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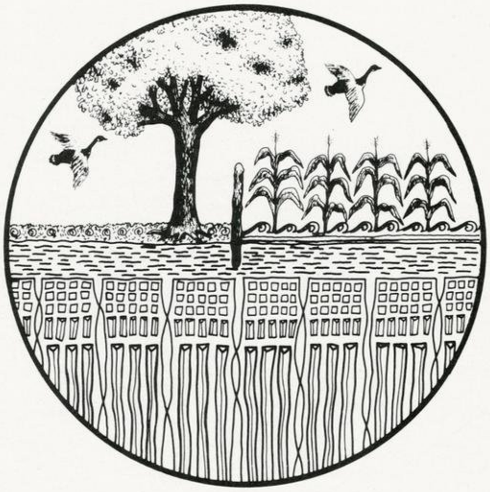

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In cooperation with the Department of Soil Science,
College of Agricultural and Life Sciences
University of Wisconsin–Madison;
and the Soil Conservation Service,
U.S. Department of Agriculture

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Preface

This book is intended to introduce students of the environment to the soils of the landscapes in which they live in Wisconsin. So important are soils that we may refer to the soil landscape by a special term: **soilscape**. It is the soils portion of the landscape which supports plant growth, and ultimately our own lives. Where rock knobs and lakes interrupt the soilscape, the versatility of the total landscape is increased.

Most of us remember visiting, as children, natural history museums where rocks and minerals, mounted plants, insects, birds, and animals were displayed. We may have made such collections ourselves. But we were not made aware of the possibility of collecting soil specimens. Neither did we have the idea that individual **soil bodies** lie upon the landscape like identifiable pieces of a mosaic. The soil body of scientific lore has been a difficult concept for humankind to come by. Today, our major libraries display shelf upon shelf of county soil survey reports with detailed soil maps printed on aerial photographic base that have been published during recent decades. Citizens turn increasingly to these publications as useful guides for evaluation and wise management of private and public lands for the routing of highways and utilities, and for the selection of suitable sites for disposal of wastes.

It is evident that we cannot know too much about soils. This book shows one way to begin the adventure of soil study . . . one way to become acquainted with the ground beneath our feet. Perhaps we may even learn to think like a soil, to paraphrase the famous words of Aldo Leopold, who learned to "think like a mountain" half a century ago. To think like a soil is to concentrate the mind and imagination on what goes on in the 2-meter-thick epidermis of the landscape, in which our life is rooted.

I am grateful to those who have taught me about this through their writings or by personal interaction. The names of soil scientists – soil walkers and diggers – who have been my teachers, include V. V. Dokuchaev and E. W. Hilgard, C. F. Marbut and C. E. Kellogg, H. Jenny, O. C. Rogers, J. Thorp, I. J. Nygard, J. K. Ableiter, R. W. Simonson, R. J. Muckenhirn, S. A. Wilde, M. L. Jackson, F. H. King, and A. R. Whitson. M. E. Ostrom, State Geologist and Director of the Geological and Natural History Survey, G. B. Lee, E. J. Tyler, J. G. Bockheim, J. R. Love, L. E. Engelbert, A. J. Klingelhoets and George W. Hudelson have given valuable suggestions.

The reader is referred to the books *Soils of Wisconsin* (Hole, Lee and Beatty, 1976), *Physical Geography of Wisconsin* (Martin, 1974), *The Vegetation of Wisconsin* (Curtis, 1959), and to a pamphlet on crop yields (Tyler, Klingelhoets, 1978).

1. The Evolution and Survival of Wisconsin Soils

The soil is the nursery and foundation of life on land. It is a biological preserve inhabited by numerous living things, ranging in size from viruses to moles, from algae to large tree roots. The smallest organisms – including viruses, bacteria, fungi, algae, protozoa, and nematodes – live in thin water films covering the soil particles (Figure 1). Soil nourishes a host of living creatures, including ourselves, and receives the debris and ashes of the dead, recycling their elements back into productive plants and animals. How did Wisconsin soils get to be? How did they evolve?

Wisconsin has inherited not only the vast population of soil creatures just mentioned, but also larger ones of the plant and animal kingdoms that we see as we walk through forests and grasslands. Among these are trees, grasses, earthworms, chipmunks, ants and beetles. Citizens of this state have also inherited geologic materials left by the glaciers, winds, and waters such as (1) rocks produced by ancient volcanic activity, both deep-seated and superficial; (2) sedimentary rocks in which fossils of marine life forms are preserved; (3) glacial drift and a silty mantle called **loess**. The living things that evolved over billions of years invaded the rock materials, along with rainwater and air, all illuminated by the sun. The influence of organisms and climate on the geologic materials shaped our soils. The earthworm has been called a "soil factory" because it mixes humus with fine rock particles and blends them into fertile soil material, in which it constructs water-conducting channels. The earthworm is just one of many builders of the soil.

Figure 1. Diagrammatic cross-section of (left) a soil pedon with A1, A2, B and C horizons, earthworm burrow and midden; and (right) 1.5 mm^2 of fresh, undisturbed subsoil (B horizon). Legend: c = clay skins (argillans) coating walls of voids; fh = fungal hyphae; mr = mycorrhizum; n = nematode; p = plasma (clay and fine silt) of soil; rpr = amoeba (rhizopodal protozoan), r = live root; rh = root hair; v = air-filled void; w = water film in void; s = skeletal sand grains.

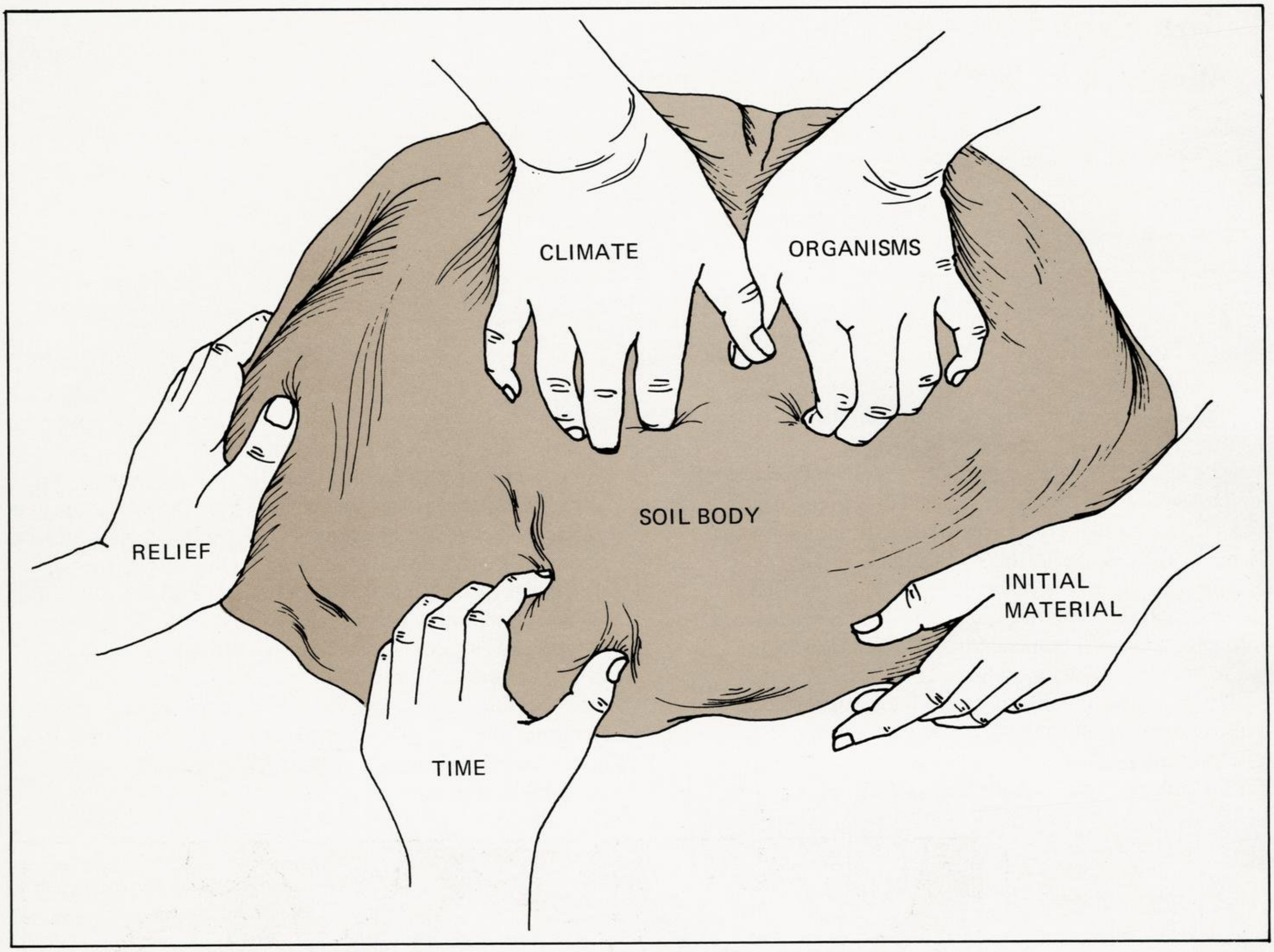


Figure 2. Symbolic diagram of the five factors of soil formation.

Organisms and climate have been mentioned as two factors of soil formation that may be compared to the two hands of a baker, shaping original ingredients into that first "staff of life," which is soil. The famous Scot economist, Adam Smith (1723-1790), had a theory about a competitive economic system that viewed individuals' pursuit of their own ends as being guided by an invisible hand in such a way that the greatest good was achieved for all members of society. The Russian soil geographer, V. V. Dokuchaev (1846-1903), like the American soil scientist, E. Hilgard (1833-1916), conceived of five factors that direct soil formation. We may think of them as five hands (not as invisible as the one in Adam Smith's theory) guiding soil development over the centuries and millenia, in harmony with the needs and capacities of plants and animals. Two of these hands (Figure 2), labeled **organisms** and **climate**, are definitely active like the baker's hands mentioned above. Two are passive, namely **initial (parent) material** and **relief (landform)**; and the fifth is the hand of **time**. How have these five guiding hands operated in Wisconsin?

They have operated, as we shall see in more detail in subsequent chapters, as follows. First, **materials** from which the soils are formed have been provided by geologic agents . . . glaciers, wind, and water for the most part. Five million acres of sandy soils, for example, are located in north and central Wisconsin (Regions C and H, Figure 17) because water and wind deposited sand (initial material) there in the first place. Second, the **relief** or "lay of the land" was also determined by geologic agents. This is illustrated by the steep soils of the Kettle Moraine, whose hills were created by glaciation. Third, **climatic conditions** in northern Wisconsin have guided soil formation in a different direction from that in southern counties. In the north, mean annual temperatures are lower, conditions usually more moist, the growing season shorter and accumulation of organic matter greater – producing notably acid soils. Fourth, differences in **vegetation** between southern and northern counties are well known. Dark prairie soils are found in the south. Pale soils have formed under pine and hemlock forests in the north. Finally, the factor of **time** is noteworthy because some major differences in soils result from age differences. Most of the 500 or so kinds of soils in Wisconsin are less than 15,000 years old. That may sound old to us human beings, but as soils go, that is a time span that allows only for early soil maturity to be reached on stable uplands. Some of the oldest soils are in the **Driftless Area** (Figure 20) that escaped invasion by the recent glaciers that occupied the rest of the state. Very youthful soils lie both on bedrock knobs and in valley bottoms. Where flood deposits are laid down frequently, soil formation starts afresh each year.

Given enough time, soils might take over entire landscapes. This happens by increments. For example, large pine and hemlock trees that have blown down in windstorms rot away into the forest soil. In a sense, the soil that once supported those majestic trees, consumes them in the end. Soils invade lakes in the form of peat, turning the bodies of water into bogs. Rock outcrops crumble and are changed to soil. Neglected buildings sag, collapse and succumb to processes of soil formation. It is only by dint of constant repair that the pavements and structures of our civilization are rescued from decay and a return to soil. The soil of the countryside naturally tends to extend itself into the cities, but is prevented from doing so by a reverse effort to extend the city into the country. Wherever this effort has slackened, soils have taken over again. Archaeologists have long known this and have excavated soil layers at sites of ancient, buried cities. In short, trees, rocks, lakes and structures of humankind are all temporarily **not-soil**. Left to itself the dynamic soil appropriates nearly everything in its way.

Soil has astonishing persistence. The soils that we see today are those that have survived. What enabled them to survive? How may we help them to continue to function as a mainstay of life in Wisconsin?

There is one part of our planet system that is more insatiable than the soil. The oceans are greater devourers. They eat away at the land and receive at the mouths of rivers vast quantities of eroded soil, which is the initial material for new sedimentary rocks. Erosion of soil to the sea is effectively slowed by the protective vegetative cover, conservation practices, and channeling by worms. Even with the shields of vegetation, mulches of gravel, humus or plant litter, and conservation practices, soils have the ultimate destiny of being transferred to the oceans, as shown by the geologic record of layers of sandstone, siltstone and humic shale. Were it not for continuing uplift above sea level of parts of the earth's crust, the soilscape would be swallowed into the seas. Wisconsin soils seem entirely remote from this fate, secure in the heart of the North American continent. Yet the waves of Lake Superior and Lake Michigan consume about 5 feet (1.5 meters) of shorelands each year, or one mile (1.7 km) in 1,000 years.

We may conclude that Wisconsin's upland soils have survived 10,000 to 20,000 years because they have been protected by vegetative cover and mulch, and have been kept porous by growing plant roots and activity of worms and other creatures. *The modern major human threat to survival of Wisconsin soils is the removal of vegetation and exposure of soil to raindrop impact which seals the surface by making a crust. The crust, in turn, speeds runoff and erosion.* Land managers help maintain a soil in good condition when they vegetate it, as with hay crops, or maintain a mulch on it, and establish other possible soil and water conservation practices.

The delicate capacity of soil to absorb water needs emphasis. Masses of solid bedrock, such as granite and quartzite knobs, shed water. A healthy soil absorbs it. In a sense, the fact that higher animal life, including birds, mammals and humans, take in water signifies their kinship to soil which was the first "drinker" on earth. These animals contain in their guts an interior body of dynamic "soil," which is continually being renewed and evacuated. The Chinese have traditionally referred to human excrement as "night soil." Long fasts voluntarily undertaken by ascetics or forced on starving people by famine may be the ultimate separation of living human beings from soil – both the exterior one that supports crop growth, and the interior one that promotes assimilation.

The "exterior soil" of Wisconsin is the subject of this book. This will now be explored, starting with some useful definitions.

2. Definition of Soil

A hierarchy of parts of a soilscape includes the following (Figures 3, 4, and 5):

Soilscape: a cluster of soil bodies associated in a landscape
Soil polypedon (soil body): a cluster of similar pedons
Soil pedon: a column of soil about a meter in diameter
Soil horizon: a significant layer in a pedon
Soil ped: a cluster of particles of mineral and organic matter constituting a structural unit in a soil horizon
Soil s-matrix and special features: solid components of and additions to peds
Soil water and soil air: soil components occupying voids

A body of soil is a soil individual. For example, a body of Ogden muck (Figure 3) lies like a black, spongey "lake" in an undulating to gently rolling landscape in Waukesha County.* This soil body is a little over one meter thick, 1500 meters (nearly a mile) long and half as wide, with an area of about 77 hectares (190 acres).

The scientific description of a soil body as a natural object of study requires that we define its practical boundaries. The upper boundary is the surface of the organic soil horizons which are the leaf litter, humus and peaty layers (Figure 4). The lower boundary is the subsurface or under surface of the soil horizons that have been changed by plant growth, animal activity and percolating water. The lateral boundary is the locus of points at which other kinds of soil bodies are encountered. A soil individual is a volume containing gaseous, liquid and solid matter, including small organisms and roots. A soil body is a definite, broad slab of soil about a meter or two thick. By convention, various vertical extensions and temporarily detached portions of it are omitted. For example, (Figure 4) bird and wasp nests made partly of soil materials, standing dead trees, and downward extensions of the B horizon are not usually considered parts of a soil body.

A soil body has many components. In fact there are components within components, as expressed by the following jingle:

Naturalists observe
Soils have parts inside them;
Each part has smaller parts,
And so ad infinitum.

*In sections 17 and 20, T.6N., R.20E. (Sheet No. 85 in Steingraeber and Reynolds, 1971).

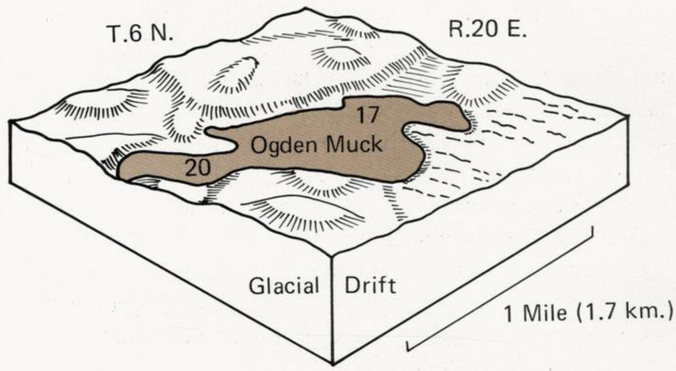


Figure 3. Block diagram of a portion of a soil landscape in Waukesha County, Wisconsin showing a body of Ogden muck, in sections 17 and 20, Township 6 North, Range 20 East.

A soil body has variations within it and possibly even small patches of other soils. But, assuming a uniform soil body, we may note that it is several-ply in structure. Each layer is called a **soil horizon.** The soil horizons are designated by capital letters:

Major soil horizons in mineral soils

Letter designation of horizon	Some attributes	
O	Organic layers (litter, humus, peaty material)	
A	Surface mineral horizons	A1–dark with organic matter A2 (or E)*–lighter colored
B	Mineral subsoil horizons	B1–upper B horizon–commonly brown color B2–middle B horizon – commonly brown color B3–lower B horizon – commonly brown color
C	Initial (parent) material	

*Some scientists refer to the pale horizon as an "eluviated" or E horizon.

The **O horizons** are composed of the litter of leaves and the humus that results from their decomposition. The decomposition process ultimately releases components back to the air and soil. The **A horizon** in many forest soils consists of a surface mixture of humus and mineral matter (sand, silt, clay), in which earthworms and other soil animals are commonly active; and a paler subsurface leached layer (A2 or E) which does not receive as much organic material as the A1. The **B horizon** has received fine clay and iron compounds washed down from the A horizon. Because of this enrichment in yellowish-brown clay, the B horizon is usually stickier than the A horizon, more subject to cracking upon drying, and browner or even redder in color than the surface soil.

The A and B horizons are made up of smaller parts called peds:

Major soil horizons and component peds in a forest soil of southern Wisconsin

Letter designation of horizons	Names (underlined) of types of peds	Approximate diameters of peds
A1	Granules and fine blocks	1 to 10 mm
A2	Fine and medium plates	2 to 5 mm
B1	Fine blocks	5 to 10 mm
B2	Medium-size blocks	10 to 20 mm
B3	Coarse blocks and fine to medium-size prisms	20 to 50 mm

The granules may be ball-shaped earthworm casts or clusters of soil particles made by activities of other animals, plant roots, or by movements of the soil itself during freeze-thaw cycles. In very clayey soils, the swelling and shrinking of the soil during wet-dry cycles causes the soil to break into fine blocks. Blockiness is on a larger scale in the B horizons, becoming progressively coarser with depth. In the lower B horizon, blocks may be observed to be arranged in vertical columns called **prisms**.

Peds (and some soil horizons that have no peds, but are rather uniform or massive throughout) are composed of smaller parts. The three major components of a blocky ped from a B horizon are as follows:

Major components of a blocky ped of soil

Ped	Components		
Block	Skeleton grains (sand and coarse silt particles)	The soil matrix (S-matrix)	
	Plasma (clay and fine silt particles, both mineral and organic		
	Voids (pores)		
	Special features (made of both mineral and organic matter)	Glaebules (ball-shaped units)	
		Tubules (rod-shaped)	
		Coatings (cutans)	
		Plasmic fabric (microscopic alignment of clay particles)	

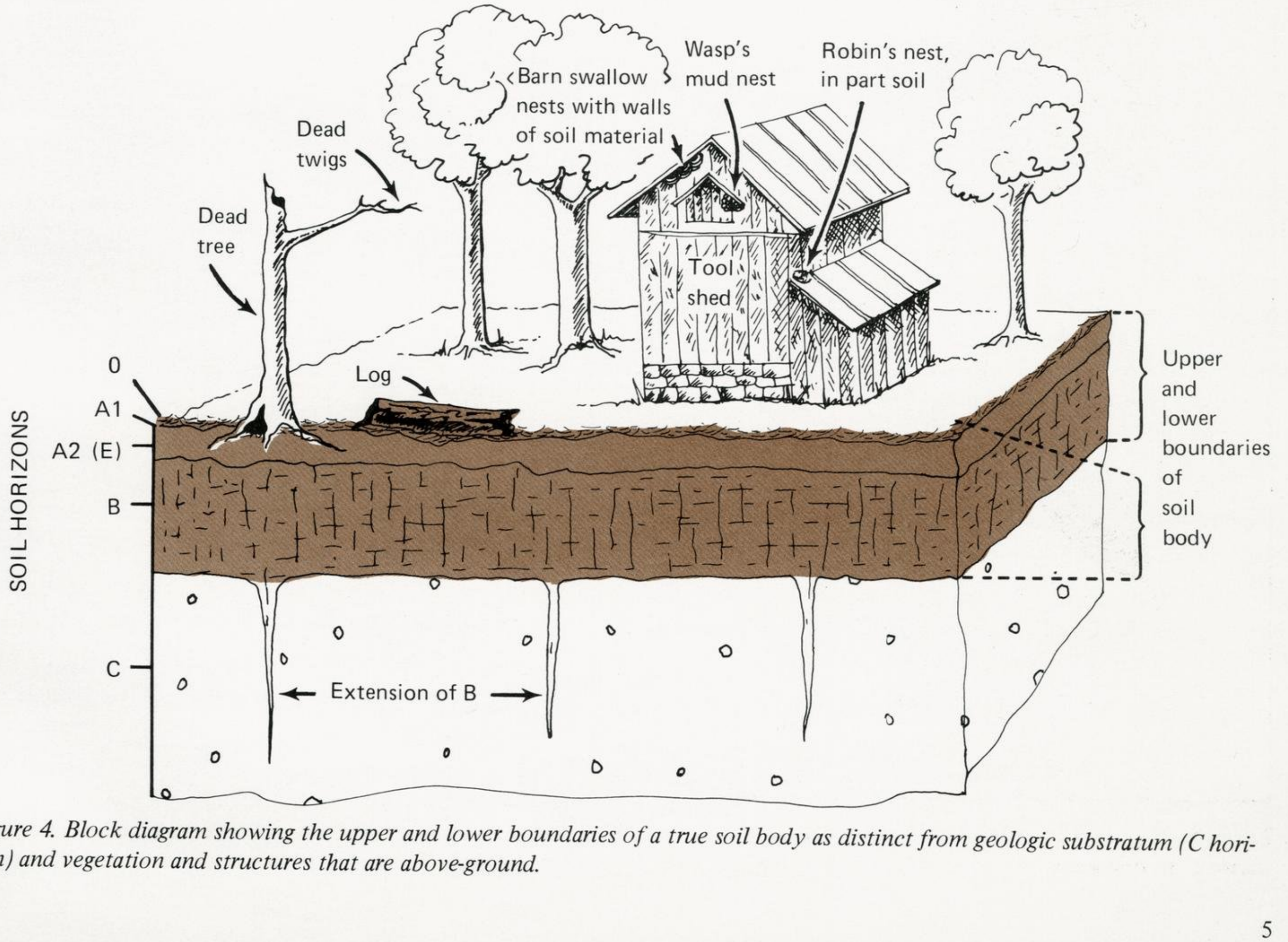


Figure 4. Block diagram showing the upper and lower boundaries of a true soil body as distinct from geologic substratum (C horizon) and vegetation and structures that are above-ground.

The presence of **voids** distinguishes soil from a solid rock like granite. A cubic centimeter of granite with 6 cm^2 of surface area has, after being weathered to soil, about 5 million cm^2 of surface area. This change involves expansion of the cubic centimeter of material to double its original volume to make room for the pores. The **plasma** is the most mobile part of the soil; that is to say, it can be washed out of the soil by seepage water more easily than can the **skeleton grains**. During thousands of years some of the plasma of the A horizon has washed gradually down into the B horizon, causing the subsoil to be stickier than the surface soil.

There are three minor components of a blocky ped that result from rearrangement of materials of the S-matrix (voids, skeleton grains and plasma, Figure 5).

(1) Small spherical and rod-shaped bodies have been produced during soil formation. These are called **glaebules and tubules**, respectively. They may contain admixed humus.

(2) Coatings on the outer surface of a ped and even linings in small channels inside peds, are called **cutans** ("clay skins" with organic matter and iron oxide included).

(3) The third component is actually a particular arrangement of plasma materials. This can be seen only in thin sections with the aid of a petrographic microscope. Hundreds of thousands of clay particles may lie parallel to each other, rather than in random fashion. The parallel arrangement is in the form of **streaks and patches of plasma**. This has probably resulted from moist soil slipping under stress, which may make the soil prone to yield under future stress.

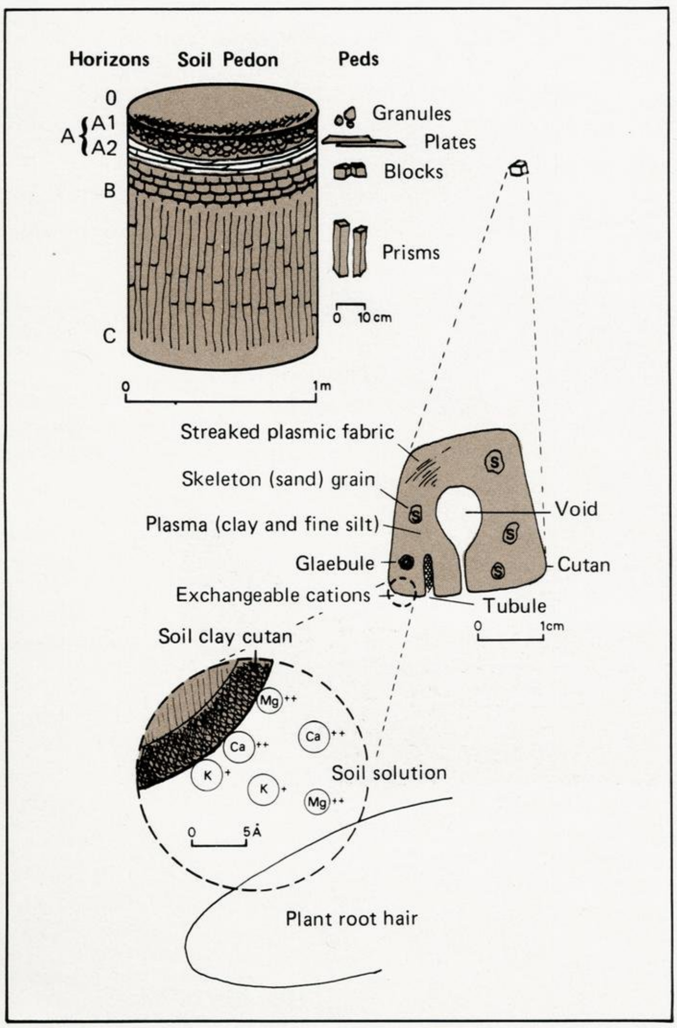


Figure 5. Diagram of a soil pedon and components of it, shown at several scales.

The glaebules may form by cementation of soft soil by iron oxide that is picked up in percolating water and then precipitated around a sand grain or organic matter particle. If the resulting hardened ball-shaped particle is concentrically layered, it is called a **concretion**. If it is not layered, it is referred to as a **nodule**. Tubules are earth fillings of earthworm and root channels. Cutans are deposits (from percolating rainwater) of fine clay, organic matter and iron oxide. Some cutans look like brown tallow that has run down the side of a candle.

The plasma contains clay particles, less than 0.002 mm or 8/100,000ths of an inch in diameter, that are remarkably responsive, especially in the colloidal range ($<.001$ mm). Shrinking on drying and swelling on wetting are typical responses to changes in moisture conditions. Exchange of nutrient elements is another response of the clay and associated colloidal humus to the soil solution. The range in clay species, in terms of responsiveness, is shown in Figure 6.

Exchange of plant nutrients takes place at the surface of clay and organic particles that are wetted by the same soil solution in which plant roots grow (Figure 5). Plant nutrients like calcium (Ca^{++}), magnesium (Mg^{++}) and potassium (K^{+}) are held loosely at the clay surfaces by electrical charges. The clays are weakly negative in charge, and the nutrient ions just mentioned are positively charged. A nutrient that is abundant in the soil solution may exchange for nutrients on the clay surfaces. The exchange process works like that in a water softener, where calcium in hard water exchanges with the sodium ions that then give the water its "softness."

