slight	Slight	Slight	Good	Good	Good	Good
Bridgehampton	30	Slight	Slight	Slight	Good	Good	Good	Good
Agawam	15	Slight	Slight	Slight	Good	Good	Good	Good
Others	15							
10. Hinckley-Merrimac (17%)		Moderate*	Moderate	Moderate	Good	Fair	Poor	Poor
Hinckley	45	Moderate: SL	Moderate: SL	Moderate: TS, SS	Good	Fair: SL, DY	Poor: DY	Poor: DY
Merrimac	25	Slight	Slight	Slight	Good	Good	Fair: DY	Fair: DY
Others	30							
11. Walpole-Scarboro-Rumney (3%)		Severe	Severe	Severe	Fair	Fair	Fair	Fair
Walpole	35	Severe: WT	Severe: WT	Severe: WT	Fair: EF	Fair: WT	Fair: WT	Fair: WT
Scarboro	30	Severe: WT	Severe: WT	Severe: WT	Good	Poor: WT	Poor: WT	Poor: WT
Rumney	10	Severe: WT, FL	Severe: FL, WT	Severe: WT, FL	Fair: EF	Fair: WT	Fair: WT, FL	Fair: WT
Others	25							
12. Carlisle-Adrian (4%)		Severe	Severe	Severe	Poor	Poor	Poor	Poor
Carlisle	50	Severe: WT, FL	Severe: WT, FL	Severe: WT, FL, EH	Poor: EH	Poor: WT	Poor: WT, FL	Poor: WT
Adrian	40	Severe: WT, FL	Severe: WT, FL	Severe: WT, FL, EH	Good	Poor: WT	Poor: WT, FL	Poor: WT
Others	10							
13. Matunuck-Udipsamments-Beaches (1%)		Severe	Severe	Severe	Fair	Poor	Poor	Poor
Matunuck	55	Severe: WT, FL	Severe: WT, FL	Severe: WT, FL, EH	Fair: EF	Poor: WT	Poor: WT, FL	Poor: WT, FL
Updipsamments	20	Severe: FL	Severe: FL	Severe: TS	Good	Poor: DY	Poor: DY	Poor: DY
Beaches	20	Severe: FL	Severe: FL	Severe: FL, TS	Good	Poor: WT	Poor: WT, FL	Poor: WT, FL
Others	5							

Possible pollution of groundwater aquifers.

Source: Guide for Interpreting Engineering Uses of Soils (19) and Rector (11).

GENERAL SOIL MAP OF RHODE ISLAND

The areas delineated on the enclosed general soil map encompass relatively large acreages. Each map unit contains several different soils, some of which have contrasting properties. There are 41 soil series presently recognized in Rhode Island, representing 111 mapping units (11); therefore, it is impossible to delineate each and every soil on a map of this scale. An attempt has been made, however, to group those soils with the most similar properties into a single map unit. The legend indicates the most common and extensively occurring soils within each area. However, in each category there are additional soils of limited acreage that are grouped as "soils of minor extent". Following are narrative descriptions of the 13 mapping units as they occur on the general soil map.

Areas of Glaciated Uplands Dominated by Deep Soils with a Friable Substratum

The four units of this group make up about 41 soils series percent of the State of Rhode Island. The soils were formed in glacial till and silt-mantled till of moraines and bedrock-controlled landforms. Most of the acreage is in woodland. Some areas are used for crops, pasture, and community development.

1. Canton-Charlton-Sutton. Nearly level to moderately steep, well-drained and moderately well drained soils formed in loamy glacial till derived from crystalline rocks.

The soils of this unit are on glacial till plains. The topography of the unit has numerous short slopes. Many areas are stony, and some have scattered rock outcrops. Slopesare dominantly 3 to 15 percent but range from 0 to 25 percent.

This map unit makes up about 21 percent of the state. The unit is about 35 percent Canton soils, 30 percent Charlton soils, 15 percent Sutton soils, and 20 percent soils of minor extent.

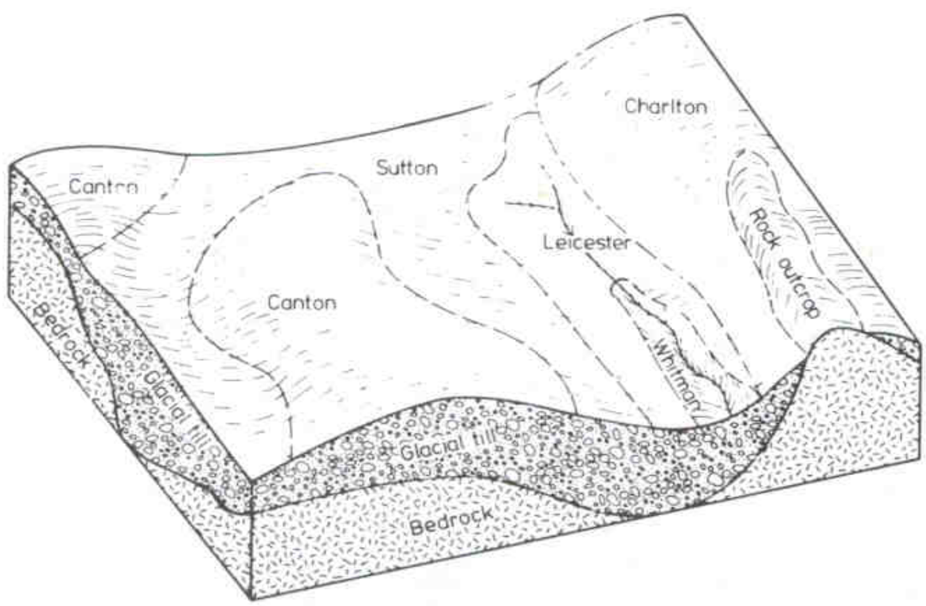


Figure 11. Block diagram illustrating the landscape relationships of soils developed in friable glacial till.

