SOIL Judging in Iowa





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Contents

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Soils have many uses, but not all soils are equally adapted to each use. Some soils are suitable for several purposes and are in high demand. For example, highly productive agricultural land often provides the easiest and cheapest sites for building houses and roads. Other soils have properties that make them well suited for some uses but poorly suited for other uses, A very gravelly soil, for example, might be an excellent source of fill material for a road even though the gravel makes the site unsuitable for building a pond. An evaluation of soil properties is essential for making intelligent decisions about land use and management.

Soil judging consists of evaluating certain properties of a soil and interpreting these evaluations into recommendations for land use. This booklet is intended to serve as a guide for making these evaluations and interpretations. The accompanying score card, PM 1107, provides space for recording both the choices made and the scores earned by the contestants in soil judging contests.

Soil differences are so important that they are difficult to ignore. Anyone using land soon notices the differences and develops some means of judging soil in order to adapt land use and management to soil properties and characteristics. Soil judging has therefore been taking place for as long as civilization has been using land.

Improved techniques for soil judging have developed along with the science of soil classification, mostly during the past 100 years. The procedures outlined in this booklet are modern versions of these techniques held to a simple form for use in soil judging contests.

The booklet and score card are divided into five main parts. Part I deals with surface features—position and slope. Part II identifies features within the soil profile—color, texture, depth, and related items. Parts III, IV, and V are interpretive. Part III describes the land capability classification and productivity potential systems, part IV deals with evaluation of management practices, and part V is concerned with the suitability of soils for nonagricultural uses. The last section of the booklet has no score card counterpart. It explains how score cards are graded by contest judges.

This publication replaces all previous editions of PM 1106.

Part 1. Surface Features

Surface features are external soil characteristics that can be identified by observing the landscape. Landscape position and slope are surface features that influence soil development and may limit the ways in which the soil can be used.

Landscape Position

Position describes the location of the soil on the landscape and indicates whether or not the soil is subject to stream flooding or potential erosion. Many different types of landscape positions can be described, but only five are included here. These five are called upland, intermittent drainageway, footslope, terrace, and bottomland.

Figure 1 shows how these five positions occur on a landscape. Contestants are encouraged to observe the landscape beyond the location of the soil pit being judged to determine landscape position.

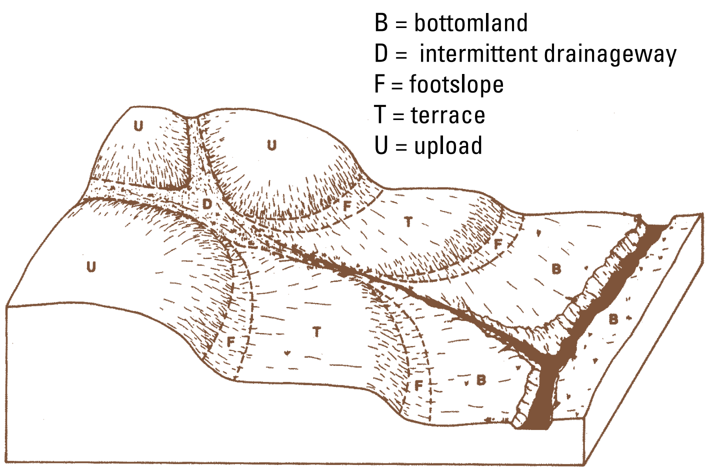

Figure 1. A Landscape diagram showing how landscape positions are related to each other.

UPLAND is the upper part of the landscape including summits and sideslopes. Upland may be subject to erosion, but it cannot receive stream deposits because it is too high to be flooded. Upland soils are normally the oldest and most strongly developed soils in their immediate vicinity. Some upland soils are low in fertility, some are shallow to bedrock, and some are flat enough to need artificial drainage.

INTERMITTENT DRAINAGEWAYS are areas where water flows through uplands and terraces during and after a rain. The water flow is wide and shallow, often without a definite channel and banks. These areas become dry at other times although tile drainage may be required if crops are to be grown on them. Permanent grass plantings are used to protect these drainageways from erosion.

FOOTSLOPE is an area of moderate slope between a relatively steep area above and a relatively flat or concave area below. The footslope is an area of accumulation of soil material that moves down from the steeper area above. The soils are usually deep and fertile. Footslopes are relatively moist sites because they receive subsurface seepage and run-on water from above in addition to normal precipitation.

A TERRACE is a remnant of a former bottomland and represents a time when the stream was at a higher level. A terrace is produced by erosion of the stream to a level too low to flood the area any more. Terraces are absent where stream levels have not changed or where stream valley erosion has removed terraces. Some rivers have occupied various levels and thereby produced several terraces. Each terrace contains flood deposits related to the time when the stream was at that level. Soils located on terraces are often quite fertile and productive. Many of them are underlain by enough gravelly material to provide good drainage. Some terrace soils are droughty because they have gravel layers at shallow depths.

Some stream terraces are cut into upland slopes and contain no stream deposits within the soil profile. The location on the landscape and surface features of these terraces are consistent with terraces that contain stream deposits.

In summary, terraces can contain alluvial deposits or have features resulting from cuts into upland slopes by water or have loess mantles over stream deposits or other parent materials.

BOTTOMLAND refers to the current floodplain of the stream, the land that may be covered with water when the stream overflows its banks. Its width ranges from narrow strips along small streams to areas miles wide along some major rivers. Successive floods over a period of years may deposit several feet of alluvial material in bottomlands. Soil material on bottomlands often contains strata and lenses of variable textures and shows little or no soil profile development. The soils are usually fertile except where they are too sandy or gravelly. Use and management of bottomland is often limited because of floods or high water tables.

Slope

Slopes may be gentle or steep, short or long, and smooth or variable. All of these characteristics influence soil development, runoff, erosion, and land use, but only the steepness will be judged as a surface feature. However, all of the slope characteristics may be considered in the interpretations section of the score card.

Steepness of slope is measured on a percentage scale and is classified into slope groups. The percentage scale tells how many feet the elevation rises or falls per 100 feet of slope length. Percent slope is always measured in the steepest direction at the site. Percent slope can be measured directly with a hand level or a clinometer designed for that purpose, or it can be calculated from elevation data. When the elevation method is used, the distance between the two stakes must be paced or measured. The distance is then divided into the elevation difference and multiplied by 100 to get percent slope, (see Figure 2).