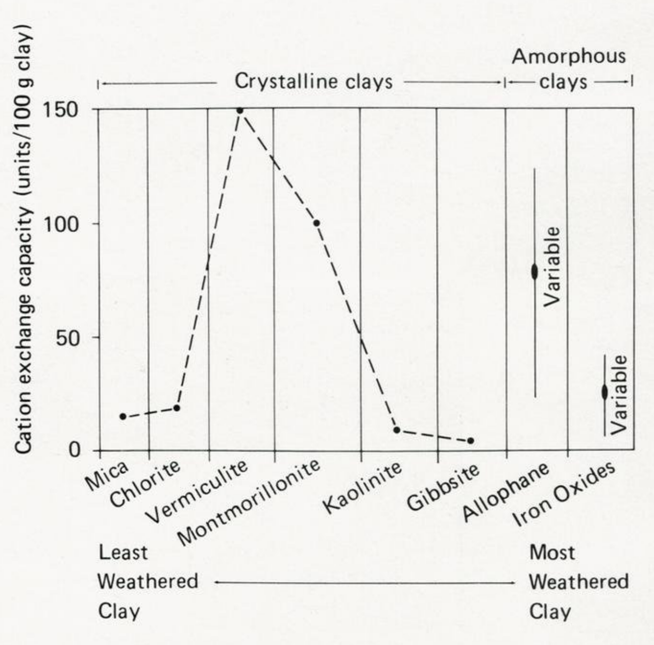
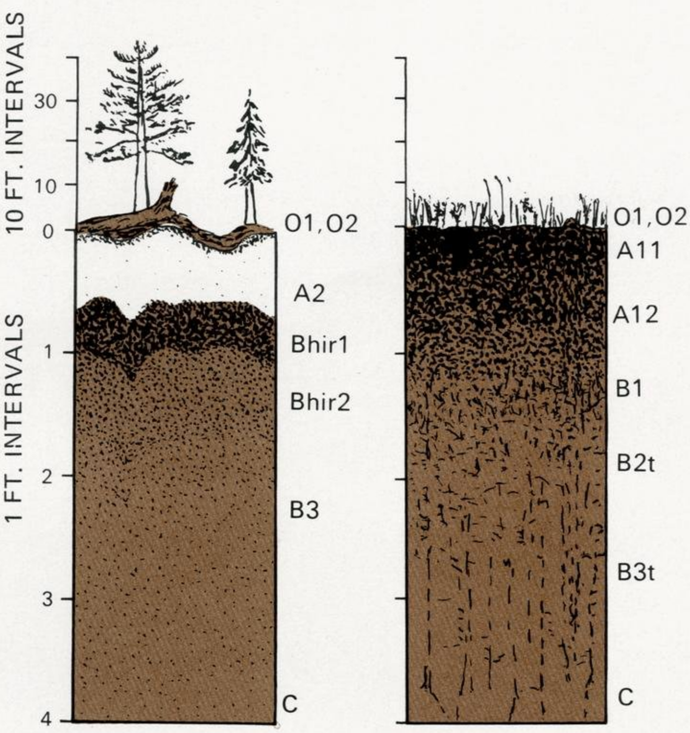


Figure 6. Diagram illustrating the range of cation exchange capacity among common kinds of soil clays. Humus has CEC comparable to vermiculite and montmorillonite.

3. A General Guide to Soil Horizons in Wisconsin

A soil horizon is a natural soil layer, lying parallel to the surface of the ground. Dark surface soil horizons take about 300 years to reach equilibrium in Wisconsin. Some of these horizons contain bits of organic matter that are thousands of years old, mixed with fresh organic matter newly formed by plants.

Black, white and red are the three extreme soil colors, and in the rare instance in which these appear together in three sequential horizons, the effect is startling. The sketch of the profile of the Pence sandy loam in Figure 7 is of a forest soil with a black O horizon under which is a nearly white A2 or E horizon and under that is a coffee-brown Bhir (humus-iron) horizon. These are sometimes referred to as the "barber-pole soils" because of the dramatic contrasts in color. Most soils are more subdued in color, however, and transitions from one horizon to another are gradual, and may escape the unpracticed eye.



Pence sandy loam, a forest soil of northern Wisconsin

Plano silt loam, a prairie soil of southern Wisconsin

Figure 7. Two contrasting soils, as seen in cross-section. (Courtesy Univ. of Wis. Press) (After Hole, 1976).

The terms **topsoil** and **subsoil** refer to what soil scientists call the A and B horizons. There are two major subdivisions to the A horizon; the dark A1 (surface) horizon and the paler A2 (subsurface) horizon. A prairie soil, like the Plano silt loam (Figure 7), has the A1 horizon so deeply developed that the A2 has been darkened and incorporated into the A1. Forest soils like the Pence soil have an A2 (E) horizon, but no A1 horizon.

The guide in Figure 8 shows that we can distinguish between horizons in true soil and also in geologic materials that have not yet changed to true soil. Examples of **geologic horizons** are solid bedrock (R), and loose geologic materials such as glacial drift (C horizons), and deposits of peat and muck saturated with water.

True soil horizons may be grouped into the two main, familiar categories: organic and mineral.

The **organic horizons** may be thin and well exposed to air, as are the forest litter layer (01) and humus layer (02 horizon), or may be moderately thick ($<$30 cm; 12 inches) and frequently saturated with water, as in a peat or muck surface layer. **An epipedon** is the "epidermis" of the soil body, and if it is moderately thick peat or muck, and commonly wet, it is called a **Histic epipedon.** Thick ($>$30 cm; 12 inches) organic horizons are placed into three major categories: **fibric** (0i) horizons are dominantly fibrous and contain plant parts easily recognizable; **hemic** (0e) horizons, with only a moderate amount of fibrous material mixed with a dark, soft, paste; and **sapric** (0a) horizons are almost free of fibrous material, and consist of a soft, dark paste.

Mineral soil horizons above the C horizon may be grouped under two headings: surface soil (A horizons) and subsoil (B horizons).

Dark A horizons are labeled A1, and may be thin **(Ochric epipedon)** or thick **(Mollic epipedon)**. A thickness of 18 cm (7 inches) is roughly the dividing point between the two. If the lower part of the A horizon is relatively pale in color, it is designated as the A2 (or E) horizon, may be included in the ochric epipedon, and if very pale, may be called an **albic horizon.**

Subsurface soil horizons include relatively bright brown ones and bluish gray ones. There are three brown horizons. First is the "weak" B which lacks a distinct accumulation of clay. It is called a **cambic B**. A clay-enriched B, sometimes labeled Bt (t = clay; der Ton is German for clay), is called the **argillic horizon.** If the B horizon is enriched with iron oxide and humus, it is labeled the Bhir and is called the **spodic horizon.** Bluish gray subsoil layers are labeled "g," and are termed **gleyed horizons.** They may be gleyed cambic (Bg) or gleyed argillic (Btg) horizons.

Soil horizons are anatomical units of a soil, somewhat analogous to organs in the human body. The O and A horizons are the locus of most of the accumulation and decomposition of organic material in the soil. It is there that "digestion" takes place. Earthworms may even excrete enzymes and digested leaf litter into the soil before ingesting the material. Accumulations of organic matter in the soil (chiefly in the A horizon) and of colloidal humus and clay (chiefly in the B horizon) are storage sites for plant nutrients and water. Some Chernozem soils (Borolls) of the U.S.S.R. are so high in content of colloidal materials that they are called "fat" Chernozems. The sand grains, pebbles and stones provide the true skeleton of the soil, but soil peds of granular, platy, blocky and prismatic forms also serve as supportive units, particularly when the soil is only moderately moist to dry.

Figure 8. Guide No. 1–Soil horizons in Wisconsin.

Categories and Properties						Horizon SYMBOL	Horizon NAME or description
All soil horizons	True soil	Organic	Thin (<30 cm; 12")	Leaf litter		01	--
All soil horizons	True soil	Organic	Thin (<30 cm; 12")	Humus	Quite thin	02[1]	--
All soil horizons	True soil	Organic	Thin (<30 cm; 12")	Humus	Not so thin	02[1]	Histic epipedon[2]
All soil horizons	True soil	Organic	Thick (>30 cm; 12")	Fibrous peat		Oi	Fibric
All soil horizons	True soil	Organic	Thick (>30 cm; 12")	Half peaty; half mucky		Oe	Hemic
All soil horizons	True soil	Organic	Thick (>30 cm; 12")	Pasty muck		Oa	Sapric
All soil horizons	True soil	Mineral	Surface soil (epipedon)	Dark	Thin	A1[3]	Ochric epipedon
All soil horizons	True soil	Mineral	Surface soil (epipedon)	Dark	Thick (> cm; ")	A1[3]	Mollic epipedon[4]
All soil horizons	True soil	Mineral	Surface soil (epipedon)	Pale		A2(E)[3]	Albic[6]
All soil horizons	True soil	Mineral	Subsurface soil	Rather brighter in color than A horizon	Weakly developed (not notably clayey or rich in iron or organic matter)	B[3]	Cambic
All soil horizons	True soil	Mineral	Subsurface soil	Rather brighter in color than A horizon	Clay-enriched	Bt[3]	Argillic
All soil horizons	True soil	Mineral	Subsurface soil	Rather brighter in color than A horizon	Iron- and humus-enriched	Bhir[3]	Spodic
All soil horizons	True soil	Mineral	Subsurface soil	Rather bluish gray in color		Bg[3]	Gleyed cambic
All soil horizons	Not yet true soil	Unconsolidated	Organic			(OM)	Very wet peat or muck
All soil horizons	Not yet true soil	Unconsolidated	Mineral			C	Loose geologic deposit
All soil horizons	Not yet true soil	Consolidated bedrock				R	Solid bedrock

[1]These organic materials are at well drained sites.
[2]This is seasonally saturated with water, if not drained artificially.
[3]After part or all of these horizons have been plowed, the plow layer is then referred to as the Ap horizon.
[4]This horizon is naturally fertile, i.e. % base saturation is more than 50%.
[5]At least not as dark as the A1 horizon above it.
[6]If at the surface, this may be called an ochric horizon also.

4. A General Guide to Soil Peds in Wisconsin

Loose sand falls apart in the hand without any tendency to clump or aggregate into balls or blocks, called peds. This is because the sand material has almost no adhesive mixed into it. Some kind of "glue" is needed to hold individual soil particles together to form peds. In the A horizon a common kind of adhesive is organic matter, including what are called **bacterial gums.** These, along with fine plant roots, bind soil particles together into porous, crumb-like peds – giving the soil a granular structure. In silty A2 horizons (see Figure 5) the soil particles commonly cling together in flat units called **plates.** Both organic and clay materials serve as binders. In the clay-enriched B horizon clay is the principal binder. The clay has the capacity to shrink, causing the soil mass to crack into columns and blocks. On wetting, the cracks swell shut again. In the shrink-swell process that has gone on for centuries, definite prisms and blocks have been formed. In this way a dry clay soil may crack into thousands of gravel-sized pieces which may become rather hard and pebble-like during a drought. When rains come again, water then runs down into the clay soil as if it were made of gravel, until the clay peds have had time to soak up enough water to soften and swell, closing the cracks and stopping rapid infiltration of water.

Peds are structural units of soil horizons in naturally structured or pedal soils. The peds range in size from that of a small pea (granules), to thumb-size (blocks) to the size of a long loaf of French bread (large prisms). Peds are usually smallest in the surface horizons and increase in size with depth. Soils that have no peds, such as the loose sand mentioned above, are called **apedal** (without peds), massive, or single grain.

Plowing may compact pedal A1 horizons into a massive

Figure 9. Guide No. 2–General terms for describing fabric[1] of pedal and apedal soils.

		General description		Terms: For natural soil fabric	Terms: For artificial soil fabric
Some general terms relating to soil fabric	Some terms relating to units in pedal soils	Units are nearly spherical		Granular peds	— — —
		Units are nearly planar		Platy peds	Plowsole platy structure
		Units are nearly box-shaped and are persistent	Units are equidimensional; nut-shaped	Blocky peds	— — —
			Units are elongated; rod-shaped	Prismatic peds	— — —
		Units are irregular; temporary; present in some plow layers (Ap horizon)		— — —	Cloddy structure
	Terms relating to apedal soils (those without peds)	Terms applied to loose coarse soil material		Single grain	Single grain
		Terms applied to fine soil material, or cemented coarse material		Massive[2]	Massive

[1]Fabric of soil comprises the size, shape and arrangement of soil constituents. Aggregates of soil particles are called peds. Pedal soils are composed of peds. Apedal soils have no peds.

[2]Plowing may change a pedal horizon (A1) into a massive one (Ap). Afterward the Ap horizon may fall apart into irregular pieces called clods.

plow layer, designated Ap horizon. The Ap horizon may fall apart into irregular chunks which are not true natural peds. The chunks or clods of soil are not bounded by surfaces which persist year after year, as is the case with surfaces of peds. An Ap horizon may have cloddy structure, but that is artificial and temporary. The Ap horizon may become massive under the pressure of agricultural machinery. Impact of raindrops on bare soil may form a compact crust 6mm (1/4 in) or so thick, that tends to shed water.

Figures 9 and 10 are simple guides to the terms commonly used in Wisconsin in describing pedal and apedal soils. These become especially meaningful to students who take the time to dissect soil pedons with spade and knife and, with aid of hand lens and microscope, study the anatomy of the soil as carefully as a medical student examines the anatomy of the human body. It is helpful to make drawings of soil fabric and its components and to label them. The study is not complete without a synthesis of the information to show how all the parts of a soil function together in handling water, plant nutrients, roots, animals, and microorganisms.

Figure 10. Guide No. 3–Specific terms for describing fabric[1] of pedal and apedal soils.

Some specific terms relating to soil fabric	Terms relating to the s-matrix[2]	Skeleton	Grains of coarse silt, sand; pieces of gravel; cobbles
		Voids	Pores, channels, chambers, cracks
		Plasma	Mobile clay (and fine silt), humus, soluble carbonates and salts
	Terms relating to pedological features	Plasma separations	Clusters of parallel clay particles inside peds, giving a "streaked" fabric to the plasma, as seen through a petrographic microscope with crossed nicols[3]
		Glaebules	Spherical units formed in the soil (unlike skeleton grains which were formed before soil genesis started). If concentric layers are present the glaebule is a concretion; if not, it is a nodule
		Tubules	Elongated fillings of small animal burrows
		Cutans	Coatings of clay, humus, iron oxide, carbonates on the surfaces of skeleton grains and peds
	Terms relating to soil structure	Granular peds Platy peds Blocky peds Prismatic peds	(See Figure 9)

[1] Fabric of soil comprises the size, shape and arrangement of soil constituents. Aggregates of soil particles are called peds. Pedal soils are composed of peds. Apedal soils have no peds.

[2] S-matrix = soil matrix.

[3] This means that light passes through a north-south oriented polarizer, then through the thin section of soil, and finally through an east-west polarizer. The domains of oriented clay particles than show up as streaked yellow patches.

5. A General Guide to Soil Texture in Wisconsin

If soil peds or clods are crushed between the fingers, and the material moistened and rubbed, the soil texture can be felt. It will feel gritty, smooth or sticky as it is rubbed. Texture of soil is the fineness or coarseness of the soil in terms of sizes of soil particles, and the mixture of particles of different sizes. Figure 11 shows a triangular diagram in which mixtures of clay, silt, sand and coarser particles are assigned names. If a tub-full of muddy water is taken from a roaring river in flood stage and the water is allowed to stand in the tub, the coarse materials such as gravel settle out first on the bottom. Then the sand, the silt, and finally, after several days, the clay settle out. The clay, silt and sand are together called the **fine earth,** which is the part of the soil from which plants derive nutrients and water. The clay settles last in the tub because the particles have such a large surface area per unit weight, as indicated in Figure 12. We can easily see coarse fragments, sand and coarse silt particles with unaided eyes, but fine silt and clay particles are too small to be seen without microscopes. Not shown in Figures 11 and 12 is **organic matter,** which can occur in particles of various sizes, too, ranging from large chunks of wood to clay-size humus. Organic matter changes the feel, appearance and behavior of soil.

To name the texture of a soil, such as a gravelly loam, is to tell how much gravel, silt, sand and clay is present. A representative mechanical composition of a dry loam might be 20% clay by weight, 40% silt and 40% sand, with an additional 25% gravel. Note that the fine earth fractions add up to 100% in most soil survey reports; coarse fragments are considered extra. The soil textural classification does not tell how the particles are arranged into structural units such as blocks the size of the thumb. We have already considered structure in the section on soil peds.

ALL SOIL PARTICLES

		Particles equidimensional	Particles flat
COARSE FRAGMENTS (particles >2mm or 1/25th in. in dia.)	Particles 2mm–7.6 cm in dia.	gravel	
	Particles 2mm–15 cm long		channer
	Particles 7.6–25 cm in dia.	cobbles	
	Particles 15–38 cm long		flags
	Particles >25 cm dia.	stones	
	Particles >38 cm long		stones
FINE EARTH (particles <2mm in dia.)	Particles 2.0–0.05 mm in dia.	SAND	
	Particles 0.05–0.002 mm in dia.	SILT	
	Particles <0.002 mm in dia.	CLAY	

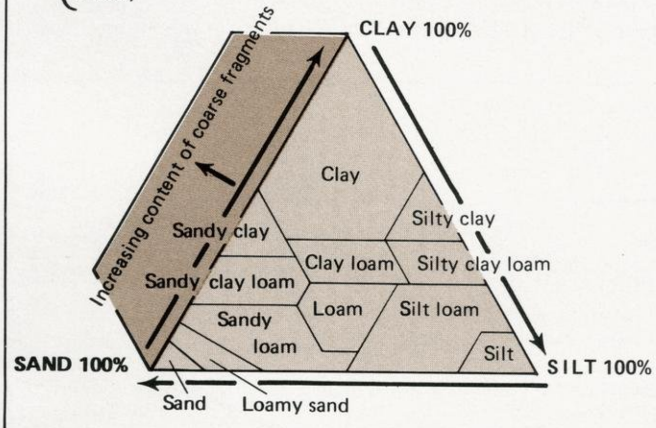


Figure 11. Guide No. 4–Soil Texture. The tables above give dimensions of mineral particle sizes, and the triangular diagram below indicates how mixtures are given class names. It is assumed that organic matter has been removed, leaving only mineral soil particles. Coarse fragments are not mentioned in a textural designation unless they amount to more than 20% of the soil by volume.

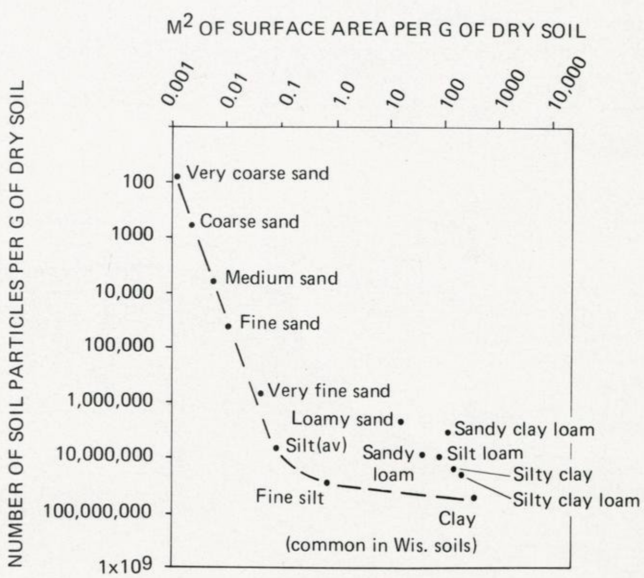


Figure 12. Approximate surface area of textural classes of soil.

6. A General Guide to Hill-Slope Sequences in Wisconsin

Trees make a forest. Soils make a soilscape or the soil blanket on the landscape. We may now consider how soil bodies are grouped together on hills and lowlands.

A soilscape is a little like a jigsaw puzzle, each piece of which is a soil body that is different from those next to it. Some Wisconsin landscapes are nearly flat, like a jigsaw puzzle (see Figure 15 right-hand portion), but many are rolling and hilly (Figure 13 and the left part of Figure 15). We find that soils line up in repeating patterns, sometimes grading from well drained to poorly drained and back again.

In hilly areas of western Wisconsin, the soils of a hill-slope sequence are typically well drained throughout. Figure 13 shows hill-top soils formed from loess that are deep on the crest (Fayette silt loam) and shallow on the edges (Dubuque silt loam). Steep slopes on sandstone and siltstone are occupied by Hixton soils. **Colluvial soils** on foot-slopes are Chaseburg silt loam. These are all deciduous forest soils, called Typic Hapludalfs (typical simple humid soils, with some aluminum and iron compounds collected in the subsoil). An explanation of the soil taxonomy, from which these terms come, is found in the book, *Soils of Wisconsin,* by Hole, Lee and Beatty (1976).

A simpler hill-slope soil sequence – sometimes called a **catena** (meaning "chain" of soils) – with rather uniform materials throughout, is represented in Figure 14. Here, soils of a loess blanket on glacial till range from well drained on the hill-top (Plano silt loam), to somewhat poorly drained on foot-slopes (Elburn silt loam), to poorly drained in the swale (Pella silt loam). This sequence of soils repeats itself on the other hill-slopes in the area.

Figure 15 shows the junction of two distinct soilscapes in the vicinity of Antigo, Wisconsin. On the right, on a nearly level outwash plain is a sequence of soils from the well drained Antigo silt loam, through the moderately well drained Brill and somewhat poorly drained Poskin to the poorly drained Rib silt loam. On the left in Figure 15 is another soilscape with the moderately well drained Spencer silt loam in the highest position, followed down-slope by the somewhat poorly drained Almena silt loam, poorly drained Auburndale and very poorly drained Adolph silt loams. The boundary between the two soilscapes lies where the Adolph and Rib soils meet in a wetland.

Soilscapes are usually more complicated than indicated in Figures 13, 14, 15. Yet a repeating soil pattern of some kind can usually be observed in any landscape of Wisconsin. Figure 16 shows three common soilscape fabrics in which arrangement of soil boundaries produces spotted and striped patterns.

Numerous soilscapes (sometimes called **soil associations)** are present in the state. Many of them are shown on the regional soilscape diagrams in later chapters in this publication.

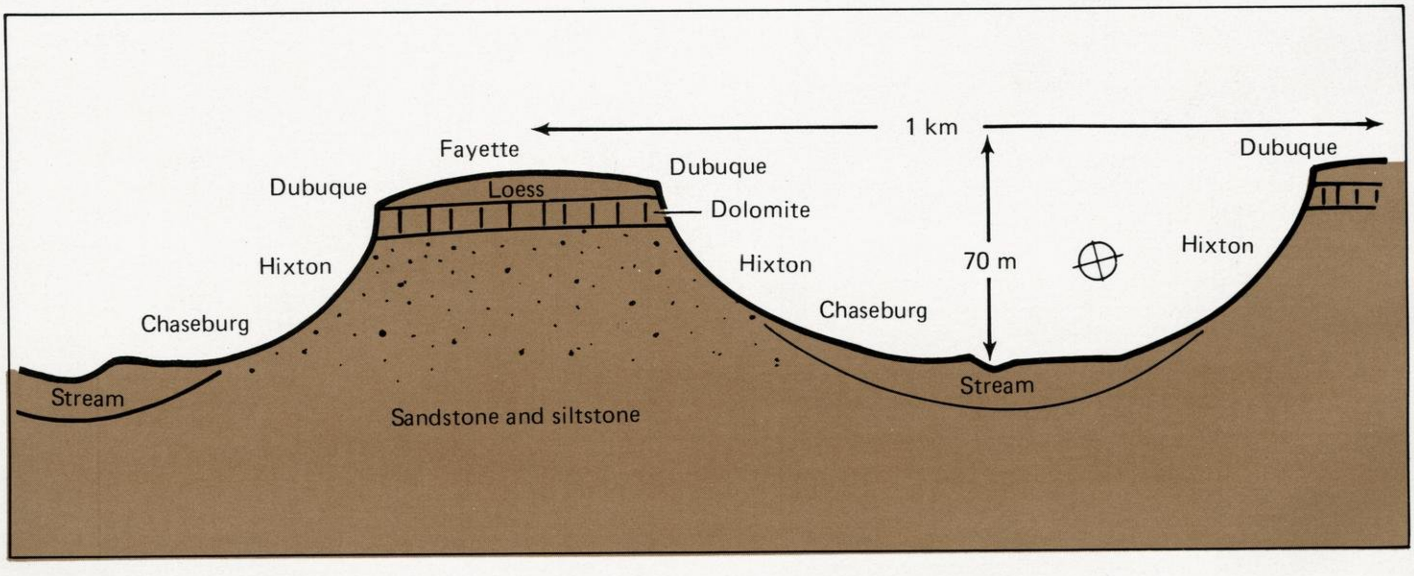


Figure 13. Arrangement of some soils on an idealized landscape of western Wisconsin.

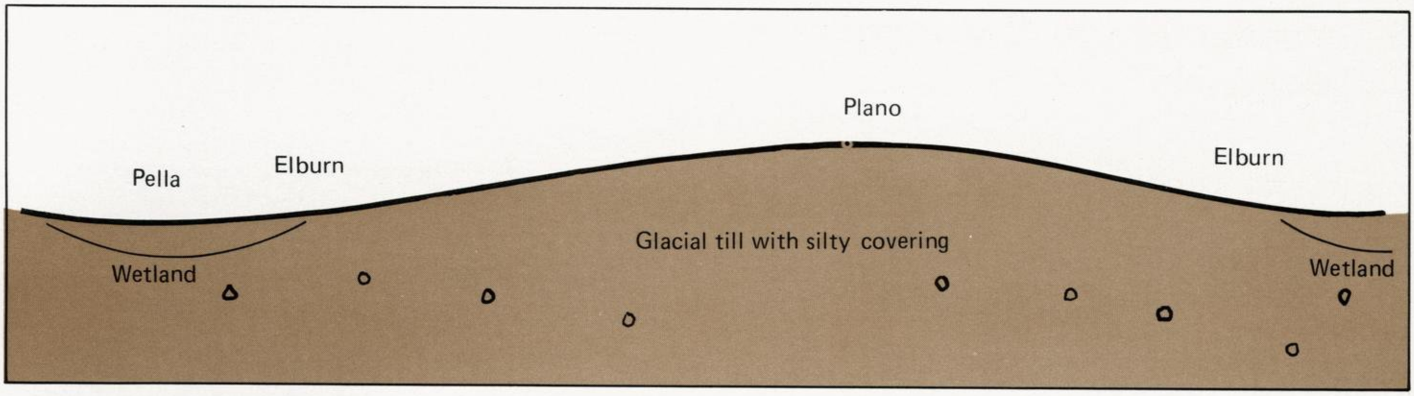


Figure 14. Arrangement of some soils on an idealized landscape of southeastern Wisconsin.

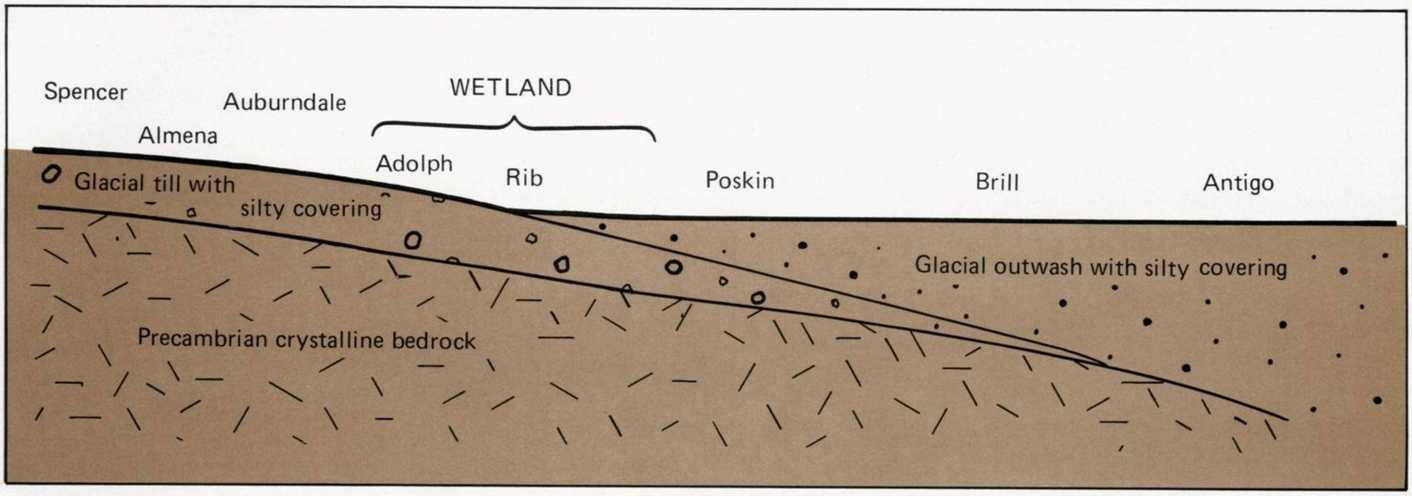


Figure 15. Arrangement of some soils on an idealized landscape of north central Wisconsin.

Each soilscape has its own characteristic way of distributing and disposing of rainfall and snow, and of maintaining a water table. Interactions between soil and vegetation, including both native and crop plants, are unique in each soilscape. Foresters and farmers learn how soilscapes "behave," and how to manage them for best production of food, fiber, wood or wildlife, and at the same time protect soils from serious erosion. Travelers get to know soilscape differences by quality of scenery and the special appeal of favorite terrains.

Soil surveyors report soilscapes in terms of soil series names. For example, Figures 13, 14 and 15 show, respectively, Fayette-Dubuque-Hixton-Chaseburg, Plano-Elburn-Pella, Spencer-Almena-Auburndale-Adolph and Antigo-Brill-Poskin-Rib soilscapes. These hyphenated soil series names are useful labels, but do not adequately express the soil patterns (see Figure 16) nor the arrangement of vegetative growth. Direct experience by traveling across these landscapes is essential to a real appreciation of them.

The rest of this booklet is chiefly concerned with the major soilscapes of Wisconsin.

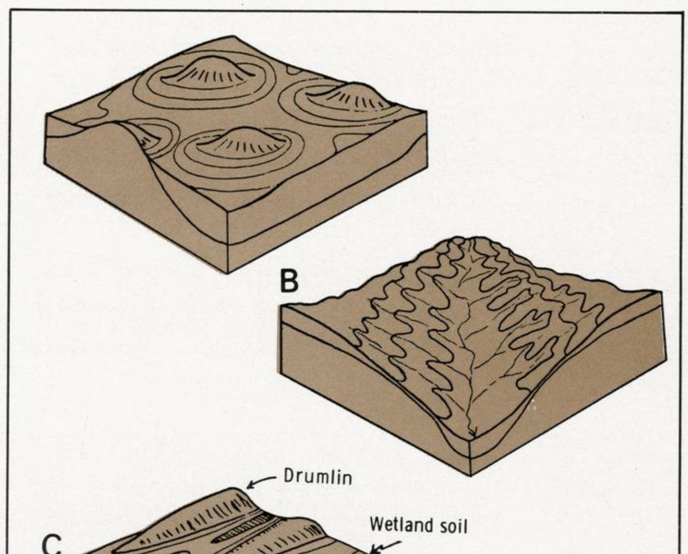


Figure 16. Three soilscape fabrics shown schematically. (A) circular or spotted, (B) irregularly striped, (C) simply and discontinuously striped.

