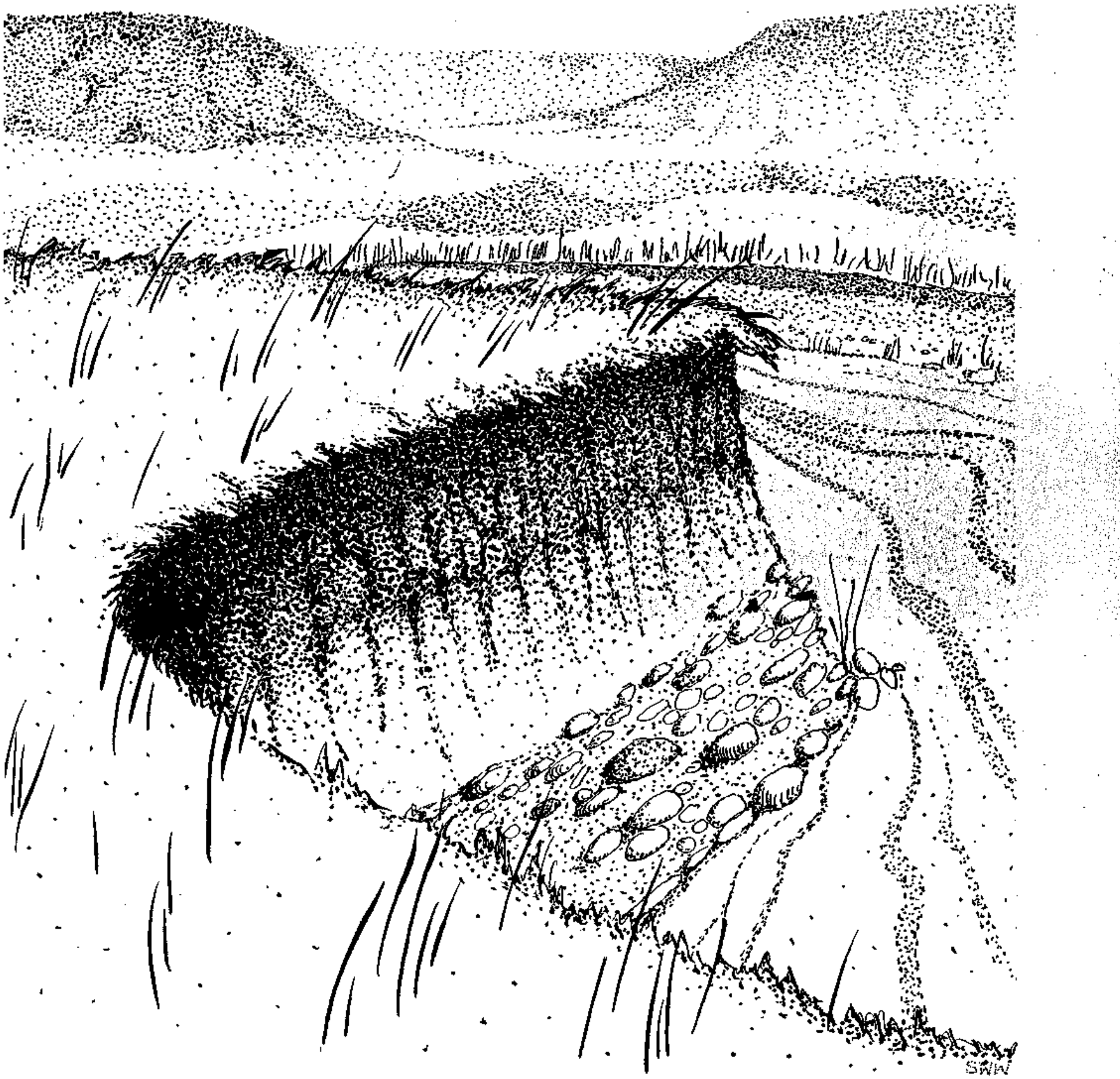
An Introduction to SOILS OF PENNSYLVANIA



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An Introduction to SOILS OF PENNSYLVANIA

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INTRODUCTION

An understanding of soils, their development, properties, and use potential, is both fascinating and important. This book, which focuses on the soils of Pennsylvania, was written to provide such an understanding.

The soil is a record of the geological and climatic history of the region where it is found. It reflects the ancient presence of rock, or rivers, or oceans. It reveals the climate it has withstood and the kind of vegetation it has supported. The many facets of the environment — weather, life forms, minerals — are clearly interrelated when we study their record in the soil, which is where they ultimately leave their impression. A familiarity with soil science brings us this insight.

Since man has settled on the landscape of Pennsylvania, he, too, has made his mark on the soil. He has turned over the surface and changed the vegetation with his agriculture. He has excavated and stripped the earth with his mining activities. And, he has largely obscured the landscape where he has built cities. However, the kinds of activities he chooses and where he practices them depend on the nature of the land he is exploiting. For example, it was not at random that Pennsylvania's cities grew up at the junctions of rivers where transportation was convenient before the age of motor vehicles and airplanes. Agriculture, an important industry in Pennsylvania, is dependable here because of plentiful water resources, although mountainous terrain limits its practice. And Pennsylvania's mining industry developed around rich natural deposits of coal and limestone.

Not only are the general kinds and locations of man's activities dependent on the physical landscape, but particular sites for any project must be precisely chosen considering immediate soil conditions. Wherever a building is erected, waste materials deposited, or the landscape otherwise disturbed, the local soil must be carefully studied and respected because soils have their own limitations. Some cannot provide required support. Others may lack necessary drainage or filtration capacity. And soil fertility is not equally distributed.

This book should help the reader to recognize some of the properties of local soils, to see how they are related to landscape features and to the soil's history, and to appreciate the limits and the potential of Pennsylvania soils.

SOIL DEVELOPMENT

The Geologic Cycle

The landscape of Pennsylvania as we see it today represents only a moment in the vast ages of geologic time during which cycles of landscape building and landscape erosion are slowly, but surely, always in progress.

Soil develops relatively quickly in terms of geologic time, although it forms at different rates in the three kinds of rock: *igneous*, *sedimentary* and *metamorphic**. Soil supports much of the life on earth. It contains its own microscopic life forms, and it recycles all of the creatures that live and die on the land. Soil, being loose, unconsolidated material, represents the phase in the geologic cycle in which the earth's mineral matter is interacting most closely with life forms.

*Italicized words may be found in the glossary on page 23.

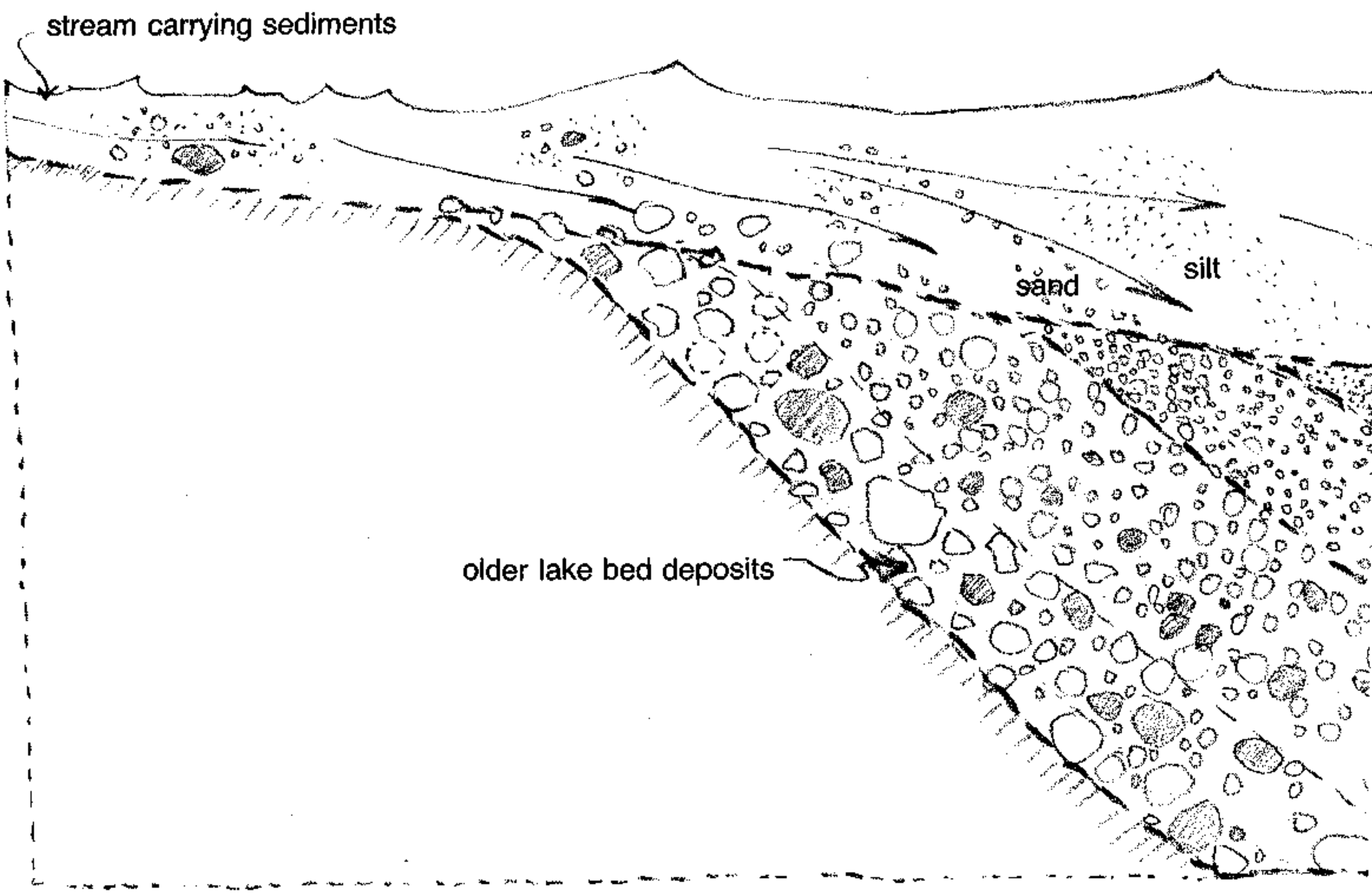
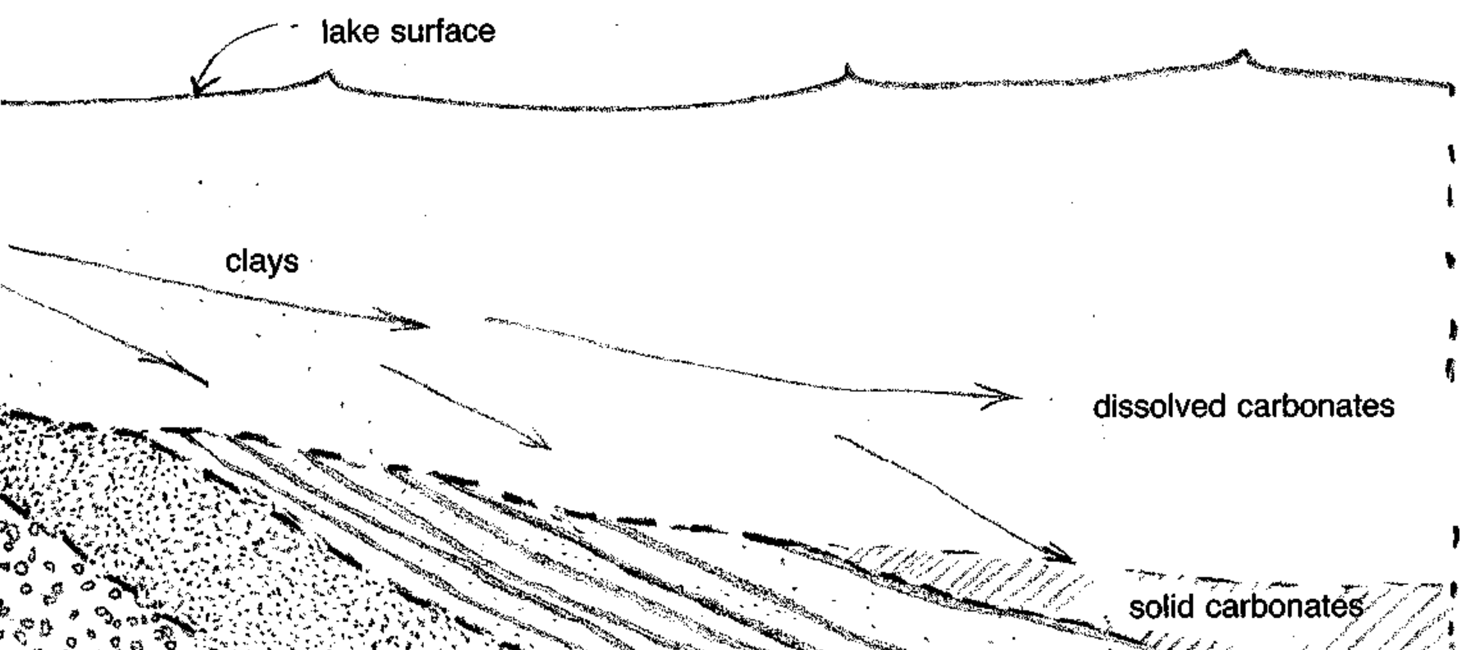