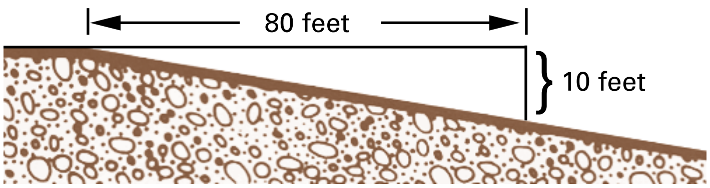

Figure 2. The percent slope can be calculated from distance and elevation data. The slope in the illustration is calculated as:

$$\frac{10 \text{ feet}}{80 \text{ feet}} \times 100 = 12.5 \text{ percent slope}$$

The slope group is determined by comparing the percent slope with the scale given below. A slope that is exactly on the borderline between two groups is considered to belong in the steeper of the two groups.

NEARLY LEVEL—0 to 2 percent

GENTLY SLOPING—2 to 5 percent

MODERATELY SLOPING—5 to 9 percent

STRONGLY SLOPING—9 to 14 percent

STEEP—greater than 14 percent

Part II. Soil Features—The Profile

A soil profile is a vertical section through the layers that make up a soil. It extends downward from the soil surface through the plant root zone. The depth may be as shallow as a fraction of an inch where bedrock is near the surface, or it may range to several feet where there are no restricting layers. Soil depths in Iowa are commonly between 30 and 70 inches.

Soil profiles are composed of various layers called soil horizons. The horizons form roughly parallel to the land surface under the influence of weathering, leaching, and plant and microbial activity. The character of each horizon is a result of the nature of its parent material and the physical, chemical, and biological processes that have acted upon it. Since the changes are progressive with time, the age of the soil also is a factor.

The master horizons in soils and material beneath the profile are designated as:

O HORIZON—layers dominated by organic material

A HORIZON—dark-colored mineral horizons formed at the surface or below an O horizon, containing an accumulation of organic matter

E HORIZON—surface or subsurface layer; a mineral horizon

B HORIZON—subsoil

C HORIZON—loose underlying material

R HORIZON—hard bedrock

These horizons may be subdivided into parts such as A1, A2, and A3 when there are important differences within a main horizon. The various horizons can be distinguished because they differ from one another in such properties as color, texture, structure, and hardness. The change from one horizon to another may be abrupt or gradual. The thickness of soil horizons ranges from a fraction of an inch to perhaps 20 or 40 inches.

A single soil profile will not have all the horizons and sub-horizons that are possible. Most Iowa soils have an A, B, and C horizon. A few soils will have only an A and C horizon.

In 1981 the procedure for naming soil horizons was revised. All Iowa county soil survey reports published after April 1983 have soil profile descriptions written with the revised horizon nomenclature. A comparison of the old and new horizon nomenclature is shown in Appendix A.

Soil profiles are best observed in excavations such as a pit, trench, or road cut. A vertical surface is best. Pits are usually used for soil judging contests.

Color of A Horizon

The upper part of the soil usually contains the most plant roots, accumulates the most organic matter, and has the darkest color of any horizon in the soil. Layers having these characteristics are called A1 horizons unless they have been tilled. Tilled layers are called Ap horizons whether the material is pure A1 or a mixture of the A1 and underlying horizons.

In addition to the accumulation of the largest amount of organic matter occurring at or in the surface of the soil, the greatest amount of physical and chemical weathering of the soil occurs in the surface horizon. Wetting and drying and freezing and thawing cycles provide for weathering of fine and very fine silt particles and for the production of clay-sized

Photo credit: G. Miller

Figure 3. A soil profile with horizon changes indicated by arrows. The depth scale is in feet.

Photo credit: G. Miller

Figure 4. A road cut is a good place to practice judging soil profiles.

Photo credit: R. Pope

Figure 5. A soil pit being used for a judging contest.

Photo credit: C. Marbut Collection

Figure 6. A soil profile with a light-colored E horizon from about 6- to 12-inch depth.

particles in the surface horizon. The products of weathering and some organic material are subsequently moved downward over time in the soil profile with percolating water.

Presence of E Horizon

Forested soils and certain other intensely leached soils commonly contain an E horizon located at the surface or a few inches below the surface. An E horizon is usually lighter in color, lower in organic matter, and contains less clay than an A1 or the overlying horizon, if present. In addition, an E horizon is characterized by soil aggregates that form a layered or platy-like structure unless the horizon has been disturbed by tillage. Percolating water removes some clay and organic matter from the A horizon or soil surface downward into lower layers of the soil profile. The depletion of these materials from the surface or near the soil surface results in the formation of an E horizon. Deposition of the clay and organic coatings along pores and root channels in the B horizon help produce a contrast in the color, aggregate structure, and clay contents of the A, E, and B horizons.

Strongly developed E horizons are commonly underlain by B horizons with much higher clay contents. The higher clay content of the B horizon reduces the subsoil permeability and may cause the E horizon to stay wet for extended periods of time. The wet condition helps leach and acidify E horizons. The light color of the E horizon results from the natural color of sand and silt particles that have been stripped of organic matter, clay coatings, and oxidized iron compounds.

The color of the A horizon of a soil is a clue to its productive potential and management needs. Dark colored soils usually are fertile. The dark color indicates that abundant vegetative growth is supplying the plant remains that decay and become soil organic matter. The amount and rate of decay of plant and animal material are influenced greatly by soil temperature and aeration. Either a cool climate or excessive wetness can cause a soil to accumulate higher levels of organic matter than well drained soils. These soils may have partially decomposed organic materials in the O and/or A horizon and may be classified as muck or peat soils.

The typical gray color and acid condition of an E horizon indicate that it has relatively low soil fertility in comparison to thick, dark A horizons. Lime and fertilizer are needed to compensate for these conditions when crops are grown.

The soil color is usually a good indicator of the organic matter content of a soil horizon up to about 4 or 5 percent. Much of the organic matter occurs as dark-colored coatings on the mineral particles. About 4 or 5 percent organic matter will make light-colored mineral particles look black when moist. Moist colors are usually used as references. Dry colors are not as dark. Contestants will use moist colors for evaluating soil color.