7. Introduction to Soil Regions of Wisconsin

It is possible to delineate **soil regions** in Wisconsin (Figure 17), just as we could outline major plant communities. With the realization that each of the ten soil regions contains considerable diversity, we may turn now to a brief consideration of them. Their general nature and extent are itemized in Table 1. The ten soil regions may be thought of as refinements of the five major physiographic provinces (Figure 18).

The soil regions are more complex in pattern than indicated on the generalized map of Figure 17. Region J, in particular, is composed of scattered patches. The regions are composite expressions of landforms, geologic materials, vegetative and climatic history and age. As in the case of a plant community, a soil region is described in terms of species present. **Soil series and soil types** are referred to in the following discussions of the soil regions.

Table 1. General nature and extent of the ten soil regions of Wisconsin.

Soil region* designations	General character of the soils and landscapes	Area: mi^2 (thousands)	Area: km^2 (thousands)	Area: Acres (millions)	Area: ha (millions)	Area: % of state
Region A	Silty soils overlying dolomite bedrock on undulating to rolling uplands and valley flats, with steep stony slopes between.	5.9	15.3	3.8	1.5	11
Region B	Silty to loamy soils on rolling to level uplands and associated wetlands on gray-brown calcareous, dolomitic glacial drift.	6.9	17.9	4.3	1.7	13
Region C	Very sandy soils on plains, rolling upland, and occasional buttes of sandstone.	3.9	10.1	2.5	1.0	7
Region D	Silty to sandy loam soils on hilly uplands, valley slopes and associated plains.	5.1	13.2	3.2	1.3	9
Region E	Sandy loams and loams of northeastern rolling uplands and plains on calcareous pink glacial drift.	2.5	6.5	1.6	0.6	5
Region F	Silty soils on undulatng uplands on acid, compact glacial drift.	8.5	22.0	5.4	2.2	16
Region G	Sandy loams and loams on hilly uplands and plains over acid gravelly and stony reddish brown glacial drift.	9.1	23.6	5.8	2.3	17
Region H	Very sandy soils on hilly uplands and plains on sandy glacial drift.	4.0	10.4	2.6	1.1	7
Region I	Silty and clayey soils on nearly level to rolling uplands on calcareous reddish brown clayey glacial drift.	4.0	10.4	2.6	1.1	7
Region J	Wet soils, including some silts and loams on alluvium; more silts and loams, peats and mucks in wetlands.	4.5	11.7	2.9	1.2	8

*These soil regions are taken from Plate I in SOILS OF WISCONSIN (Hole, Lee and Beatty, 1976).

Distribution of geologic materials from which the soils are formed

Six major groups of **bedrock** (Table 2) are shown on the geology map (Figure 19) in eleven subdivisions. These rocks outcrop over only about 5% of the area of the state, but loose particles derived from them are found in the soils. Glacial drift covers about three-quarters of the state (Figure 20). Wind-blown sand and silt (leached loess) occupy about 70% of the land surface (Figure 21).

Table 2. Major groups of bedrock in Wisconsin

Group name	Area (%)
Sandstone	34.5
Dolomitic limestone	27.0
Shale	2.5
Light colored crystalline rocks	23.0
Dark colored crystalline rocks	12.0
Quartzite	1.0
	100.0

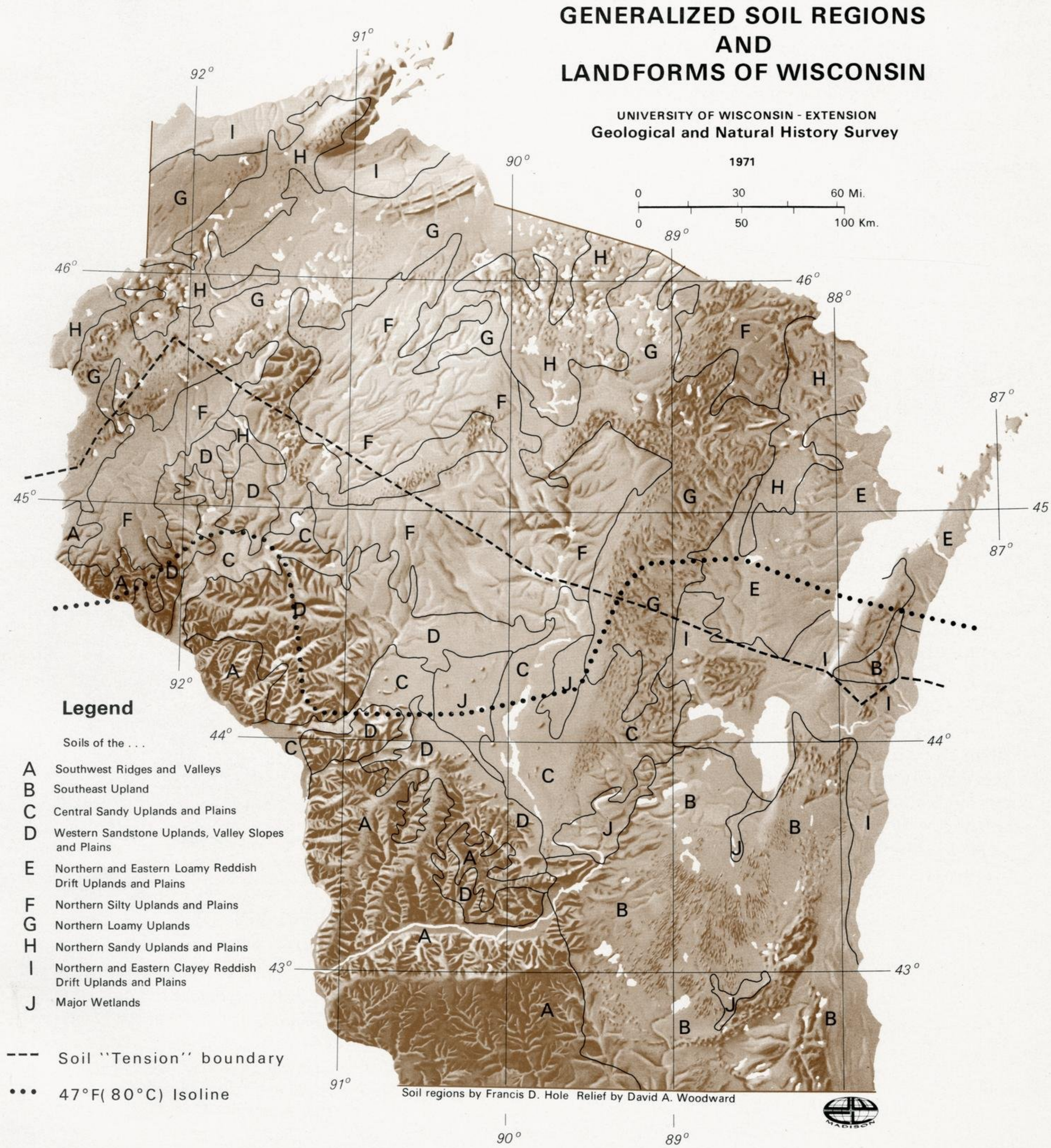


Figure 17. Major soil regions and landforms of Wisconsin.

Climatic factors affecting the soils

Rainfall during the growing season amounts to about 21 inches (53 cm). It is sufficient to keep the subsoil moist much of the time and to maintain the flow of rivers (Figure 23). Droughts are common in late summer, particularly in regions of sandy soils (Regions C and H). The seasons march from southwest to northeast in the spring and early summer (Figure 24). In classifying soils, scientists use a line marking the position of mean annual soil temperature of 47°F (8°C) to separate **frigid soils** in the north from **mesic** (with moderate temperatures) **soils** in the south (Figure 17). Measurements are made in the soil at a depth of 20 inches (50 cm). The growing season for crops ranges from 170 days in the south to 80 days in the north, with amelioration along the shores of the Great Lakes. Variations in several soil properties, such as content of organic matter in undisturbed areas, are related to these climatic factors.

Figure 19. **BEDROCK GEOLOGY**

The oldest rocks, called Precambrian, include igneous rocks, such as granite, and associated metamorphic rocks (0 where data are sparse, 1 elsewhere), trap rock (2), quartzite (3), and sandstone (4). Over that lies Cambrian sandstone (5), Prairie du Chien Dolomite (6), Ancell sandstone (7), Sinnipee Dolomite (8), Maquoketa Shale (9), Silurian dolomite (10), and Devonian shale (11).

Figure 18. **GEOGRAPHIC PROVINCES** *(after Martin, 1932)*

The Lake Superior Lowland is an old glacial lake bottom sitting in a much older depression in the bedrock surface. The Northern Highland is a glacial-drift-covered Precambrian "dome," a southern extension of the "Canadian Shield" of igneous and metamorphic rocks. The Central Plain is on an arc of Cambrian sandstones. The drift-covered Eastern Ridges and Lowlands are crossed by dolomite escarpments. The Western Upland is dissected by numerous tributaries to the Mississippi and Wisconsin Rivers.

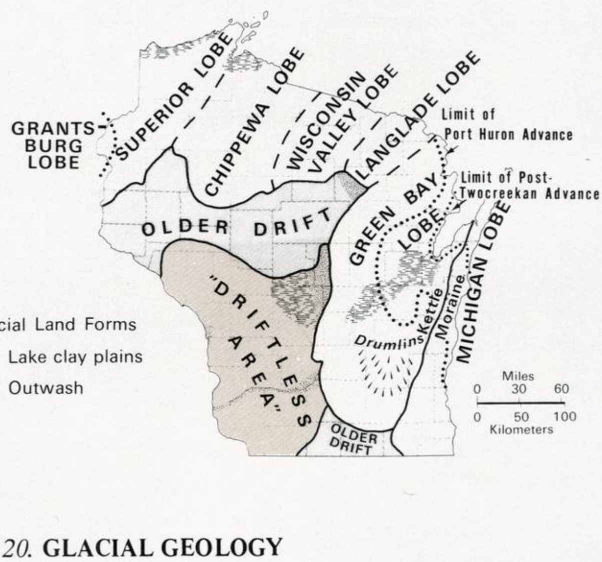


Figure 20. **GLACIAL GEOLOGY**

The last major advance of the ice sheet over Wisconsin was about 16,000 years ago. It covered all but the "driftless" and "older drift" areas. One of two later advances (dotted boundaries) buried a forest in Manitowoc County about 11,000 years ago. Many land forms were created by the glacial ice and meltwaters: Moraines (solid lines), elongated hills called drumlins, outwash, and lake clay plains. Many peat bogs and lakes occupy glacial pits called kettles.

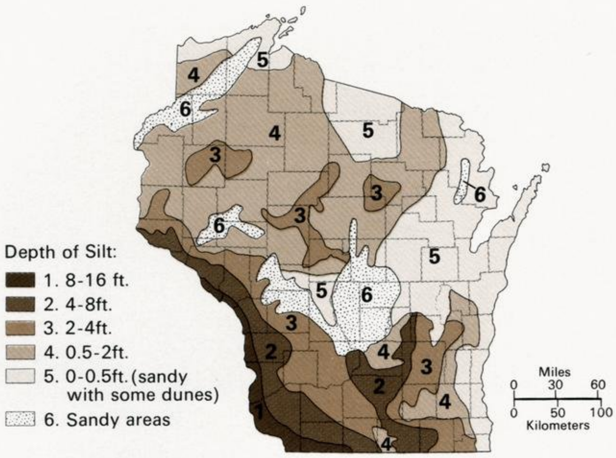


Figure 21. **WIND-DEPOSITED SILT (LOESS) AND SAND**

Large quantities of silt (loess) were blown in by dust storms during the ice age, from the Mississippi River flood plain north-eastward onto uplands. In sandy areas (6) the silt blanket did not stay but was blown still further probably because of erodibility of the sandy terrain. Soils that developed from the fertile silt (areas 1 through 5) have good capacities to hold water and nutrients for the benefit of plant growth.

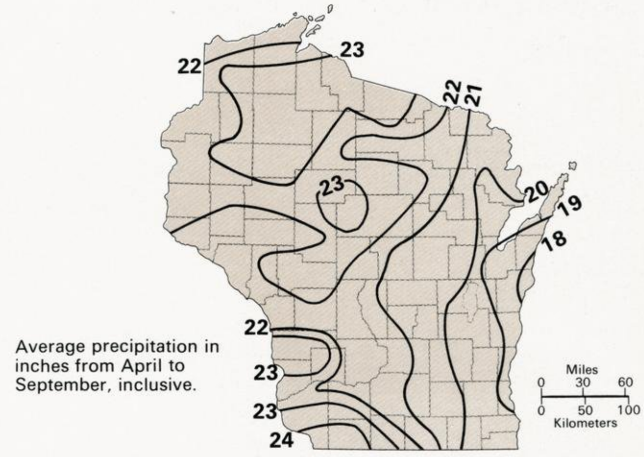


Figure 22. **AVERAGE PRECIPITATION** *(April to September, inclusive)*

The April to September rainfall is 23 to 24 inches in the far northern highland and at the southwestern corner of the state; and 18 to 21 inches in east central Wisconsin. Of the 31 inches of annual precipitation, 68 percent falls during these six months when plants are growing. The rainiest month is June; the driest, December. Soils are commonly saturated in April when the snow and ice melt. Soils are commonly driest during August through autumn.

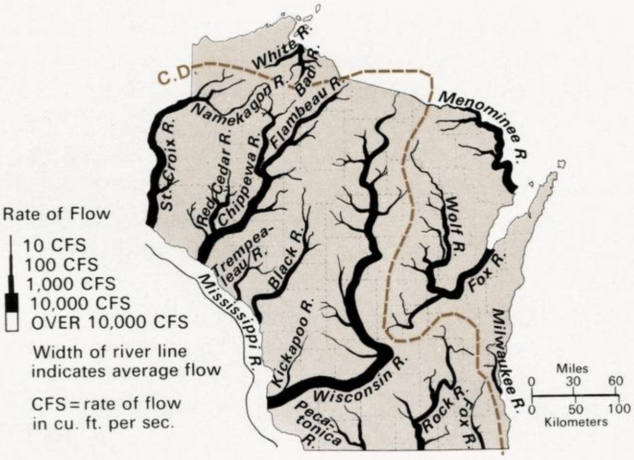


Figure 23. **PRINCIPAL RIVERS AND THEIR AVERAGE FLOW**

Thirty percent of the state drains to the St. Lawrence River basin, and the remaining 70 percent to the Mississippi River basin. The dashed line represents the continental divide (C.D.) between these two major basins. Peak flows are in March, April and June. The Wisconsin River drains 21 percent of the area of the state; the Chippewa-Flambeau system drains 17 percent; the Fox-Wolf system in northeastern Wisconsin drains 12 percent of the state.

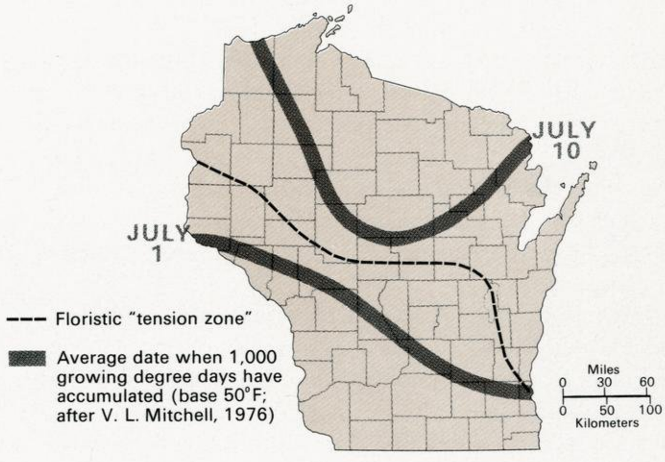


Figure 24. **CLIMATIC ZONATION IN WISCONSIN**

The difference in early growing season temperature between northern and southern Wisconsin is shown by the July 1–10 lapse time required for the same amount of solar heat to accumulate in the north as in the south. The floristic "tension zone" separates northern pine country from southern prairie-oak forest country.

8. A General Guide to the Classification of Wisconsin Soils

Soils probably occupy about 80% of the land surface of the earth. Glaciers, rock outcrops, talus slopes and barren flats of sand, clay or salt account for the remainder. Ninety percent of the area of Wisconsin is covered with soils that lie on varied land forms and support contrasting plant and animal communities. The remaining 10% is about equally divided between water and rock outcrops. The associated network of lakes and rivers is closely related to the soil pattern.

Soils may be classified into two main groups. First are **mineral soils** that are largely made up of particles of minerals such as quartz and feldspar. Second are **organic soils** made up largely of the remains of wetland plants. The mineral soil group is by far the more extensive of the two. In Wisconsin only about 5% of the land area is occupied by peats and mucks which comprise the Histosol order of organic soils.

Mineral soils can be placed in three groups on the basis of **degree of weathering**. Weathering is the changing of rock and rock materials into soil by impact of climate and organisms, those two active forces that have been discussed in a previous section. For example, during the process of weathering, particles of feldspar change to clay and nutrient elements such as calcium dissolve from the mineral and begin to leach away to the sea. They are soon checked, however, by being drawn out of the soil solution and adsorbed on surfaces of clay and organic particles by a process called **cation exchange** (Figure 5). Most of Wisconsin soils are supplied with nutrient ions like those of calcium, which are cycled by plants and retained in the landscape.

Figure 25 shows the place of six representative soils in a general world-wide scheme. Wisconsin has no black "self-plowing" soils (Vertisols), no desert soils (Aridisols), Red-Yellow Podzolic forest soils (Ultisols), nor intertropical Latosols (Oxisols). Six soil orders are well represented in the state, as follows (Table 3). Individual soil series, such as the Antigo series, are named after places. The soil type designation, Antigo silt loam, tells the texture of the surface soil.

1. **The Entisol order** includes the simplest soils that have a topsoil (A horizon) resting directly on C horizon material. Alluvial soils (Fluvents) have this horizon sequence. The Arenzville and Brule soil series are examples. Sandy soils (Psamments) are extensive in Wisconsin and among them are the Chelsea series on wind-blown deposits. Other Entisols are Coloma soils on glacial till, Plainfield, Omega and Roscommon soils on outwash deposits, Boone soils on Cambrian sandstone, and Shawano soils on glacial lake deposits.

2. **The Inceptisol order** includes slightly-developed soils that usually have between the topsoil (A horizon) and parent material (C horizon) a weakly expressed subsoil layer (B horizon). Examples are fairly fertile, pale soils (Eutrochrepts) of the somewhat droughty Urne series on coarse Cambrian greensands, and the Hennepin soils on calcareous glacial till. More numerous are poorly drained soils, with low humus content (Haplaquepts) or high humus content (Humaquepts). The Haplaquepts include soils of wetlands on glacial till (Angelica, Cable, Pickford series), glacial outwash (Lows, Rib series), and loess over Cambrian strata (Vesper). The Humaquepts are in low spots in sandy outwash plains (Dillon and Newton series).

3. **The Mollisol order** includes soils with a thick, very dark, soft, fertile topsoil (A1 or Ap horizon), such as formed under prairies, both wet and dry. An example from outwash sand at xeric sites is the Sparta series. At mesic* sites are the Tama, Dodgeville, Plano, Hesch, and Pebbles series. In wetlands are the Pella, Granby, Adolph, Warman, Poygan and Mussey series.

4. **The Alfisol order** consists of soils developed under deciduous forest that show thin dark surface soil (A1) over a pale subsurface layer (A2 or E horizon), over a subsoil (B horizon) that is distinctly higher in clay content than the overlying horizons. Most of these soils are well-drained and are found at mesic sites. Examples are the Fayette, Palsgrove, Dodge, Tilleda, Kennan and Kewaunee series, all formed from leoss or from glacial till or both at naturally well drained sites. On outwash plains are found soils of the Fox, Gotham and Antigo soil series. The Hixton soils are developed in Cambrian siltstones and fine sandstones. Wetlands and wetland borders include soils of the Withee and Dancy series.

5. **Spodosols** are soils in northern predominantly sandy or coarse silty lands. A typical soil profile shows a forest litter and humus layer over a pale subsurface horizon (A2 or E) over a coffee-brown subsoil (B horizon) enriched in humus (h) and iron oxide (ir). All but two of the soil series of this order that are named in Table 1 are developed in very sandy glacial drift or Cambrian strata. The Superior soils are exceptional in having a layer of red clay under the sandy loam surface soil. Goodman and Summerville soils formed in silt covering till.

*The term mesic is used here in the plant ecological sense (Curtis, 1959), not as a soil climatological term.

6. The Histosol order consists of peats and mucks, called organic soils. These soils are represented in wetlands all over the state, but are least extensive in soil region A, which is dominantly hilly land with few bogs. The various soil series are distinguished from each other by depth, kind of organic fibers present, degree of decomposition of the plant materials, degree of acidity or alkalinity, and texture of underlying mineral material. Artificial drainage and cultivation favor conversion of raw, coarse peat to a soft muck.

The reader is referred to the book, *Soils of Wisconsin* (Hole, Lee and Beatty, 1976) for further explanation of classification of Wisconsin soils. In the appendix of this booket is an alphabetical list of common soil series of Wisconsin, with their complete classification according to the Soil Taxonomy (U.S.D.A., 1975).

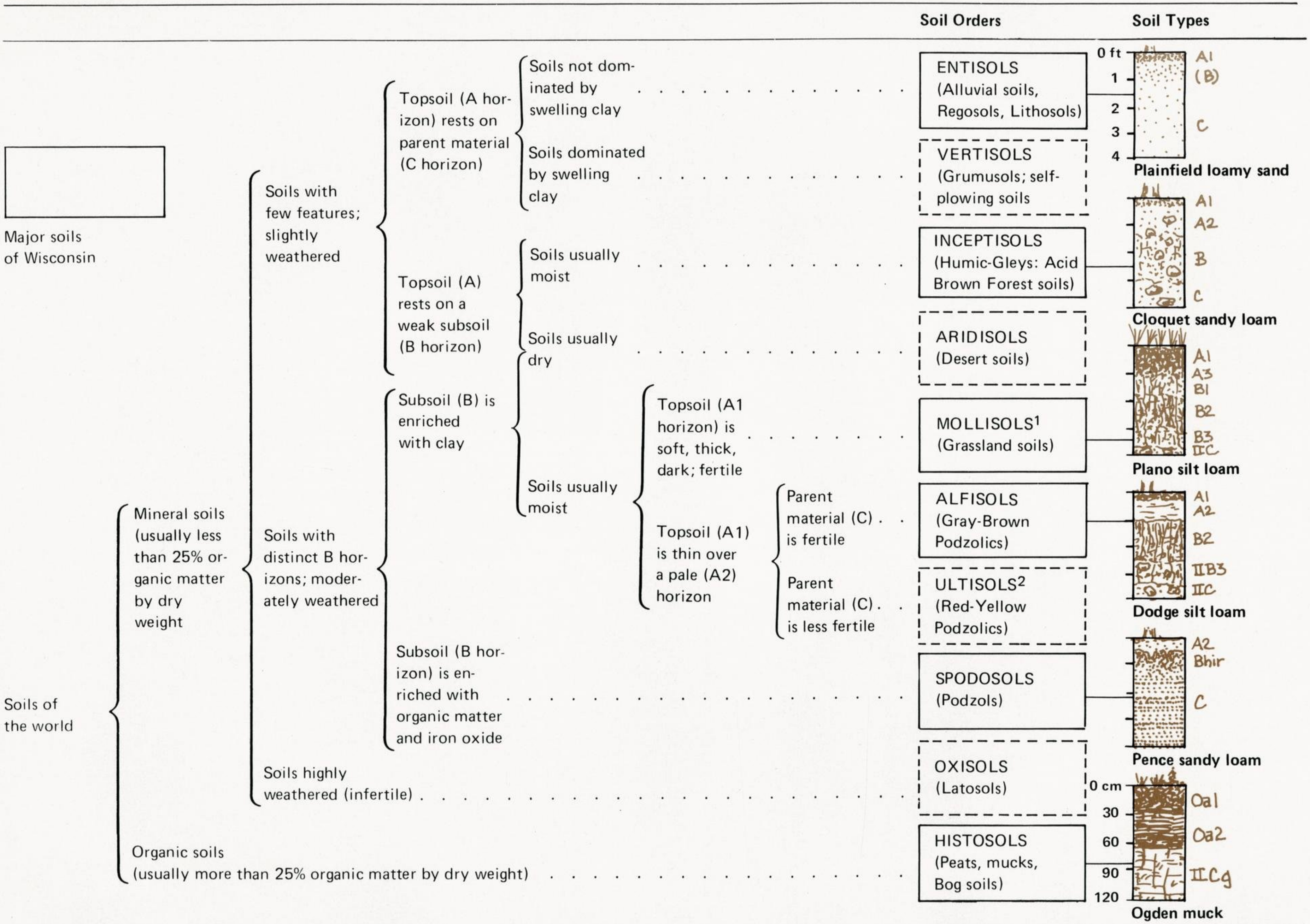
Table 3. Representative soils[1] in Wisconsin's six orders and ten soil regions.

Six soil orders present in Wisconsin	Soil Regions of Wisconsin[2]									
	A	B	C	D	E	F	G	H	I	J
Entisols	Arenzville Chelsea	Coloma	Plainfield	Boone	Shawano			Omega	Brule	Roscommon
Inceptisols	Urne	Hennepin	Dillon	Lows Vesper	Angelica	Rib	Cable		Pickford	Newton
Mollisols	Tama Dodgeville	Plano Pella	Sparta	Hesch	Granby		Adolph		Peebles Poygan	Mussey
Alfisols	Fayette Palsgrove	Dodge Fox	Gotham	Hixton	Tilleda	Antigo Withee	Kennan		Kewaunee	Dancy
Spodosols					Humbird Summerville	Good- man	Iron River Pence	Rubicon Vilas	Superior	Saugatuck Kinross
Histosols	Carlisle	Ogden Houghton	Adrian	Adrian	Tacoosh	Cathro	Spalding	Dawson	Sheboygan	Carbondale

[1]Soil series are listed. See Appendix 2.

[2]See Figure 17.

Figure 25. Guide No. 5–Six major soils of Wisconsin related to a world classification of soils.



[1]The B horizon may be weak or even absent.

[2]Some cherty red clay subsoils in southwestern Wisconsin may contain some remnants of ancient Ultisols and Oxisols.

9. Soils of Southwestern Wisconsin (Soil Region A)

These are silty and clayey soils of the hills, smooth uplands and valley benches of southwestern counties. Region A (Figure 26) accounts for 11% of the area of the state. It occupies a little more than half of the Driftless Area and also includes some soil bodies outside that area. It is a stair-step landscape (Figure 27). Each escarpment and backslope constitutes the landform called **cuesta**. Silty and clayey soils occur on low valley terraces (benches), and on sandstone, dolomite, quartzite and shale benches. These land surfaces are blanketed with silty material (leached loess) in which at least the upper soil horizons have formed. The highest dolomite bench (the Sinnipee) forms Military Ridge which runs for 65 miles almost due east from near the confluence of the Wisconsin River with the Mississippi River (Martin, 1974; Hole, Lee and Beatty, 1976).

Palmquist (1965) believed that the form of the land surface of the upland attained equilibrium about 250,000 years ago. However, Dury and Habermann (1977) suggested that the summit surface **(pedeplain)** may be 40 million years old, that dissection of the surface by shallow valleys began 20 million years ago, and that the cutting of the deep inner valleys began as early as 3.5 million years ago, but was mainly done in Kansan time (300,000? years ago). In any case the cherty, reddish-brown clay subsoil, which is probably residual in part from the dolomite and in part an illuvial B (argillic) horizon, is quite old. Hence soils like the Valton silt loam with thick Bt horizon partly developed in the cherty "red" clay are called Paleudalfs, rather than Hapludalfs. "Pale" means ancient and "Hapl" means simple.

The diagram at the top of Figure 27 shows the stair-step form of landscapes of this region. At any one valley, there appear to be two levels: the valley bottom and the ridge top levels. In the lower part of the figure the two-story nature of the landscape is indicated by the ridge top and valley landscape positions of the soils. Emphasis is also placed on the difference between prairie soils (the Mollisols) and forest soils (the Hapludalfs). A third characteristic of silty soil is depth: deep (more than a meter) and moderately deep (0.5 to 1 meter) to stony clay or bedrock. The deeper soils (Fayette, Seaton; Tama and Port Byron series) are closer to the Mississippi River Valley than shallower soils (Dunbarton and Sogn series). That valley was the source of the wind-blown silt from which the silty soils formed.

Upland ridges and valley flats are rather free of woodland because conditions are favorable for cultivation. Forests cover the steep slopes.

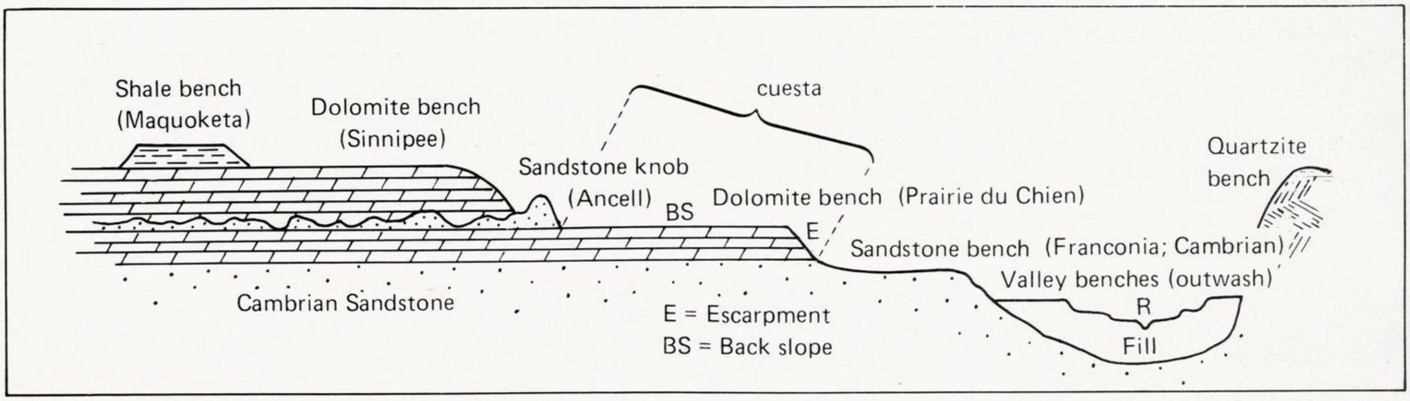
Figure 26. Distribution of southwestern silt loams (Region A).