Canton soils are well-drained. Typically the surface layer is fine sandy loamy sand. The subsoil is brownish, fine sandy loam. The substratum is gravelly loamy sand. Charlton soils are similar to the Canton soils, but have a gravelly sandy loam substratum. These soils occur mostly on higher positions and upper slopes.

Sutton soils are moderately well drained. Typically, the surface layer is fine sandy loam. The subsoil is brownish, fine sandy loam with mottles in the lower part. The substratum is mottled gravelly sandy loam. Sutton soils are mostly at lower positions and on lower slopes. The water table is at a depth of about 18 inches during wet seasons.

Soils of minor extent are mainly well-drained Paxton soils, moderately well drained Woodbridge soils, and poorly drained Ridgebury and Leicester soils. Paxton soils are on landscape positions similar to those of Canton and Charlton soils. Woodbridge soils are on positions similar to those of the Sutton soils. Ridgebury and Leicester soils are in small depressions and low-lying areas.

Most areas of this map unit are in unmanaged woodland. Some areas have been cleared for crops and pasture or are idle or used for low-density housing and other types of community development.

Surface stoniness and slope are the main limitations affecting the use of the soils. Sutton soils are also limited by seasonal wetness.

2. Charlton-Rock Outcrop. Sloping and moderately steep, well-drained soils formed in loamy glacial till derived from crystalline rocks and rock outcrop(Figure 11).

The soils of this unit are on glacial till plains and bedrock-controlled landforms. The topography has numerous short slopes. Most areas are stony. Slopes are dominantly 8 to 15 percent, but range from 8 to 25 percent.

This map unit makes up about 12 percent of the state. The unit is about 50 percent Charlton soils, 15 percent Rock Outcrop, and 35 percent soils of minor extent. Charlton soils are well drained. Typically, the surface layer is fine sandy loam. The subsoil is brownish, fine sandy loam. The substratum is gravelly sandy loam. Charlton soils are mostly on higher positions and upper slopes.

Rock Outcrop consists of exposes bedrock. It is generally on the highest points on the landscape.

Soils of minor extent are mainly somewhat excessively drained Lippitt soils; well-drained Canton, Paxton, and Narragansett soils; and moderately well drained Sutton and Woodbridge soils. Lippitt, Canton, Paxton, and Narragansett soils are on landscape positions similar to those of the Charlton soils. Sutton and Woodbridge soils are in lower positions and on lower slopes.

Most areas of this map unit are in unmanaged woodland. Some areas have been cleared for pasture and hay, some are isle, and some are used for low-density housing. Surface stoniness, slope, and shallow depth to bedrock are the main limitations affecting the use of soils.

3. Gloucester-Hinckley. Rolling and hilly, somewhat excessively drained and excessively drained soils formed in mixed sandy glacial till and stratified deposits derived from crystalline rocks (Figure 12).

The soils of this unit are on glacial moraines. The topography has numerous short slopes. The landscape consists mainly of low ridges, knobs, and hills. Most areas are stony. Slopes are dominantly 8 to 15 percent, but range from 8 to 25 percent.

This map unit makes up about 2 percent of the state. The unit is about 55 percent Gloucester soils. 20 percent Hinckley soils, and 25 percent soils of minor extent.

Gloucester soils are somewhat excessively drained. Typically, the surface layer is gravelly sandy loam. The subsoil is brownish, gravelly sandy loam and gravelly loamy sand. The substratum is very gravelly loamy sand. Gloucester soils are on side slopes and ridge crests.

Hinckley soils are excessively drained. Typically, the surface layer is gravelly sandy loam. The subsoil is brownish, gravelly sandy loam and gravelly loamy sand. The substratum is very gravelly sand. Hinckley soils are on side slopes and ridgetops.

Soils of minor extent are mainly some what excessively drained Merrimac soils, well-drained Enfield soils, and moderately well-drained Sudbury soils. Merrimac soils are on landscape positions similar to those of

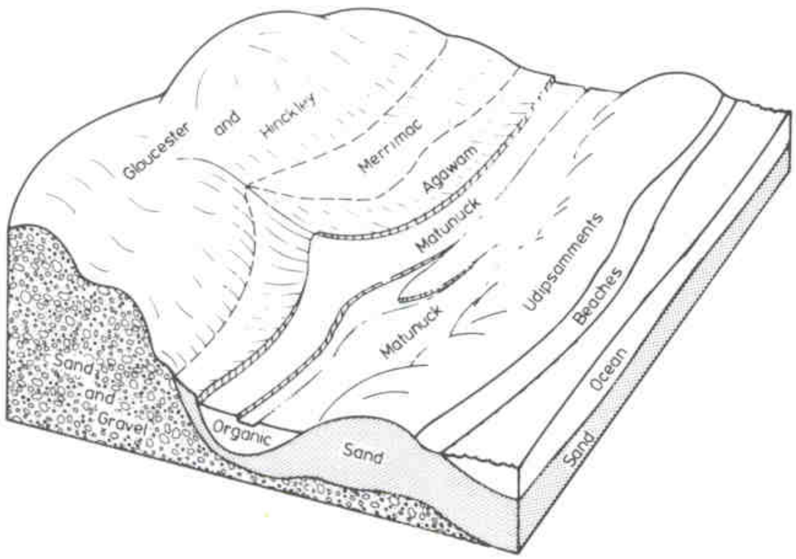


Figure 12. Block diagram illustration the landscape relationships of soils in the coastal regions of Rhode Island.

the Hinckley soils. Enfield and Sudbury soils are in depressions and low-lying areas.