When judging soil, the soil color is described for the A1 or Ap horizon if an inch or more of such material is present. If an E horizon is at the soil surface, the E horizon color will be identified for the contest. Where tillage has mixed the E horizon with the A horizon, the soil color for the A horizon will be indicated. In these cases the E horizon will be marked as not present. The E horizon should be marked absent if it is less than an inch thick.

Four color groups are used in soil judging: **dark**, **moderately dark**, **light**, and **very light**. Dark includes soils that are black or very dark brown when moist. Moderately dark includes soils that are very dark gray to dark brown in color when moist. Light colored soils are usually light brownish gray when dry but are dark gray or dark grayish brown when moist. If a Munsell color book is available, these moist soil colors can be related to values of 2, 3, 4, and 5 respectively for the dark, moderately dark, light, and very light colors.

For the purpose of the soil judging contest, recently deposited lighter colored sediments less than 24 inches in thickness on the soil surface overlying the A horizon are to be ignored when considering the color, thickness, and texture of the A horizon. Where 24 inches or more of light colored sediments overlie a buried A horizon the light colored sediments will be judged as the A horizon and the buried A horizon will be ignored when evaluating properties of the A horizon. Contestants will evaluate the horizon below the buried A horizon for the second horizon. In the event the buried A horizon extends to the full depth of the exposed soil profile, the contestant will judge the profile as no B horizon present and the buried A horizon will be judged as the second horizon.

Thickness of A Horizon

The A horizon, especially the A1 horizon, is usually the most fertile part of a soil and is likely to be the most permeable to air and water movement. It usually contains a much higher concentration of plant roots than other parts of the soil. The thickness of the A horizon is therefore a significant factor in the productivity of the soil.

The total A horizon is to be considered in judging thickness including whatever is present of A1, AE, E (if between an upper and lower A horizon), EA, A2, A3, and so on to include recently deposited lighter colored material, 24 inches or more in thickness. A horizons vary in thickness even in virgin soils. Original thicknesses range from less than 6 inches in some soils to over 20 inches in other soils. Climate, vegetation, slope, landscape position, and parent material all influence thickness of the horizon. Erosion commonly removes some or all of the A horizon from soils on slopes.

The A horizon is distinguished from the B horizon on the basis of color, texture, and structure. The A horizon tends to accumulate organic matter but loses other materials by leaching. The B horizon tends to accumulate clay or, in some soils, humus and iron. Typical characteristics are therefore a darker color and a more open structure in the A horizon versus a higher clay content and a more dense structure in the B horizon. An A horizon that has little or minimal recent disturbance will have a granular or granular-like structure. Where excessive disturbance has occurred, the structure may be platy or have no observable soil aggregates.

Thickness of the A horizon is judged on the basis of what is currently present regardless of what the virgin condition may have been. An A horizon or an A plus an E horizon measuring more than 12 inches is considered **thick**. **Moderately thick** includes those between 7 and 12 inches in thickness. **Moderately thin** ranges from 3 to 7 inches thick and includes Ap horizons (tilled layers) or AE horizons that are composed of more A or A and E horizon than B horizon material. An A horizon is called thin if it is less than 3 inches thick or if the tilled layer is more than 50 percent B horizon material.

Texture of A Horizon

The texture of the A horizon has a strong influence on soil productivity and management requirements. In general, sandy soils are easy to cultivate but are low in fertility. Soils with high clay content are usually fertile but are hard to till because they are sticky and plastic when wet and hard when dry. High clay content soils are likely to have low permeability to air and water and high resistance to root penetration. The structural strength of aggregates and potential erosion of the soil are also greatly dependent on texture.

The proportions of sand, silt, and clay in soil determine its texture. Each soil horizon may have a texture slightly different from any other. However, texture variations within an A horizon are usually small enough to permit it to be considered as a unit even if A and E horizons are both present.

Sand, silt, and clay are mineral grains that are defined on the basis of size, (see Table 1). Sand grains are .05 mm to 2.0 mm in diameter—large enough to be seen and to impart a gritty feel to the soil. Silt particles are .002 mm to .05 mm in diameter-these particles produce a smooth "floury" feel. Clay particles are less than .002 mm in diameter—small enough to make the soil sticky and plastic when wet or hard when dry. A mixture of sand, silt, and clay that exhibits the properties of all three materials about equally is called loam. Clay properties tend to be strongly expressed compared to the amount present. For example, an average loam contains about 40 percent sand, 40 percent silt, and 20 percent clay (Figure 7).

Table 1. Some characteristics and size limits of soil separates (USDA classification).

SOIL SEPARATE	DIAMETER (range in mm)	NUMBER OF PARTICLES per gram*	IDENTIFICATION
Sand	2.0-0.05		Can see individual grains, feels gritty. Similar to table salt crystals.
Very coarse sand	2.0-1.0	90	
Coarse sand	1.0-0.5	720	
Medium sand	0.5-0.25	5,700	
Fine sand	0.25-0.10	46,000	
Very fine sand	0.10-0.05	722,000	
Silt	0.05-0.002	5,776,000	Feels smooth like talc or flour.
Clay	less 0.002	9,260,853,000	Sticky when wet. Hard to dry.

** Henry D. Foth, Fundamentals of Soil Science (New York: Wiley, 1978), p. 26*

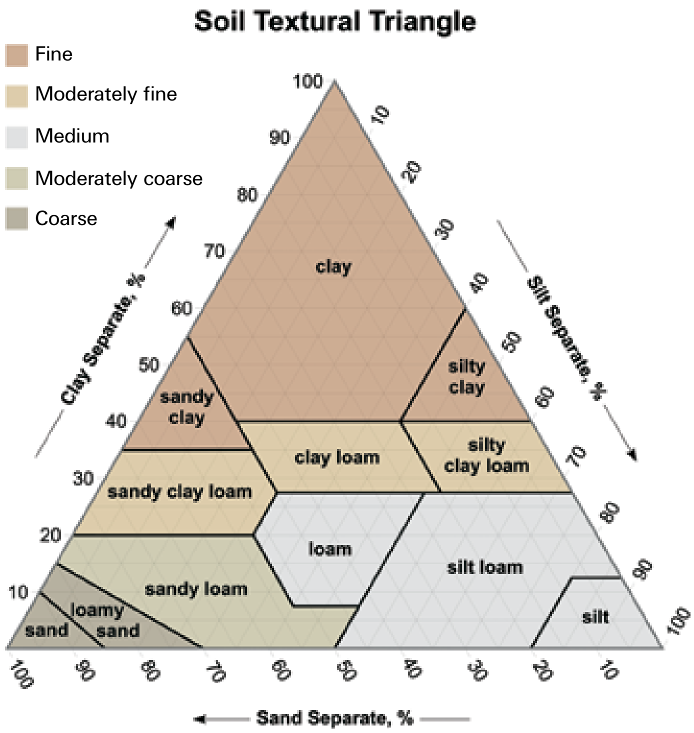

Figure 7. The standard USDA triangle for determining the 12 textural classes and 5 textural groups. (Modified from Soil Survey Staff, USDA).