Representative soil sequences are shown in the diagrams in Figure 27 (also See Table 4). Different thicknesses of loess covering over Maquoketa shale have given rise to both relatively shallow and deep soil sequences under original forest and prairie covers. Thinning of the loess cover over dolomite from the very thick, relatively coarse silt loam of the Seaton soil to the shallow Dunbarton fine silt loam (the deciduous forest soil-litho-sequence) is paralleled by a prairie lithosequence of soils: Port Byron to Edmund and Sogn. Two soils formed in leached loess on quartzite are indicated. Sequences of soils on valley benches that rise above the Wisconsin River flood plain and up into the tributaries, show increase in depth of loess over sand, but also increasing wetness as the water table comes closer to the surface where the small valleys narrow. Soils on the sandstone benches will be discussed under the heading of Region D.

The average slope of cultivated land in Region A is about 12%. It is no wonder that soils in more than half of the region are eroded – some severely – but most of them moderately so. Soil erosion control practices were developed early through experiments in this area. August Kramer, a farmer in Mormon Coulee near LaCrosse, began strip cropping on his own initiative in 1870. For 30 years (1933 to 1963), the U.S. Department of Agriculture and the Wisconsin Agricultural Experiment Station operated the Upper Mississippi Valley Conservation Experiment Station, where measurements were made of actual amounts of soil lost annually on different slopes and under different cropping systems.

It is fortunate that the dolomite and sandstone bedrock of this region was blanketed with wind-blown silt (loess). Without it, the area would be much less productive in crops and forests, and would likely be considered a hilly wasteland – useful only for recreational purposes.

Major Landscape Positions



Representative Soils

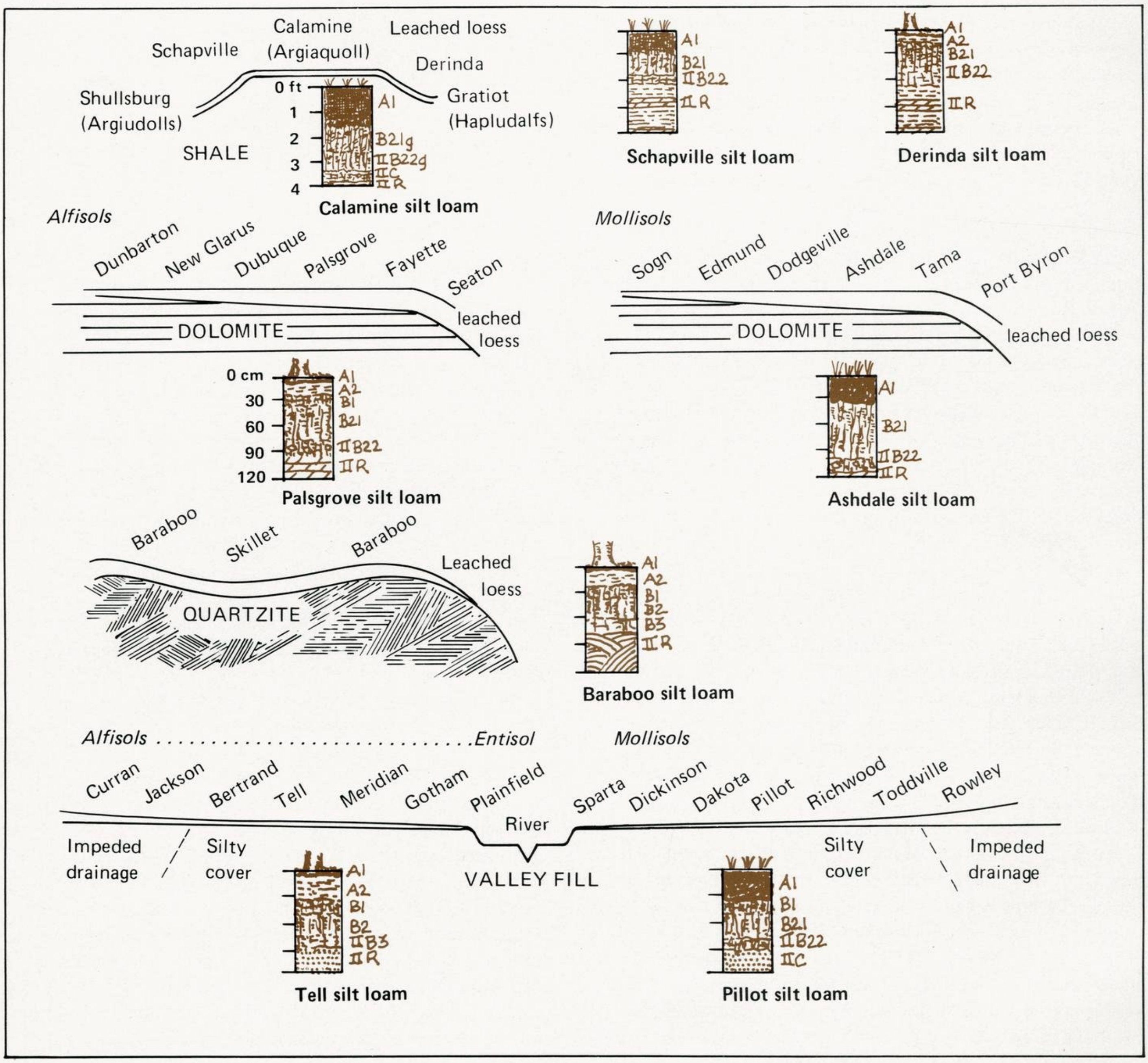


Figure 27. Landscape positions of some representative soils of southwestern Wisconsin (Soil Region A).

Table 4. Chart of representative soils[1] of southwestern Wisconsin as related to depth of leached loess[2] and sandy[3] coverings

Natural drainage condition	Thickness of leached loess or loamy cover					
	6-18" Av. 12" (30 cm)	10-20" Av. 15" (38 cm)	15-20" Av. 22" (55 cm)	20-40" Av. 30" (75 cm)	36-48" Av. 42" (105 cm)	48-120" (more than 120 cm)
Excessively drained	Dunbarton sil (Lithic Hapludalf)					
	Edmund sil (Lithic Argiudoll)	Northfield sil (Lithic Hapludalf)				
	Sogn sil (Lithic Haplustoll)			Gotham ls (Psammentic Hapludalf)		
Well and moderately well drained				Dickinson sil (Typic Hapludoll)	Palsgrove sil (Typic Hapludalf)	Seaton sil[4] (Tyic Hapludalf)
				Meridian l (Mollic Hapludalf)	Ashdale sil (Typic Argiudoll)	Port Byron sil[4] (Typic Hapludoll)
			New Glarus sil (Typic Hapludalf)	Dakota l (Typic Argiudoll)	Bertrand sil (Typic Hapludalf)	Fayette sil (Typic Hapludalf)
			Dodgeville sil (Typic Argiudoll)	Tell sil (Typic Hapudalf)	Richwood sil (Typic Argiudoll)	Tama sil (Typic Argiudoll)
				Pillot sil (Typic Argiudoll)	Jackson sil (Typic Hapludalf)	
				Gale sil (Typic Hapludalf)	Toddville sil (Typic Argiudoll)	
				Dubuque sil (Typic Hapludalf)		
				Norden sil (Typic Hapludalf)		
Somewhat poorly drained					Curran sil (Udollic Ochraqualf)	
					Rowley sil (Aquic Argiudoll)	

[1]Abbreviations of soil texture are: sil = silt loam; l = loam; ls = loamy sand.
[2]The deeper the loess cover the more productive the soil for crops and trees, because this cover stores both water and plant nutrients in forms available to plants.
[3]Gotham, Dickinson, Meridian and Dakota soils have an admixture of silt and sand.
[4]This is a coarser silt loam than in the Fayette and Tama series.

10. Soils of Southeastern Wisconsin (Soil Region B)

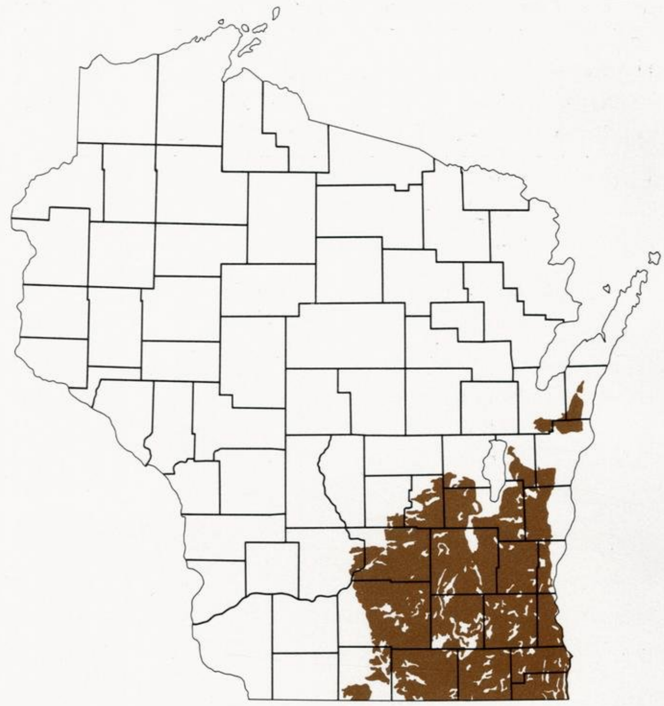


Figure 28. Distribution of southeastern loams and silt loams (Region B).

This region covers about 13% of the area of the state and consists of one major body and two others – one northeast of Lake Winnebago and a smaller one in southern Green County (Figure 28).

These are silty to sandy soils developed on **calcareous glacial drift** on landforms characteristic of recently glaciated terrain: moraines, drumlins, outwash plains, kames, and the serpentine eskers (Table 5). **Cuestas** are heavily blanketed and obscured by glacial drift. However, the Silurian ("Niagara") cuesta is still quite prominent, particularly near the southern end of Lake Winnebago. The three levels of the stair-step landscape are otherwise rather subdued and the glacial land forms just listed are present in most places (Figure 29).

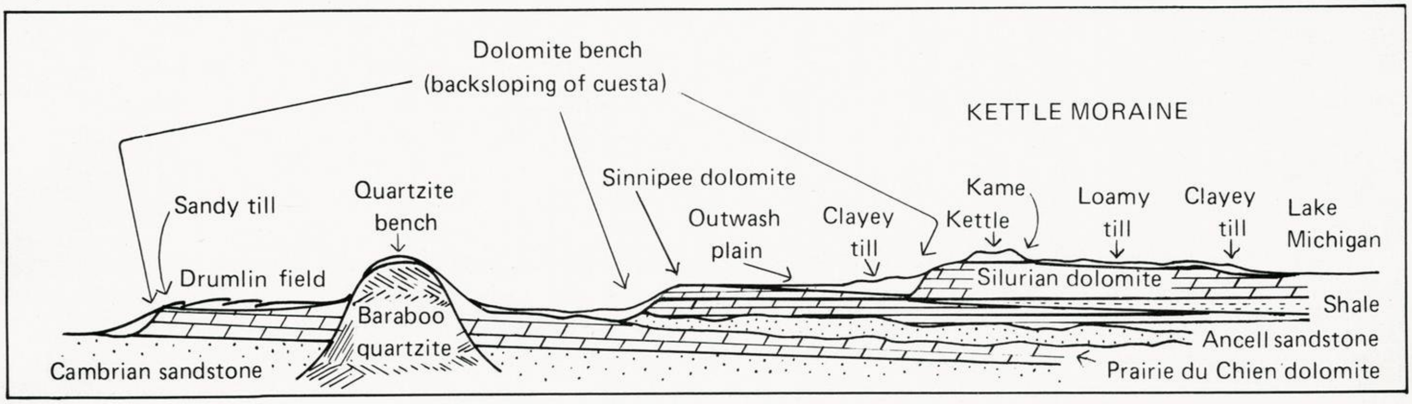
Glacial deposits and loess were nearly all calcareous originally. Leaching by percolating rain water during the thousands of years since the glacier melted away accounts for the acidity of the upper meter of soil. But in most soils of this Region B there is finely divided lime (calcite) below the zone of leaching. Leaching is deepest in sandy soils. Sand content increases and lime content decreases in the glacial drift from Milwaukee westward to the Wisconsin River at Portage.

Two ages of glacial drift are recognized here. One, called "older" in Table 6, is probably 20,000 to 30,000 years old. The other, called "younger," is about 15,000 years old.

Table 5. Chart of kinds of Pleistoecene (ice-age) deposits and their landforms.

Kinds of materials		Kinds of landforms
Glacial till (ice-laid)	*Moraines* (sheet or belt of till)	*Ground moraine* (rolling to undulating till plain)
		End moraine (belt or ridge of rolling to hilly land marking a position of the ice front)
		Drumlins (stream-lined hills, shaped by the moving ice)
		Kettle (See Outwash, below)
Glacial outwash or *inwash* (deposited by rapidly flowing water)	*"Moraines"* (ridges resembling true end moraines)	*Kettle moraine* (one or more ridges [eskers] or chains of hills [kames] with deep natural pits [kettles] between)
	Plains (near level areas)	*Unpitted* (without kettles)
		Pitted (with kettles)
	Eskers (serpentine ridges)	Ridges of gravel deposited in former tunnels under stagnant glacial ice.
	Kames (conical hills)	Hills of gravel deposited in former caves under the glacier, in some cases at the upstream end of an esker; or hills resulting from slump during melting of buried ice
	Kettles (depressions without outlet)	Depressions in outwash (or till) created by the melting of a buried block of glacial ice
Glacial lake deposit (laid down in quiet water)	*Lake plains*	Stratified clay to very fine sand
	Beaches	Stratified sand and gravel
Dunes and *loess* (wind-blown)		Sand *dunes*
		Blankets: Of sand
		Blankets: Of silt *(loess)*

Major Landscape Positions



Representative Soils

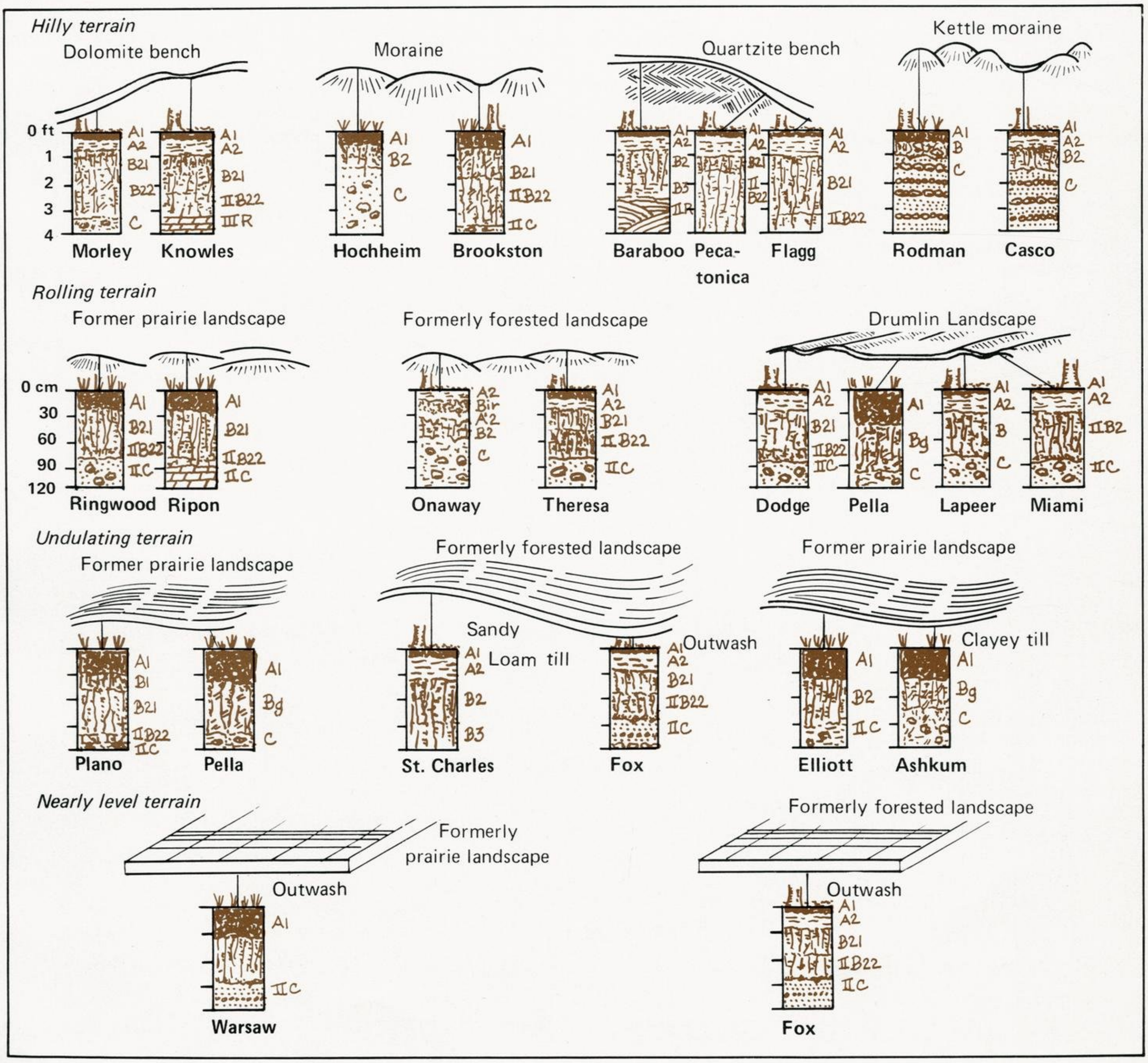


Figure 29. Landscape positions of some representative soils of southeastern Wisconsin (Soil Region B).

As in Region A, depth of loess cover is important to soil genesis and land use. Table 7 groups the soils of Region B with respect to this characteristic. It can be seen that in Region B there are no soils with an average of more than 105 cm of silty material, and that there are some soils without any distinct silt cover. These two differences from conditions in Region A result from Region B's greater distance from the Mississippi River Valley, from which the largest volume of loess was blown across the state by west winds.

It seems likely that wind-blown clay has gradually washed down into the main subsoil (B2t horizon) and into a dark zone (the "beta"-B horizon) at the bottom of the subsoil just above a coarse substratum. Erosion has in many places removed the mellow surface soil and exposed the sticky subsoil. Plants do not germinate nor do roots develop as easily in the clay-enriched B horizon as in the more friable A horizon.

The grouping of soils shown in Figure 29 is based on several factors: differences between prairie soils and forest soils; differences in texture of surface soil, ranging from silty clay loam to sandy loam; depth of silty soil; topography, ranging from rolling and hilly to nearly level; age of glacial drift; content of lime (carbonates) in the till. The Knowles silt loam is on glacial till shallow (about 30 inches or 75 cm) over dolomite bedrock. Where Maquoketa shale underlies the dolomite ledge, the glacial till is clayey and is the material in which the B horizon of the Morley silt loam formed. This soil is more extensive near Milwaukee, on glacial drift containing considerable amounts of Devonian shale. The Hochheim loam developed in glacial till that is so highly calcareous that soil organic matter has tended to accumulate in the topsoil, making it thick like that of a prairie soil. Wetland mineral soils of silty to silty clay loam surface texture include the Brookston, Ashkum and Pella series. Soils of the eastern glaciated portion of the Baraboo Range include the Baraboo silt loam, formed in nearly a meter of silty material over quartzite bedrock; and the Flagg and Pecatonica silt loams, formed in leached loess over older acid glacial till. The Kettle Moraine is characterized by the dark gravelly sandy loam called Rodman and associated shallow loam called Casco. There are patches of outwash and lacustrine flats scattered between bodies of these steeper soils. The Ripon series is the prairie equivalent of the Knowles, already mentioned. Where the sandy loam glacial till is deep the Ringwood soil formed under prairie. The Theresa soils (formerly forested) have deeper silty **sola** (surface and subsoil layers) and

Table 6. Relationship of some representative soil series of Soil Region B to relief and other factors

HILLY SOILS	On dolomite bench—Knowles, Morley					
	On glacial moraine—Hochheim, Theresa, Brookston					
	On quartzite bench—Flagg, Baraboo, Pecatonica					
	On Kettle Moraine—Casco, Rodman, Fox, Lapeer					
ROLLING SOILS	Prairie soils—Ringwood, Ripon					
	Forest soils	On older glacial drift	Locally shallow to bedrock—Pecatonica			
			Deeper drift—Flagg			
		On younger drift	Locally shallow to bedrock—Lapeer			
			Deeper drift	Moraine landscape	Loam till	Mod. lime—Miami
						High lime—Theresa, Hochheim
					Sandy loam till—Lapeer	
				Drumlin landscape—Miami, Dodge, Pella		
UNDULATING SOILS	On clayey drift	Forest soils—Morley				
		Prairie soils—Elliott, Ashkum				
	On loamy drift	Older drift—Flagg, Pella				
		Younger drift	Till deep	Deep loess	Prairie soils—Plano	
					Forest soils—St. Charles, Dodge	
				Shallower loess	Moderate lime	Sandy—Lapeer
						Loamy—Miami
					High lime—Theresa, Hochheim	
			Till locally shallow—Drainage good—Dodge, Knowles			
			Outwash—Drainage good—Fox, Casco			
NEARLY LEVEL SOILS	On outwash	Prairie soils—Plano, Warsaw				
		Forest soils—St. Charles, Fox				

are slightly more leached than the Hochheim, but are on the same kind of highly calcareous glacial till. In the northern outlier of Region B, the Onaway soil shows evidence of **podzolization** through the presence of a Spodosol (Podzol) sequence of horizons above the normal clay-enriched subsoil (B2t horizon). The Onaway soil has a double profile, in this sense. It is likely that the Spodosol sequence has formed and disappeared during the thousands of years required to develop the B2t horizon. The Dodge soil is a common forest soil (Typic Hapludalf) of southeastern counties, found both on drumlins and on rises on moraines that have a moderately deep covering of leached loess. The Plano and St. Charles series are the prairie and forested soils of the deep silt blankets on undulating terrain, of loam to sandy loam glacial till. The Fox soil is underlain by glacial outwash. The Elliott soil is the prairie equivalent of the Blount (see page 57). The Warsaw and Fox soils are representatives of the prairie and forested areas on nearly level outwash flats.

This soil region is the most intensively urbanized one in the state. Considerable areas of these soils are being progressively withdrawn from agriculture. Severe erosion takes place locally during episodes of urban and suburban construction, and of intensive and careless cropping of sloping lands that are especially subject to urban pressures. Progress is being made in setting aside parcels of land as conservation and scientific areas where the vegetation and soils are still largely in their natural wild state.

Table 7. Chart of representative soils[1] of southeastern Wisconsin as related to depth of leached loess cover.

Natural drainage condition	Thickness of leached loess or loamy cover				
	None	Av. 12" (30 cm)	Av. 15" (38 cm)	Av. 30" (75 cm)	Av. 42" (105 cm)
Excessively drained	Rodman sl (Typic Hapludoll)				
Well drained	Onaway l)Alfic Haplorthod)	Morley sil (Typic Hapludalf) Hochheim l (Typic Argiudoll) Warsaw l (Typic Argiudoll) Fox l (Typic Hapludalf)	Casco l (Typic Hapludalf)	Knowles sil (Typic Hapludalf) Baraboo sil (Typic Hapludalf) Ringwood sil (Typic Argiudoll) Ripon sil (Typic Argiudoll) Theresa sil (Typic Hapludalf) Dodge sil (Typic Hapludalf)	Flagg sil (Typic Hapludalf) Pella sil (Typic Haplaquoll) Plano sil (Typic Argiudoll) St. Charles sil (Typic Hapludalf)
Somewhat porly drained		Elliott sil (Aquic Argiudoll)			
Poorly drained		Ashkum sicl (Typic Haplaquoll) Brookston l (Typic Argiaquoll)			

[1] Abbreviations of textures signify: l = loam; sil = silt loam; sl = sandy loam

11. Soils of the Central Sandy Plain of Wisconsin (Soil Region C)

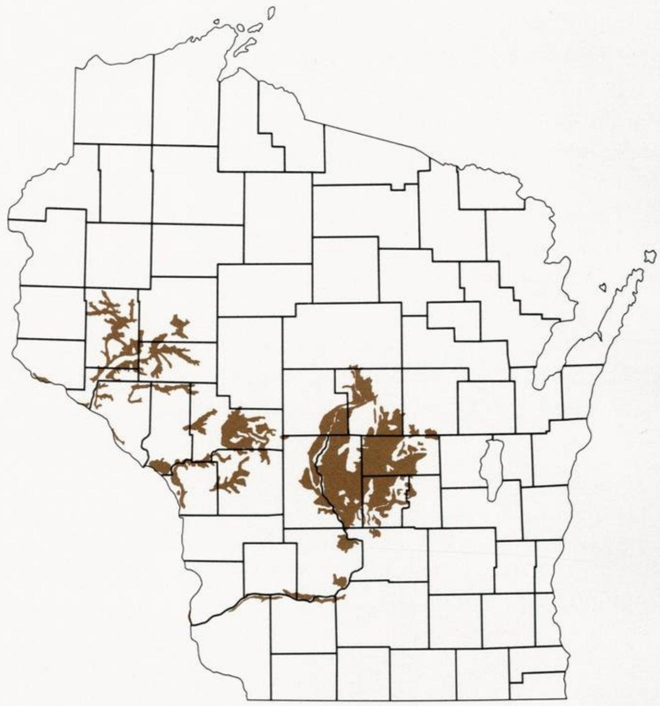


Figure 30. Distribution of central sandy soils (Region C).

Droughty, sandy soils predominate in this region on terrain that consists mostly of nearly level **outwash plains and terraces,** interrupted in places by scattered **sandstone buttes and small mesas** (Figure 31). There are also rolling **moraines** and ancient glacial lake beds. The water table stands close to the surface in places. These sandy soils developed in coarse deposits made by glacial meltwaters, glacial ice, wind, and in the case of the sandstone, ancient seas. This soil region occupies about 7% of the area of the state (Figure 30).

The sandy soils respond quickly to the first warm weather in spring. Native ground cover plants flower sooner in parts of this region than in Region B. Without irrigation, crops and native vegetation alike suffer from water shortage in mid- and late-summer. The presence of native prickly pear cactus *(Opuntia compressa)* on foot-slopes of many buttes gives a semi-desert quality to the landscape in dry seasons. Frosts are frequent in lowlands of the Central Sand Plains and limit plant growth. Hill's oak *(Quercus ellipsoidalis)* and jack pine *(Pinus banksiana)* show rather poor growth in "scrub forest" on the extensive Plainfield loamy sand.

Before modern forest fire control measures were instituted, fires set by lightning or by native Americans must have been common in Region C. Extensive prairies and countless oak openings resulted. The impact of these circumstances on the sandy soil materials produced dark prairie soils, notably the Sparta loamy sand, and more productive but less extensive Dakota sandy loam, both on outwash plains. Where trees predominated, the Plainfield loamy sand formed, both in outwash flats and moraines made predominately of sandy till. Where the till was somewhat less sandy, the Mecan and Wyocena soils formed. Table 8 presents a classification of soils of the Region, which straddles the end moraine boundary and includes till country to the east, the outwash plain, and parts of the bed of ancient Glacial Lake Wisconsin, to the west.

The grouping of Soils in Figure 31 is based on several factors: differences between prairie sands and forest sands, between wet sands and excessively drained sands; between landscapes with sandstone mounds and landscapes without them; between hilly terrain and nearly level areas.

Increased use of large-scale irrigation equipment in recent years has earned the title of "Golden Sands" for many square kilometers of the Central Sands Region, where snap beans, potatoes and sweet corn are grown. Large acreages of "scrub forest" are used as a source of wood for paper pulp and, to a lesser extent, for charcoal for use by campers.

In rolling country and around buttes and "mounds," the soils are used for wildlife and recreation.

Reference to cranberry production will be made under the heading of Soil Region J.