Most areas of this map unit are in unmanaged woodland. Scattered areas have been cleared for pasture, are idle, or are used for low-density housing.

Surface stoniness, slope, and droughtiness are the main limitations affecting the use of the soils.

A Block Island scene illustration a landscape with Gloucester and Bridgehampton soils.

4. Narragansett-Bridgehampton-Wapping.

Nearly level to sloping, well-drained and moderately well drained soils formed in silt-mantled glacial till derived from crystalline rocks (Figure 13).

The soils of this unit are on glacial till plains. The topography has long and short slopes. Many areas are stony, and some have scattered rock outcrops. Slopes are dominantly 0 to 8 percent, but range from 0 to 15 percent.

This map unit makes up about 6 percent of the state. The unit is about 40 percent Narragansett soils, 25 percent Bridgehampton soils, 15 percent Wapping soils, and 20 percent soils of minor extent.

Narragansett soils are well-drained. Typically, the surface layer is silt loam. The subsoil is brownish, silt loam. The substratum is gravelly loamy sand. Narragansett soils are mostly on higher positions and upper slopes.

Bridgehampton soils are mainly well-drained. Typically, the surface layer is silt loam. The subsoil is brownish, silt loam and mottles generally occur in the lower part. The substratum is gravelly sandy loam. Bridgehampton soils are mostly on higher positions and upper slopes.

Wapping soils are moderately well drained. Typically, the surface layer is silt loam. The subsoil is brownish, silt loam with mottles in the lower part. The substratum is mottled gravelly sandy loam. Wapping soils are mostly at lower positions and on lower slopes. The water table is at a depth of about 20 inches during wet seasons.

Soils of minor extent are mainly well-drained Charlton, Canton, and Broadbrook soils and moderately well drained Scio soils. Charlton, Canton and Broadbrook soils are on landscape positions similar to those of Narragansett and Bridgehampton soils. Scio soils are on positions similar to those of the Wapping soils.

Most areas of this map unit are in unmanaged woodland. Some areas have been cleared for crops or pasture, some are idle, and some are used for low-density housing and other types of community development.

Surface stoniness and slope are the main limitations affecting the use of the soils. Wapping soils are also limited by seasonal wetness.

Areas of Glaciated Uplands Dominated by Deep Soils with a Firm Substratum

This group consists of four units that make up about 29 percent of the state. The soils formed in glacial till of ground moraines and drumlins. Most of the acreage is in woodland. Some areas have been cleared for crops and some are used for community development.

5. Newport-Pittstown. Nearly level to sloping, well-drained and moderately well drained soils formed in silty glacial till derived from dark, fine-grained rocks(Figure 14).

The soils of this unit are on glacial till plains and drumlins. The topography has long and short slopes. Some areas are stony, and a few have scattered rock outcrops. Slopes are dominantly 0 to 8 percent, but range from 0 to 15 percent

This map unit makes up about 6 percent of the state. The unit is about 60 percent Newport soils, 25 percent Pittstown soils, and 15 percent soils of minor extent.

Newport soils are well-drained. Typically, the surface layer is silt loam. The subsoil is olive brown, silt loam. The substratum is channery loam. Newport soils are mostly on higher positions and upper slopes.

Pittstown soils are moderately well drained. Typically, the surface layer is silt loam. The subsoil is olive brown, silt loam with mottles in the lower part. The substratum is mottled channery silt loam. Pittstown soils are mostly at lower positions and on lower slopes. The water table is at a depth of about 20 inches during wet seasons.

Soils of minor extent are mainly well-drained Broadbrook and Poquonock soils, moderately well drained Rainbow and Birchwood soils, and poorly drained Stissing soils. Broadbrook and Poquonock soils are on landscape positions similar to those of the Newport soils. Rainbow and Birchwood soils are on positions similar to those of the Pittstown soils. Stis sing soils are in depressions and low-lying areas.

Soils of minor extent are mainly well-drained Broadbrook and Poquonock soils, moderately well drained Rainbow and Birchwood soils, and poorly drained Stissing soils. Broadbrook and Poquonock soils are

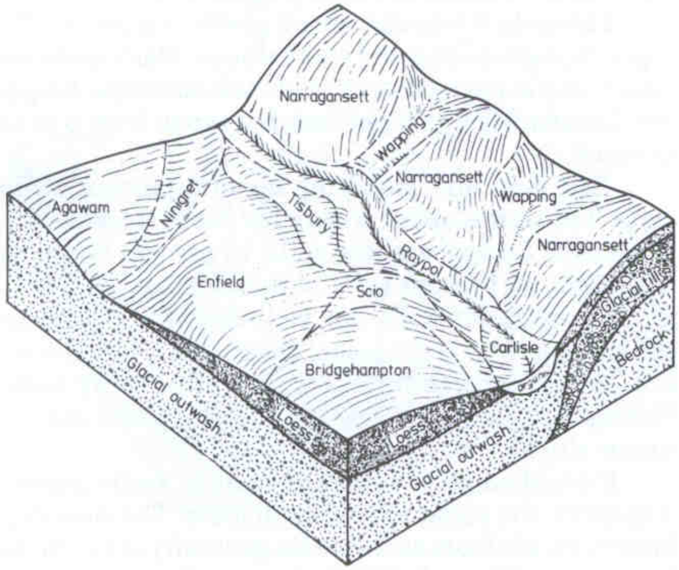


Figure 13. Block diagram illustrating the landscape relationships of soils developed in loess-covered glacial drift.