The terms sand, silt, clay, and loam are used in various combinations to name 12 soil textural classes. For example, one of the classes is loamy sand and another is silty clay loam. However, a simpler classification containing five textural groups will be used for the contest. The five groups are called coarse, moderately coarse, medium, moderately fine, and fine. These textural groups include one or more of the textural classes as shown in Figure 7.

Soil texture is determined in two different ways. The actual percentages of sand, silt, and clay can be determined by a laboratory procedure called a mechanical analysis. In the field; however, it is necessary to estimate the soil texture by feeling it with the fingers. This skill can be developed with practice and will be used in the contest. Contestants should work with samples of known texture to gain proficiency.

The field procedure for determining the five classes used in the contest are summarized as follows, in Table 2, and examples are shown in Figure 8.

1. Look at the soil to see whether it appears to be sandy, silty (floury), or aggregated into groups or masses of particles.
2. If the soil is dry, check the hardness of aggregates if any are present. Hard aggregates usually contain more than 20 percent clay.
3. Moisten a sample of the soil (about enough soil to fill a teaspoon) with enough water to make it as plastic (formable like putty or modeling clay) as possible. If the soil initially becomes sticky, it is too wet. Knead the soil thoroughly between your thumb and fingers. People experienced at estimating texture by feel keep one hand clean for writing while using the other hand to knead the soil.
4. Squeeze the moist soil between your thumb and forefinger, and try to flatten it into a thin ribbon about one-half inch wide and not more than one-eighth inch thick. The length of ribbon that can be formed is a good indicator of clay content.
   - **a.** Soils that readily form flexible ribbons more than 3 inches long and retain their ribbon form without separation may have at least 40 percent clay. The sample is designated fine.
   - **b.** Soils that form weak ribbons are called moderately fine.
5. Soils that form little or no ribbon and are obviously low in sand must be high in silt. These are designated medium.
6. Fine, moderately fine, and medium-textured soils may have sand particles that are visible in the sample. A general rule of thumb is that if individual sand grains can be seen, the sample usually consists of a minimum of 15 percent sand.
7. Sandy soils must be checked to see how much fine material there is between the sand grains. Add enough water to make a thin film of water apparent around the sand grains. Work the soil into a thin layer to see how much fine material there is.
   - **a.** Sandy soils with obvious fine material, abundant enough to make the hand dirty, are designated moderately coarse.
   - **b.** Soils that appear to be nearly pure sand are designated coarse.

Presence of B Horizon

The B horizon normally occurs in the subsoil position and affects water and air movement and plant growth. B horizons can be identified by texture, structure, and color. These properties may be in combination or may be alone, but of sufficient difference from other horizons to be identified as a B horizon. Some B horizons are dense enough to restrict air and water movement except when they are dry and cracked. Other soils are wet because of landscape position or contain horizons or layers with low permeability in the soil profile. Part or all of the soil may be saturated with water for extended periods of time.

Table 2. Soil characteristics for classifying soils in soil textural groups (see Figure 7).

CHARACTERISTICS OF THE SOIL	SOIL TEXTURAL GROUP				
	COARSE	MOD. COARSE	MEDIUM	MOD. FINE	FINE
1 . Feel (moistened sample)					
a. Loose	X				
b. Gritty and somewhat gritty		X			
c. Smooth, floury, can have some grit			X		
d. Smooth, sticky, occasional grit				X	
e. Smooth, very sticky, can have few grit					X
2. Appearance of natural (non-kneaded) sample					
a. Single grain, few or no fines. Mostly sand grains.	X				
b. Many visible sand grains, some fines.		X			
c. Flour-like, can have single grains of sand			X		
d. Putty-like, can have grains of sand				X	
e. Forms smooth, massive appearance; may have single grains of sand					X
3. Appearance of kneaded sample (moistened sample)					
a. Loose, falls apart, can not knead into ribbon	X				
b. Loose, little cohesion, can knead into ribbon less than one-half inch long		X			
c. Kneads into short ribbons, usually less than 1 inch long. Readily breaks apart			X		
d. Readily kneads into ribbons, occasional discontinuous breaks at 1- or 2-inch intervals				X	
e. Forms long continuous ribbons, often 3 or more inches in length					X
4. Plasticity characteristics (moistened sample)					
a. Nonplastic	X				
b. Exhibits little evidence of plasticity		X			
c. Slightly plastic and smooth			X		
d. Plastic and sticky				X	
e. Highly plastic, compost, massive					X

Long periods of saturation are a serious restriction on the development of plant roots and therefore on the effective depth of the soil for plant growth. A soil that is too wet in the spring often limits root development enough to aggravate drought problems in the summer. A shallow root system can also produce fertility problems because the plants have too little soil from which to obtain nutrients. A favorable subsoil must retain enough water for plant growth but permit excess water to drain out so air and roots can enter and roots can grow and develop.

Moist Color of B Horizon

The color of the B horizon is a good indicator of the air and water relationships in the soil. Well aerated soils have uniform, brightly colored subsoils—commonly a shade of yellowish brown or brown. Soils that are frequently or constantly wet have dark gray, olive gray, or bluish gray colors in their subsoils.