Figure 1. A stream sorting and depositing its load at its delta, where it enters a lake.

The mineral component of the soil was once part of the molten liquid at the earth's core. As the earth cooled, its surface hardened into solid rock. Today, molten rock still surfaces as volcanoes, or spurts up unseen into the *bedrock* below the ground. Outcrops of this cooled, hardened molten rock, known as *igneous rock,* are found in southeastern Pennsylvania.

Exposed to the assaults of weather and time, solid rock slowly and continually crumbles and disintegrates. This weathering process produces the unconsolidated mineral material in which soil forms. On a stable landscape, soil develops and matures in this material directly above the weathering rock. On an eroding terrain, it is carried away by water and eventually flows into the sea.

Water sorts transported particles by size, separating *sand, silt,* and *clay* (Fig. 1). The water-borne and sorted deposits accumulate, are compressed, and harden over long periods of time. Carbonates, substances which are completely dissolved in water, ultimately precipitate out as solids, forming limestone. Clay deposits become shale, silt becomes siltstone, and sand becomes



sandstone. Eventually in geologic time what was once the sea bottom rises and becomes the *sedimentary rock* of dry land.

Exposed at the earth's surface, sedimentary rock weathers anew. But where it lies deep within the earth, great heat and pressure further harden and change it into *metamorphic rock.* When geologic events bring metamorphic rock to the surface, it too will slowly weather, form soil materials, erode away, and eventually form rock again, as the cycle continues.

Weathering

Soil formation starts with weathering, which happens to bare rock as well as to buried rock. Several factors bring about weathering:

1. Temperature fluctuation, which causes expansion and contraction.
2. Erosion by water, wind, and ice.
3. Plant roots growing into tiny cracks, causing them to spread.
4. Chemical reactions of soil minerals with water and air.

You might expect soils to have the same composition as the rock from which they originate. However, in the transformation of rock to soil, minerals undergo so many changes that the soil minerals, although remaining representative of the original rock minerals, usually change their composition. For example, by the time limestone rock becomes soil, it contains no calcite ($CaC0_3$), the predominant mineral in that rock. Because calcite is highly soluble, it dissolves in humid climates, leaving just insoluble impurities, which become the limestone soil. Only an estimated 5 percent of the original limestone rock remains. Thus a 5-inch layer of limestone soil represents the weathering of 100 inches of bedrock.

Soil, however, is more than just weathered rock. *Organic matter* is another important component. Organic matter includes the decomposing and decomposed parts of animal and plant material and a multitude of soil organisms, mostly microscopic. The microorganisms contribute to the weathering of minerals and the breakdown of organic residues.

The medium in which soil develops is called *parent material.* This material is usually weathered rock in Pennsylvania, but in bogs and marshes it is decayed organic matter. Parent material may also be loose material, gravel, for example, deposited along rivers and streams during floods. Within the parent material, processes such as leaching and redistribution of minerals take place. These processes result in the differentiation of *horizons* below the surface (Fig. 2), visible when the land is excavated.

The topsoil, which has the most organic matter and is the root zone, is called the A horizon. The next layer, the subsoil or B horizon, contains higher concentrations of clay and is denser than the A horizon. The C horizon is the parent material — the altered organic deposit or the weathered bedrock. Bedrock is the last layer, the R horizon. The depth and thickness of the horizons vary with each soil.

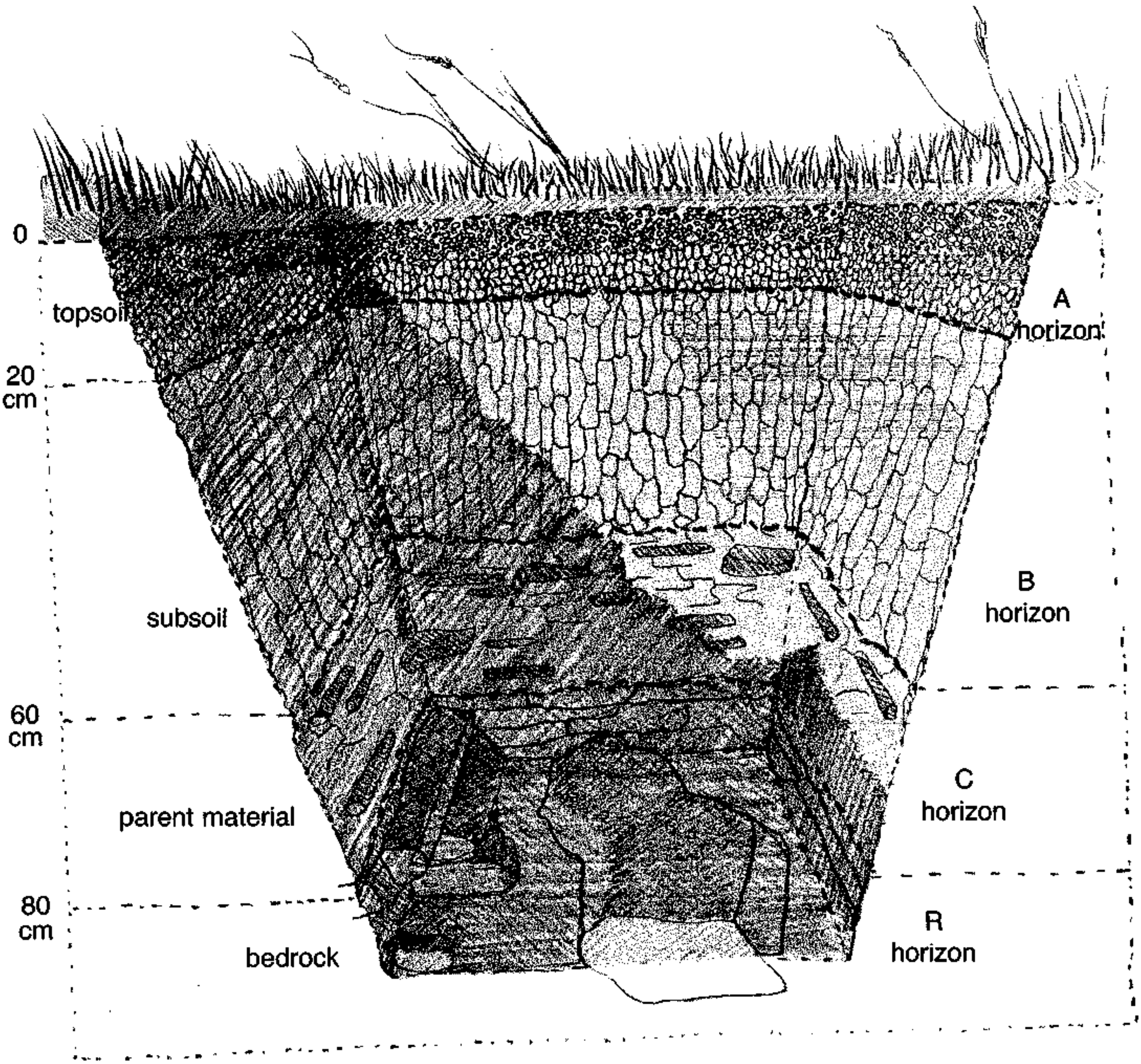


Figure 2. A soil profile: the different soil horizons are visible on the sides of this pit where changes in soil color and texture can be distinguished.

Vegetation

Mature soil develops slowly. When it stays in place for a long time, vegetation begins to grow on the surface, providing organic matter from litter and dead roots, and darkening the soil nearest the surface. As organic matter accumulates, conditions become increasingly favorable for plant growth.

The kind of vegetation growing on the surface affects the development of the soil below. Grasses have extensive root systems, a large portion of which die off and are replaced by new shoots each season. After many years, grasses give topsoil a well-aerated, crumbly structure and high levels of organic matter (Fig. 3). The soils of the Midwest are highly productive, largely because they were grasslands for many centuries before they were farmed.