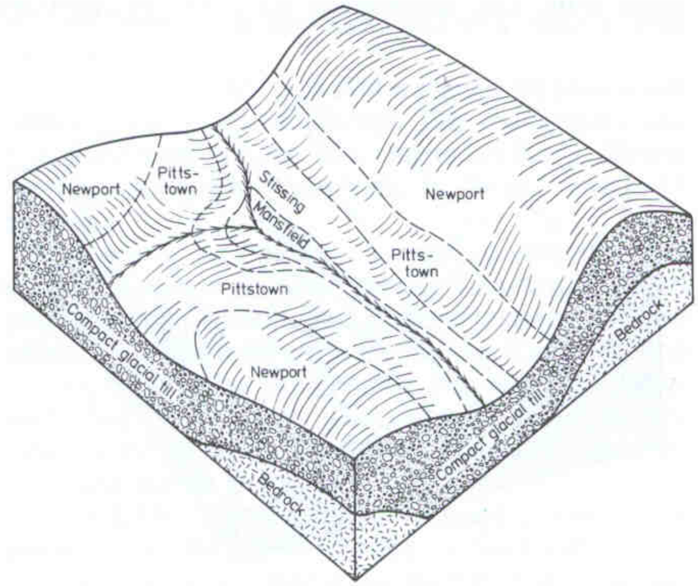


Figure 14. Block diagram illustrating the soil-landscape relationships of the Newport catena which has developed in compacted glacial till.

on landscape positions similar to those of the Newport soils. Rainbow and Birchwood soils are on positions similar to those of the Pittstown soils. Stissing soils are in depressions and low-lying areas.

Most areas of this map unit are cleared and used for crops, pasture, or low-density housing or are idle. Some areas are in unmanaged woodland or are covered by shrubs and brush.

Slow permeability in the substratum, slope, and surface stoniness are the main limitations affecting the use of the soils. Pittstown soils are also limited by seasonal wetness.

Landscape with Wapping soils in North Kingstown where stones have been removed to make walls and clear the land for farming.

Newport and Pittstown soils in Little Compton have good potential for farming.

6. Paxton-Woodbridge. Nearly level to moderately steep, well-drained and moderately well drained soils formed in loamy glacial till derived from crystal line rocks (Figure 15).
The soils of this unit are on glacial till plains and drumlins. The topography has long and short slopes. Many areas are stony, and a few have scattered rock outcrops. Slopes are dominantly 0 to 15 percent, but range from 0 to 25 percent.

This map unit makes up about 13 percent of the state. The unit is about 40 percent Paxton soils, 40 percent Woodbridge soils, and 20 percent soils of minor extent.

Paxton soils are well-drained. Typically, the surface layer is fine sandy loam. The subsoil is brownish, fine sandy loam. The substratum is fine sandy loam. Paxton soils are on higher positions and upper slopes.

Woodbridge soils are moderately well drained. Typically, the surface layer is fine sandy loam. The subsoil is brownish, fine sandy loam with mottles in the lower part. The substratum is sandy loam. Woodbridge soils are mostly at lower positions and on lower side slopes. The water table is at a depth of about 20 inches during wet seasons.

Soils of minor extent are mainly well-drained Broadbrook and Char soils, moderately well drained Sutton soils, and poorly drained Ridgebury and Leicester soils. Broadbrook and Char soils are on landscape positions similar to those of Paxton soils. Sutton soils are on positions similar to those of the Woodbridge soils. Ridgebury and Leicester soils are in depressions and low-lying areas.

Most areas of this map unit are in unmanaged woodland. Some areas have been cleared for crops or pasture, some are idle, and some are used for low- density housing and other types of community development.

Surface stoniness, slope, and slow permeability in the substratum are the main limitations affecting the use of the soils. Woodbridge soils are also limited by seasonal wetness.

7. Ridgebury-Whitman-Leicester. Nearly level, poorly drained and very poorly drained soils formed in loamy glacial till derived from crystalline rocks (Figures 11 and 15).

The soils of this unit are in low-lying areas, adjacent to small drainageways, or in depressed areas of glacial till plains. Most areas are stony and slopes range from 0 to 3 percent.

This map unit makes up about 8 percent of the state. The unit is about 40 percent Ridgebury soils, 20 percent Whitman soils, 20 percent Leicester soils, and 20 percent soils of minor extent.

Ridgebury soils are poorly drained. Typically, the surface layer is fine sandy loam. The subsoil is mottled, brownish, fine sandy loam. The substratum is mottled, brownish, gravelly fine sandy loam. The water table is at a depth of about 6 inches during wet seasons.

Whitman soils are very poorly drained. Typically, the surface layer is fine sandy loam. The subsoil is grayish, gravelly fine sandy loam. The substratum is gravelly, fine sandy loam. The water table is at a depth of about 6 inches during wet seasons.

Leicester soils are poorly drained. Typically, the surface layer is fine sandy loam. The subsoil is mottled, grayish and brownish, fine sandy loam. The substratum is mottled, gravelly sandy loam. The water table is at a depth of 6 inches during wet seasons.

Soils of minor extent are mainly moderately well drained Woodbridge soils, poorly drained Walpole soils, and very poorly drained Scarboro and Adrian soils. All of these soils are in low-lying areas.

Most areas of this map unit are in unmanaged woodland. A few scattered areas have been cleared for pasture.

Wetness, surface stoniness, and slow permeability in the substratum are the main limitations affecting the use of the soils.