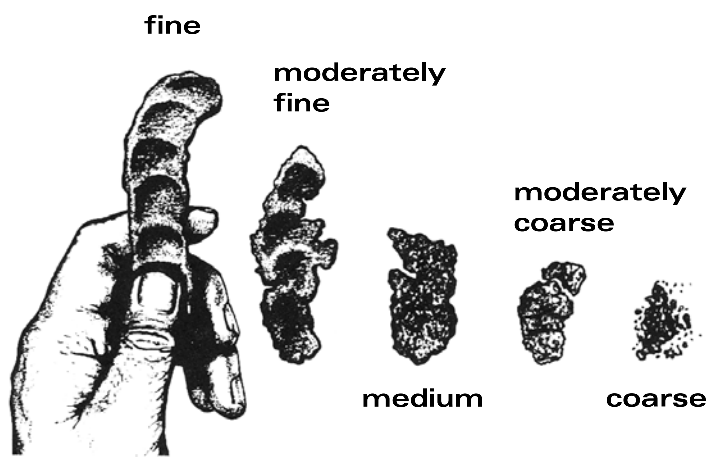

Figure 8. Field method "ribbon test" for soil textural groups (see Figure 7 for textural groups).
Drawing by David Sauke, Iowa State university.

Intermediate moisture status and wet stages of internal drainage within the soil profile have redox features. Redox features consist of spots or concentrations of one or more contrasting colors on a background of another color or a near uniform gray color present in the soil matrix. Redox features indicate the presence or absence and concentration of various compounds of iron and manganese in the soil due to the degree of oxidation and hydration. Redox colors can range from a rust, dusky red, to gray or grayish green. The coloration of redox features may be expressed across a range from prominent to faint. Faint redox features are described as casts or tints in this manual. Some soils have redox features in the subsoil that are not an indication of present air-water relationships. These colors are an indication of air-water conditions that were present in the soil profile during an earlier geological period when soil development occurred in an environment that may be different from the soil environment that has dominated during the most recent climatic conditions. This is termed as relict conditions. These redox features may occur in soils occupying slope gradients greater than 2 percent. For the purpose of the contest these relict features will be used to determine the color of the B horizon (or C horizon if a B horizon is not present) and the internal drainage class of the soil.

Many soils have B horizons thick enough to require designation of the part to be described for the contest. If the B horizon is more than 10 inches thick, only the upper 10 inches will be described and used for the contest; if it is less than 10 inches thick, the entire B horizon will be described and used for the contest.

Some soils have not had sufficient time to develop a B horizon. The B horizon section of the score card will be scored for the C horizon for such soils. In these soils the 10-inch zone immediately below the A horizon will be used for the contest.

Classes will be used for designating the color of the B horizon (or buried A horizon if overlain by 24 inches or more of light colored sediments or C horizon if there is no B horizon). These classes are:

a. Uniformly brown, dark brown, or strong brown.
b. Uniformly brown, dark brown, or strong brown. Includes olive or yellowish or reddish cast or tints or other faint redox features in the soil matrix.
c. Grayish brown or olive gray with no redox features.
d. Grayish brown or olive gray with gray or rust redox features.
e. None of the above.

a. Gray with redox features. Redox features are often rust in color, but the gray color covers more than 50 percent of the area.
b. Uniform gray. May have a bluish or greenish cast. Rust redox features, cast, or tints may occur around roots or small pores, but not elsewhere.
c. Black. May contain a few rust redox features. This class includes a buried A horizon if present (at a depth of 24 inches or greater and extends to the full depth of the exposed soil profile).
d. None of the above.

Texture of B Horizon

The texture of the B horizon influences other properties such as structure, permeability to air and water, resistance to root penetration, and strength for supporting construction and buildings. B horizon characteristics are important because the A horizon is seldom thick enough to meet all the needs of growing plants.

As a result of clay movement, the B horizon usually contains more clay than the A horizon. Most of the transported clay is present as coatings on sand and silt grains, on soil structural units, and on the inside of soil structural units. The material should therefore be kneaded well in the process of determining the texture of the B horizon. The methods of determining the texture and the classes to be used are the same for the B horizon as for the A horizon. If 24 inches or more light-colored sediments overlie a buried A horizon, the texture of the buried A horizon will be determined by the contestant if the buried A horizon extends to the full depth of the exposed profile. If the buried A horizon does not extend to the full depth of the exposed profile, the horizon will be ignored as described in the previous section discussing horizons.

Soil Depth

The total thickness of material available for plant root development is important. Plants obtain not only water and nutrients from the root zone but mechanical support as well. The thickness of soil above a layer that stops root development is therefore considered to be the soil depth. The usable soil includes the A and B horizons and may include C horizon material in some soils. The limiting layer for root penetration and development may be a hard layer such as bedrock or a strongly cemented layer, or it may be a very porous material greater than 2 mm in size such as gravel, cobbles, or boulders that store very little water and nutrients for plant growth. A porous layer such as coarse sand and fine gravel does not stop root development and should be considered as part of the soil depth. For purposes of the contest a porous layer is defined as a layer consisting of boulders, cobbles, gravel (coarser than fine), and very coarse sand that contains voids 1 mm or larger in size. These voids are not filled with finer sand, silt, or clay material.

About 30 to 70 inches of soil depth are enough for most crops to grow quite satisfactorily Any soil less than 20 inches deep is likely to be restrictive for most plants. The depth classes to be used for the contest are:

DEEP—more than 40 inches of usable soil.

MODERATELY DEEP—30 to 40 inches of usable soil.

MODERATELY SHALLOW—20 to 30 inches of usable soil.

SHALLOW—less than 20 inches of usable soil.

Soil Parent Material

The loose or disintegrated rock material from which the mineral part of the soil originated is called the soil parent material for mineral soils. The parent material for organic soils is called peat, but organic soils are relatively rare in Iowa.

Parent material influences soil texture and all of the properties related to soil texture. Also, the gradual transfer of minerals from the parent material releases nutrient elements that are essential to plant growth. Once released, these nutrients may be cycled many times from growing plants to soil organic matter and back to another generation of growing plants.

Soil parent materials will be divided into six classes for contest purposes. These six classes are:

GLACIAL DRIFT—ground up material left by glaciers. Glacial drift is sometimes divided into till and drift, where drift has been carried away from the glacier by its melt water rather than deposited directly by the ice. Some soils formed in glacial drift may have formed in a thin layer of local sediments as part of the parent material.