Pennsylvania may once have had some grasslands, but in recent times it has been mostly forested. Trees contribute organic matter largely through the annual falling of leaves rather than through their root systems. Thus forest soils tend to have a layer of dark, matted organic residue over the surface, with a relatively low level of organic matter within the soil (Fig. 4).

Not only does vegetation contribute to soil development, it also reveals much about soil conditions. To thrive, many species require particular ranges of soil moisture, texture, and acidity (pH). For example, wet and neutral soil favors cattails and teasel. Where the soil is acid, rhododendron and laurel bushes thrive. Knowledge of wild vegetation can be an index to soil properties.

Climate and Time

Climate is a major influence on the rate of soil development. Pennsylvania has a humid climate, with an annual rainfall ranging from 34 to 50 inches. Its soils reflect centuries of rainwater flowing through them, slowly breaking down minerals. When soluble components such as the alkaline ions — calcium, magnesium, and potassium — are carried off to the groundwater, soil fertility diminishes and acidity increases.

Rain also very slowly carries down from the topsoil the smallest soil particles, the fine clays. These settle in the subsoil, making it finer-textured (more clayey) than the topsoil. Over time, the recognizably different horizons develop.

Mature soil has its own *soil structure* which is composed of aggregates of sand and silt held together by clay and organic matter. If you take a handful of mature soil and let it spread over your palm, you will notice that it falls into little angular or crumbly lumps. These structural units, or *peds*, are the product of centuries of development.

Heat, as well as rainfall, accelerates the process of soil development. Because Pennsylvania has a humid temperate climate, with seasonal fluctuations and annual freezing and thawing, the surface is continually subject to expansion and contraction and the effects of water. These factors result in a soil that has greater maturity — *pedologic age* — than that of the same initial parent material developing in the Arctic for the same length of time. However, no soil in Pennsylvania is as mature as the oldest tropical soils.

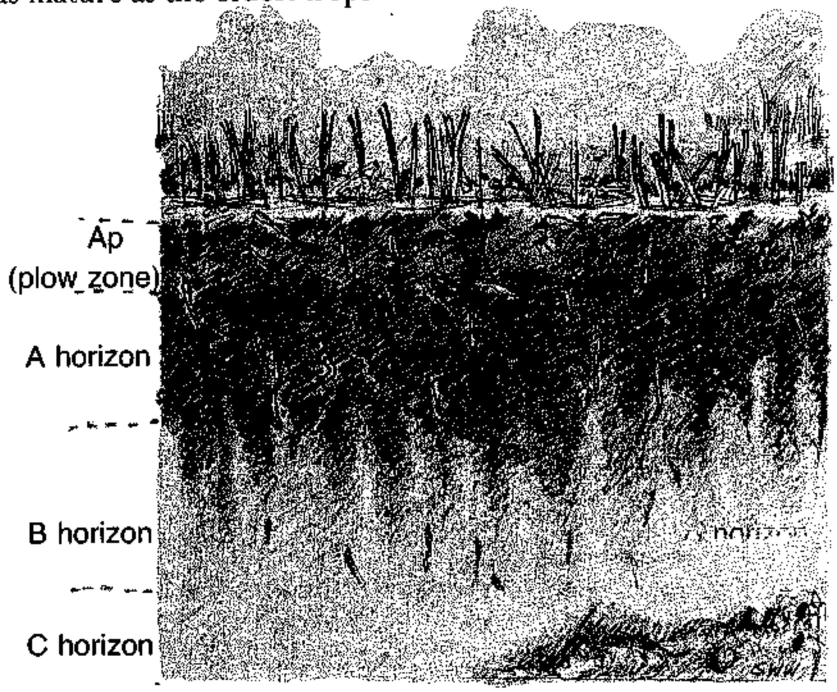


Figure 3. Profile of a grassland soil. Note the thick A horizon.

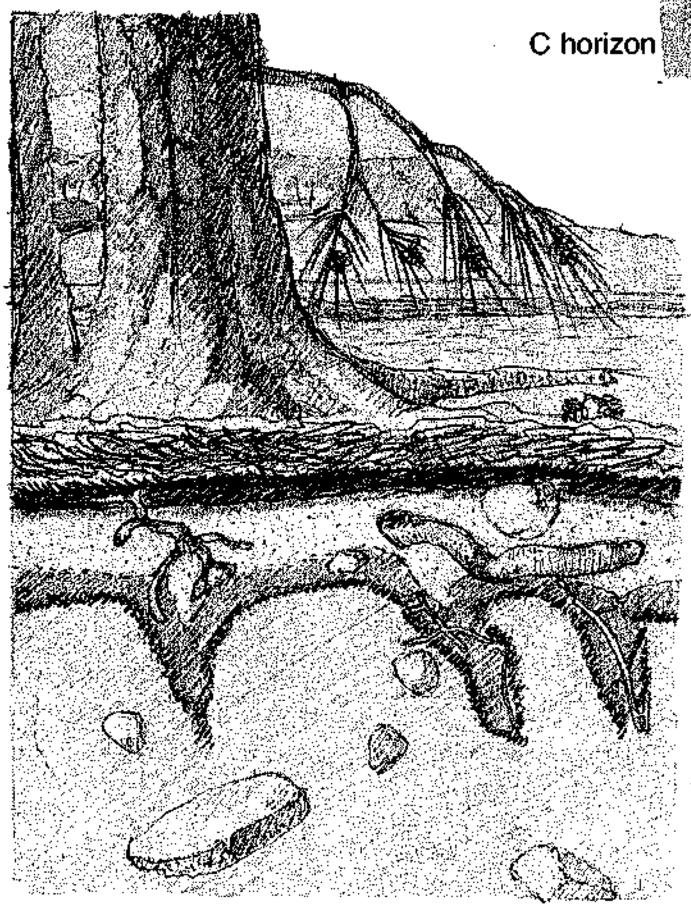


Figure 4. Profile of a forest soil. Note the litter on the surface and the thin A horizon.

FORMATION OF PENNSYLVANIA SOILS

Bedrock and Topography

Pennsylvania soils are the product of the general forces of weathering, vegetation, climate, and time working on the particular parent material and topography of the region.

Many different types of bedrock underlie Pennsylvania. Bedrock and its weathering characteristics are not only responsible for the nature of the developing soil, but also influence the topography of the landscape. As Figure 5 shows, bedrock and topography generally correspond across the state.

At the southeastern and northwestern edges of Pennsylvania, soils are not derived from massive rock, but from sands deposited when this land was once seashore. Coastal deposits like these are found on flat, open lowlands. The sands weather and accumulate organic matter to become soil. The Williamson soils of Erie County were formed from coastal deposits. These soils are well suited to growing vegetables and fruit.

In the southeastern part of the state, a band of very old metamorphic rock lies under the soil. This bedrock — schist, gneiss, and quartzite — is the oldest outcrop in the state. Formed in the pre-Cambrian era more than 600 million years ago, it is the remnant of mountains once higher than the Rockies. These great mountains weathered away very slowly to form the rolling topography found in Montgomery County today.

Where siltstone occurs in southeastern Pennsylvania, it contains veins of very hard igneous rock. These intrusions weather more slowly than the siltstone, leaving rocky deposits which interfere with agriculture.

Underlying the rest of the state is sedimentary rock — shale, sandstone, and limestone — formed from material deposited in lakes and seas once present in Pennsylvania. Low mountain ridges and valleys run northeast and southwest across central Pennsylvania. This topography is the result of a series of geologic events which occurred after the shale, sandstone, and limestone sediments formed. Horizontal layers of rock were upturned, wrinkled, and folded. Subsequent erosion of this convoluted surface exposed the upturned layers, creating the landscape we see today.

Pennsylvania's ridges and valleys are evidence of the differential rates of weathering of the layers. Sandstone, the hardest and most chemically resistant sedimentary rock, forms the ridge caps. Limestone, the least resistant, forms the valleys. Shale, of intermediate resistance, underlies the slopes (Fig. 6).

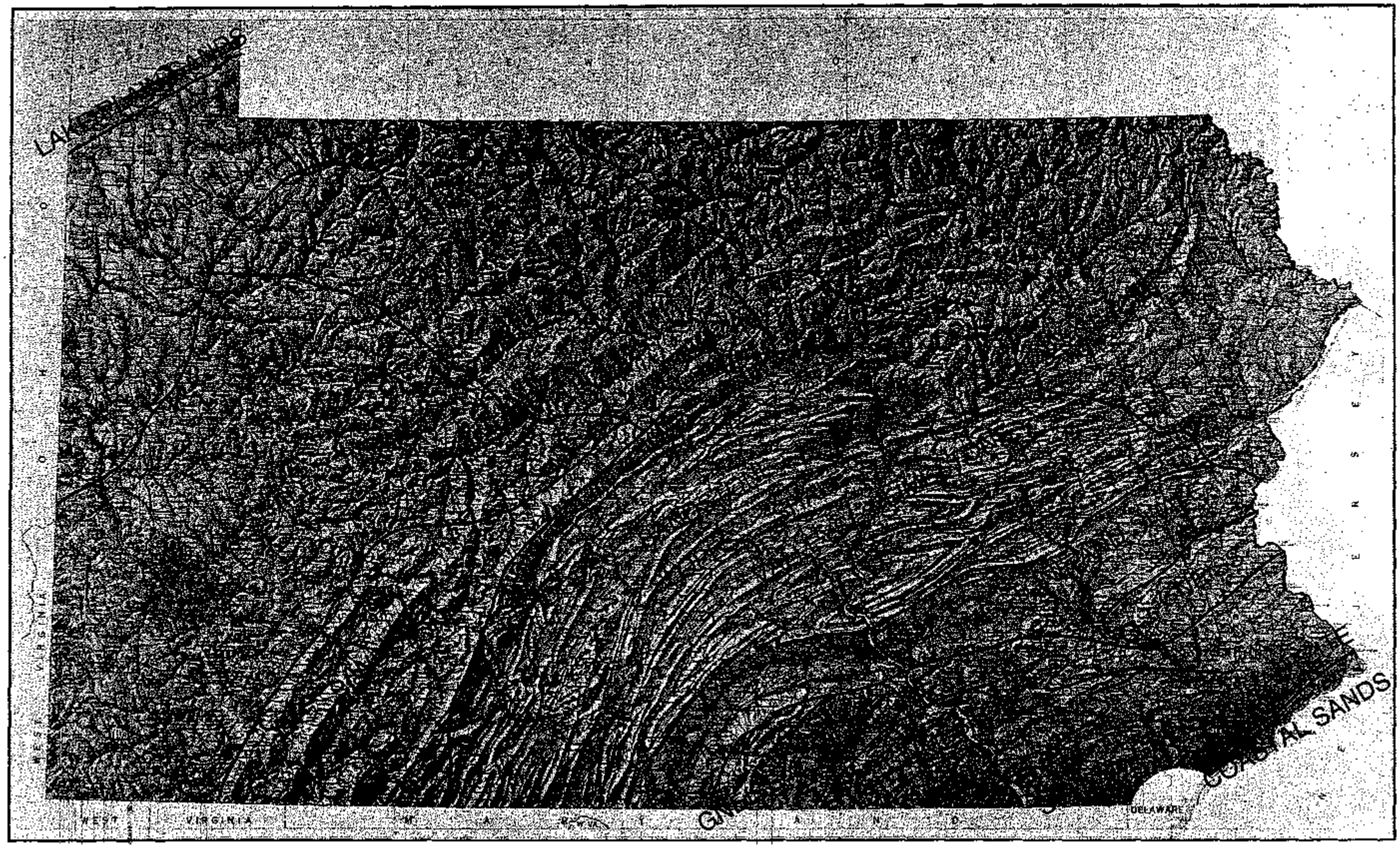


Figure 5. The bedrock and topography of Pennsylvania.