8. Stissing-Mansfield. Nearly level, poorly drained and very poorly drained soils formed in silty glacial till derived from dark, fine-grained rocks(Figure 14).

The soils of this map unit are in low-lying areas, adjacent to small drainageways, or in depressed areas of glacial till plains. Many areas are stony and slopes range from 0 to 3 percent.

This map unit makes up about 2 percent of the state. The unit is about 45 percent Stissing soils, 35 percent Mansfield soils, and 20 percent soils of minor extent.

Stissing soils are poorly drained. Typically, the surface layer is silt loam. The subsoil is mottled, brownish, silt loam. The substratum is silt loam. The water table is at a depth of about 6 inches during wet seasons.

Mansfield soils are very poorly drained. Typically, the surface layer is mucky silt loam. The subsoil is grayish, silt loam. The substratum is channery silt loam. The water table is at or near the surface during wet seasons.

Soils of minor extent are mainly moderately well drained Pittstown soils and very poorly drained Scarboro and Adrian soils. All of these soils are in low-lying areas.

Most areas of this map unit are in unmanaged woodland. A few areas have been cleared for pasture of are idle and have reverted to brushy vegetation.

Wetness, surface stoniness, and slow permeability in the substratum are the main limitations affecting the use of these soils.

Areas of Outwash Plains, Terraces, Kames, and Eskers Dominated by Deep Soils with a Sandy and Gravelly Substratum

This three units of this group make up about 25 percent of the State of Rhode Island. The soils were formed in stratified glacial deposits. Much of the acreage is urbanized. Some areas are in woodland or are used for crops.

9. Enfield-Bridgehampton-Agawam. Nearly level to sloping, well-drained and moderately well drained soils formed in silt-mantled stratified deposits derived from crystalline rocks (Figures 12 and 13).

The soils of this unit are on terraces and outwash plains. The topography has medium to long slopes that are dominantly 0 to 8 percent, but range from 0 to 15 percent. The main soils in this unit are closely intermingled with each other.

This map unit makes up about 5 percent of the state. The unit is about 40 percent Enfield soils, 30 percent Bridgehampton soils, 15 percent Agawam soils, and 15 percent soils of minor extent.

Enfield soils are well-drained. Typically, the surface layer is silt loam. The subsoil is brownish silt loam. The substratum is very gravelly sand.

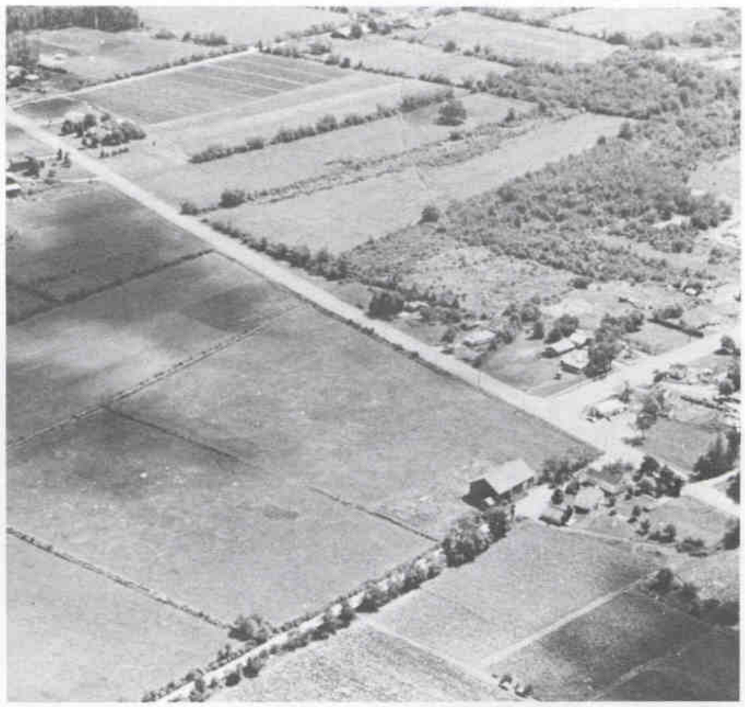
Bridgehampton soils are mainly well drained. Typically, the surface layer is silt loam. The subsoil is brownish silt loam and mottles generally occur in the lower part. The substratum is very gravelly sand. The subsoil below a depth of 24 inches is saturated during wet seasons.

Agawam soils are well drained. Typically, the surface layer is fine sandy loam. The subsoil is brownish and yellowish, fine sandy loam. The substratum is gravelly sand.

Soils of minor extent are mainly moderately well drained Tisbury and Ninigret soils and poorly drained Raypol soils. These soils are in slight depressions.

Most areas of this map unit have been cleared for crops or pasture. Some areas are used for low- density housing or unmanaged woodland, and some are idle.

Slope is the main limitation affecting the use of these soils.



Glacial outwash plains make prime farmland composed here of Enfield, Bridgehampton and Agawam soils.

10. Hinckley-Merrimac. Nearly level to hilly, excessively drained and somewhat excessively drained soils formed in stratified deposits derived from crystalline rocks (Figure 12).

The soils of this unit are on outwash plains, ter races, kames and kettles. Slopes are dominantly 3 to 25 percent, but range from 0 to 35 percent.

This map unit makes up about 17 percent of the state. The unit is about 45 percent Hinckley soils, 25 percent Merrimac soils, and 30 percent soils of a minor extent.

Hinckley soils are excessively drained. Typically, the surface layer is gravelly sandy loam. The subsoil is brownish, gravelly sandy loam and gravelly loamy sand. The substratum is very gravelly sand. Hinckley soils are generally on the more sloping parts of the landscape.