LOESS—dominantly silt-sized rock material transported and deposited by wind. Loess is a rather uniform material with little or no apparent layering. The origin of most loess is related to glacial action. The particles were first transported by the ice, then carried by glacial melt water to broad floodplains, and finally picked up by the wind and deposited as a loess parent material. Loess deposits range in thickness from many feet down to a layer of dust. Loess deposits less than 20 inches thick are difficult to identify because shallow loess becomes mixed with the material it covers and loses the high silt content characteristic of loess deposits. Soils formed in 20 to 40 inches or more of loess over bedrock, sands and gravels, or glacial drift will be considered to be formed in loess parent material for the purpose of soil judging. In certain landscapes, loess covered stream terraces exist. These landscapes are broad and flatter than the upland sideslopes above them and footslopes and alluvial stream terraces below.

ALLUVIUM—sediments deposited by running water. The water usually sorts the material by particle size, and deposits the coarser material where the current is faster and the finer material where the flow is slower. Variable flows and shifting currents cause most alluvial material to be stratified into layers and lenses of differing textures.

COLLUVIUM—material that has moved down a steep slope with gravity as the pulling force (water usually acts as a lubricant but not as the transporting agent) and accumulated on a lesser slope at the bottom. The movement may be either very fast (a landslide) or very slow (soil creep), but in either event, the colluvium is unsorted in contrast to the sorted nature of alluvium.

RESIDUUM—material formed in place by the weathering of bedrock into a disintegrated mass. Weathered bedrock occurring within 20 inches of the surface will be considered residuum for the purpose of this contest.

PEAT—organic materials that accumulate in bogs, marshes, and wetlands because the wet conditions retard decomposition.

Native Vegetation

The organic material in soil comes from the plants growing in the area and is modified by the animals, insects, and microorganisms living there. The effect of vegetation is strong enough to influence the chemical and physical properties of the soil as well as its biological characteristics. For example, a soil formed under forest vegetation is usually more acid and has had more clay movement from the A horizon to the B horizon than a soil formed under similar conditions but developed under grass vegetation. The resulting soil differences persist for hundreds of years even if the vegetation changes. Consequently, it is possible to identify the native vegetation of a soil that has long been under cultivation.

For contest purposes, native vegetation will be classified as forest, transition, prairie, or marsh. These types can be identified as follows:

FOREST. The A1 horizon formed under forest is usually no more than 3 to 6 inches thick and is underlain by an E horizon. The Ap horizon produced by tilling a forested soil contains a mixture of A and E materials that usually are lighter colored than an Ap in a prairie soil. The B horizon has a marked accumulation of clay, and both A and B horizons tend to be acid unless lime has been applied to neutralize the surface soil. Figure 6 is a picture of a soil formed under forest vegetation.

TRANSITION. Soils that show the influence of both grass and trees have A horizons nearly as dark as those of prairie soils but have E horizons between the A and B horizons (unless the E horizon is destroyed by tillage and/or erosion). Typically the A horizons are between 6 and 10 inches thick if uneroded. The E horizons are less distinct than those developed under full forest vegetation and are commonly 1 to 3 inches thick. The B horizon development also tends to be intermediate between those of forest and prairie soils.

PRAIRIE. Soils developed under grass vegetation usually have thick, dark, and moderately dark A1 horizons unless the soil is so steep that major erosion has occurred or the soil is located on a floodplain and has received recent deposits of light colored sediment. Prairie derived soils can have E horizons but only if they have poor internal drainage resulting from flat or concave topography and clayey subsoils. The B horizons usually have less clay accumulation than soils formed under forest vegetation occupying adjacent landforms and developed in similar parent material.

MARSH. Reeds, sedges, cattails, and other water-loving vegetation grow in areas so wet that organic materials accumulate and form peat. The particular kind of vegetation can often be identified from the nature of the peat.

Surface Drainage

Adequate drainage to dispose of excess water within a reasonable time is essential for many uses of soil. Inadequate drainage produces waterlogged soil that is likely to prevent growth of plant roots because of poor aeration. Also, wet soils when exposed to mechanical disturbance become muddy and may fail to support loads placed on them. A building may settle, or a vehicle may get stuck in the mud when soil drainage is inadequate.

Excess water received beyond what the soil can store for plant growth must either pond, run off the surface, or pass through the soil. The surface drainage depends greatly on slope, texture, surface roughness, and vegetative cover. Soils with coarse and moderately coarse textures in the surface horizon usually have a greater potential for increased surface drainage when compared to soils with medium, moderately fine, or fine surface textures on similar slope gradients. The rate that water can escape by flowing across the soil surface is evaluated as rapid, medium, slow, or ponded surface drainage. For purposes of the contest, judges will select soils that 1) are not saturated across the depth of the entire profile and 2) has potential for infiltration of water in the upper part of the profile. The classes may be defined as follows:

RAPID. The soil surface is steep enough and smooth enough that water can flow rapidly across it. The water flow is so fast that water remains on the soil surface only a few minutes after rainfall ceases. Much water runs off that could have been stored for plant growth if it had infiltrated. Soils occurring on slopes greater than 9 percent gradient will experience rapid surface drainage unless they have a sod-based plant cover. Soils with a sod-based plant cover (sod-based defined as consisting of perennial plants) on slopes 9 to 14 percent will have medium surface drainage. All soils occupying slopes greater than 14 percent will have rapid surface drainage.

MEDIUM. Water is held on the soil surface long enough to give it an opportunity to infiltrate but not long enough to cause excessive wetness. Gentle and moderate slopes with a smooth or rough surface are likely to have medium surface drainage. Soils occurring on nearly level slopes classified with excessive internal drainage are included in this category of medium.

SLOW. Water has an avenue to escape across the soil surface, but its movement is slow because the slopes are nearly level, the surface is quite rough, or vegetation impedes its flow. Water may stand on the soil surface for several hours after a rain.

PONDED. Water has no avenue to escape across the soil surface, so it accumulates in a pond. The water remains in the pond until it either infiltrates or evaporates. Soils formed in closed landform depressions are included in this category.

Internal Drainage

Internal soil drainage takes effect after the water is in the soil. It is a measure of the amount of water held and the rate that water moves in the soil profile. Internal drainage is most critical for soils that absorb excessive amounts of water.