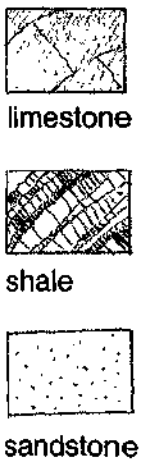
Parent Material

When bedrock becomes the *parent material* for the soils developing on it, it is the source of important soil properties. For example, sandstone soils, which tend to be coarse, dry out so fast that they do not support many crops. Limestone soils in the valleys are generally fertile and productive — the best agricultural soils in Pennsylvania, such as the Hagerstown and Duffield soils in Lancaster County, are limestone soils. Shale soils are fine-textured and tend to be acidic and low in nutrients — with large additions of fertilizer, they are farmed. On mountainsides they often support mixed forests.

Much of the land overlying shale deposits has been ruined by *strip mining,* because shale contains Pennsylvania's rich coal beds. Strip mining removes all the rock and soil material above the coal, and then backfills the depleted mine with crushed rock, called *mine spoil.* Because the soil surface is gone, almost nothing grows on the mine spoil, leaving a barren wasteland which erodes and clogs up streams (Fig. 7).

More acreage has been disturbed by strip mining in Pennsylvania than in any other state. Legislation passed in 1971 requires that topsoil be replaced at future strip mines. Researchers are working on methods of economically treating the bare mine spoil, which is often very acid, infertile, and too coarse for plant growth, and are identifying species that are tolerant to spoil conditions. Eventually they hope to revegetate land disturbed before 1971.

Parent material can be classified according to its history, as transported or residual. *Residual soils* have formed in their present location. On gently rolling uplands, residual soil is likely to be well developed and productive, as is the Chester soil of Chester County, which produces corn and tobacco. However, while residual soils formed on steep slopes are deep, they are not suitable for cultivation with modern equipment. In Pennsylvania, vast forests represent the best use of steep mountainsides because they provide a cover that minimizes erosion.



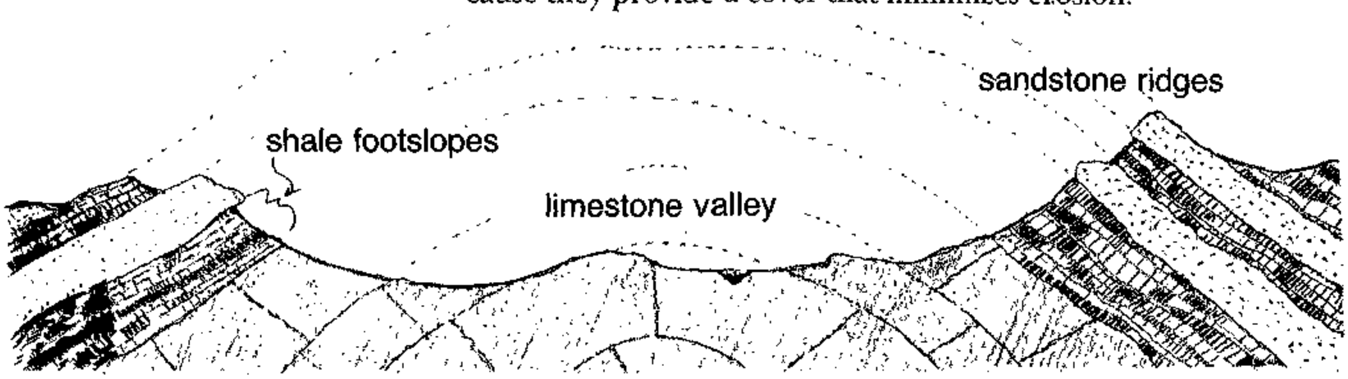


Figure 6. A cross-section of a small portion of ridge and valley topography showing resistant rock at the top of the ridges and faster weathering rock in the valley.

The forces of ice, water, wind, and gravity carry small particles as well as rocks across the landscape. Soil forms in this transported material deposited over the original soil or bedrock. Transported parent material can be glacial, aeolian, colluvial, or alluvial in origin.

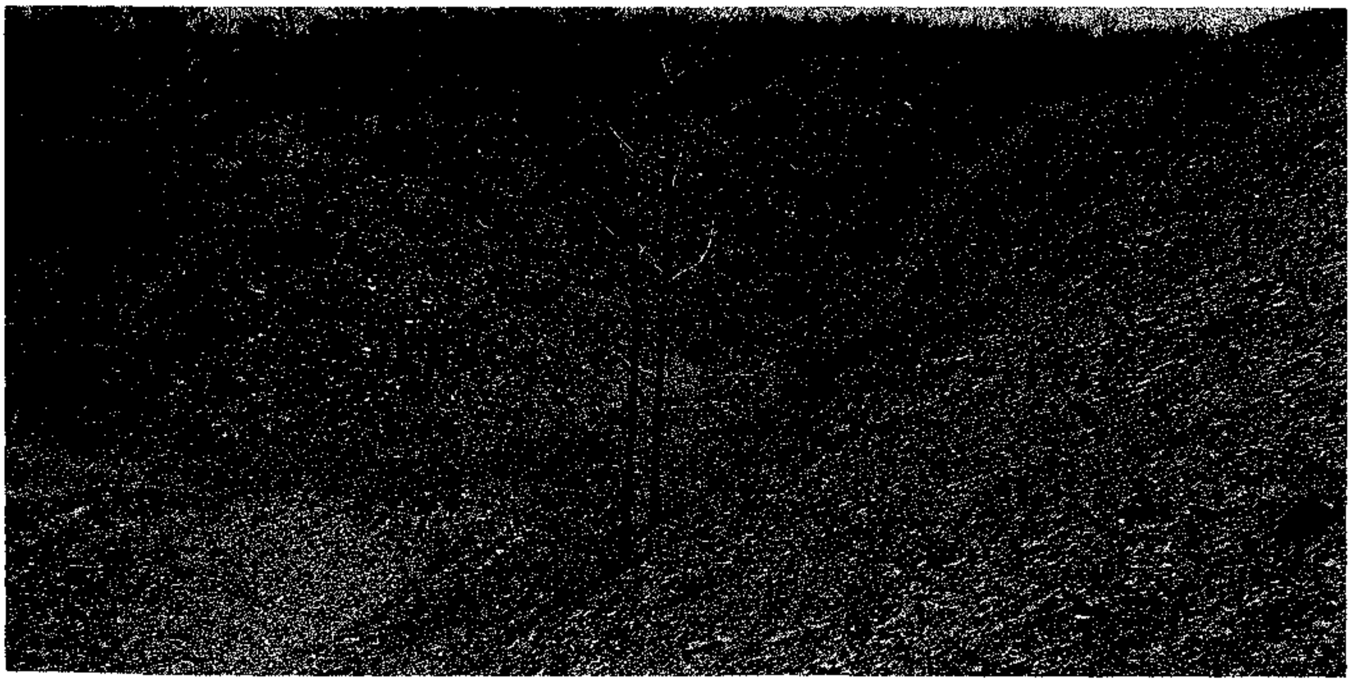
The once glaciated northern corners of Pennsylvania have glacial features superimposed on older topography. *Glacial till* deposits consist of rock material of all kinds and sizes, from boulders to clay, brought in by the ice and left where it stands today. *Outwash features,* made of material carried and sorted by water flowing from the melting glacier, are found on relatively open topography.

Because they have very compacted, firm subsoil, glacial till soils generally have drainage problems. They are not well suited to row-crop agriculture, but make good pasture and hayland. The Volusia soils of Tioga County are glacial till soils.

Parent material deposited by the wind is called *aeolian,* or *loess,* material. Chalfont soil, found in Bucks County and largely used for row crops, is an example. Loess soils are not widespread in Pennsylvania, but in the midwest the great grasslands developed in loess soils. The loess, which provides an optimum soil texture, combined with the effects of growing grasses over time, created some of the richest agricultural soil on earth.

While transported parent materials such as aeolian or glacial deposits cover large regions, others are only transported locally. Footslopes of the mountains in Pennsylvania are often created by rock which has tumbled down from above. Such loose rock material is called *colluvium.* The forested Buchanan soil of Centre County is formed from sandstone colluvium.

Figure 7. A common landscape at the site of abandoned strip mined land.



Because colluvial soils have a problematic feature called *fragipans,* they are often used for pastures rather than for development. Fragipans, also found in glacial till soils, are subsoil layers of exceptionally dense material which may be a few inches to several feet thick (Fig. 8). They are relatively impermeable to water and impenetrable to plant roots; hence the soil above them is often waterlogged. Fragipans interfere with any kind of land use for which drainage is important. Residential development of these soils requires artificial drainage and a sewage treatment system.

In river and stream valleys, *alluvium* — sediment carried by flowing water — is deposited during floods. New parent materials are continually added to existing deposits. This new material keeps these soils fertile as well as pedologically young. Alluvial soils, while good for farming, are generally hazardous for building because they are subject to flooding. The Linden soils along the Susquehanna, periodically the site of devastating floods, are an example.

Observing the landscape features around you is a good way to determine the kind of parent material which formed the soil on which you are standing.