Merrimac soils are somewhat excessively drained. Typically, the surface layer is sandy loam. The subsoil is brownish, sandy loam. The substratum is gravelly sand. Merrimac soils are generally on the smoother, less sloping parts in the landscape.

Soils of minor extent are mainly excessively drained Windsor and Quonset soils and moderately well drained Sudbury and Deerfield soils. Windsor and Quonset soils are on landscape positions similar to those of the Hinckley and Merrimac soils. Sudbury and Deerfield soils are in depressions and low-lying areas.

Areas of this map unit are widely used for housing and for industrial and commercial purposes. Some areas are in unmanaged woodland, and some are used for crops and pasture.

Slope and droughtiness are the main limitations affecting the use of the soils.

11. Walpole-Scarboro-Rumney. Nearly level, poorly drained and very poorly drained soils formed in sandy stratified deposits derived from crystalline rocks.

The soils of this unit are in low-lying areas on outwash plains and terraces and on flood plains. Slopes range from 0 to 3 percent.

This map unit makes up about 3 percent of the state. The unit is about 35 percent Walpole soils, 30 percent Scarboro soils, 10 percent Rumney soils, and 25 percent soils of minor extent.

Walpole soils are poorly drained. Typically, the surface layer is sandy loam. The subsoil is mottled, grayish, sandy loam. The substratum is mottled, gravelly sand. The water table is at a depth of about 6 inches during wet seasons.

Scarboro soils are very poorly drained. Typically, the surface layer is mucky sandy loam. The subsoil is grayish, loamy sand. The substratum is mottled, gravelly coarse sand. Scarboro soils are at the lowest positions in the landscape. The water table is at or near the surface most of the year.

Rumney soils are poorly drained. Typically, the surface is fine sandy loam. The subsoil is mottled, brownish, fine sandy loam. The substratum is sand.

Rumney soils are on flood plains and are subject to periodic flooding. The water table is at a depth of about 6 inches during wet seasons.

Soils of minor extent are mainly moderately well drained Podunk soils, poorly drained Raypol soils, and very poorly drained Adrian soils. All of these soils are in low-lying areas.

Most areas of this map unit are in unmanaged woodland, A few areas have been cleared for pasture or are idle.

Seasonal wetness and flooding are the main limitations affecting the use of the soils.

Areas of Inland Depressions and Low-Lying Posi lions Dominated by Organic Soils

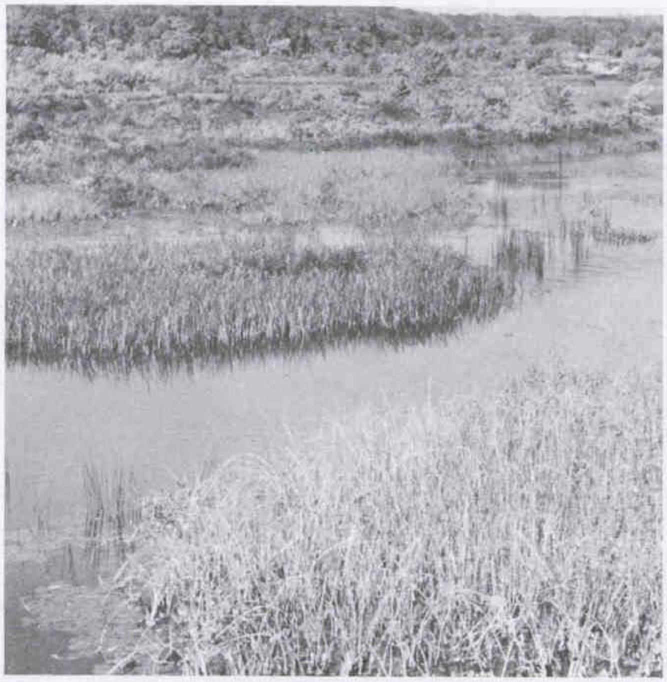
The one unit in this group makes up about four percent of the state. The soils formed in deposits of partially decomposed plant materials. Most of the acreage is in woodland.

12. Carlisle-Adrian. Nearly level, very poorly drained soils formed in organic deposits derived from plant materials (Figure 13).

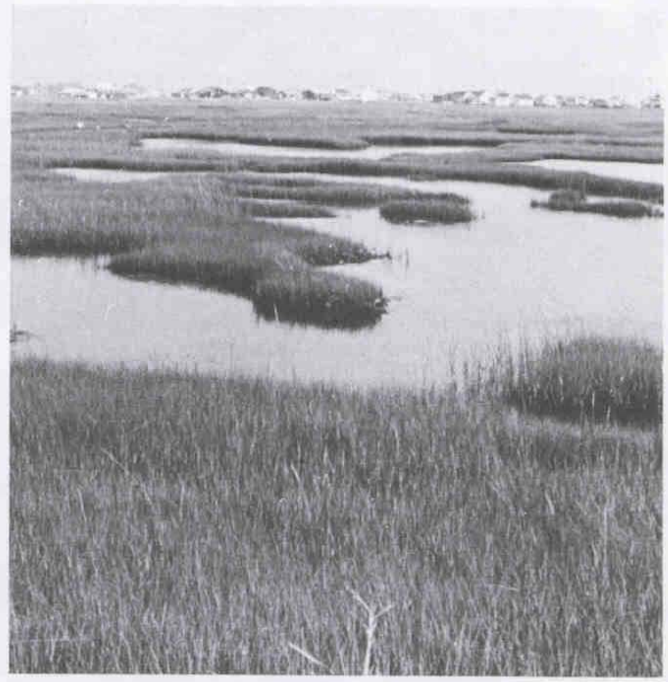
The soils of this unit are in swamps, bogs, and slackwater areas of glacial till plains, terraces, and flood plains. Slopes range from 0 to 2 percent.