Excessive absorption may be caused by ponded or slow surface drainage, by high infiltration rates, or by seepage from adjoining soils. Too much water from any of these sources may cause the soil to be waterlogged and poorly aerated.

The internal soil drainage state determines how long excess water remains in the soil. The relative permeability of the various soil horizons helps to determine the internal soil drainage. The material beneath the soil and the presence or absence of a water table are also very important.

The soil colors and organic matter contents show the effects of internal soil drainage. These effects remain for many decades even if the soil drainage is improved with surface drainage ditches or subsurface tile drains. Color and organic matter criteria therefore are used to determine the natural internal drainage of the soil. Evaluation of the internal drainage class is best accomplished by identifying the dominant colors at the base of the A horizon. For the purpose of the contest, the contestant will use the 10-inch zone below the base of the A horizon to determine the internal drainage class. The identification of the dominant colors in this zone of the soil profile provides the soil judge with a basis to interpret the internal drainage class of the soil.

The five internal drainage classes used in the contest are excessively drained, well drained, somewhat poorly drained, poorly drained, and very poorly drained.

EXCESSIVELY DRAINED. These soils are well aerated and have low water holding capacity. The texture of the subsoil or C horizon is coarse or moderately coarse, and the color of the B or C horizon is usually uniform brown to include yellowish-brown or strong brown. The base of the A horizon has Munsell chroma 3 or higher and a value 4 or higher.

WELL DRAINED. Aeration is adequate. The color of the A may be dark or black and may be one color group lighter than that of nearby wetter soils. The B horizon has a uniform brown color with no redox features. The base of the A horizon has Munsell chroma 3 or higher and a value of 3 or higher.

For purposes of the contest, well drained includes those soils classified as moderately well drained. In these soils the color of the A may be dark or black and may be one color group lighter than that of nearby wetter soils. The B horizon has a uniform brown color with a few red or gray redox features. The base of the A horizon has Munsell chroma 3 or higher and a value of 3 or higher.

SOMEWHAT POORLY DRAINED. The soil may be waterlogged for several days or a few weeks at a time during wet seasons but is aerated at other times. Soils occupying level or nearly level slopes may require tile drainage to achieve their agronomic potential. The A1 is likely to be relatively dark or black in color, and the B is usually grayish-brown or olive gray with or without redox features. The base of the A horizon has Munsell chroma 2 and a value 3 to 5.

POORLY DRAINED. The soil is waterlogged for several weeks during wet seasons and usually cannot be satisfactorily cropped without artificial drainage. Ponding of water on the surface occurs for short periods of time. The A1 is black in color, and the B horizon is almost entirely uniform gray with no or few grayish brown redox features or uniform gray with rust redox features, (see Figure 9). The base of the A horizon has Munsell chroma 0 to 1 and value 2 to 6.

VERY POORLY DRAINED. These soils often occur in depressions on uplands, terraces, and bottomlands. The soil is covered with ponded water part of the time and is water-logged most of the time unless it is artificially drained. The surface soil may be muck or peat, the A horizon is black, and the subsoil has a uniform gray color or mostly olive gray. The base of the A horizon or the lower A horizon has Munsell chroma 0 to 1 and a value 2 to 6. A few rust colored redox features may be present within the black A horizon and the B horizon.

Erosion Class

A very slow rate of erosion called geologic erosion occurs under natural conditions. Geologic erosion removes weathered material from the soil surface while soil formation converts fresh mineral matter from the C horizon into soil. During the past 2,000 to 3,000 years, before settlement by European immigrants in Iowa, geologic erosion and soil formation were generally in equilibrium with each other. Therefore, soils on stable landscape positions remained at the same relative thickness. The total effect of these processes is beneficial to soil fertility because there is recycling and a gradual replenishment of plant nutrients in the soil.

When people use land, they usually disturb the vegetative cover and thereby increase the rate of erosion. This induced erosion, properly named accelerated erosion, is what most people mean when they speak of erosion. Accelerated erosion is detrimental because it removes soil and plant nutrients faster than soil formation replenishes them. The detrimental effects of accelerated erosion are classified into erosion phases on the basis of how severely they restrict the use of the land. These classes are overwash, uneroded or slightly eroded, moderately eroded, severely eroded, and gullied land.

OVERWASH—present on land downslope from some adjacent land and receives sediment from these adjacent lands or land that occupies floodplains and received recent stream deposited sediment. These soils will have 7 to 24 inches of lighter colored material deposited on an existing A horizon.

Figure 9. A poorly drained soil with a black A1 horizon and a gray B horizon with redox features.

UNERODED OR SLIGHTLY ERODED—land that still has the same use potential and management needs as it had when the settlers first began cultivating the land. The tilled layer consists of A horizon material. Soils on 0 to 2 percent slopes usually have an A horizon thickness of 10 inches or greater for this class. Soils on 2 to 5 percent or steeper slopes usually have 7 to 12 inches of A horizon material for this class. Mixing of subsoil material usually is not present in the tilled layer if cultivated, but mixing can occur in deeply tilled soils. Recently deposited sediments on the soil surface with minimum organic matter accumulation of less than 7 inches thickness may be included in this class.

MODERATELY ERODED—land with use potential somewhat impaired by erosion. The same use potentials are still available, but the intensity needs to be reduced (as, for example, fewer years of row crops in a rotation with a sod base crop), or special conservation practices are needed (perhaps terracing or contouring or contour strip cropping). The dark or moderately dark colored A horizon or A plus E horizon material is 3 to 7 inches thick. If cultivated, some mixing of subsoil or parent material occurs in the tilled layer.

SEVERELY ERODED—land with use potential significantly reduced by erosion so that some choices are eliminated, as for example, land that was formerly suited for row crops is now best suited to close-growing crops and sod-based crops. The A horizon is thin or depleted. The dark or moderately dark colored A horizon, if present, is less than 3 inches thick. If cultivated, a major portion of the tilled layer consists of subsoil or parent material.

GULLIED LAND—land so cut up by gullies that traffic across the area is difficult or impossible. The A and B horizons are gone from a considerable percentage of the area.