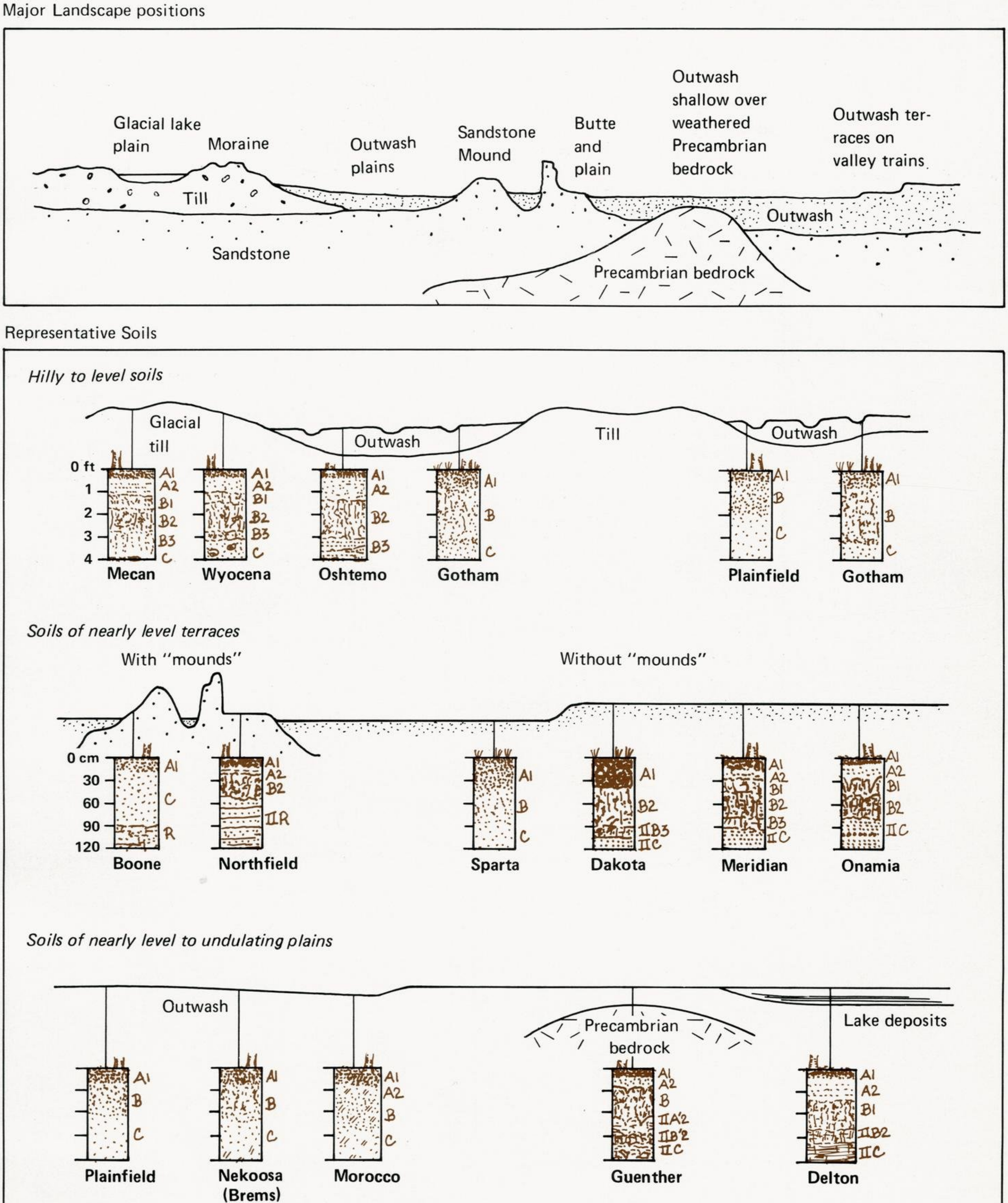


Figure 31. Landscape positions of some representative soils of the central sandy plain (Soil Region C).

Table 8. A classification of principal soils of Region C.

Initial material	Native vegetation	Natural soil moisture regime	Deep, very sandy soils	Sandy soil 20-40" (50-100 cm) thick over sandy outwash	SOIL TEXTURAL GROUPS — Loamy soils — 20-40" (50-100 cm) thick over: Sandy outwash	Sandy calcareous till	Acid glacial lake clay	Over loamy residuum from igneous bedrock	40-60" (100-150 cm) thick over: Calcareous sandy and gravelly outwash	Reddish calcareous glacial till
Sandstone	Forest	Excessively well drained	Boone loamy sand (Typic Quartzipsamment, mixed, uncoated)							
Glacial drift	Prairie	Excessively well drained	Sparta loamy sand (Entic Hapludoll, sandy, mixed, mesic)							
		Well drained			Dakota sandy loam (Typic Argiudoll, fine-loamy over sandy or sandy-skeletal, mixed, mesic)					
	Forest	Excessively well drained	Plainfield loamy sand (Typic Udipsamment, mixed, mesic) Nymore loamy sand[1]	Gotham loamy sand (Psammentic Hapludalf, sandy, mixed, mesic)	Richford sandy loam (Psammentic Hapludalf, sandy, mixed, mesic)					
		Well drained			Meridian sandy loam (Mollic Hapludalf, fine-loamy over sandy or sandy-skeletal, mixed mesic)	Wyocena sandy loam (Typic Hapludalf, coarse-loamy, mixed, mesic	Delton sandy loam (Arenic Hapludalf, coarse-loamy over clayey, mixed, mesic)	Guenther sandy loam (Alfic Haplorthod, sandy over loamy, mixed, frigid)	Oshtemo sandy loam (Typic Hapludalf, coarse-loamy, mixed, frigid)	Mecan sandy loam (Typic Hapludalf, coarse-loamy mixed, mesic)
		Moderately well drained	Brems loamy sand (Aquic Udipsamment, mixed, mesic)							
		Somewhat poorly drained	Morocco loamy fine sand (Aquic Udipsamment, mixed, mesic)							
		Poorly drained	Newton sandy loam (Typic Humaquept, sandy, mixed, mesic)							

[1]Same as Plainfield, except a weak spodic horizon is present, certainly not strong enough to resemble that of Omega loamy sand, an Entic Haplorthod in the frigid soil zone.

12. Soils of the Western Sandstone Uplands and Valleys (Soil Region D)

Figure 32. Distribution of loams over sandstone (Region D).

This region accounts for 9% of the area of the state. More than two-thirds of it lies in the Driftless Area, and the rest is on northern Border Drift, which is a term for the areas of Older Drift shown on Figure 20.

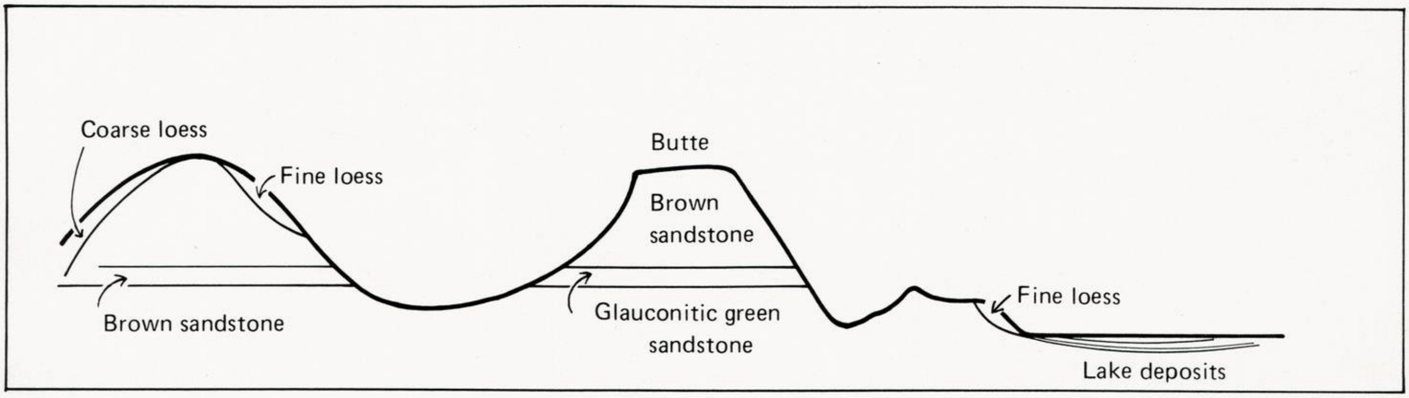
The western sandstone uplands have been dissected by numerous valleys, giving this region a hilly to rolling topography that smooths to a plain on the north and east. No dolomite ledge is present on the tops of hills and ridges as in Region A. The cover of wind-blown silt – so common in Regions And B – is patchy, so one finds droughty sandy soils and productive deep silty soils in the same landscape, associated with intermediate loams. Where the silt cover is deep the Fayette and Seaton silt loams are found; where moderately deep, the Gale silt loam developed. Where a thin layer of glacial till rests on the sandstone, the Arland soils are recognized. Table 9 presents a classification of the soils of the Region. Some of the Cambrian sandstone layers are nearly entirely made up of quartz and support poor, infertile soils. These include the moderately deep Boone loamy sand and the shallow Northfield loamy sand. Certain sandstone layers are given a greenish gray color by an abundance of a dark mineral called **glauconite,** that contains potassium, an important plant nutrient. Soils formed from this **greensand** are placed in the Norden soil series. Similar soils that lack the greensand are called Hixton loams and sandy loams. Where shale layers are present in the sandstone, sandy soils with a somewhat clayey subsoil have formed: Merrillan and Elm Lake sandy loams; Kert, Vesper, and Veedum loams on plains at the northeastern edge of the Region.

The groupings of soils in Figure.33 are based on several factors: good drainage and impeded drainage; rolling and hilly topography as contrasted with nearly level terrain; presence or absence of greensand; coarse silt as contrasted to fine silt; presence or absence of silt (loess) cover; differences in depth of leached loess, where present; presence of till or of outwash.

Some landscapes are picturesque with many wooded slopes, some with sandstone cliffs. Trempealeau Mountain at Perrot State Park presents a typical array of forested steep slopes and sandy to silty soils. Gentler slopes in this Region are commonly farmed.

A century ago narrow sandstone ridges were real barriers to trade and social contacts between farm communities on either side. The Mindoro Cut, a hand-hewn road cut through a sandstone ridge thinly capped with dolomite near the village by that name in LaCrosse County, was a major improvement in early days.

Major Landscape Positions



Representative Soils

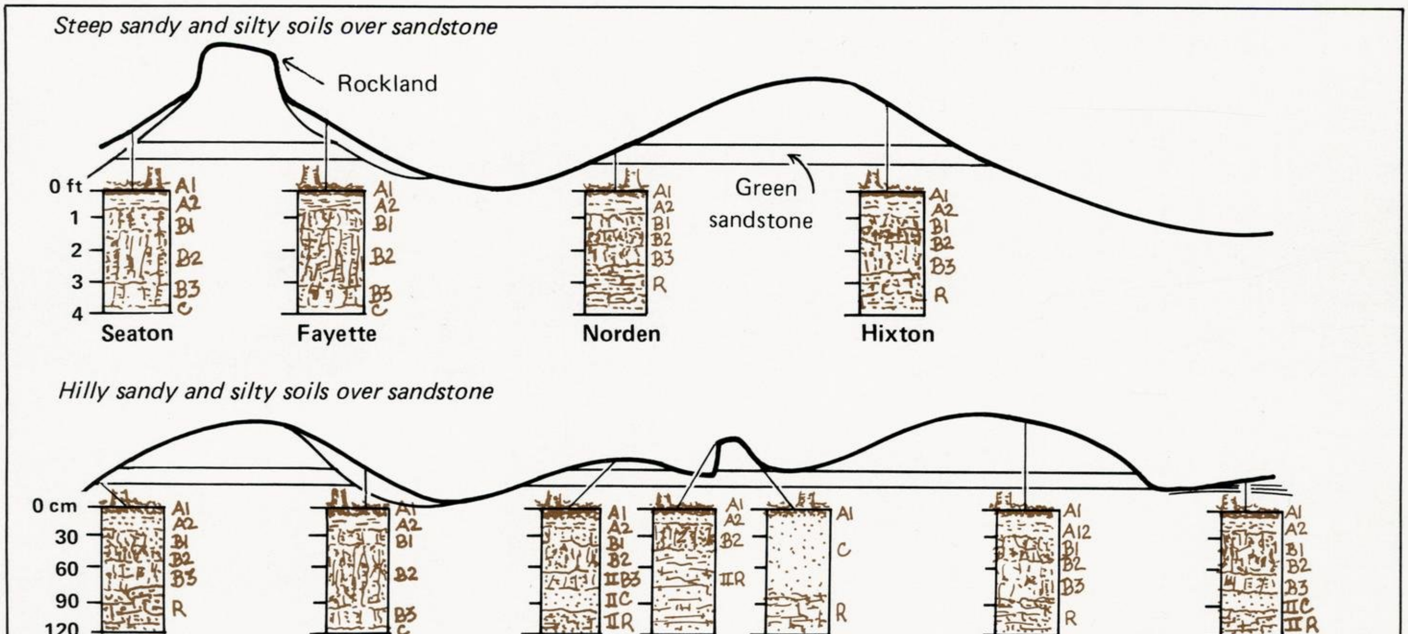


Figure 33. Landscape positions of some representative soils of the western sandstone uplands and valleys. (Soil Region D).

Table 9. A classification of principal soils of Region D.

Natural soil drainage condition	Soils formed from silty covering over sandstone				Soils formed from loamy (or silty) covering on sandstone							Loamy (to silty) covering present over acid stratified sand and gravel	
	Silt is 4 ft. (120 cm) or more thick				Loamy cover is 20-40" (50-90 cm) thick					Loamy cover is 10-20" (25-50 cm) thick	No cover present		
										On brown sandstone			
	Silt is coarse	Silt is fine	Silt is 20-36" (50-90 cm) thick	Silt is less than 20" (50 cm) thick	On green sandstone	On brown sandstone	On till over sandstone	On shaly sandstone	Silt may be 20" thick	Cemented	Not cemented	Covering is 20-40" (50-100 cm) thick	Covering is 12-20" (30-50 cm) thick
Excessive										Northfield sandy loam, silt loam	Boone sand		
Good	Seaton silt loam	Fayette silt loam	Gale silt loam	Norden silt loam, sandy loam		Hixton loam, sandy loam	Arland loam, sandy loam					Onamia loam, silt loam	Chetek sandy loam, loam
Somewhat poorly								Merrillan loamy sand, sandy loam	Kert sandy loam, silt loam				
Poor								Elm Lake sand, sandy loam	Vesper silt loam				
Very poor									Veedum silt loam				

13. Soils of the Northern and Eastern Sandy and Loamy Reddish Drift Uplands and Plains (Soil Region E)

Figure 34. Distribution of pink loams (Region E).

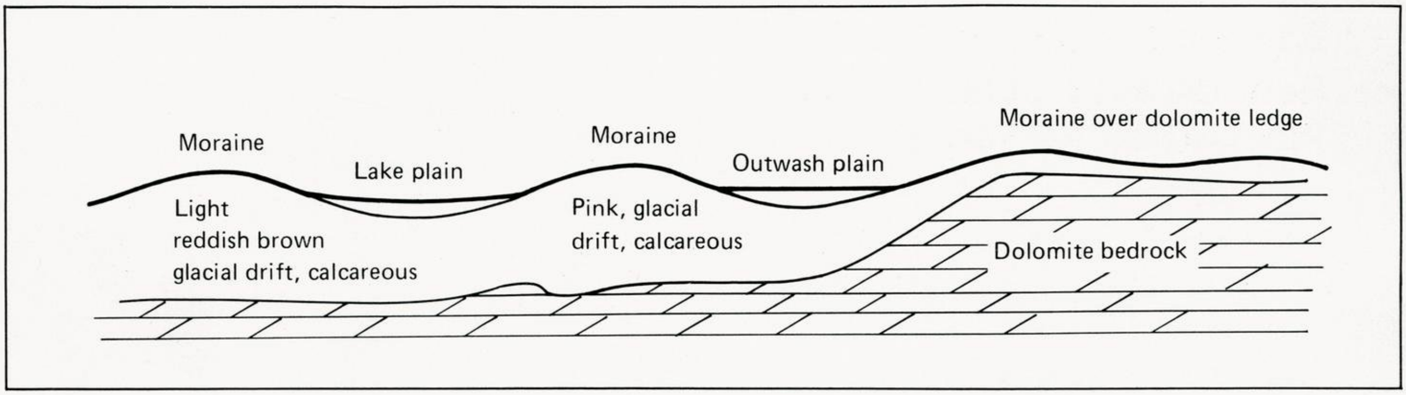
Soils of this region lie on either side of Green Bay and cover nearly 5% of the area of the state. There is a small, isolated body of these soils in Juneau and Monroe Counties (Figure 34). On the Door Peninsula, shallowness to bedrock is a common feature (Figure 35). This has forced some cherry orchardists to dynamite holes in dolomite in planting cherry trees and has required rural homeowners to seek permission to build soil mound systems in which to safely dispose of septic system effluent. The glacial till on both sides of Green Bay is a light pinkish brown in color, gradational in this respect as well as in texture between the red clays of Soil Region I and the brown sandy loams and sands of Regions G and H. To the west of Green Bay soils are on rolling moraines with some striking knob and kettle topography, and on nearly level old lake plains. Some soils developed in the glacial lake deposits are silty to very fine sandy and have little or no accumulation of clay in the B horizon. An example is the Shiocton series, whose soils present drainage problems to farmers growing corn, cabbages, beets, and pickles.

In many places **"double" soil profiles** may be seen. These consist of a shallow Spodosol (Podzol) solum (surface and subsoil layers) overlying the Bt horizon of a Udalf (Gray-Brown Podzolic). The carbonate content of the glacial drift grades from fairly high on the Door Peninsula to only a few percentages at the northeast borders of the Region. Table 10 gives a classification of the major soils of the region.

Groupings of soils in Figure 35 are based on several factors: presence or absence of dolomite bedrock near the surface; natural drainage condition from excessive in Omega to poor in Angelica; presence or absence of an accumulation of clay in the B horizon; presence or absence of a Spodosol (Podzol) sequence of soil horizons; nature of the drift (till, outwash, lacustrine deposits).

This soil region is unusual because here a northern, cool, moist climatic zone overlaps calcareous substrata so that processes of podzolization are operating on alkaline materials. The movement of iron into the spodic B horizon (Bhir) is aided by the affinity that some humus (chelates) have for iron, which permits this movement even in neutral (pH 7) or alkaline soil. The soils display some characteristics of northern zones and some of southern. It is no wonder that double profiles are present. They express the dual nature of soil formation in the region.

Major Landscape Positions



Representative Soils

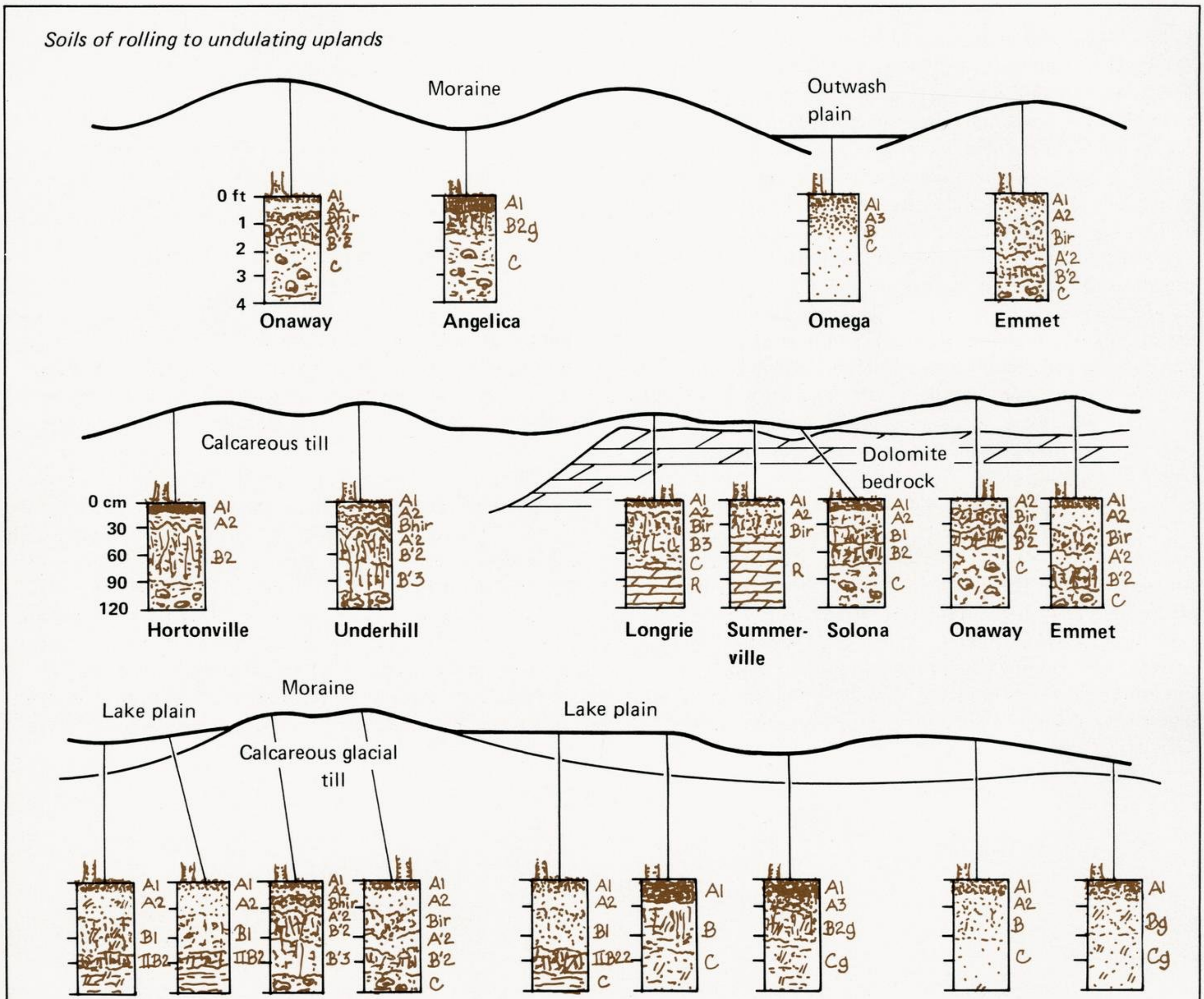


Figure 35. Landscape positions of some representative soils of the northeastern sandy and loamy reddish drift uplands and plains (Soil Region E).

Table 10. A classification of principal soils of Region E.

Depth and texture of surface material	Character of substratum		Natural soil drainage condition: Excessive	Good	Somewhat poor	Poor to very poor	Very poor
25-40" (55-100 cm) of loam	Pink calcareous glacial till; sandy loam to loam			Emmet sandy loam, loam			
40" (100 cm) of loam to silt loam	Pink calcareous glacial till; sandy loam to loam			Underhill silt loam Onaway sandy loam, loam	Solona sandy loam	Angelica loam, silt loam	Histosols (bogs; peat, muck)
20-40" (50-100 cm) of loam to silt loam	Dolomite bedrock			Longrie loam			
10-20" (25-50 cm) of loam	Dolomite bedrock			Summerville loam, silt loam			
Less than 20" (50 cm) silt	Calcareous reddish clay, silty clay loam, loam glacial till (Bt has 27-35% clay)			Hortonville fine sandy loam, silt loam			
Very deep (40" 100 cm) loam, silt loam	Stratified fine sands, silts				Shiocton very fine sandy loam, silt loam	Keowns silt loam	
20-40" (50-100 cm) sands	Acid clayey glacial drift			Delton loamy sand, loam	Wyeville loamy sand, loam		
	Calcareous clayey glacial drift			Tustin loamy sand, sandy loam			
	Fine sand			Shawano fine sand, loamy fine sand			
Deep sand	Medium sand	Neutral				Granby loamy sand, fine sandy loam	
		Acid	Omega loamy sand				

14. Soils of the Northern Silty Uplands and Plains (Soil Region F)

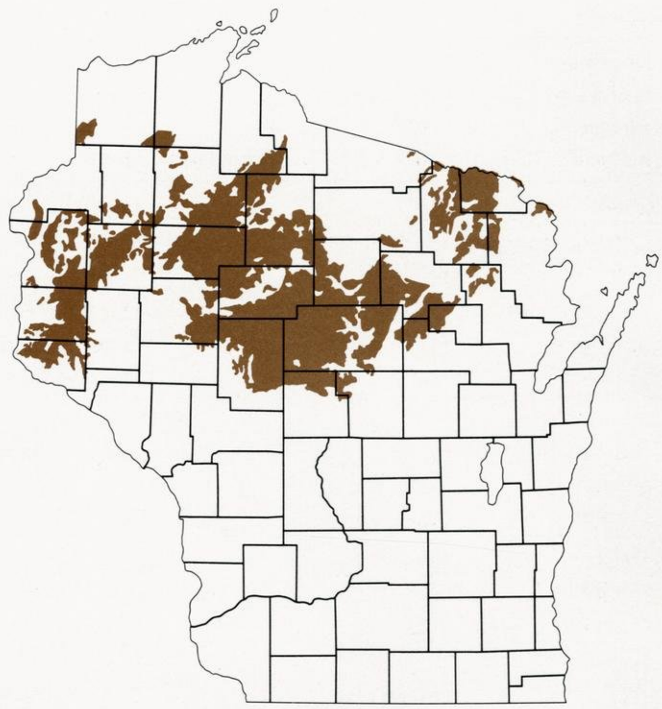


Figure 36. Distribution of northern silt loams (Region F).

These silt loams extend across 16% of the area of Wisconsin, both north and south of the end moraine belt of the middle Wisconsin glaciation (Figure 36). A silty covering about two-thirds of a meter (2 feet) thick overlies acid reddish brown glacial till, sand and gravel outwash, lacustrine deposits, and Precambrian bedrock in this Region. The topography is undulating to gently rolling, except on end moraines and near large river valleys where slopes are steeper (Figure 37). Drift is shallow (2 or 3 meters) to bedrock on the south, thickening to 100 feet and more in the north. Where naturally well drained, as on the outwash plain called the Antigo Flats, these soils are productive of forest and crops alike. Vast areas (60% of the Region) have impeded drainage, however, because of the subdued topography, inherited from a preglacial surface on the **peneplained bedrock**, and also because of the compactness of the acid glacial till. This has made crop production and disposal of liquid wastes difficult.

The silty material was probably originally a local loess. It is coarser in texture than the loess of southwestern Wisconsin, from which the Fayette and Tama soils formed, and was probably never calcareous. The shallowness of the silt layer has permitted stones and sand from the underlying glacial drift to mix into it by tree-tipping in storms, frost action, and probably some animal activity.

Table 11 presents a classification of representative soils of the Region. It can be seen that soils with impeded drainage predominate.

The grouping of soils in Figure 37 is based on several factors: differences between prairie and forest soils; contrast between soils on outwash and till; depth of silty covering over glacial drift; differences in natural soil drainage conditions; presence or absence of a Spodosol (Podzol) soil horizon sequence; presence or absence of Precambrian bedrock close to the surface; differences between soils on calcareous till from those on acid till. The soil association Cushing-Bluffton is unusual in that the glacial till is highly calcareous. There is also a productive strip of soils about a mile wide and 20 miles long that is underlain by calcareous silty till in the Withee-Auburndale association southeast of Marshfield in Wood County. Scattered bodies of calcareous lake-laid silts in northern counties are parent materials for Campia and related soils. The Jewett-Waukegan (Pillot) soil association in St. Croix County is the only representative of prairie soils in the Region.

In many of the subsoils a striking mottling of yellowish brown and pale gray colors and a coarse platy structure are evident. Application of lime and fertilizer, and land-forming practices on undulating and gently rolling moraines make possible the production of alfalfa hay and successful operation of dairy farms. The two-story nature of the soils (silty layer over coarser drift) favors tree-tipping in wind storms.

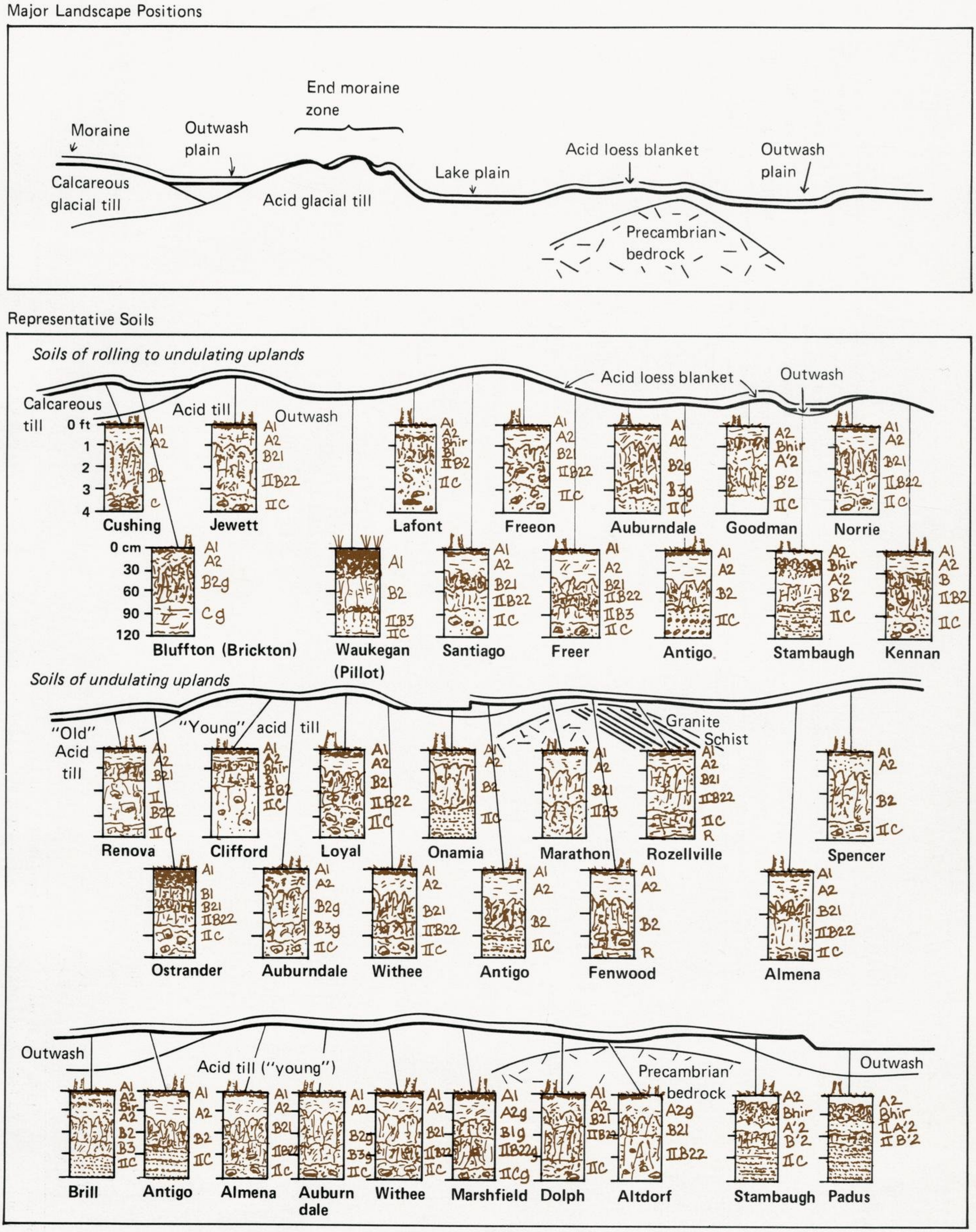


Figure 37. Landscape positions of some representative soils of the northern silty uplands and plains (Soil Region F).