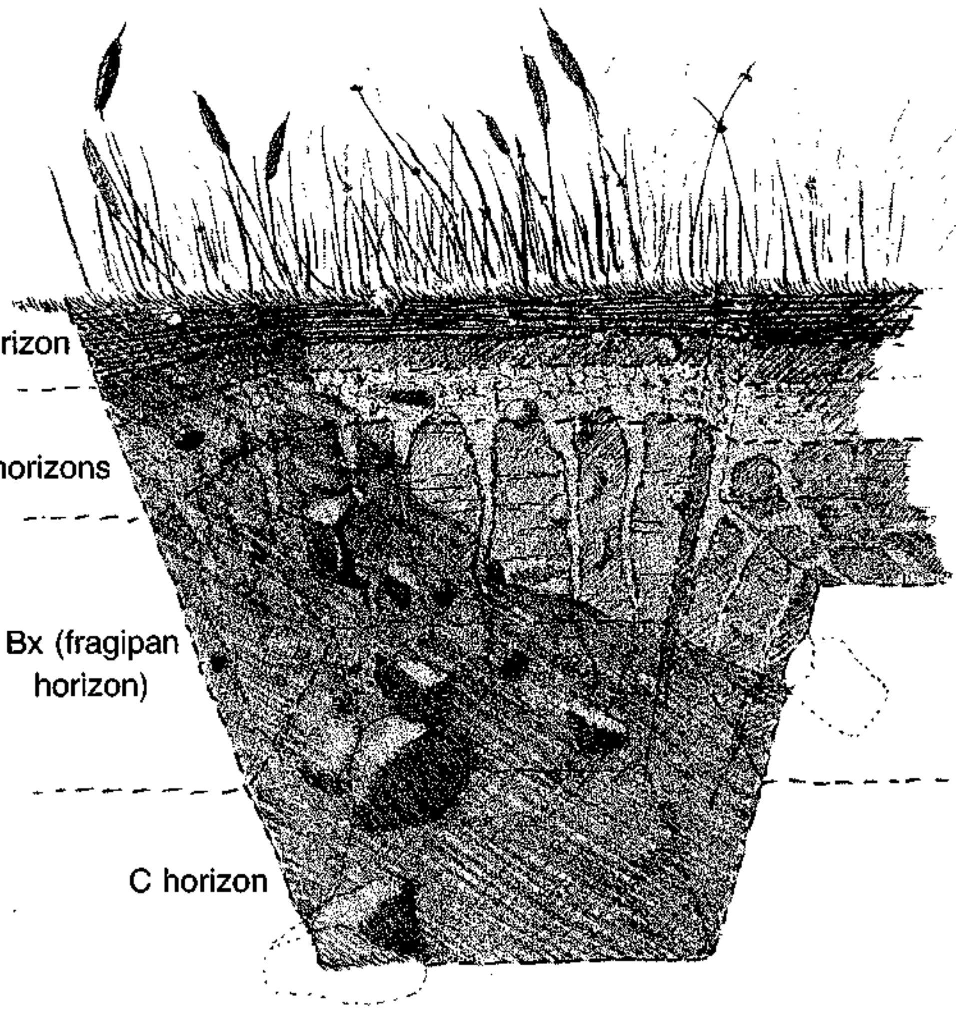


Figure 8.

Soil profile showing a fragipan at the bottom of the B horizon. The fragipan is characterized by bleached vertical streaks which form a polygonal pattern in horizontal cross-section. On the right is a cut-away of the fragipan.

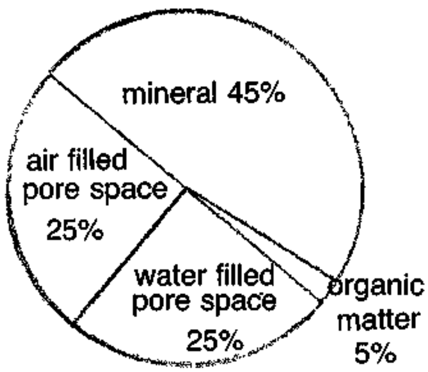
SOIL PROPERTIES

Soil Texture

Once formed by various environmental processes, soils have a number of important properties of their own that determine their potential uses.

Soil particles of various sizes have pore spaces between them that also vary in size. Particle-size distribution, also called *soil texture,* determines how readily air and water will pass through, be held, or be blocked by the soil.

Plants are quite sensitive to the texture of the soil environment. The soil should both retain moisture and allow air circulation. The ideal agricultural soil composition is 45 percent mineral, 5 percent organic matter, and 50 percent pore space. For optimum plant growth, half of the pore spaces should be filled with water, half with air.



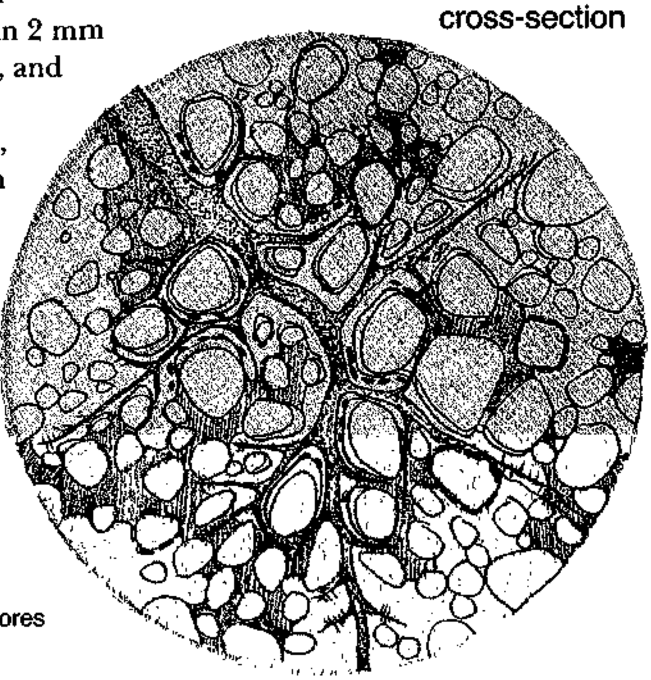
physical composition of an ideal soil

Sound foundations for buildings and roads require a soil texture which provides adequate bearing strength and drainage characteristics. Waste disposal systems require good drainage and enough fine material (see the *active fraction,* page 17) to filter out toxins before they reach the groundwater and the water supply.

Soil texture can be felt by rubbing the soil between the thumb and fingers. With practice, one can tell approximately what percentage of each particle size makes up a given soil, and where it belongs on the textural triangle (Fig. 9). Particles larger than 2 mm are called coarse fragments. Soil-size particles, referred to as fine earth, are less than 2 mm in diameter and are divided further into sand, silt, and clay.

The terms *sand, silt,* and *clay* refer only to size, not to the chemical makeup of the particles, which may be the same for clay as for sand. Sand particles are 2 mm to 0.05 mm in diameter, and sandy soil feels gritty between the fingers. Silt particles are 0.05 to 0.002 mm in diameter; silt feels silky or floury. Clay particles are smaller than 0.002 mm in diameter. Moist clay feels sticky and slick when rubbed between the fingers.

greatly enlarged cross-section




sand and silt particles forming air filled pores


water filled pores


clay coating sand grains with plant root


organic matter coating sand grains

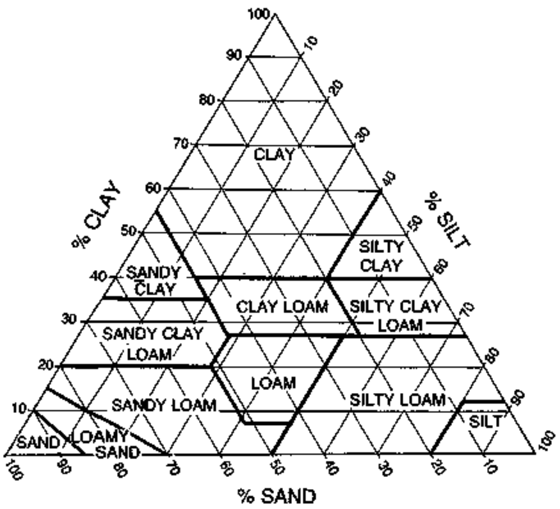


Figure 9. The Textural Triangle

This diagram is used to identify the texture of a soil. To use it, locate the appropriate percent clay on the clay scale, and silt on the silt scale. Follow the lines inward. Clay lines run parallel to sand scale; silt lines run parallel to clay scale. The lines will intersect in the compartment which represents the texture of a given soil.

All of these sizes seem very small to us. Nonetheless, a coarse sand is 1,000 times larger than a coarse clay, and this difference has a great impact on the behavior of water and air molecules making their way through the soil.

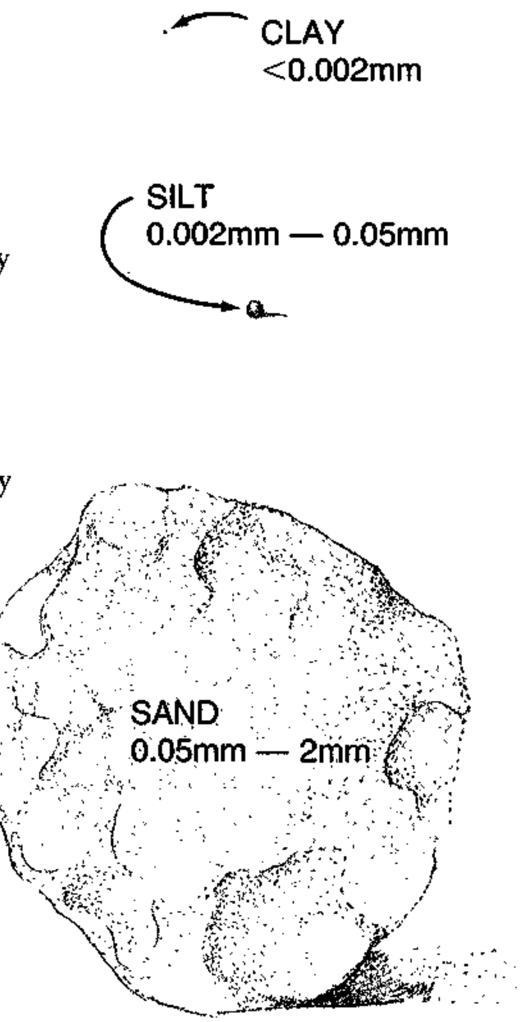
Since sands are the largest particles in the soil, they create large pore spaces. A sandy soil drains rapidly and remains soft or light so that roots can easily penetrate and spread. However, soil composed of too much sand will not hold enough water or nutrients for good plant growth. Because sand has high bearing strength, it makes a stable foundation for building.

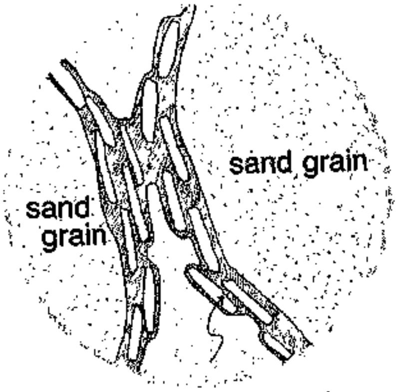
Silt allows the optimal amount of soil water retention and soil air circulation for agriculture. Silt-sized particles are readily carried by the wind, so loess soils (page 13) are silty soils.