This map unit makes up about 4 percent of the state. The unit is about 50 percent Carlisle soils, 40 percent Adrian soils, and 10 percent soils of minor extent.

Carlisle soils consist of brownish or black muck. The water table is at or near the surface most of the year.



About four percent of Rhode Island is made up of freshwater swamps and bogs. These areas are valuable for recreation, flood control and wildlife habitat.



The Matunuck soils, such as these in Succotash Marsh in Jerusalem, provide valuable wildlife habitats.

Adrian soils consist of a layer of black muck overlying gravelly sand. The water table is at or near the surface most of the year.

Soils of minor extent are mainly very poorly drained Scarboro and Whitman soils and poorly drained Rumney soils. All of these soils are in low, wet areas.

Most areas of this map unit are in unmanaged woodland or low brush and shrubs. Wildlife habitat is the main use of these soils.

Wetness, flooding, and instability are the main limitations affecting the use of the soils.

Areas of Coastal Lowlands Affected by Tidal Water and Dominated by Soils Formed in Sandy Sediments

The one unit of this group makes up only about one percent of the state. The acreage is used mostly for wildlife habitat and recreation.

13. Matunuck-Udipsamments-Beaches. Nearly level and undulating, very poorly drained and excessively drained, sandy soils of tidal marshes, dune areas, and beaches (Figure 12).

The soils of this unit are mostly in narrow areas adjacent to the ocean shore. They are subject to tidal inundation and to wave and wind action. The Matunuck soils are nearly level, and Beaches and Udipsamments are gently sloping to undulating.

This map unit makes up about 1 percent of the state. It is about 55 percent Matunuck soils, 20 percent Udipsamments, 20 percent Beaches, and 5 percent soils of minor extent.

Matunuck soils are very poorly drained. Typically, they have a mucky peat surface layer. The sub soil and substratum consist of grayish sand. Matunuck soils are in coastal tidal marsh areas. They are regularly inundated by tidal water.

Udipsamments are excessively drained. The soils consist of deep sand deposits. Udipsamments are mostly on undulating, dunelike landforms.

Beaches are gently sloping coastal deposits of sand with varying amounts of pebbles, cobbles, and sea shells. Beaches are between the low tide line and areas of Udipsamments. They are subject to continuous wave action.

Soils of minor extent are mainly the moderately well drained Udipsamments and the Ipswich soils. The wetter Udipsamments are in depressions in Udipsamments. Ipswich soils are in the tidal marsh areas.

Most areas of this map unit are covered with saltmarsh grasses, dune grasses, and other salt- tolerant vegetation.

Beaches support practically no vegetation. Most of this unit is used for wildlife habitat or recreational purposes.

Tidal flooding, wetness, instability, salinity, acidity, and droughtiness are the main limitations affecting the use of the soils.

A western Rhode Island farm on stony soils.

LITERATURE CITED

1. Baldwin. Mark, Charles E. Kellogg, and James Thorp.
1938. Soil Classification. In U.S. Dep. Agric. Yearb., Soils and Men.
2. Bartelli L. J., A. A. Klingebiel. 3. V. Baird, and M. R. Heddleson. 1966. Soil Surveys and Land Use Planning. Soil Sci. Soc. Amer. Madison, \Vis.
3. Bonsteel, F. B. and B. P. Carr. 1905. Soil Survey of Rhode Island. Bureau of Soils, U.S. Dep. Agric.
4, Goldstein, Sidney. 1972. Population Change in Rhode Island. 1960-1970. Rhode Island Business Quarterly. Vol. 8. No. 1. College of Business Administration, Univ. of RI.. Kingston, R.I.
5. Harris, B. K. and T. E. Odland. 1948. Rhode Island Veather. RI. Agric. Exp. Sta. Bul. 299. Kingston. RI.
6. Havens. James M. and Paul J. Jaillet. 1976. Climatog raphy of Kingston, RI. Part II. A. Air Temperature on a Calendar-Day Basis, 1930-1975. Occasional Papers in Geography No. 1. Dep. of Geography, Univ. of RI., Kingston. RI.
7. Jenny, Hans. 1941. Factors of Soil Formation: A System of,Quantitative Pedology. McGraw-Hill Book Co.. Inc. New York, N.Y.
8.. Kupa. J. J. and W. R. Whitman. 1972. Land-CoverTypes of Rhode Island: an Ecological Inventory. RI. Agric. Exp. Sta. Bul. 409. Kingston, RI.
9. NOAA. 1975. Climatography of the United States No.
10. Quinn. Alonzo W. 1976. Rhode Island Geology for the Non-Geologist. RI. Dept. of Natural Resources. Providence. RI.
11. Rector. Dean D. Soil Survey State of Rhode Island. U.S. Dept. Agric. Soil Cons. Serv. (In press).
12. Roberts, R. C., H. C. Knoblauch, S. V. Madison, and V. A. Hendrick. 1939. Soil Survey of Kent and Washing ton Counties, Rhode Island. U.S. Dept. Agric. Bureau of Chemistry and Soils.
13. Schafer, 3. P. andj. H. Hartshorn. 1965. The Quaternary of New England. In H. E. Wright, Jr. and David G. Frey (ed). The Quaternary of the United States. Princeton Univ. Press. Princeton, N.J.
14. Shearin. A. B., S. V. Madison, and W. S. Colvin. 1942. Soil Survey of Newport and Bristol Counties, Rhode Island. U.S. Dept. Agric. Bureau of Plant Industry.
15. Shearin, A. E., S. V. Madison, 'A'. S. Colvin, and Vladimir Shutak. 1943. Soil Survey of Providence County, Rhode Island. U.S. Dept. Agric. Bureau of Plant Indus try.
16. Simonson, R. W. 1959. Outline of a Generalized Theory of Soil Genesis. Soil Sci. Soc. Amer. Proc. 23:152-156.
17. United States Bureau of Census. U.S. Census of Agriculture: 1959. \'ol. 1, Counties. Parts, Rhode Island, Washington. D.C. 1960.
18. United States Department of Agriculture. 1951. Soil Survey Manual. U.S. Dept. Agric. Handb. 18, 503 pp.
19. United States Department of Agriculture. 1971. Guide for Interpreting Engineering Uses of Soils. Soil Cons. Serv., U.S. Dept. Agric., 87 pp.
20. United States Department of Agriculture. 1975. Soil Taxonomy: A basic system of soil classification for making and interpreting soil surveys. Soil Cons. Serv., U.S. Dept. Agric. Handb. 436, 754 pp.
21. United States Department of Commerce, Bureau of the Census.1974. Census of Agriculture, Vol. 1, Part