Table 11. A general key to principal soils of Region F.

Nature of substratum			Nature of "cover"	Soils in northern parts of the region: Well drained	Soils in northern parts of the region: Somewhat poorly drained	Soils in northern parts of the region: Poorly drained	Soils in central parts of the region: Well drained	Soils in central parts of the region: Moderately well drained	Soils in central parts of the region: Somewhat poorly drained	Soils in central parts of the region: Poorly drained	Soils in southern parts of the region: Well drained	Soils in southern parts of the region: Somewhat poorly drained	Soils in southern parts of the region: Poorly drained
Glacial till	"Young" till	Acid till	Shallow silt[1]	Lafont	Clifford	Auburndale					Kennan		
Glacial till	"Young" till	Acid till	Moderately deep silt[2]				Santiago[10] Loyal[10]	Freeon	Freer[10] Withee[10]	Marshfield[10]			
Glacial till	"Young" till	Acid till	Deep silt[3]						Almena	Auburndale	Norrie		
Glacial till	"Young" till	Neutral till	Moderately deep silt[2]				Jewett						
Glacial till	"Young" till	Calcareous till	Deep loam[4]				Cushing			Bluffton (Brickton)			
Glacial till	"Older" till	Forest soil	Shallow silt[1]				Renova						
Glacial till	"Older" till	Prairie soil	Shallow silt[1]				Ostrander						
Glacial outwash			Shallow silt[5]	Padus			Onamia						
Glacial outwash			Deep silt[6]	Stambaugh			Antigo Pillot	Brill	Poskin				
Precambrian bedrock	Clayey residuum		Shallow silt[7]										Altdorf
Precambrian bedrock	Fine-grained rock		Shallow silt[8]								Rozellville	Dolf	
Precambrian bedrock	Coarse-grained rock		Deep loam[9]								Marathon		

1 $<$24" (60 cm). 2 15-30" (37-75 cm). 3 24-40" (60-100 cm) 4 20-42" (50-105 cm). 5 $<$20" (50 cm). 6 20-40" (50-100 cm). 7 30" (75 cm).
8 $<$15" (38 cm). 9 30-60" (75-150 cm). 10 The acid reddish brown glacial till is a sandy loam under the Santiago catena and a tight loam under the Loyal catena.

15. Soils of the Northern Loamy Uplands and Plains (Soil Region G)

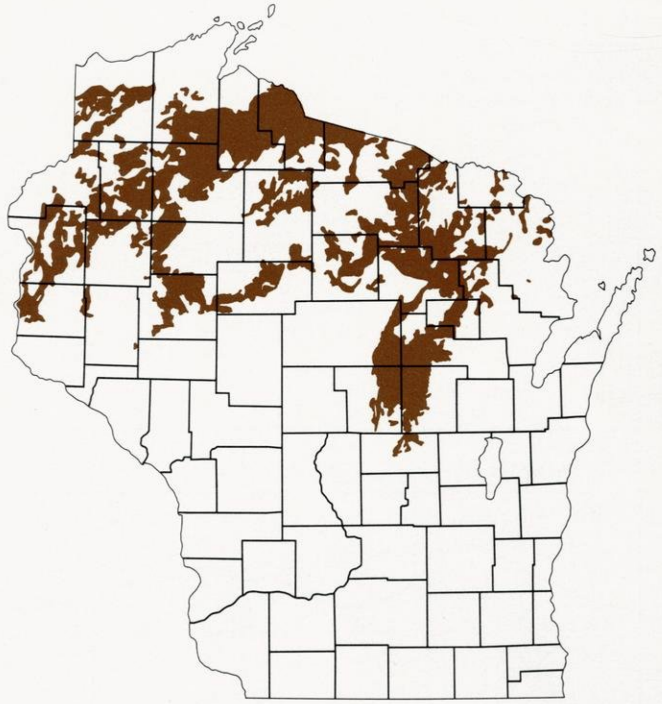


Figure 38. Distribution of northern loams (Region G).

This region is made up of strips and patches of land that are largely forested and cover nearly 17% of the area of Wisconsin (Figure 38). In this Region soils formed principally from glacial drift (Figure 39). There is no definite silty covering, as is common in adjacent portions of Soil Region F. The loams, sandy loams and loamy sands are developed in glacial outwash on both level and pitted terrains and in till on glacial moraines, some of which are quite rugged and stony. The fact that most of the soils are formed in a **loamy covering** as much as a meter thick over the glacial drift (Table 13), strongly suggests that wind-blown silt and clay have been mixed into upper layers through the centuries. Precambrian bedrock underlies most of the area at depths of 50 to 350 feet. The glacier incorporated great quantities of the bedrock materials into the thick drift layer. As a result, the soils are acid with few exceptions. Southern extensions of this landscape are farmed more than northern areas. In Portage and Waupaca Counties this is in large part a result of the presence of carbonates from dolomitic material in the glacial till. Elsewhere the till is generally acid. In northeastern Sawyer County a southwest-trending streaking of glacial land forms is evident.

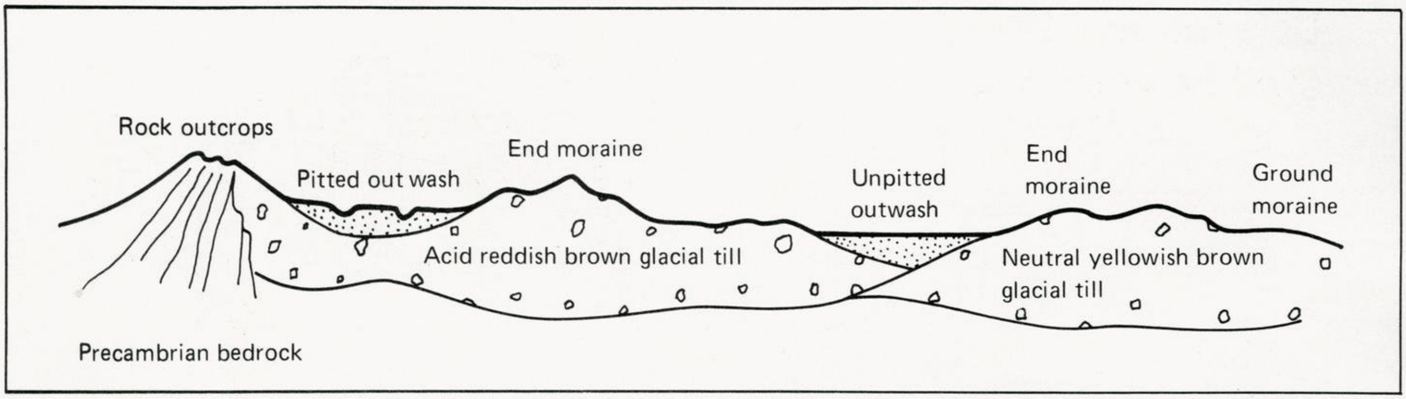
Two soil forming processes have been at work in the upland soils. One is the accumulation of clay in the subsoil to form weak argillic horizons (B2t). The other is the concentration of organic matter and iron oxide in lower surface soil and upper subsoil to form the spodic horizon (Bhir). Some soils, like the Padus loam (Table 12) have both horizons: The Bhir rests on top of the B2t, to form what is called a "double" or bisequal profile.

In the northern third of this Region **fragipans** are present in the lower B horizon and obstruct growth of roots. A polygonal pattern of cracks is found in some fragipans. It is down these cracks that tree roots extend preferentially in distinct sheets. The albic (A2) horizon extends down the same cracks in the B2t horizon. This tonguing of the albic horizon is a common phenomenon in the Region and is one expression of podzolization. The B2t horizon is apparently being degraded by the A2 horizon, which grows downward at the expense of the argillic horizon. The process has been going on for thousands of years and is assumedly very slow.

Probably the one tree species that has most favored the formation of Spodosols is the hemlock *(Tsuga canadensis)*. Where natural forest succession has allowed the sugar maple *(Acer saccharum)* to replace the hemlock, the spodic B horizon has faded. There is evidence in the Menominee Tribal Lands to suggest that this fading requires about 400 years to reach completion. Agricultural activity in the Region has disturbed spodic soil profiles by means of plowing, fertilizing, and exposing the soil to the elements.

With addition of manure and other amendments and with well-timed irrigation on level soils like the Chetek and the Onamia, good crops of potatoes, beans and short-season corn can be produced. It is an area in which pasture and hay do well – as do trees – both in plantations and in naturally regenerating forests.

Major Landscape Positions



Representative Soils

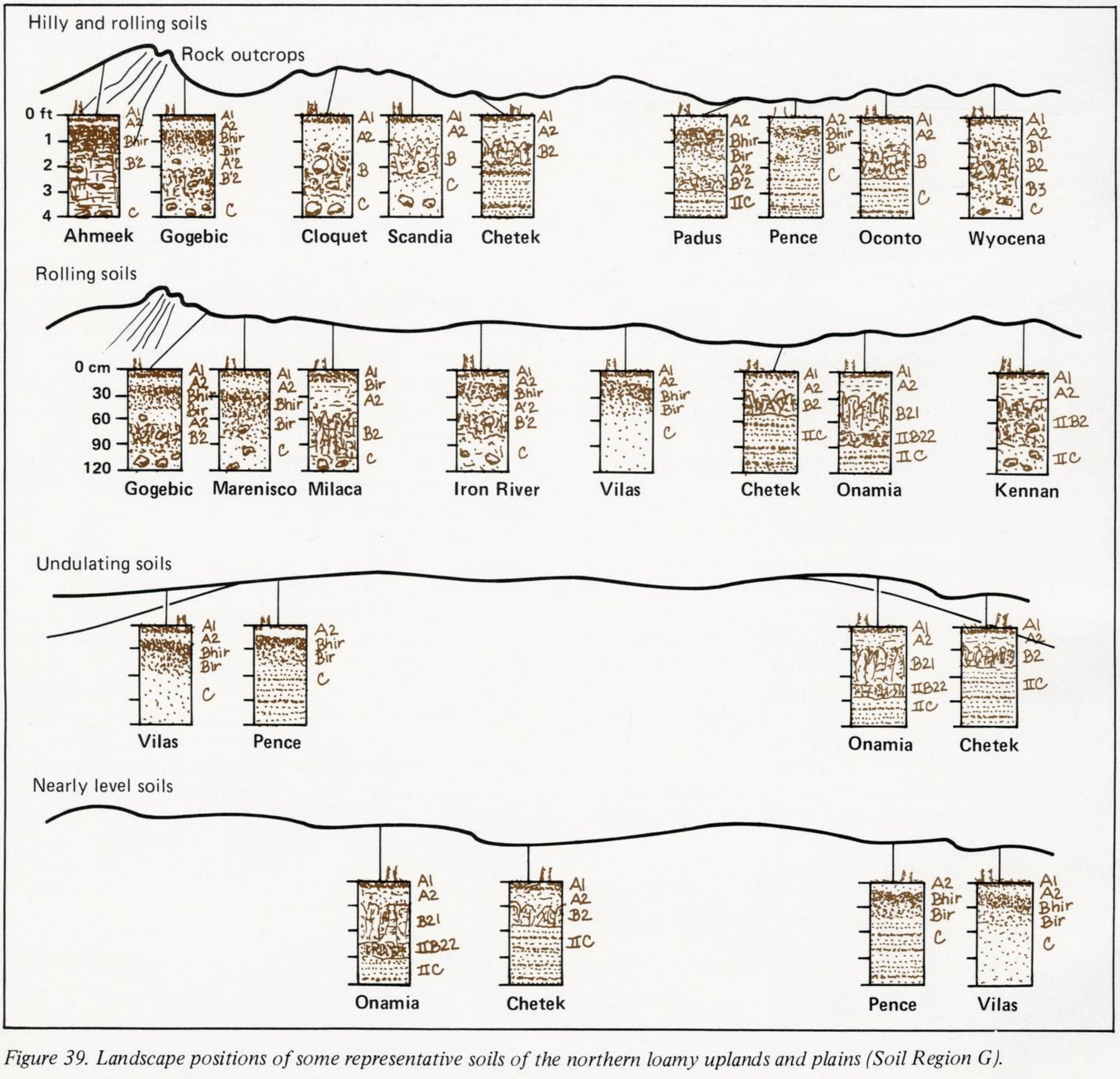


Figure 39. Landscape positions of some representative soils of the northern loamy uplands and plains (Soil Region G).

Table 12. A classification chart of representative soils of Region G.

	Initial material		Depth of surficial covering		Inceptisol	Well drained: Alfisols	Well drained: Spodosols
Glacial till	Calcareous; sandy		20-40" (50-100 cm) loamy material			Wyocena	
Glacial till	Acid sandy loam	Brown[1]	No covering		Cloquet		
Glacial till	Acid sandy loam	Brown[1]	20-40" in loamy covering	No silt		Scandia	
Glacial till	Acid sandy loam	Brown[1]	20-40" in loamy covering	< 20" silt		Kennan	
Glacial till	Acid sandy loam	Red[2]	No covering				Marenisco
Glacial till	Acid sandy loam	Red[2]	20-40" in loamy covering	No silt			Gogebic
Glacial till	Acid sandy loam	Red[2]	20-40" in loamy covering	< 24" silt			Iron River
Glacial till	Acid sandy loam	Red[2]	30-50" in loamy covering	< 15" silt		Milaca (Amery)	
Glacial outwash	Acid	Brown[1]	No covering				Vilas
Glacial outwash	Acid	Brown[1]	10-20" in loamy covering				Pence
Glacial outwash	Acid	Brown[1]	12-20" in loamy covering			Chetek	
Glacial outwash	Acid	Brown[1]	20-40" in loamy covering	No silt			Oconto
Glacial outwash	Acid	Brown[1]	20-40" in loamy covering	< 20" silt			Padus

[1] Brown = 10YR 5/4, moist color on the Munsell soil color chart.
[2] Red = 7.5YR and 5YR 4/2, moist soil.

16. Soils of the Northern Sandy Uplands and Plains (Soil Region H)

This northern region covers about 7% of the area of the state as scattered strips and patches of sandy land (Figure 40). The soils are formed in glacial drift on terrains ranging from rough, pitted, somewhat stony moraines to level, smooth sandy plains. Probably most of the material is outwash, but some of it may be till, or at least slumped masses of outwash in which stratification has been lost. Some of the sands are stone-free; others are somewhat gravelly or even contain boulders. It is likely that wind action has winnowed silt and clay out of the sandy materials at times of disturbance by frost action, water wash, slump, and animal digging. This winnowing process could also have concentrated gravel and stones at the surface. Because of the geologic instability of the materials in hilly landscapes and fragility of the vegetative cover, well-developed soils are rare.

The Omega soil is an expression of conditions in **sand barrens**, where fires must have been common in prehistoric time. The dark A1 horizon above the weak spodic Bhir together reflect the presence of grasses between scattered jack pine *(Pinus banksiana)* and scrub oak *(Quercus ellipsoidalis)*. The Pence soils developed from sandy drift that was for some reason more stable than that under the Omega and Vilas soils (Fig. 41). As a result it contains loamy material in the upper 60 cm, that has either not been winnowed out, or has been reintroduced by **eolian** (wind) and mixing processes.

Many of the numerous natural pits (kettles) in this sand country measure 2 to 40 meters deep and are places into which air drains, creating **frost pockets** on cold nights, and **hot pockets** on sunny days. Conditions for plant growth are made more difficult by these wide variations in temperature of soil and air in these pockets than on surrounding slopes.

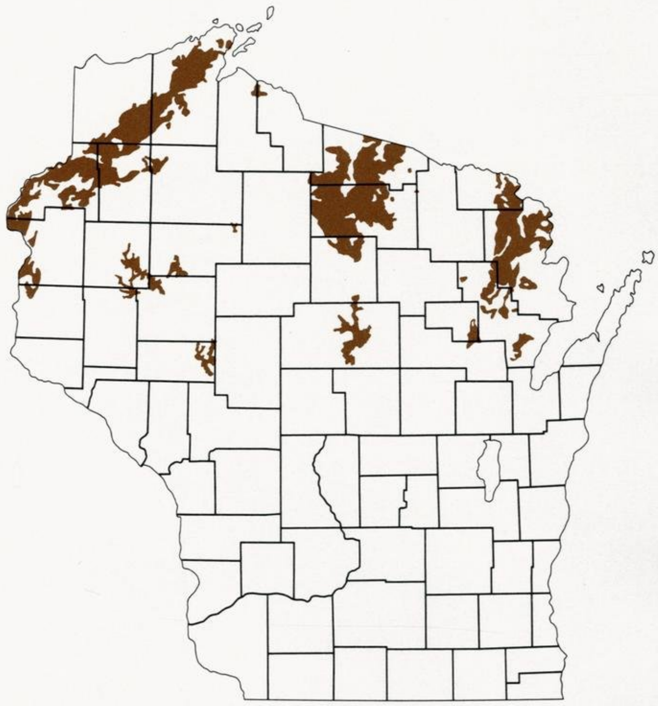
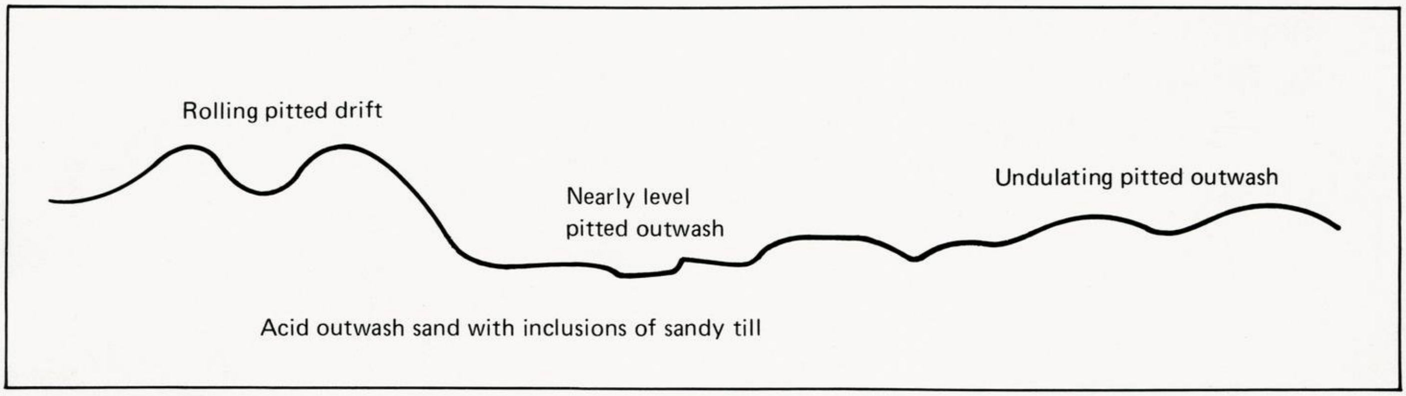


Figure 40. Distribution of northern sandy soils (Region H).

The central body of this soil region in Vilas and Oneida Counties is more completely covered with forest than the other two bodies (in northwestern and northeastern Wisconsin, respectively). The central area is known as a prime recreational and retirement area.

Crop production is not good in this region, except with careful irrigation and fertilization on level sandy loams like the Pence soils. Potato yields are good. Because of the lowered evapotranspiration in the northern counties, these somewhat loamy sands are not as droughty as soils of similar texture would be in southwestern Wisconsin. Timber growth is satisfactory, under good management on soils of Region H. In the vicinity of Lake Superior, extra moisture in the form of fog causes drip from the needles which doubles or triples the growth rate in some red pine *(Pinus resinosa)* plantations.

Major Landscape Positions



Representative Soils

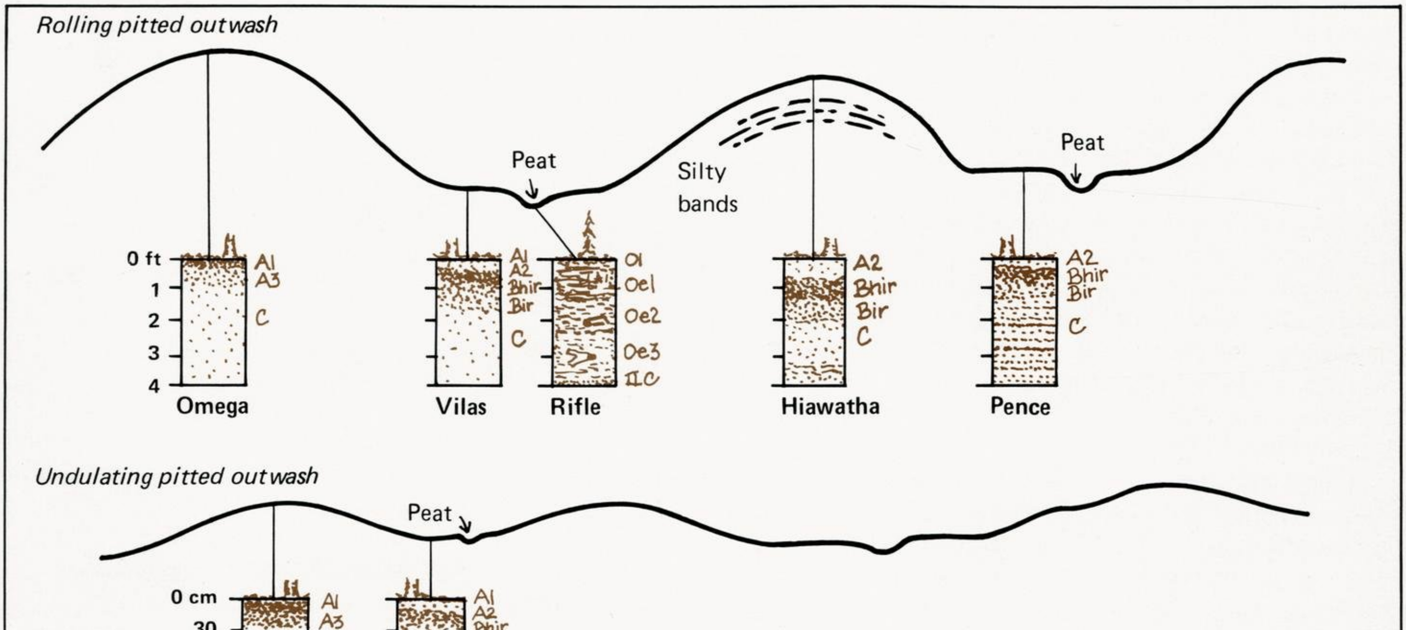


Figure 41. Landscape positions of some representative soils of the northern sandy uplands and plains (Soil Region H).

17. Soils of the Northern and Eastern Clayey and Loamy Reddish Drift Uplands and Plains (Soil Region I)

Figure 42. Distribution of reddish brown clayey soils (Region I).

This region includes the **red clay soils** of lands bordering Lake Superior, Green Bay and Lake Michigan, and a few scattered patches of similar soils elsewhere (Figure 42). The area amounts to a little over 7% of the state. An early center of trading northeast of Green Bay was called Red Banks. The red silts and clays in soils of the Region are colored by glacially pulverized Precambrian iron formation. The content of iron oxides (Fe_2O_3) is about 3% in the coarse and medium clay. This very fine, flour-like material that also includes ground-up dolomite, was distributed widely in former high-standing glacial lakes. Readvances of the ice lobes mixed these red materials with stones and sand to form red tills, which are much more widespread than the undisturbed old lake deposits. The lake deposits are represented by patches of soil in Burnett, Florence, Adams, Marquette, Douglas, Ashland, and Winnebago Counties.

These clayey soils are associated, particularly in the north, with sandy soils. Both laterally and vertically, clayey materials and sand lie adjacent to each other (Figure 43). There is a variety of thin coverings on the clayey materials, ranging from sand in the Superior sandy loam, to loam and silt loam in Hibbing silt loam and Hibbing loam. Where no such covering is present, the soil type is silty clay loam or clay loam. Decreasing clay content in the initial material and B horizon is represented by the lithosequence: Kewaunee (50% clay in the B)-Hortonville (32% clay in the B)-Onaway (18% clay in the B).

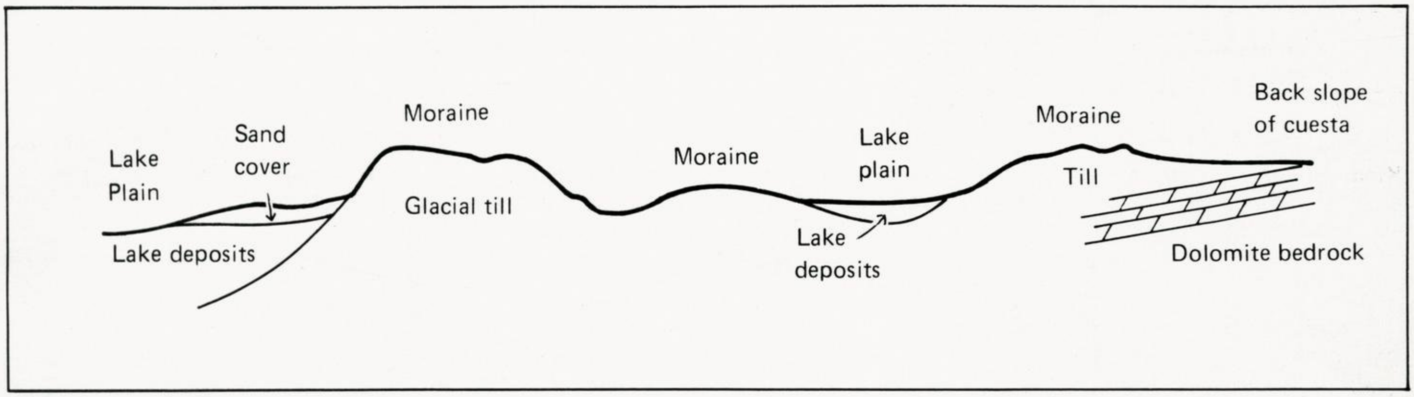
Toposequences of soils in clayey terrains are represented by the Ontonagon-Rudyard-Pickford sequence in the north, and the Kewaunee-Manawa-Poygan sequence in the south. Table 13 lists major soil series of the region.

The northern clayey substratum contains about 13% carbonates and the soils are leached to a depth of about 2-1/2 feet (75 cm) on the uplands, but only 16 inches (40 cm) in wetlands (Pickford soils). The southern clayey substratum contains nearly 30% carbonates and the upland and wetland soils are both leached about 2 feet (60 cm). Much more study is needed of depths of leaching as related to texture, age of materials and landscape position in this region.

Forest is fairly extensive in the northern area where steep lands and impeded drainage and tribal reservation restrictions limit agricultural activity. Row-cropped fields and pastures predominate in the southern and eastern areas.

Pine plantations on red clayey soils are most successful where parallel ridges and furrows are made and seedlings are planted on the ridges to avoid saturation of the entire root systems during the wet spring season.

Major Landscape Positions



Representative Soils

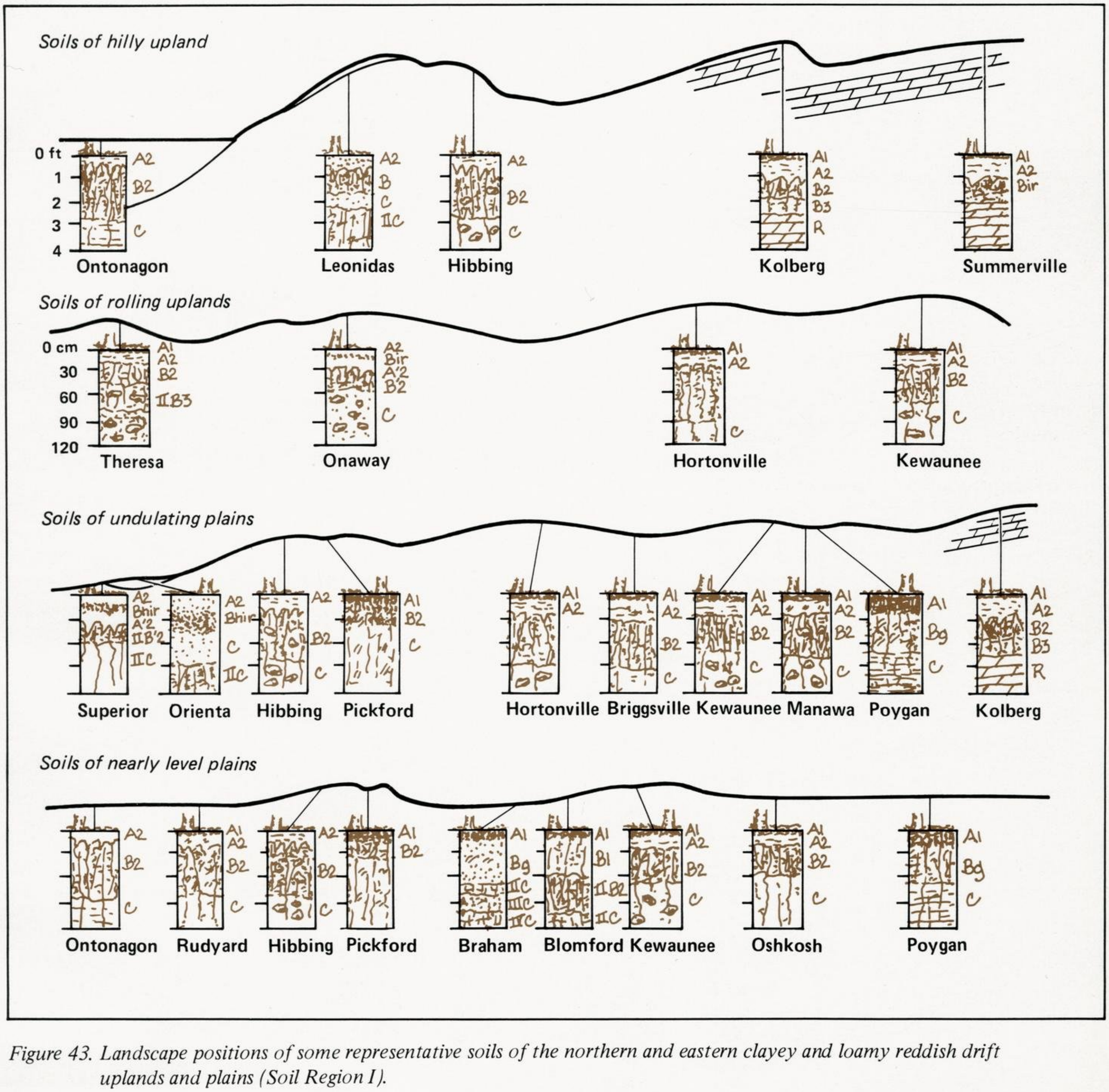


Figure 43. Landscape positions of some representative soils of the northern and eastern clayey and loamy reddish drift uplands and plains (Soil Region I).