Clay contributes water-holding capacity in soils. Because clay is so fine, water molecules cling to its surfaces and are held tightly within its tiny pores. Clays coat larger soil particles and bind them together, creating aggregates. Soil having well-defined aggregates and therefore well-defined drainage channels is said to have good structure.

Soil containing a high percentage of clay is considered heavy because it creates drag on the plow as well as on plant roots trying to penetrate it. If the soil contains too much clay, water may never drain through it. When such soils are wet, the small pores collapse if anything heavy presses on the surface, such as feet along a path or tires on a dirt road or cornfield. Compaction smashes the soil aggregates and closes the channels for air and water, destroying the soil structure. The surface becomes impermeable, slippery, and muddy when wet, and hard and cracked when dry. Because plants cannot grow in compacted soil, a well-worn path will not become overgrown.

Clay soils do not make good building foundations because they are likely to change volume and crack as moisture content changes.





clay particles with tightly held coating of water

Active Fractions

Clay and organic matter both have a remarkable and important property that makes them the *active fractions* of the soil. Clays are so tiny that they have more surface than they have internal mass. Thus, electrical forces which hold the crystalline clay particles together are felt along their surface. Electrically charged ions dissolved in the soil water are attracted or repelled by the charges on the clays (Fig. 10).

For example, a positively charged potassium ion floating in soil water will be attracted to a negatively charged site on clay. If the potassium ion is more strongly attracted to the site than the ion occupying that site, the two will exchange places. The potassium will adhere, or become *adsorbed,* to the clay, and the ion it replaces will be free to flow with the water. This property of trading ions is called the *exchange capacity* of the soil (Fig. 11).

Organic matter in soil has a far greater exchange capacity than has clay. It is found on humus — clay-sized particles of organic matter. Although the product of decomposition, humus is very resistant to further breakdown. Pennsylvania soils usually have much less humus than clay.

Clay and humus interact with materials which are introduced into the soil. Fertility depends upon the active fraction adsorbing and holding nutrients by ion exchange. Applied fertilizer does not drain through a soil with adequate clay and organic matter, but is retained and made available to the plants.

This same property explains how soil can renovate waste products. When effluent from a septic system, for example, is released into the soil, clays *adsorb* undesirable substances, preventing them from being washed into the groundwater. Eventually microorganisms decompose these substances, rendering them harmless.

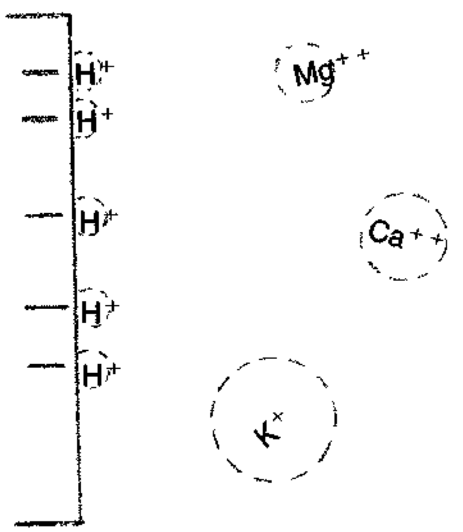


Figure 10. Diagram representing ion exchange in soil. Hydrogen ions adsorbed on clay surface.

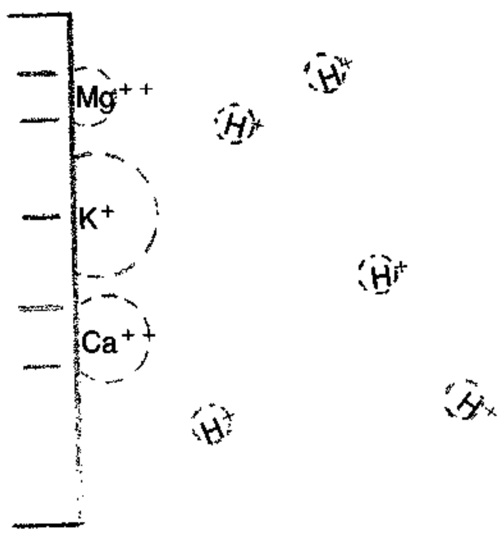


Figure 11. Hydrogen ions have exchanged places with ions in soil solution (soil water).

Soil Water

After a heavy rain, excess water normally drains away. Water left after a day or so makes the soil moist, but not wet. The dynamics of the active fraction occur in this moisture, which is not a free liquid, but a coating around and between soil particles.

Moisture and texture determine soil strength or consistency. Up to a point, sandy soil becomes firmer as water content increases. The water fills the empty pore spaces and acts as a weak adhesive between the particles. A clay soil becomes softer as water is added because water interferes with the attractive forces between the clay solids.

The balance between particle size and water content is critical both for engineering and agricultural uses of soil. An illustration of this delicate relationship is found in the right combination of water and kaolin clay, a combination both plastic and cohesive enough for molding into pottery.

Drainage conditions are often indicated by soil color. Where drainage is poor and the soil is saturated for part of the year (usually in spring), patches of gray and orange discolorations, called *mottles,* appear. Their presence and depth may reveal shallow bedrock, the presence of a fragipan, or soil containing too much clay.

Soil Drainage Classes

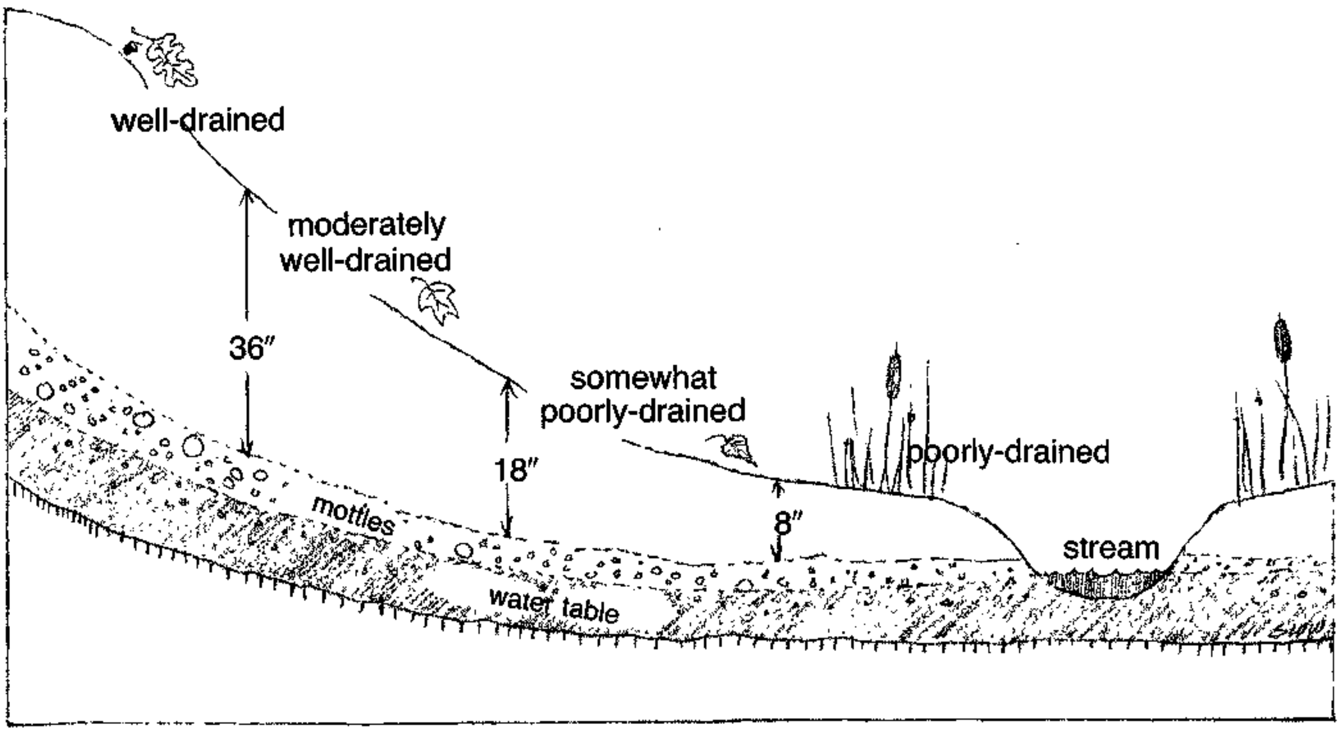


Figure 12. Relationship of drainage conditions to landscape position. Vegetation also indicates drainage conditions.

Drainage is often related to landscape position (see Fig. 12). Whereas the upland and upper slopes are usually well drained, the low spots are poorly drained. Drainage is an important factor in land-use decisions. Buildings on poorly drained sites are likely to have wet basements, and septic effluent cannot drain away.

Soil pH

A *soil pH* of 6.5 is optimal for most crops. Acid soils require liming to raise the pH for good crop production. Pennsylvania soils usually have a lower, or more acidic, pH because the abundant rainfall leaches out alkaline ions. Across this continent, annual average rainfall decreases from east to west. For example, 45 inches of rain fall in Pennsylvania, and 10 inches fall in Colorado. As a result, soils range from acid in the east to neutral in the midwest to alkaline in the western states (Fig. 13).

The effect of rainfall on soil pH is a good example of how soil-forming factors such as climate, time, parent materials, vegetation, and topography have created Pennsylvania soils. These factors impose limitations on land use, but our understanding and imagination are ultimately the limiting factors in the appropriate and productive development of the landscape.