GLOSSARY

Ablation till. Loose, permeable till deposited during the final donwnwasting of glacial ice. Lenses of crudely sorted sand and gravel are common.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point.

Basal till. Compact glacial till deposited beneath the ice.

Base saturation. The degree to which material having cation exchange properties is saturated with ex changeable bases (sum of Ga. Mg, Na, K), expressed as a percentage of the total cation exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.
Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.
Catena. Sequence of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.
Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium. magnesium. sodium, and hydrogen.
Cation exchange capacity. The total amount of exchange able cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil.
Channery soil. Soil that is, by volume, more than 15 percent thin, flat fragments of sandstone, shale, slate, limes tone. or schist as much as 6 inches along the longest axis. A single piece is called a fragment.
Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is4O percent or more clay, less than 45 percent sand, and less than 40 percent silt.
Coarse textured soil. Includes the sand, loamy sand, and coarse sandy loam textural classes.
Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping.
Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers.
Drainage class. Refers to the frequency and duration of periods of saturation or partial saturation during soil formation. Seven classes of natural soil drainage are recognized.
Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.
Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.
Excess fines. Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.
Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has drained away. Commonly measured at 1/3 atmosphere tension in the laboratory.
Fine textured (heavy textured) **soil.** Includes the clay loam, sandy clay loam, silty clay loam, sandy clay, silty clay, and clay textural classes.
Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.
Fragipan. A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist it tends to rupture suddenly under pressure rather than to deform slowly.
Frost action. Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.
Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.
Glacial drift. Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.
Glacial outwash. Gravel, sand, and silt, commonly stratified. deposited b glacial melt water.
Glacial till. Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and de posited by glacial ice.
Glaciofluvial deposits. Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.
Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the pro file and in gray colors and mottles.
Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume. rounded or angular rock fragments. not prominently flattened, tip to 3 inches (7.5 centimeters) in diameter,
Groundwater. Water filling all the unblocked pores of underlying material below the water table.
Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes.
Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.
Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually ex pressed in inches per hour.
Kame. An irregular, short ridge or hill of stratified glacial drift.
Large stones. Rock fragments 3 inches (7.5 centimeters) or more across.
Leaching. The removal of soluble material from soil or other material by percolating water.
Loess. l'ine-grained material, dominantly of silt-sized particles, deposited by wind.
Medium textured soil. Intermediate between fine-textured and coarse-textured soils. Includes the very fine sandy loam, loam, silt loam, and silt textural classes.
Miscellaneous areas. Areas that have little or no natural soil and support little or no vegetation.
Moraine. An accumulation of earth, stones, and other debris, deposited by a glacier. Some types are terminal, lateral, medial, and ground.
Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.
Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage.
Muck. Dark-colored, finely divided, well decomposed organic soil material.
Organic matter. Plant and animal residue in the soil in various stages of decomposition.
Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial me
Outwash plain. A landform of mainly sandy or coarse- textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.
Parent material. The unconsolidated organic and mineral material in which soil forms.
Peat. unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture.
Ped. An individual soil aggregate with naturally preserved boundaries, a structural unit of soil.
Pedogenic. The process of soil formation. (See Genesis, soil.)
Percolation, The downward movement of water through the soil.
Percs slowly. The slow movement of water through the soil adversely affecting the specified use.
Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves downward through the saturated soil.
Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, surface texture, differences in slope, stoniness, and thick ness.
pH value. A numerical designation of acidity and alkalinity in soil (See Reaction, soil.)
Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.
Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to p1 7.0 is described as precisely neutral in reaction.
Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.
Relief. The elevations or inequalities of a land surface, considered collectively.
Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that ac cumulated as consolidated rock disintegrated in place.
Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders,
Runoff. The water that flows off the surface of the land without sinking i- to the soil is called surface runoff.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter As a soil textural class, soil that is 80 per cent or more silt and less than 12 percent clay.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feel of horizontal distance.

Small stones. Rock fragments less than 3 inches (7.5 centimeters) in diameter.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has proper ties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 mm in equivalent diameter and ranging between specified size limits.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A and B horizons.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil.

Till plain. An extensive flat to undulating area underlain by glacial till.

Toposequence. See "Catena."

Topsoil. The upper part of the soil, which is the most favor able material for plant growth.

Upland. Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the low lands along streams.

Wilting point (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which a plant wilts so much that it does not recover when placed in a humid, dark chamber.