Table 13. A classification of representative soils[1] of Region I.

Initial material: Kind	Texture		Approximate $CaCO_3$ equiv. (%)	Features	Natural soil drainage condition: Well drained	Moderately well drained	Somewhat poorly drained	Poorly or very poorly drained
Glacial till (calcareous)	Clayey		13	With loamy covering		Leonidas		
	Clayey		13	Without loamy covering		Hibbing		Pickford
	Clayey		30		Hortonville			
	Clayey		50			Kewaunee	Manawa	Poygan
	Loamy	Deep	50	Pink	Onaway			
	Loamy	Deep	50	Brown	Theresa			
	Loamy	Shallow to bedrock	70	Spodosol	Longrie			
	Loamy	Shallow to bedrock	70	Alfisols	Kolberg			
	Loamy	Very shallow to bedrock	80		Summerville			
Glacial lake deposits (calcareous)	Red clay		13	With sand cover: Shallow cover		Superior		
	Red clay		13	With sand cover: Deep cover		Bibon.	Orienta	
	Red clay		13	Without sand cover		Ontonagaon.	Rudyard	
	Red clay		30	60% clay in B		Oshkosh		Poygan
	Red clay		30	40% clay in B		Briggsville		
	Pink loam		?		Braham			Blomford

[1]The soils listed are soil series. See Appendix 2.

18. Soils of Stream Bottoms and Major Wetlands (Soil Region J)

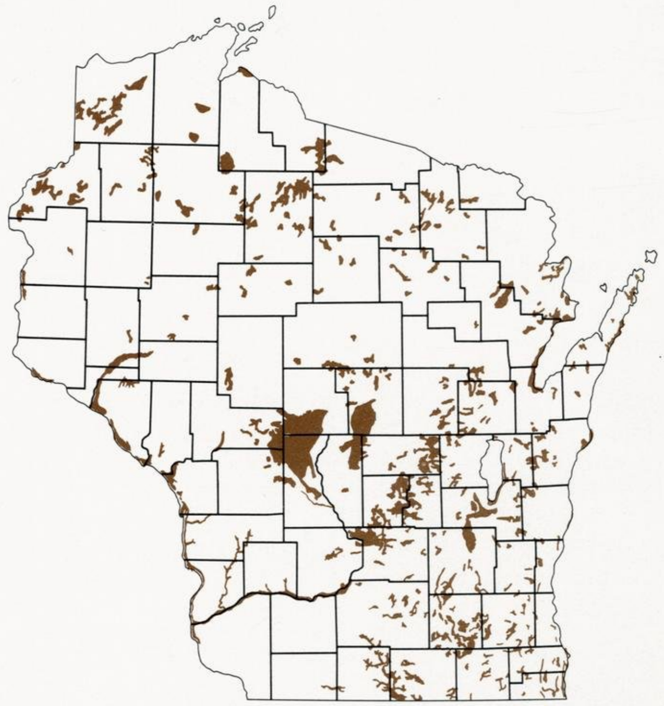


Figure 44. Distribution of soils of major wetlands (Region J).

The general soil map (Figures 17 and 44, this publication; Plate I, Hole, Lee, Beatty, 1976) shows that these soils occupy about 8.2% of the state. However, the actual area may be much larger because of the vast number of scattered soil bodies that are too small to show on the map. If wetlands are defined to include those hydrologically transitional soils of footslopes, called "somewhat poorly drained," then the extent of this Region is indeed greater than indicated. In actual practice, the degree to which a soil body is part of a wetland depends on the season. In very wet years, high water tables occur over a much larger portion of the landscape than in periods of drought. Table 14 presents a classification of principal soils of this Region.

More than two-thirds of the area of **alluvial soils** are wetlands on floodplains, reported to occupy 0.8% of the state on the basis of the general survey (Hole, Lee and Beatty, 1976). Yet, in a typical county in southwestern Wisconsin, alluvial soils cover 5 to 10% of the area of a county, and in glaciated southeastern counties the range is between 1 and 2%. Alluvial soils are some of the most fertile soils of the state because they contain concentrations of fine particles of organic matter and clay, well supplied with nutrients leached from the uplands. Where serious accelerated erosion has produced deposits of coarse sand, gravel and cobbles on footslopes and stream bottoms, conditions for plant growth are inhibited. Some of the alluvial soils are so wet and subject to alteration by flooding that they are mapped as "wet alluvial soils, indifferentiated." Alluvial soils on "high bottoms" are flooded only occasionally. Where these soils occur in large bodies and are not cut into inconveniently irregular parcels by flood channels and ox-bow ponds, they produce first rate corn in growing seasons free of storm flood damage.

Wetland mineral soils occupy at least 2.9% of the state. These soils contain less than about 25% organic matter by weight in the surface soil. Typically these soils consist of nearly black A1 horizons (with or without a shallow peat or muck covering) overlying bluish gray subsoils which may show mottles of yellowish brown stains of hydrous oxides of iron. The glaciated landscapes, which occupy about 75% of Wisconsin, are dotted with thousands of depressions which are occupied by or edged with mineral wetland soils, ranging in texture from sand to clay. Where feasible, large bodies of these soils have been artificially drained and cropped.

The third and most extensive (at least 4.5% of the area of the state) group of wetland soils are the organic soils, sometimes referred to as **bog soils**, or **peats and mucks**. Peats are largely undecomposed (histic); mucks are decomposed (sapric). They commonly lie in depressions which have a wetter hydrologic regime than the wetland mineral soils. The accumulation of a meter or more of plant debris and its decomposed products has taken one to several thousand years. One can contrast Lake Winnebago – a vast open lake – with the Horicon Marsh, which is largely a body of organic soils that occupy a former lake basin. Some organic soils lie on footslopes at the sites of seeps and springs. The lower parts of the quartzite talus on slopes around Devil's Lake contain some organic soils that fill the spaces between the boulders and that support the growth of mature pine trees. In Jefferson County are a number of peat mounds approximately 3 meters high and 25 meters across which formed directly over flowing springs on nearly level ancient lake bottom. The fascinating flora of bogs include black spruce, tamarack, Labrador tea, leatherleaf, pitcher plants, sundew, sphagnum moss, orchids, and poison sumac. Cranberry culture, in which Wisconsin is a leader in the nation, is in bodies of peats and very wet sands in central and northern Wisconsin. Where "sanding" of the cranberry bogs has been done for many years by the operator to stabilize the soil, a unique "cranberry soil" has formed 30 cm thick (one foot) consisting of alternating layers of sand, cranberry plant roots and decomposing residues.

Drainage of Histosols permits their oxidation and accelerated destruction. In fact, soil formation (or "ripening" as the Dutch term it) actually can begin only upon drainage. Some truck garden muck farms produce impressive yields of carrots, lettuce, onions, potatoes, mint, sod and other crops in southeastern counties. Once ditched and tiled, the organic soils which were once nearly continuously saturated, take on some of the qualities of dry soils. Winds blow the black soil, despite shelter belts of trees, sending clouds of dark dust into the air. Irrigation is a common sight on muck farms in summer. Subsidence or sinking of the fields goes on at a rate of about 15 or 20 cm (a half foot) per decade. In time, due to exposure of the substratum, mucklands may revert to mineral soils when the muck has wasted away, or to lakes if drainage operations are stopped.

In northern Wisconsin and along major rivers most landscapes of this region are under forest and sedge vegetation. In southern and eastern counties intensive agriculture is practiced on selected wetlands that have been artificially drained. Undisturbed wetlands, such as the Horicon Marsh, are prime wildlife areas.

Table 14. Chart of representative soils of alluvial bottoms and wetlands of Wisconsin, with some well drained associates.

	Mineral soils[1]							Organic soils[2]		
	Alluvial soils			Other soils						
Initial materials	Well drained	Somewhat poorly drained	Poorly drained	Well drained	Somewhat poorly drained	Poorly drained	Very poorly drained	Saprists (Mucks)	Hemists (Peaty mucks)	Fibrists (Peats)
Silts and fine loams, stratified	Arenzville	Orion	Wet alluvial soils							
Outwash sand				Plainfield	Morocco	Newton	Granby			
15-30" silt/acid reddish sandy loam till					Freer	Cable				
20-40" coarse loam/calcareous clayey drift						Wauseon Keowns				
24" loam over calcareous silt and clay				Hebron		Navan				
> 24" silt over calcareous loam till						Brookston	Pella			
< 24" silt over calcareous sand and gravel					Matherton	Will				
Calcareous reddish clay with local sand beds below 30"					Zittau		Poygan			
Herbaceous material — Mesic								Houghton, Palms, Adrian, Willette Sheboygan, Ogden		
Herbaceous material — Frigid								Loxley, Dawson Carbondale	Rifle Greenwood	
Mixed herbaceous and woody — Mesic								Carlisle		
Mixed herbaceous and woody — Frigid								Lupton	Spalding	
Sphagnum — Frigid										Couderay, Lobo

[1]Soils with less than about 25% of organic matter by dry weight.
[2]Soils with more than about 25% of organic matter by dry weight.

19. General Relationship of Soil Resources to Other Natural Resources and to Human Activity

In preceding chapters we have considered the nature of the soil resource and its distribution in Wisconsin. This resource is intermediate in fragility between the vegetative cover –which can be changed quickly by fire or agricultural and silvicultural practices–and consolidated bedrock, which is resistant to change.

Conditions are favorable for dairy and vegetable agriculture in the state. The topography (Figure 45) is so moderate that the National Atlas shows Wisconsin to be a collection of nine plains (Figure 46). Rather favorable precipitation is found throughout the state (Figure 22). Except for sandy areas, the soils have moderate to good water-holding capacity. There is an abundance of water for irrigation in many areas. The climate provides a long enough growing season to permit maturation of adapted crops in most years. The presence of Lakes Superior and Michigan ameliorates the severity of the climate.

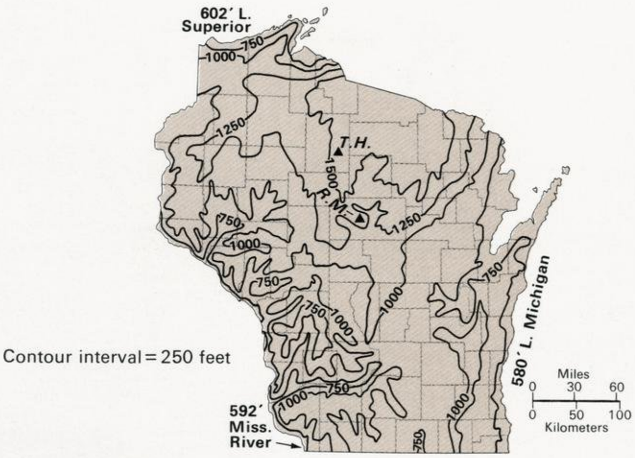


Figure 45. **LAND SURFACE** *(Elevations in Feet)*

The rise from the surface of Lake Michigan to the top of Tim's Hill (TH) (1,953 ft; 595 m) on a glacial moraine in Price County is 1,373 ft (419 m), which is 81 ft (24 m) less than the height of the Sears Building (1,454 ft; 443 m) in Chicago. The top of Rib Mountain (RM) (1,941 ft; 591 m), near Wausau, stands 780 ft (237 m) above the nearby Wisconsin River. On a national scale, Wisconsin is considered to be a plain (see Land Surface map).

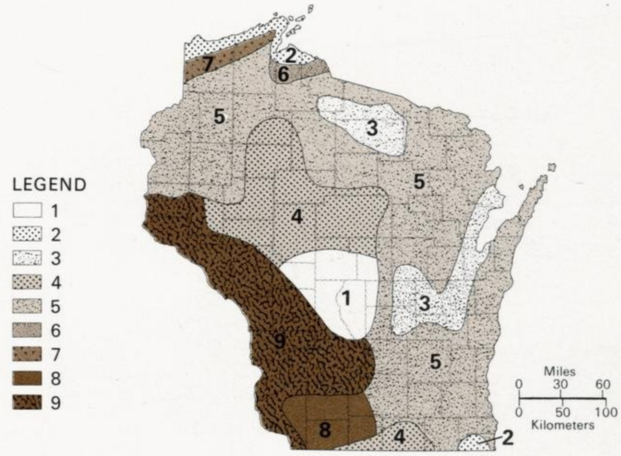


Figure 46. **LAND-SURFACE FORMS** *(after the National Atlas)*

The flattest area is in Central Wisconsin (1). Undulating plains, with little wetland (2) and with considerable wetland (3) are mostly in the north. Irregular plains, with little wetland (4) and with considerable wetland (5) occupy much of the state. Plains with high hills (6) are in Iron and Ashland Counties. A tableland with escarpment to Lake Superior (7) is in the northwest. Open hills, with broad ridges (8), and narrow ridges with deeply incised valleys (coulees) (9) are in the southwest.

Forestry is favored in northern counties (Figures 47, 48) where agriculture is not dominant (Figure 49), where tribal lands and state and national forests are extensive (Figure 50), and where—except in retirement and recreational areas in Oneida and Vilas Counties—rural land sales are low (Figure 51). The cool, moist climate of northern Wisconsin is another factor that promotes tree growth. Near Lake Superior fogs bring in extra moisture that is not recorded in the measure of precipitation.

The bedrock geology map (Figure 19), shows us that the three dolomites (units 6, 8 and 10) form a "U" that frames the central and northern core of the state. Glaciation (Figure 20) and wind blowing of silt (Figure 21) blurred somewhat but did not basically obscure this bedrock pattern. It is this U-shaped belt that is naturally productive of major agricultural crops. Alfalfa production (Figure 52) reveals this most clearly. Corn for grain production (Figure 53) shows the same trend. It is the presence of natural dolomite in the substratum that accounts to some extent for the excellent alfalfa yields. The addition by farmers of plant nutrients to the soil through manure and commercial fertilizers has made the strip of land extending from Green Bay westward through Marathon and Clark Counties more productive than it was naturally (Figure 54). Because it does well in the cool climate of north central counties, oats (Figure 55) is productive both in the "fertile U" and the north central east-west belt. Figure 55 shows the central lowland, where droughty sands and wetlands are extensive, to be about as low in productivity for oats as both the far northern counties and the urban area around Milwaukee are. The percent of land in farms is low in about the same places (Figure 49).

Soils that are unsuitable for disposal of liquid waste from septic systems are extensive (Figure 56) in some of the major population areas of the state where land is expensive (Figure 51) and pressure for urban and recreational development is great. The people of Wisconsin have long been dedicated to the principle of good stewardship of natural resources. To uphold this principle in the future, when pressure on soil and water resources will be greater than at present, we need to have a better understanding of the relationships between natural resources and the effect of human impact on them.

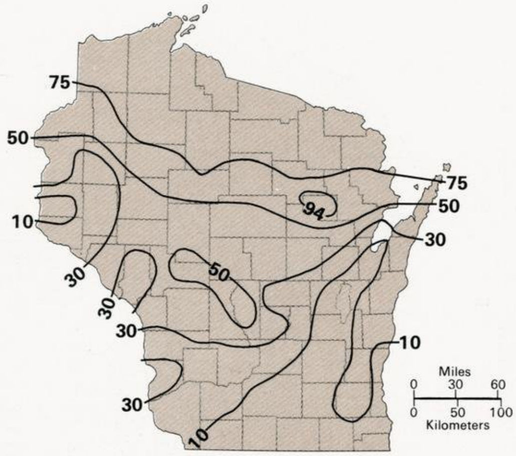


Figure 47. **PERCENT OF LAND IN FOREST OF COMMERCIAL VALUE**

Forests and woodlands of Wisconsin occupy about 40 percent of its area, 99 percent of which are capable of producing wood for commercial purposes. Pulpwood is produced in greater volume than lumber and veneer. There are two national forests, two state forests, 27 county forests and numerous town, school, and private forests. Sixty-one percent of Wisconsin's forests are in the north.

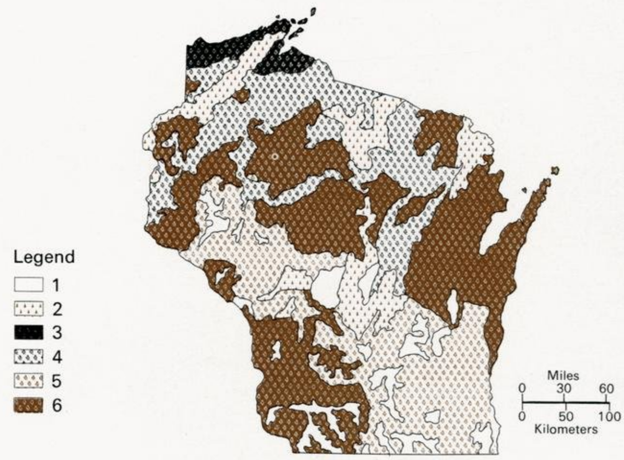


Figure 48. **FOREST PRODUCTIVITY** *(Mean Annual Increment, Cu. Ft. per Acre) (After J. G. Bockheim)*

(1) Non-forested or rarely harvested lands, including former prairies and present wetlands,
(2) Red pine (Pinus resinosa) > 50,*
(3) Aspen (Populus sp.) 40-49,
(4) Aspen (Populus sp.) > 50,*
(5) Northern red oak (Quercus borealis) 30-39,
(6) Northern red oak (Quercus borealis) 40-49,

**This high figure reflects emphasis on harvesting species of rapid growth.*

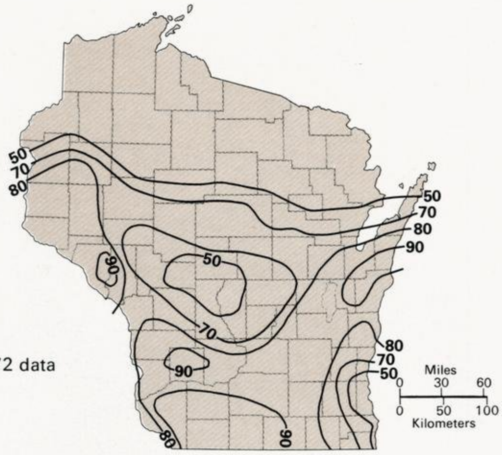


Figure 49. **PERCENT OF LAND IN FARMS (1972)**

Half of the area of the state is in farms. Most of the farmland is in the southern two-thirds of the state. The west central plain and urban counties have fewer farm acres. Forests, parks, and wildlife areas are extensive in the north.

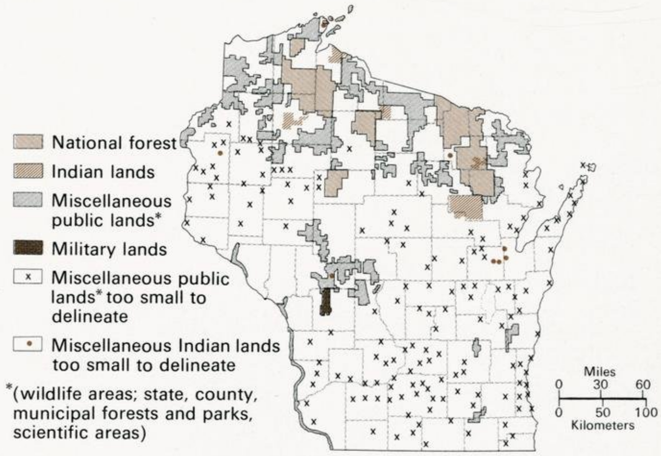


Figure 50. **MAJOR PUBLIC, INDIAN, AND MILITARY LANDS**

Public lands are for the development of natural and wildlife resources and their appreciation by visitors. Indian lands are for the use and enjoyment of members of Indian tribes established in Wisconsin. Military lands are for military training. Some small parcels of land are designated as "scientific areas" for the preservation of choice landscape types that are threatened with extinction.

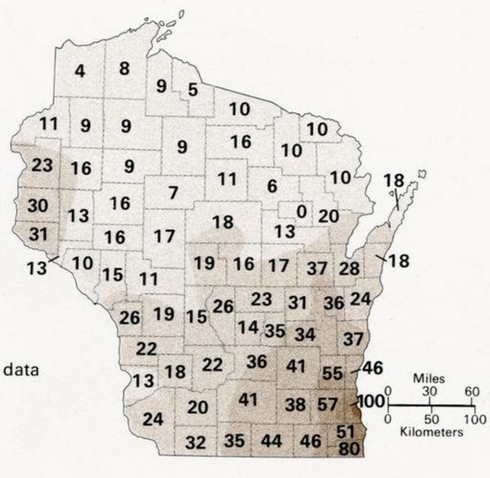


Figure 51. **RURAL LAND SALES INDEX (1973 base)**

The rural land sales index is based on a scale of 100, with the rural land sale value in Milwaukee County as 100 (over $1,500 per acre in 1973) and that in the Menominee Indian Tribal Lands as 0. The index is highest near urban centers. Irrigation of sands in Adams County in recent years has apparently raised the index there above indices for Jackson and Juneau Counties. Northern counties show relatively low rural land sale indices. Indices for Oneida and Burnett Counties may reflect tourists' and retirees' interest in rural lands.

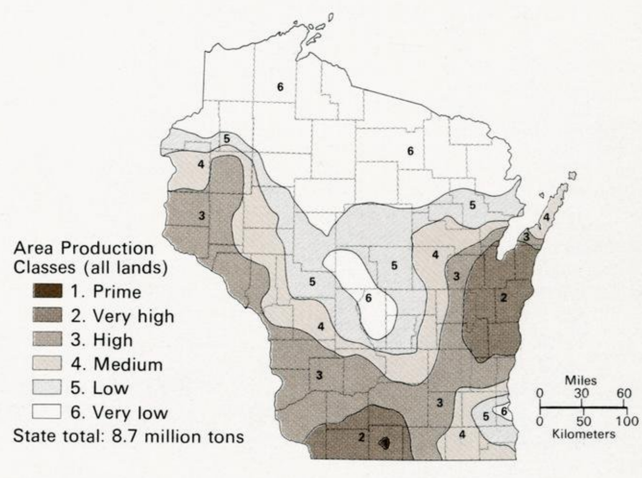


Figure 52. **ALFALFA HAY PRODUCTION** *(based on hundreds of thousands of tons per county, 1975)*

In 1975, 3 million acres of alfalfa hay were harvested in Wisconsin. This high-protein forage crop is a mainstay of dairy agriculture. Because alfalfa uses much lime, the alfalfa "belt" coincides approximately with the limestone (dolomite) belt (see Bedrock Geology map). Extensions of the major alfalfa-producing area onto acid soils of north central Wisconsin were made possible by an agricultural lime and fertilizer program.

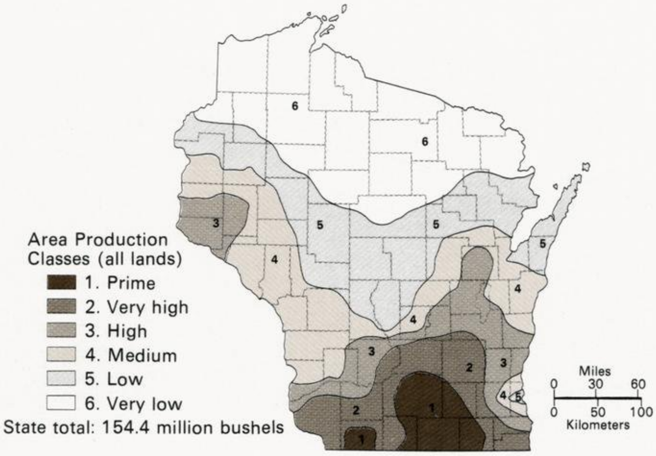


Figure 53. **CORN FOR GRAIN PRODUCTION** *(based on millions of bushels per county, 1975)*

Nearly two-and-a-half-million acres of corn for grain and one million acres of corn for silage were harvested in Wisconsin in 1975. This crop demands less lime than alfalfa, and so is not as closely associated with the state's "limestone belt". The development of short-season corn varieties has made cultivation of this crop possible in many northern counties.

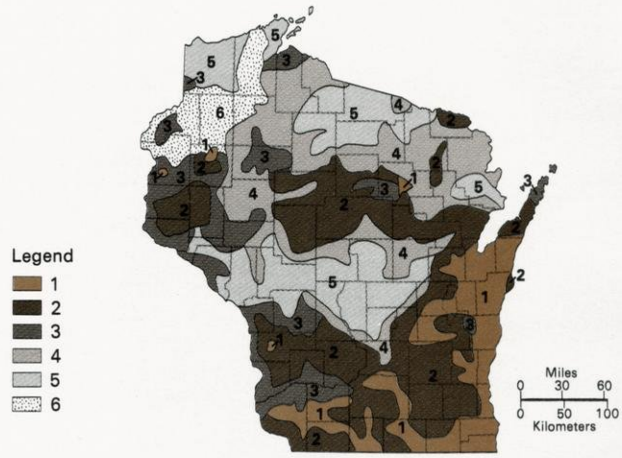


Figure 54. **SOIL RATINGS FOR AGRICULTURE**

Using a soil ratings system with a range from 1 (best) to 10 (least productive), this map shows major soil areas by level of agricultural productivity. Prairie and some eastern red clay soils rate first, silt loams second, and some loams third. Sands in the north have agricultural productivity of only 6, on the average. Less productive soils are not shown because they are scattered in patches too small to be delineated. Acid, undrainable peat bogs and steep, rocky slopes are of little or no agricultural value.

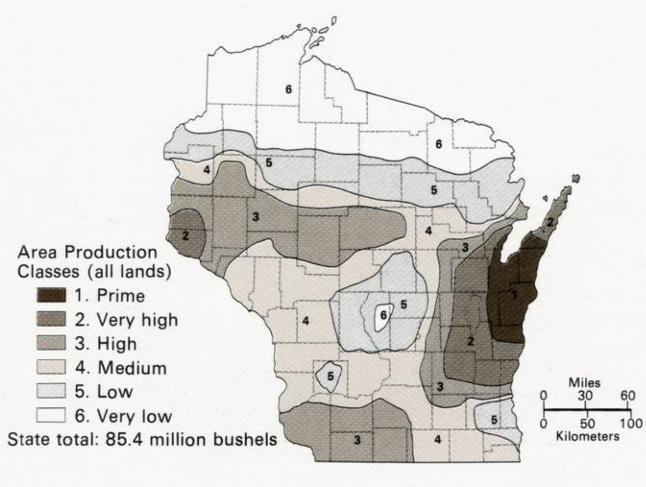


Figure 55. **OATS PRODUCTION** *(based on millions of bushels per county, 1975)*

One and one-third million acres of oats were harvested in Wisconsin in 1975. This crop is important in producing feed and in serving as a nurse crop to alfalfa and other hay crops. Oats is a cool season grain, and so is well adapted to north central Wisconsin.

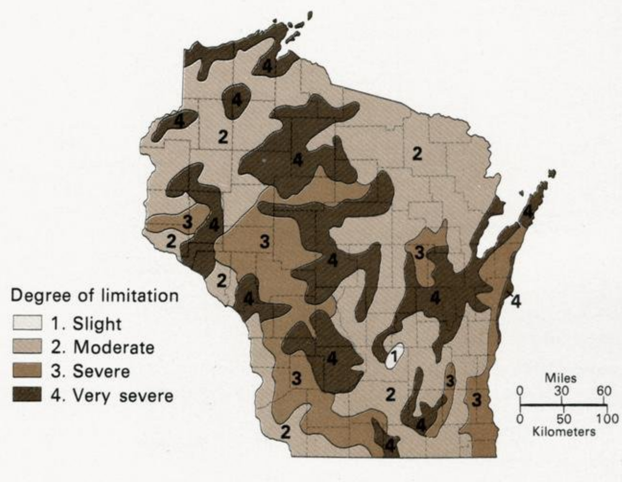


Figure 56. **SOIL LIMITATIONS FOR SEPTIC SYSTEMS**

A successful septic system is designed to distribute sewage effluent through porous pipes laid in gravel beds set in natural soil. In at least 60 percent of the area of the state small scale septic systems commonly fail to work properly because the land is too steep, or soils are too wet, impervious or shallow to bedrock, with resulting contamination of surface and ground waters. There are various technical ways to improve the performance of septic systems. Some areas should simply not be used for waste disposal, because of danger of polluting wells and surface waters. This figure shows general problem areas.

Appendix 1. Glossary of Terms

(For an extended glossary, see *Soils of Wisconsin* by Hole, Lee and Beatty, 1976, University of Wisconsin Press).
(Also consult the index to this book).