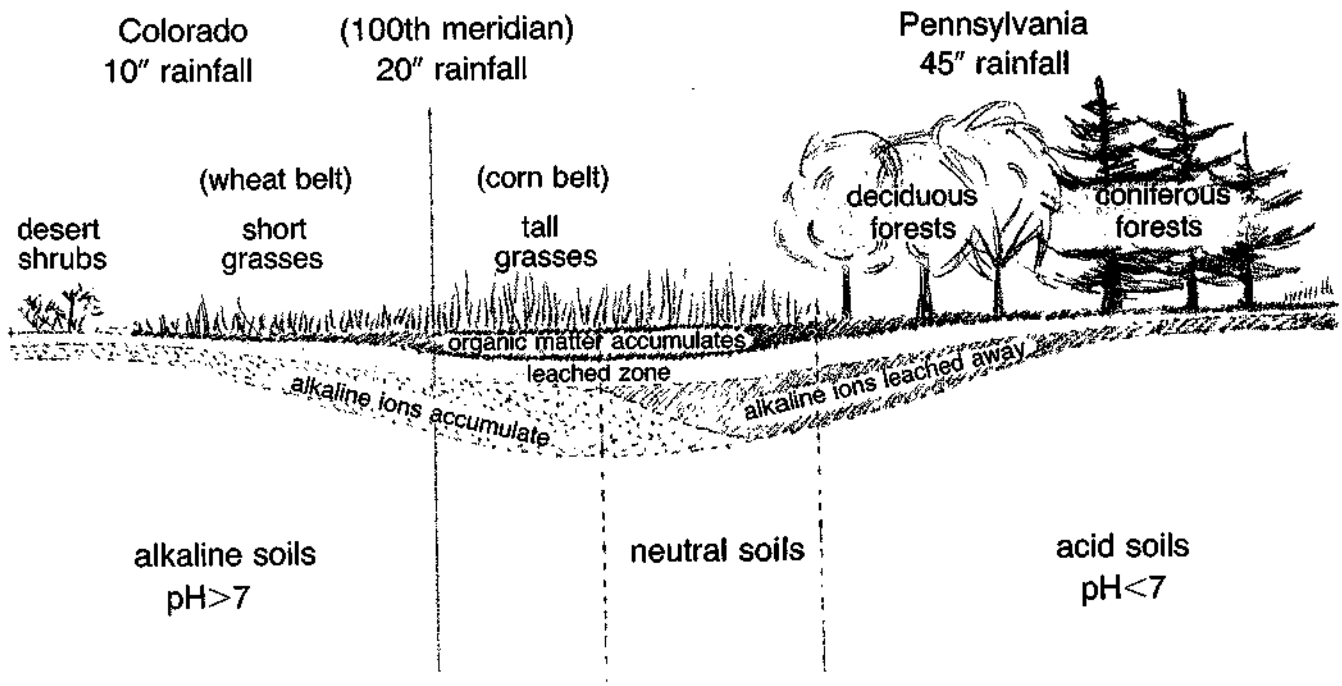


Figure 13. Diagram showing relationship of rainfall, vegetation, soil profile, and soil pH across the United States.

CLASSIFYING SOILS

Soil Series

Soils have been classified into orders, suborders, great groups, subgroups, and families. Pedological age, temperature and water regimes, and special features such as fragipans, are some of the characteristics on which the system is based.

A local soil has a combination of traits unique to it, such as parent material, texture, drainage characteristics, horizon sequence, and landscape position. A given soil is likely to be found over a limited geographic region wherever the same bedrock and landscape position are found. It is ordinarily associated with other local soils on associated bedrock and landscape positions. Such an individual soil has its own name (e.g., Duffield, Volusia, or Conotton) and is called a *soil series* (see Fig. 14).

County Soil Surveys

The Soil Conservation Service of the U.S. Department of Agriculture surveys and maps the soils of the United States, and publishes survey reports. Soil surveys contain valuable data about local soils, including maps, yield potentials for each soil series, limitations for development, and detailed soil-identifying features. Surveys for most counties in Pennsylvania have been completed and are available. You can get one by requesting it from your county agent, your representative in Congress, or your local office of the Soil Conservation Service. Soil surveys for every county in Pennsylvania will be available by 1989.

A bulletin with detailed tabular information for the soils of Pennsylvania can be ordered from: Agronomy Extension, 106 Agricultural Administration Building, The Pennsylvania State University, University Park, PA 16802. Ask for *Soils of Pennsylvania — Their Extent, Classification, Characteristics, and Uses.*

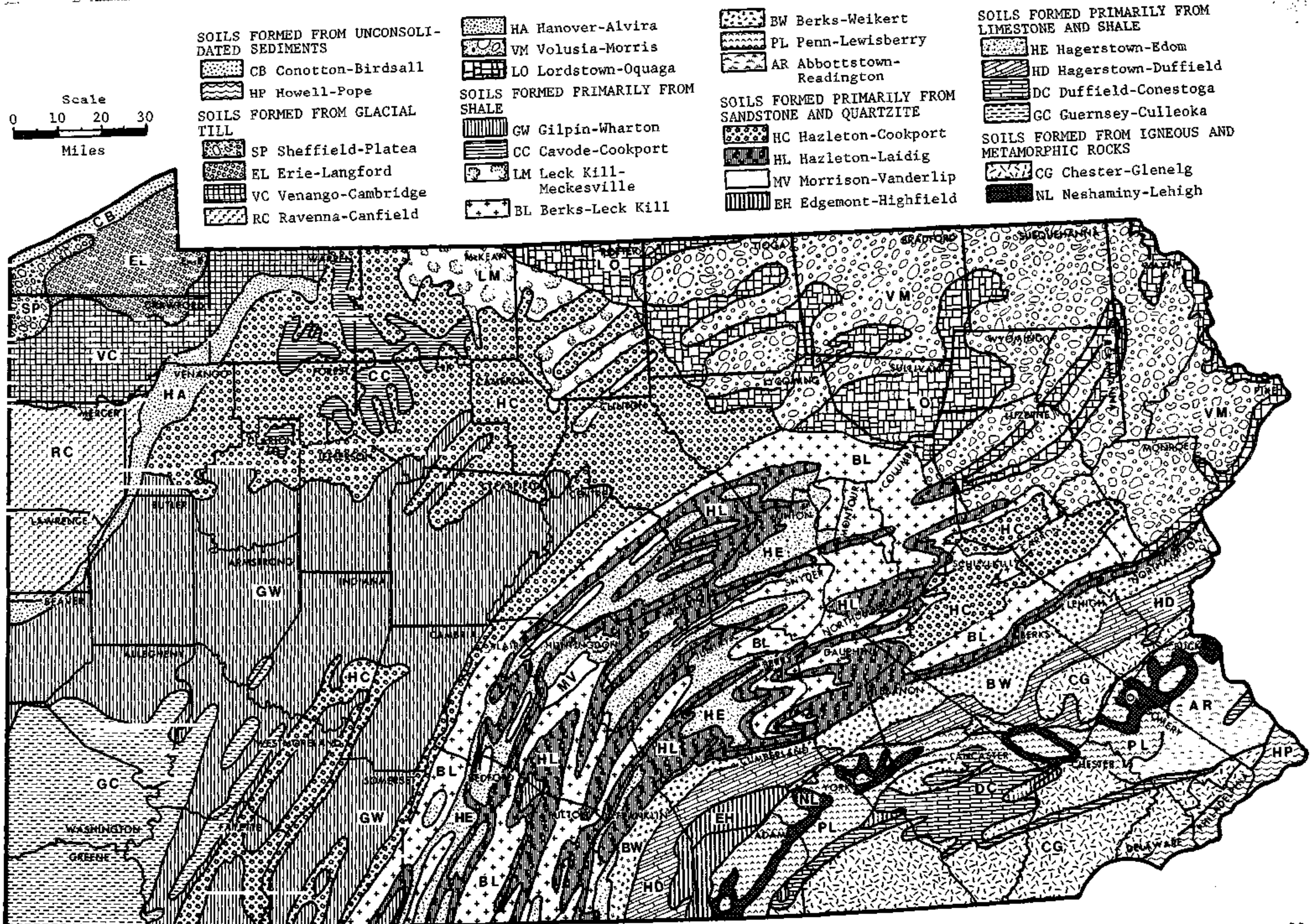


Figure 14. Diagram of Pennsylvania soil associations. Soil associations are groups of soil series commonly found together.

SOIL ASSOCIATIONS OF PENNSYLVANIA

By Edward J. Ciolkosz, Robert L. Cunningham, and Gary W. Petersen Agronomy Series No. 62, The Pennsylvania State University 1980

Symbol	Soil Series	Depth Class	Drainage Class	Surface Texture	Subsoil Texture	Color	Parent Material
AR	Abbottstown	Deep**	Somewhat Poorly	Silt Loam	Silt Loam+	Grayish Red	Acid Red Shale
	Readington	Deep**	Moderately Well	Silt Loam	Silt Loam+	Reddish Brown	Acid Red Shale
BL	Berks	Mod. Deep	Well	Loam+	Loam++	Yellowish Brown	Acid Brown Shale
	Leck Kill	Deep	Well	Silt Loam	Silt Loam+	Reddish Brown	Acid Red Shale
BW	Berks	Mod. Deep	Well	Loam+	Loam++	Yellowish Brown	Acid Brown Shale
	Weikert	Shallow	Well	Loam+	Loam++	Yellowish Brown	Acid Brown Shale
CB	Conotton	Deep	Well	Sandy Loam+	Sandy Loam++	Brown	Sand and Gravel
	Birdsall	Deep	Very Poorly	Silt Loam	Silt Loam	Gray	Glacial Silts
CC	Cavode	Deep	Somewhat Poorly	Silt Loam	Silty Clay	Grayish Brown	Acid Clay Shale
	Cookport	Deep**	Moderately Well	Loam	Clay Loam+	Yellowish Brown	Acid Brown Shale
CG	Chester	Deep	Well	Silt Loam	Silty Clay Loam	Brown	Gneiss and Schist
	Glenelg	Deep	Well	Loam+	Silt Loam+	Brown	Gneiss and Schist
DC	Duffield	Deep	Well	Silt Loam	Silty Clay Loam	Yellowish Brown	Shaly Limestone
	Conestoga	Deep	Well	Silt Loam	Silty Clay Loam	Brown	Micaceous Limestone
EH	Edgemont	Deep	Well	Sandy Loam+	Loam+	Yellowish Brown	Quartzite
	Highfield	Deep	Well	Silt Loam+	Silt Loam+	Yellowish Brown	Metarhyolite
EL	Erie	Deep*	Somewhat Poorly	Silt Loam+	Loam+	Grayish Brown	Calcareous Till
	Langford	Deep**	Moderately Well	Silt Loam+	Loam+	Yellowish Brown	Calcareous Till
GC	Guernsey	Deep	Moderately Well	Silt Loam	Clay+	Yellowish Brown	Limestone and Shale
	Culleoka	Mod. Deep	Well	Silt Loam	Silt Loam+	Brown	Limestone and Shale
GW	Gilpin	Mod. Deep	Well	Silt Loam+	Silt Loam+	Yellowish Brown	Shale and Sandstone
	Wharton	Deep	Moderately Well	Silt Loam	Silty Clay Loam+	Brown	Shale and Siltstone
HA	Hanover	Deep**	Well-Mod. Well	Silt Loam+	Silt Loam+	Yellowish Brown	Leached Till
	Alvira	Deep**	Somewhat Poorly	Silt Loam+	Silt Loam+	Grayish Brown	Leached Till
HC	Hazleton	Deep	Well	Sandy Loam+	Sandy Loam++	Yellowish Brown	Acid Sandstone
	Cookport	Deep**	Moderately Well	Loam	Clay Loam+	Yellowish Brown	Acid Sandstone
HD	Hagerstown	Deep	Well	Silt Loam	Clay	Red	Limestone
	Duffield	Deep	Well	Silt Loam	Silty Clay Loam	Yellowish Brown	Shaly Limestone
HE	Hagerstown	Deep	Well	Silt Loam	Clay	Red	Limestone
	Edom	Deep	Well	Silty Clay Loam	Clay+	Yellowish Brown	Shaly Limestone
HL	Hazleton	Deep	Well	Sandy Loam+	Sandy Loam++	Yellowish Brown	Acid Sandstone
	Laidig	Deep**	Well	Loam+	Loam+	Brown	Sandstone Colluvium
HP	Howell	Deep	Well	Sandy Loam	Clay	Brown	Sand, Silt and Clay
	Pope	Deep	Well	Loam	Loam	Yellowish Brown	Silty Alluvium
LM	Leck Kill	Deep	Well	Silt Loam	Silt Loam+	Reddish Brown	Acid Red Shale
	Meckesville	Deep**	Well	Loam	Clay Loam	Reddish Brown	Red Shale Colluvium
LO	Lordstown	Mod. Deep	Well	Silt Loam+	Silt Loam+	Yellowish Brown	Acid Brown Till
	Oquaga	Mod. Deep	Well	Loam+	Loam+	Reddish Brown	Acid Brown Till
MV	Morrison	Deep	Well	Sandy Loam	Sandy Clay Loam+	Brown	Sandy Limestone
	Vanderlip	Deep	Well	Loamy Sand	Loamy Sand+	Yellowish Brown	Sandy Limestone
NL	Neshaminy	Deep	Well	Silt Loam	Clay Loam+	Yellowish Red	Diabase
	Lehigh	Deep	Mod. Well-S.W. Poorly	Silt Loam	Silt Loam+	Gray	Metamorphosed Shale
PL	Penn	Mod. Deep	Well	Silt Loam+	Silt Loam+	Reddish Brown	Red Shale
	Lewisberry	Deep	Well	Sandy Loam+	Sandy Loam+	Reddish Brown	Red Sandstone
RC	Ravenna	Deep**	Somewhat Poorly	Silt Loam	Loam+	Grayish Brown	Neutral Till
	Canfield	Deep**	Moderately Well	Silt Loam	Loam+	Yellowish Brown	Neutral Till
SP	Sheffield	Deep**	Poorly	Silt Loam	Silty Clay Loam	Brownish Gray	Fine Textured Till
	Platea	Deep**	Somewhat Poorly	Silt Loam	Silt Loam	Grayish Brown	Fine Textured Till
VC	Venango	Deep**	Somewhat Poorly	Silt Loam	Loam+	Grayish Brown	Calcareous Till
	Cambridge	Deep**	Moderately Well	Silt Loam	Loam+	Yellowish Brown	Calcareous Till
VM	Volusia	Deep*	Somewhat Poorly	Silt Loam+	Silt Loam+	Grayish Brown	Acid Brown Till
	Morris	Deep*	Somewhat Poorly	Loam+	Loam+	Grayish Red	Acid Red Till

*Fragipan at 10-16 inches from the soil surface; **Fragipan at 16-36 inches from the soil surface;
[illegible] coarse fragments

GLOSSARY

active fraction — component of the soil having an ion exchange capacity, specifically clay and organic matter

adsorb — collect and adhere relatively loosely on a surface

aeolian — wind borne

alluvium — river-borne deposit of rock and fine particles

bedrock — solid rock mantle underlying soil or transported rock material

calcareous — soil or rock material with high calcium carbonate content

clay — a) particle size less than 0.002 mm
b) soil containing more than 45 percent clay, less than 40 percent silt, and less than 45 percent sand

colluvium — a deposit of rock fragments and soil material accumulated at the base of steep slopes as a result of gravitational action

exchange capacity — interchange between an ion in solution and another ion on the surface of any surface-active material such as a clay or organic colloid

fragipans — natural subsurface layers with high bulk density relative to the soil above, seemingly cemented when dry, somewhat brittle when moist; low in organic matter, mottled, slowly or very slowly permeable to water and often showing bleached cracks forming polygons

glacial till — unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion

horizons (soil horizons) — layers of soil or soil material approximately parallel to the surface, occurring naturally, and distinguishable from adjacent horizons by differences in color, texture, quantity of organic matter, etc. Simplified horizon designations are: 0 = the surface litter, A = topsoil, root zone, B = subsoil, containing more clay and less organic matter than A, C = parent material, and R = bedrock

igneous rock — rock formed from the cooling and solidification of molten rock, and that has not been changed appreciably since its formation

loess — material transported and deposited by wind and consisting primarily of silt-sized particles

metamorphic rock — rock derived from pre-existing rocks but differing from them in physical, chemical, and mineralogical properties as a result of natural geologic processes, principally heat and pressure, originating within the earth. The pre-existing rock may have been igneous, sedimentary, or another form of metamorphic rock

mine spoil — shattered rock material removed to make way for mining operations and replaced at the site when the mine is abandoned

mottles — spots or blotches of different color or shades of color interspersed with the dominant color

organic matter — any organisms, alive or dead, and any material derived therefrom

outwash — water-sorted glacial material deposited by glacial meltwater

peds — units of soil structure formed by natural processes

pedologic age — maturity of a soil in terms of its developmental characteristics rather than its chronological age

parent material — unconsolidated and more or less chemically weathered mineral or organic matter from which the soil developed

residual soil (residuum) — unconsolidated and partly weathered mineral materials accumulated by disintegration of rock in place

sand — a) particle size between 2 mm and 0.05 mm
b) soil containing more than 84 percent sand

sedimentary rock — rock formed from materials deposited from suspension or precipitated from solution, usually more or less consolidated

silt — a) particle size between 0.05 mm and 0.002 mm
b) soil containing more than 80 percent silt and less than 12 percent clay

soil pH — also soil reaction – the negative logarithm of the hydrogen ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by a suitable indicator at a specified moisture content or soil water ratio, and expressed in terms of the pH scale

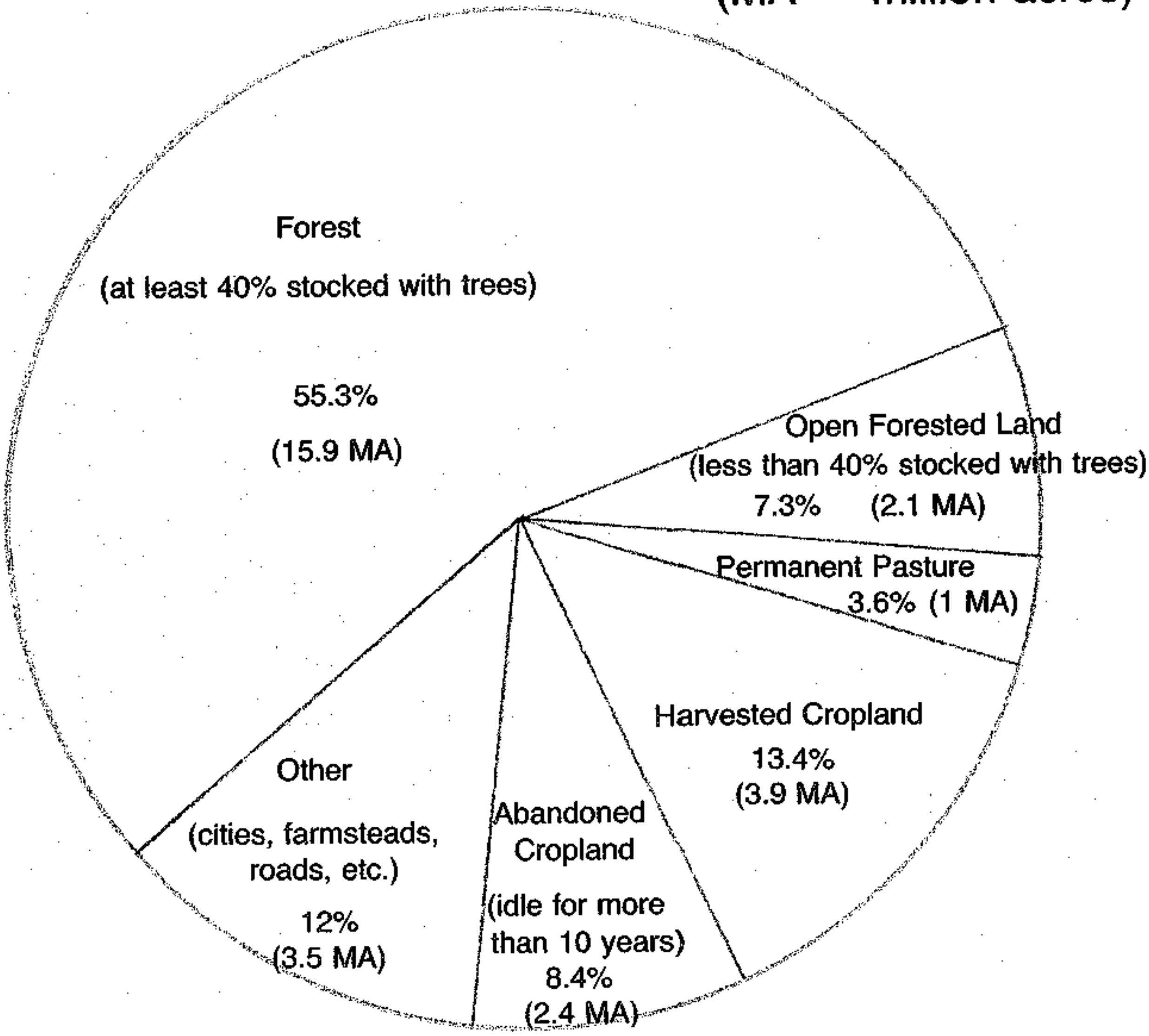
soil series — the basic unit of soil classification, being a subdivision of a family and consisting of soils which are essentially alike in all major profile characteristics except the texture of the A horizon

soil structure — combination or arrangement of soil particles into larger units, or peds

soil texture — relative proportions of various soil sized particles characterizing a soil, as described by the classes of soil texture shown on the textural triangle

strip mining —mining technique involving removal of all rock, soil, and plant material above the desired deposit. When the mine is abandoned, the disturbed material is replaced in the pits, leaving the surface without soil or plant cover.

Land Use in Pennsylvania
(MA = million acres)



From "Open and Forested Upland Range for Beef Production", Final Research Report for the Pennsylvania Department of Agriculture, project no. 2128, College of Agriculture, The Pennsylvania State University, 1981.

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