Allophane – A gel-like clay present in small amounts in Wisconsin soils.
Alluvial – Pertaining to processes and deposits made by streams.
Argillic – Pertaining to clay and clay-enriched soil materials.
Barrens – a tract of land, with poor tree cover because of unsuitable soil or recurrent fire.
Calcareous – Pertaining to presence of free lime (calcite and dolomite, which are calcium and magnesium carbonates).
Catena – A sequence or "chain" of soil bodies from a hill top, down-slope to an adjacent depression.
Cuesta – A Spanish word denoting an unsymmetrical ridge with one slope long and gentle and the other slope short and steep.
Drumlin – An oval or fish-shaped hill of glacial drift shaped by moving glacial ice.
Eolian – Pertaining to processes and deposits brought about by wind action.
Epipedon – The surface soil horizon. The "epidermis" of a soil.
Escarpment – The steep slope of a cuesta or other similar steep slope.
Esker – Serpentine ridge of rudely sorted glacial drift deposited under a glacier.
Evapotranspiration – The process of loss of water by vaporization from surfaces of soil, rock and stems (evaporation) and from respiring leaves of plants.
Fragipan – A loamy subsurface soil horizon that is brittle.
Frigid – A specific term designating northern Wisconsin climatic conditions.
Glaebule – A spherical particle in a soil. The particle results from cementation of soil material by natural processes.
Gleyed – Pertaining to the bluish grey color of subsurface horizons of many wetland soils.
Horizon – A naturally formed layer in a soil that parallels the ground surface. See the index for reference to definitions in the text of various kinds of soil horizons.
Ion – An atom or group of atoms having a positive or negative charge.
Kame – A roughly conical hill of rudely sorted glacial drift.
Kettle – A natural pit in a glacial drift landscape. The pit resulted from the melting of a buried block of glacial ice.
Lacustrine – Pertaining to a lake and deposits in a lake and soils formed from them.
Leaching – The process of removal in solution of material from soil by percolating water.
Loess – A wind-blown deposit of silt-size particles.
Mesa – A flat-topped, table-shaped hill.
Mesic – Pertaining to moderate ecological conditions. See index.
Moraine – A deposit of unsorted glacial drift made by glacial ice.
Outwash – Sorted sand and gravel deposit made by glacial meltwaters.
Peat – Undecomposed plant debris found in wetlands.
Pedeplain – Summit surface, as seen in southwestern Wisconsin, that was shaped by slow erosion over thousands of years.

Ped – A unit, such as a natural block, in a soil, formed by processes of clustering of soil particles.

Plasma – The material in a soil that is most susceptible to movement by percolating water, by squeezing of the soil under pressure of frost action, or the swelling of clay upon wetting.

Podzolization – The sum total of processes which move material out of the surface horizon of a soil and deposit it in the subsoil. Strictly speaking, the material moved should be iron, aluminum and organic matter; but clay is included in the thinking of some students of soils.

Skeleton grains – Particles of sand size and larger in soil.

Soilscape – The soil blanket on a landscape, surrounding lakes, rock outcrops and other "not-soil" bodies.

Solum (plural, sola) – The surface and subsoil layers taken together.

Talus – Coarse material deposited at the toe of a steep slope by natural processes of erosion.

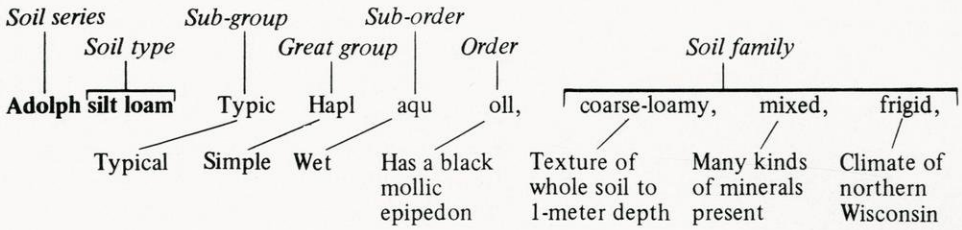
Tubules – Cylindrical units in soil that formed by filling channels with particulate material.

Voids – Empty (air-filled) or water-filled spaces in soil: pores, channels, cracks.

Xeric – Pertaining to dry ecological conditions.

Appendix 2. Alphabetical List of Representative Soils of Wisconsin With Their Classification

Explanation* The terminology of the soil classification may be clarified by this example:



Series Name	REGION
Adolph silt loam. Typic Haplaquoll, coarse-loamy, mixed, frigid	F,G,J
Adrian muck. Terric Medisaprist, sandy or sandy-skeletal, mixed, euic . . .	B,C,D,J
Ahmeek sandy loam. Typic Fragiochrept, coarse-loamy, mixed, frigid . . .	F
Almena silt loam. Aeric Glossaqualf, fine-silty, mixed, frigid	F
Altdorf silt loam. Aeric Glossaqualf, fine, mixed, frigid	F
Amery loam. Typic Glossoboralf, coarse-loamy, mixed	G
Angelica loam. Aeric Haplaquept, fine-loamy, mixed, nonacid, frigid . . .	E
Antigo silt loam. Typic Glossoboralf, fine-silty over sandy or sandy-skeletal, mixed	A,F
Arenzville silt loam. Typic Udifluvent, coarse-silty, mixed, nonacid, mesic . .	A,J
Arland silt loam. Eutric Glossoboralf, fine-loamy, mixed	D
Ashdale silt loam. Typic Argiudoll, fine-silty, mixed, mesic	A
Ashkum silt loam. Typic Haplaquoll, fine, mixed, mesic	B
Auburndale silt loam. Typic Glossaqualf, fine-silty, mixed, frigid	F,J
Baraboo silt loam. Typic Hapludalf, fine-silty, mixed, mesic	A,B
Bertrand silt loam. Typic Hapludalf, fine-silty, mixed, mesic	A
Bibon loamy sand. Typic Haplorthod, sandy, mixed, frigid	I
Blomford sandy loam. Arenic Ochraqualf, loamy, mixed, frigid	I
Blount silt loam. Aeric Ochraqualf, fine, illitic, mesic	B
Bluffton silt loam. Typic Haplaquoll, fine-loamy, mixed, frigid	F
Boone loamy sand. Typic Quartzipsamment, mesic, uncoated	C,D
Boyer sandy loam. Typic Hapludalf, coarse-loamy, mixed, mesic	B
Braham sandy loam. Arenic Eutroboralf, loamy, mixed	I
Brems loamy fine sand. Aquic Udipsamment, mixed, mesic	C
Brickton silt loam. Mollic Ochraqualf, fine, mixed, frigid	I,F
Briggsville sandy loam. Typic Hapludalf, fine, mixed, mesic	I
Brill silt loam. Typic Glossoboralf, fine-silty over sandy or sandy-skeletal, mixed.	F
Brookston silt loam. Typic Argaquoll, fine-loamy, mixed, mesic	B,J
Brule loam. Typic Udifluvent, coarse-loamy, mixed, non-acid, frigid	U
Cable loam. Typic Haplaquept, coarse-loamy, mixed, nonacid, frigid	G,J

*For more information about the soil classification, see Hole, Lee and Beatty (1976) and Soil Survey Staff (1975).

Calamine silt loam. Typic Argiaquoll, fine, mixed, mesic . . . . A
Carlisle muck. Typic Medisaprist, euic . . . . A,B,J
Carbondale muck. Hemic Borosaprist, euic . . . . G,J
Casco loam. Typic Hapludalf, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B
Cathro muck. Terric Borosaprist, loamy, mixed, euic . . . . F,G,J
Chelsea loamy sand. Alfic Udipsamment, mixed, mesic . . . . A
Chetek sandy loam. Eutric Glossoboralf, coarse-loamy, mixed . . . . . . D,G
Clifford silt loam. Aqualfic Haplorthod, coarse-loamy, mixed, frigid . . . . F
Cloquet loamy sand. Typic Dystrochrept, coarse-loamy over sandy or sandy-skeletal, mixed, frigid . . . . G
Coloma loamy sand. Alfic Udipsamment, mixed, mesic . . . . B,C
Couderay peat. Hemic Borofibrist, dysic . . . . G,J
Curran silt loam. Udollic Ochraqualf, fine-silty, mixed, mesic . . . . . . A
Cushing silt loam. Glossic Eutroboralf, fine-loamy, mixed . . . . F
Dakota sandy loam. Typic Argiudoll, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . A,C
Dancy sandy loam. Aeric Glossaqualf, fine-loamy, mixed, frigid . . . . . C,J
Dawson muck. Terric Borosaprist, sandy, mixed, dysic . . . . G,J
Delton loamy sand. Arenic Hapludalf, loamy, mixed, mesic . . . . C,E
Derinda silt loam. Typic Hapludalf, fine, mixed, mesic . . . . A
Dickinson sandy loam. Typic Hapludoll, coarse-loamy, mixed, mesic . . . A
Dillon loamy sand. Typic Humaquept, sandy, mixed, mesic C
Dodge silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . B
Dodgeville silt loam. Typic Argiudoll, fine, montmorillonitic, mesic . . . . A
Dolph silt loam. Aquic Glossoboralf, fine-loamy, mixed . . . . F
Dubuque silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . A,B
Dunbarton silt loam. Lithic Hapludalf, clayey, montmorillonitic, mesic . . . A
Durand silt loam. Typic Argiudoll, fine-loamy, mixed, mesic . . . . . . B
Edmund silt loam. Lithic Argiudoll, clayey, montmorillonitic, mesic . . . . A
Elderon loam. Alfic Haplorthod, sandy-skeletal, mixed, frigid . . . . . . G
Elliott silt loam. Aquic Argiudoll, fine illitic, mesic . . . . B
Elm Lake sandy loam. Typic Haplaquent, sandy over loamy, mixed, acid, frigid . . . . D
Emmet sandy loam. Alfic Haplorthod, coarse-loamy, mixed, frigid . . . . E
Fabius silt loam. Aquic Argiudoll, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B
Fayette silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . A,D
Fenwood silt loam. Typic Glossoboralf, fine-loamy, mixed . . . . F
Flagg silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . B
Fox silt loam. Typic Hapludalf, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B
Freeon silt loam. Typic Glossoboralf, fine-loamy, mixed . . . . F
Freer silt loam. Aeric Ochraqualf or Glossoboralf, fine-loamy, mixed . . . F,J
Gale silt loam. Typic Hapludalf, fine-silty over sandy or sandy-skeletal, mixed, mesic . . . . D
Gogebic sandy loam. Alfic Fragiorthod, coarse-loamy, mixed, frigid . . . . G
Goodman silt loam. Alfic Haplorthod, coarse-silty, mixed, frigid . . . . . F
Gotham loamy sand. Psammentic Hapludalf, sandy, mixed, mesic . . . . A,C
Granby loamy sand. Typic Haplaquoll, sandy, mixed, mesic . . . . . . E,J
Gratiot silt loam. Aquollic Hapludalf, fine, mixed, mesic . . . . A
Greenwood peaty muck. Typic Borohemist, dysic . . . . G,J
Guenther loamy sand. Alfic Haplorthod, sandy over loamy, mixed, frigid . . C,F
Hebron loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . B
Hennepin sandy loam. Typic Eutrochrept, fine-loamy, mixed, mesic . . . . B
Hesch sandy loam. Typic Argiudoll, coarse-loamy, mixed, mesic . . . . . D
Hiawatha loamy sand. Typic Haplorthod, sandy, mixed, frigid . . . . . . H
Hibbing loam. Typic Eutroboralf, fine, mixed I
Hixton loam. Typic Hapludalf, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . D

Hochheim sandy loam. Typic Argiudoll, fine-loamy, mixed, mesic . . . . B
Hortonville silt loam. Glossoboric Hapludalf, fine-loamy, mixed, mesic . . . E,I
Houghton muck. Typic Medisaprist, euic . . . . B,J
Humbird loamy sand. Alfic Haplorthod, coarse-loamy over clayey, mixed, frigid . . . . D,E
Iron River sandy loam. Alfic Fragiorthod, coarse-loamy, mixed, frigid . . . G
Jackson silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . . . A
Jewett silt loam. Eutric Glossoboralf, fine-loamy, mixed . . . . F
Kellner (Nymore) loamy sand. Typic Udipsamment, mixed, frigid C
Kennan sandy loam. Typic Glossoboralf, coarse-loamy, mixed . . . . . . F,G
Kert sandy loam. Aquic Glossoboralf, fine-loamy, mixed . . . . D
Keowns silt loam. Mollic Haplaquept, coarse-loamy, mixed, nonacid, mesic . . . . E,J
Kewaunee sandy loam. Typic Hapludalf, fine, mixed, mesic I
Kinross loamy sand. Typic Haplaquod, sandy, mixed, frigid . . . . . . H,J
Knowles silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . . . B
Kolberg loam. Glossic Eutroboralf, fine, mixed . . . . B,I
Lafont silt loam. Alfic Haplorthod, coarse-loamy, mixed, frigid . . . . . F
Lapeer loam. Typic Hapludalf, coarse-loamy, mixed, mesic . . . . B
Leonidas sandy loam. Dystric Eutrochrept, coarse-loamy over clayey, mixed, frigid I
LeRoy silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . . . B
Lobo peat. Hemic Sphagnofibrist, dysic . . . . B,J
Lomira silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . B
Longrie loam. Entic to Alfic Haplorthod, coarse-loamy, mixed, frigid . . . E
Loyal silt loam. Typic Glossoboralf, fine-loamy, mixed . . . . F
Lows sandy loam. Mollic Haplaquept, fine-loamy over sandy or sandy-skeletal, mixed, nonacid, frigid . . . . A,C,D
Loxley muck. Typic Borosaprist, dysic . . . . G,J
Lupton muck. Typic Borosaprist, euic . . . . G,J
Manawa loam. Aquollic Hapludalf, fine, mixed, mesic I
Marathon silt loam. Typic Glossoboralf, coarse-loamy, mixed . . . . . . F
Marenisco loamy sand. Typic Haplorthod, sandy, mixed, frigid . . . . . G
Marshfield silt loam. Typic Ochraqualf, fine-loamy, mixed, frigid . . . . . F
Matherton loam. Udollic Ochraqualf, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B,J
McHenry silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . . B
Mecan sandy loam. Typic Hapludalf, coarse-loamy, mixed, mesic C
Meridian sandy loam. Mollic Hapludalf, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . A,C
Merrillan sandy loam. Aqualfic Haplorthod, coarse-loamy over clayey, mixed, frigid . . . . D
Metea loamy sand. Arenic Hapludalf, loamy, mixed, mesic . . . . B
Miami silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . . . B
Milaca (Amery) sandy loam. Typic Glossoboralf, coarse-loamy, mixed . . . D,G
Monico sandy loam. Aqualfic Haplorthod, coarse-loamy, mixed, frigid . . . F,J
Moquah (Brule) sandy loam. Typic Udifluvent, coarse-loamy, mixed, non-acid, frigid I
Morley silt loam. Typic Hapludalf, fine, illitic, mesic . . . . B
Morocco loamy sand. Aquic Udipsamment, mixed, mesic . . . . C,J
Mussey sandy loam. Typic Argiaquoll, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B,J
Navan loam. Typic Argiaquoll, fine-loamy, mixed, mesic . . . . B,J
Nekoosa (Brems) loamy fine sand. Aquic Udipsamment, mixed, mesic . . . C
Nenno silt loam. Aquic Argiudoll, fine-loamy, mixed, mesic . . . . . . B
New Glarus silt loam. Typic Hapludalf, fine-silty over clayey, mixed, mesic . A
Newton loamy sand. Typic Humaquept, sandy, mixed, mesic . . . . . . C,J
Norden loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . D
Norrie silt loam. Typic Glossoboralf, fine-loamy, mixed . . . . F

Northfield sandy loam. Lithic Hapludalf, loamy, mixed, mesic . . . . . . C,D
Nymore (Kellner) loamy sand. Typic Udipsamment, mixed, frigid C
Oconto sandy loam. Alfic Haplorthod, corase-loamy, mixed, frigid . . . . G
Ogden muck. Terric Medisaprist, clayey, euic . . . . B,J
Omega loamy sand. Typic or spodic Udipsamment, mixed, frigid . . . . . E,H
Onamia sandy loam. Typic Glossoboralf, coarse-loamy, mixed . . . . . . A,C,D,F,G
Onaway sandy loam. Alfic Haplorthod, fine-loamy, mixed, frigid . . . . . B,E,I
Ontonagon loam. Glossic Eutroboralf, very fine, mixed, frigid I
Orienta loamy sand. Aquic Haplorthod, sandy, mixed, frigid I
Orion silt loam. Aquic Udifluvent, coarse-silty, mixed, nonacid, mesic . . . J
Oshkosh loam. Typic Hapludalf, very fine, mixed, mesic I
Oshtemo sandy loam. Typic Hapludalf, coarse-loamy, mixed, mesic C
Ostrander silt loam. Typic Hapludoll, fine-loamy, mixed, mesic . . . . . F
Ozaukee silt loam. Typic Hapludalf, fine, mixed, mesic . . . . B
Padus sandy loam. Alfic Haplorthod, coarse-loamy, mixed, frigid . . . . . F,G,H
Palms muck. Terric Medisaprist, loamy, euic . . . . B,J
Palsgrove silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . . . A
Pardeeville sandy loam. Mollic Hapludalf, coarse-loamy, mixed, mesic . . . B
Pecatonica silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . . B
Peebles silt loam. Typic Argiudoll, fine, mixed, mesic I
Pella silt loam. Typic Haplaquoll, fine-silty, mixed, mesic . . . . B,J
Pence sandy loam. Entic Haplorthod, sandy, mixed, frigid . . . . G,H
Pickford silt loam. Aeric Haplaquept, fine, mixed, nonacid, frigid I
Pillot silt loam. Typic Argiudoll, fine-silty over sandy or sandy-skeletal, mixed, mesic . . . . A,F
Plainfield loamy sand. Typic Udipsamment, mixed, mesic . . . . A,C,J
Plano silt loam. Typic Argiudoll, fine-silty, mixed, mesic . . . . B
Port Byron silt loam. Typic Hapludoll, fine-silty, mixed, mesic . . . . . A
Poskin silt loam. Aquic Glossoboralf, fine-silty over sandy or sandy-skeletal, mixed . . . . F
Poygan loam. Typic Haplaquoll, fine, mixed, mesic . . . . E,I,J
Puchyan loamy sand. Arenic Hapludalf, loamy, mixed, mesic . . . . . . B
Renova silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . . . F
Rib silt loam. Mollic Haplaquept, fine-silty over sandy or sandy-skeletal, mixed, nonacid, frigid . . . . F
Richford silt loam. Psammentic Hapludalf, sandy, mixed, mesic C
Richwood silt loam. Typic Argiudoll, fine-silty, mixed, mesic . . . . . . A
Rifle peaty muck. Typic Borohemist, euic . . . . G,H,J
Ringwood silt loam. Typic Argiudoll, fine-loamy, mixed, mesic . . . . . B
Ripon silt loam. Typic Argiudoll, fine-silty, mixed, mesic . . . . B
Rodman gravelly sandy loam. Typic Hapludoll, sandy-skeletal, mixed, mesic . B
Roscommon loamy sand. Mollic Psammaquent, mixed, frigid . . . . . . J
Rowley silt loam. Aquic Argiudoll, fine-silty, mixed, mesic . . . . A
Rozellville silt loam. Typic Glossoboralf, fine-loamy, mixed . . . . . . F
Rubicon loamy sand. Entic Haplorthod, sandy, mixed, frigid . . . . . . H
Rudyard silt loam. Aquic Eutroboralf, very fine, illitic I
St. Charles silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . . . B
Santiago silt loam. Typic Glossoboralf, fine-loamy, mixed . . . . F
Saugatuck loamy sand. Aeric Haplquod, sandy, mixed, mesic, Ortstein . . . G,H,J
Saybrook silt loam. Typic Argiudoll, fine-silty, mixed, mesic . . . . . . B
***(Scandia loamy sand.** Typic Hapludalf, coarse-loamy, mixed, mesic) . . . A,G
Schapville silt loam. Typic Argiudoll, fine, mixed, mesic . . . . A
Seaton silt loam. Typic Hapludalf, fine-silty, mixed, mesic . . . . A,D
Shawano loamy fine sand. Typic Udipsamment, mixed, frigid . . . . . . E,J
Sheboygan muck. Hemic Medisaprist, euic . . . . I,J
Shiocton very fine sandy loam. Aquic Haploboroll, coarse-silty, mixed . . . E
Shullsburg silt loam. Aquic Argiudoll, fine, mixed, mesic . . . . A
***(Skillet silt loam.** Aquic Hapludalf, fine-silty, mixed, mesic) . . . . . . A

(*) Signifies that the series has been dropped from the official list of soils of Wisconsin. It is given here because it is included in the legend of the large color soil map of Wisconsin (Hole, Lee and Beatty, 1976).

Sogn silt loam. Lithic Haplustoll, loamy, mixed, mesic . . . . A
Spalding peaty muck. Typic Borohemist, dysic . . . . F,G,J
Sparta loamy sand. Entic Hapludoll, sandy, mixed, mesic . . . . A,C
Spencer silt loam. Typic Glossoboralf, fine-silty, mixed . . . . F
Solona sandy loam. Aquic Eutroboralf, fine-loamy, mixed . . . . E
Stambaugh silt loam. Alfic Fragiorthod, coarse-silty over sandy or sandy-skeletal, mixed, frigid . . . . F
Summerville loam. Entic Lithic Haplorthod, loamy, mixed, frigid . . . . . E,I
Superior sandy loam. Alfic Haplorthod, coarse-loamy over clayey, mixed, frigid I
Tacoosh peaty muck. Terric Borohemist, loamy, mixed euic . . . . . . E,G,J
Tama silt loam. Typic Argiudoll, fine-silty, mixed, mesic . . . . A
Tell silt loam. Typic Hapludalf, fine-silty over sandy or sandy-skeletal, mixed, mesic . . . . A
Theresa silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . B,I
Tilleda loam. Typic Glossoboralf, fine-loamy, mixed . . . . E
Toddville silt loam. Typic Argiduoll, fine-silty, mixed, mesic . . . . A
Tustin sandy loam. Arenic Hapludalf, clayey, mixed, mesic . . . . E,J
Underhill silt loam. Typic Eutroboralf, fine-loamy, mixed . . . . E
Urne fine sandy loam. Dystric Eutrochrept, coarse-loamy, mixed, mesic . . A
Valton silt loam. Mollic Paleudalf, fine-silty, mixed, mesic . . . . A
Varna silt loam. Typic Argiudoll, fine, illitic, mesic . . . . B
Veedum silt loam. Typic Humaquept, fine-loamy, mixed, acid, frigid . . . D
Vesper silt loam. Humic Haplaquept, fine-loamy over sandy or sandy-skeletal, mixed, acid, frigid . . . . D
Vilas loamy sand. Entic Haplorthod, sandy, mixed, frigid . . . . G,H
Warman loam. Histic Haplaquept, coarse-loamy, mixed, nonacid, frigid . . . F,J
Warsaw loam. Typic Argiudoll, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B
Waukegan (Pillot silt loam). Typic Argiudoll, fine-silty over sandy or sandy-skeletal, mixed, mesic . . . . A,F
Wauseon sandy loam. Typic Haplaquoll, coarse-loamy over clayey, mixed, mesic . . . . B,J
Whalan silt loam. Typic Hapludalf, fine-loamy, mixed, mesic . . . . . . B
Will loam. Typic Haplaquoll, fine-loamy over sandy or sandy-skeletal, mixed, mesic . . . . B,J
Willette muck. Terric Medisaprist, clayey, illitic, euic . . . . B,J
Withee silt loam. Aeric Glossaqualf or Aquic Glossoboralf, fine-loamy, mixed, frigid . . . . F
Wyeville loam. Aquic Arenic Hapludalf, clayey, mixed, mesic . . . . . . C,E
Wyocena sandy loam. Typic Hapludalf, coarse-loamy, mixed, mesic . . . . C,G
Zittau silt loam. Aquollic Hapludalf, clayey over sandy or sandy-skeletal, mixed, mesic . . . . I,J

Appendix 3. Guide for a Soil Walk

We have long been familiar with bird walks, flower walks, and treks for collecting rocks and fossils. Now, with increasing interest in landscapes and the mystery of soil itself, we may find ourselves taking a soil walk with a soil scientist. Although surface soil layers and even the configuration of the land may be examined without digging, excavation is still required to study soils out-of-doors. Happily, a soil auger ("screw" type) with a bit about one inch (2.5 cm) in diameter can be used to bring up soil from as deep as a meter or so. (Ask an experienced soil geographer to show you how to use the auger without straining or injuring your back.) Soil augers may be purchased at agricultural supply places and are invaluable. They leave scarcely a trace of disturbance on the landscape.

This mini-guide is for students of landscape who, by means of auger and spade, explore the soils as they walk: identifying, interpreting, reading the landscape record in the soils and land forms. Published soil maps show only principal soils present, but cannot possibly show all the gradations between them. On a soil walk, we may encounter more examples of "in-between" soils than of the principal soils. This is the justification for this little guide, which helps the observer to see the nature and function of any soil to a depth of a meter or so. Some of the common functions of soil are to store organic "wastes" from plant communities, to shed water or to store it. A study of soils reveals clues as to which of these functions the soil is performing.

It is probably enough to designate a soil as an AC or ABC soil, etc. (see Figure 57), or as a prairie, marsh or forest soil, without searching for a place name such as Antigo silt loam; or a technical classification such as Typic Glossoboralf, fine-silty over sandy or sandy-skeletal, mixed, frigid (Gray-Brown Podzolic or Gray Wooded soil). The layers (soil horizons) are pages in Nature's books called soils. For letters and words, we see stains of dark organic matter, brown and yellow iron oxides, and sticky clay.

This mini-guide consists of two displays: (1) some common kinds of soil profiles (Fig. 57), and (2) a check list to facilitate observations and interpretations of soils and soil landscapes (Fig. 58).

Simple soils are those with only one A horizon. Complex soils have two A horizons, one on top of the other. An A/ABC soil consists of a deposit resulting from erosion (A) overlying a buried soil (ABC). A "double profile" is found in northern Wisconsin, and consists of a shallow forest soil (Podzol: Spodosol) developed in the upper part of a deeper forest soil (Gray Wooded soil).

(1) Some Common Kinds of Soil Profiles

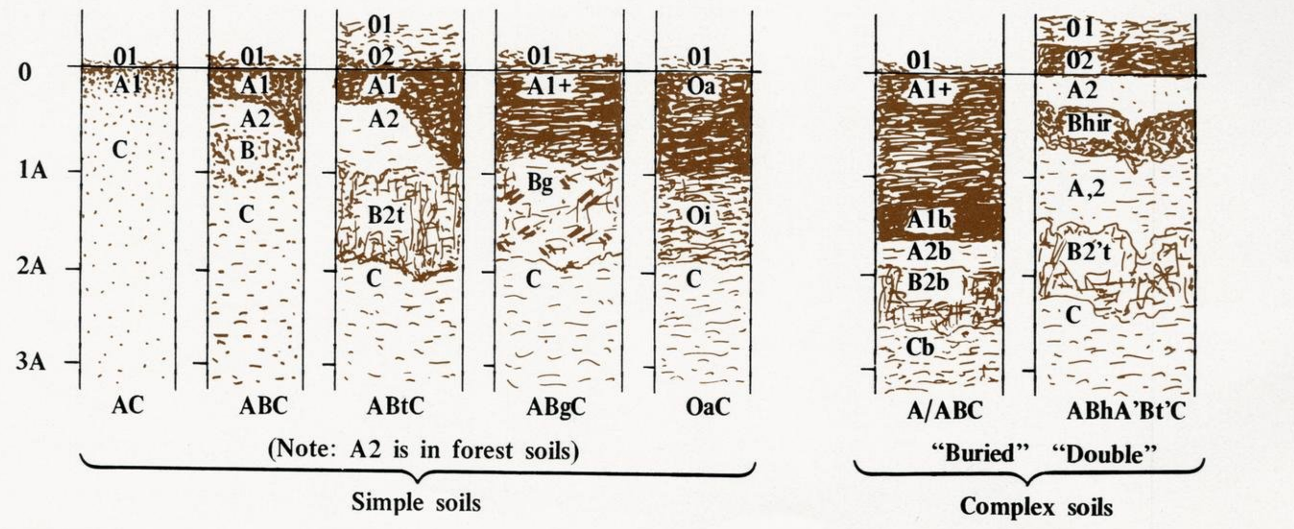


 Figure 57.

(2) A Check List to Help in Making Observations of Soils and Landscapes

The list consists of nine bars which show ranges of conditions, from left to right. With the help of a soil scientist, you can learn to place a particular soil on each bar and thus identify its characteristics. From these you may interpret its function in the landscape. This might even have practical value, such as determining whether or not a soil will accept septic tank effluent safely.

We learn something new on each soil walk that we take. With training and experience, we may become accustomed to "think like a soil," and find real pleasure in exploring the landscape in this manner. It is important to get permission from the land owner to soil-walk on his/her holdings. Many nature study preserves make a point of providing soil study pits (with removable covers) and trails, along which augering in the soil is permitted.

I. Kind of litter and humus layers

grassy, sedge mossy — leafy — leafy+ humus

II. Estimated % organic matter to depth of 15 in. (38 cm.)

0 — 5% — 15% — 25% — 100%

Forest, Prairie (mineral soils) — Peats, mucks (organic soils)

III. Darkness of A1 horizon

10/2 White — 3/2 Dark — 2 0 Black

← Ochric → ← Mollic →

IV. Thickness of black or dark A1 mineral horizon

0 — 7" (18cm) — 10" (25cm)

← Ochric → ← Mollic →

V. Degree of accumulation of clay in B2t horizon, as contrasted with that in A horizon

0 — slight — moderate — notable — great

← Weak B (Cambic) → ← Clay-enriched B2t (Argillic) →

VI. Degree of accumulation of iron and humus in Bhir (Spodic) horizon

0 — slight — moderate — notable — great

← Weak B (Cambic) → ← Spod. horizon Bhir →

VII. Dryness or wetness of soil (natural drainage)

Not mottled — Mottled — Gleyed

Excessively drained — Well drained — Somewhat poorly drained — Very poorly drained

Position of water table in wet spring season.

6 ft. + 2 meters+

VIII. Total thickness of true soil (0+A+B horizon)

0	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	10 ft.
	30cm	60cm	90cm	120cm	150cm	300cm
					1.5 m	3 meters

IX. Landscape position of soil

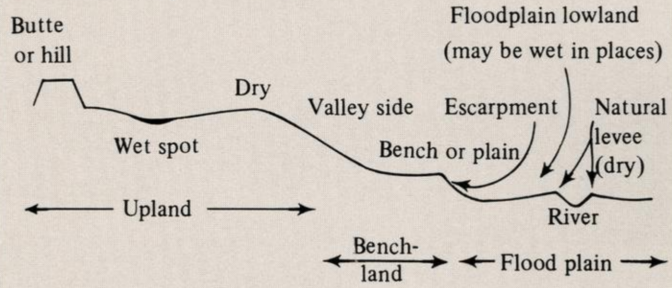


Figure 58. A check list for observers of landscapes and soils.

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