Calcareous Surface Soils and Subsoils

Calcareous or high lime soils occur in two kinds of situations in Iowa. One situation occurs where erosion has been so rapid that calcareous parent material is exposed at the surface. These soils are likely to be more limited by drought conditions and erosion hazard than by the calcareousness, but the calcareous condition is an additional disadvantage.

The other situation where calcareous soils occur is caused by wetness. North central Iowa has many depressed areas or "potholes" that contain calcareous materials or have calcareous materials distributed as rims or bands around the depressed area. Some floodplains also have calcareous soils. Water evaporating from the wet soils leaves behind enough calcium carbonate to cause the calcareous condition. Snail shells also contribute calcium carbonate to many of these soils because snails like the wet environment.

Calcareous conditions raise the soil pH above neutral and limit the availability of phosphorus and iron, Larger than usual applications of phosphorus fertilizer may be needed for crops such as corn and alfalfa. These same crops are likely to need extra potassium fertilizer because of wetness. Soybeans growing on these soils often suffer from iron deficiency. Calcareous conditions can also influence the type and amount of herbicides that will give best results in a field.

Calcareous soils can be identified in two ways—by color and by an acid test. Calcium carbonate is white or grayish white and causes the soil to be lighter colored than otherwise similar soils. For example, calcareous soils that have 6 percent organic matter are dark gray instead of black. The contrast with adjoining soils is usually easy to see.

Positive identification, however, is made by the acid test. A few drops of dilute hydrochloric acid will cause a calcareous soil to effervesce (emit bubbles of carbon dioxide). A 10 percent solution by volume of hydrochloric acid in a dropper bottle is suitable for this test. The score card should be marked to indicate whether the surface soil and the B horizon, or C horizon if the B horizon is absent, is calcareous or noncalcareous.

Stoniness or Rockiness

Technically, stoniness means loose stones, and rockiness means exposed bedrock. Either condition should be noted where it is serious enough to limit the use of the land. Rocks are defined as fragments greater than 2.0 mm in size. Rock fragments of any size may be included in this item if they cause a serious limitation for tillage, conser-vation practices, or construction. For a serious limitation to occur, the surface layer of the soil should contain 15 percent or more rock or rock fragments by volume.

Part III. Land Capability and Productivity

Land Capability Classification

The soil characteristics judged in Parts I and II can be interpreted into land capability classes. The classification criteria used were developed by the USDA Natural Resources Conservation Service and are widely used in the preparation of conservation plans. Land capabilities identify the limitations and hazards of using land for agricultural purposes. The degree and type of limitations can be marked on soil maps as a basis for planning land use and management. Contiguous soils may be grouped together into one common land capability class. The land characteristics emphasized are important factors in determining whether an area of land is best suited for crops, pasture, or woodland.

There are eight land capability classes based on the degree of hazard or limitation for use of the land. Classes I through IV are suitable for almost any use (including cropland), but with varying degrees of hazards or limitations if they are used as cropland. Class I has the broadest potential and class IV is the most restricted for use as cropland. A similar pattern applies to pasture or woodland use for classes V through VII. Class VIII land is so restricted that its use is limited to recreation, wildlife, or watershed protection purposes.

CLASS I land is suitable for nearly any use because it has no special hazards or limitations. It has soil that is deep, well to somewhat poorly drained, nearly level, medium, and moderately fine textured. These soils are productive and easy to manage. Good management is sufficient to meet their needs without any special conservation practices. Although Class I soils have no limitations that restrict their use for intensive crop production, tile drainage is often recommended for moderately well and somewhat poorly drained soils in this class. Class I land is colored green on land capability maps from the Natural Resources Conservation Service.

CLASS II is good land that can be adapted for nearly any use by taking some precautions to meet its needs. For example, land with slopes between 2 and 5 percent is likely to be in class IIe and needs an erosion control practice such as contouring or conservation tillage. Or, land may be placed in class IIw because it needs tile drainage. Also, land occupying 0 to 2 percent slopes with an A/C soil profile (no B Horizon) and moderately coarse or coarse textures in all or part of the C horizon above 40 inches may be placed in this class. However, if coarse textures are identified above 40 inches and extend below 40 inches, these soils are generally placed in Class III. Several other hazards or limitations may cause land to be placed in class II if they are not too severe. In general, class II land has nearly the same potential as class I land except that its special needs must be met. Class II soils have some limitations that restrict their use for intensive crop production. Class II land is identified by a yellow color on land capability maps.

CLASS III is fairly good land, but it needs more intensive treatment than class II land. The slope may be between 5 and 14 percent for sloping soils, or the soil may have clayey textures that make it difficult to work or difficult to drain. These wetter soils may be on 0 to 1 percent slopes. Droughtiness caused by shallow or sandy soils may also make soils class III. Normal crops of the area can be grown on class III land, but to control erosion, they usually must be rotated with more soil conserving crops or have intensive practices installed such as terraces. Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices, or both. Class III land is colored red on land capability maps.

CLASS IV can be used occasionally for cropland under careful management but is better adapted for hay or pasture most of the time. The slope may be between 14 and 18 percent, or some other soil property may be equally limiting. Some land is class IV because it has already been severely eroded by previous misuse. Soils in class IV have very severe limitations that restrict the choice of plants, require very careful management, or both. Class IV land is colored blue on land capability maps.

CLASS V land is not suitable for cropland but is not likely to be damaged by pasture or woodland use. Soils in class V have little or no surface erosion hazard. Class V land is nearly level, but its use is limited by some permanent obstruction such as rock outcrops or remnant of a meandering stream channel or very poor drainage that cannot be remedied practically. The soil is suitable for growing grass or trees, and the land is well adapted for grazing or woodland use. Good management for these uses will adequately protect these soils. Class V land is colored dark green or left white on land-use capability maps.

CLASS VI land needs some special management even when used for pasture woodland. Overgrazing or careless logging might cause excessive erosion. Some class VI land is so shallow that even a small amount of erosion is very detrimental to soil productivity. Some is very stony, some is very wet, and some is very droughty. Lack of moisture is the most common reason for land being designated as class VI in arid and semi-arid regions. Some class VI land could be tilled, but it would still be unsuitable for cropland because of some factor such as slopes over 18 percent. Soils in class VI have severe limitations that make them unsuited to cultivation. Class VI land is colored orange on land capability maps.

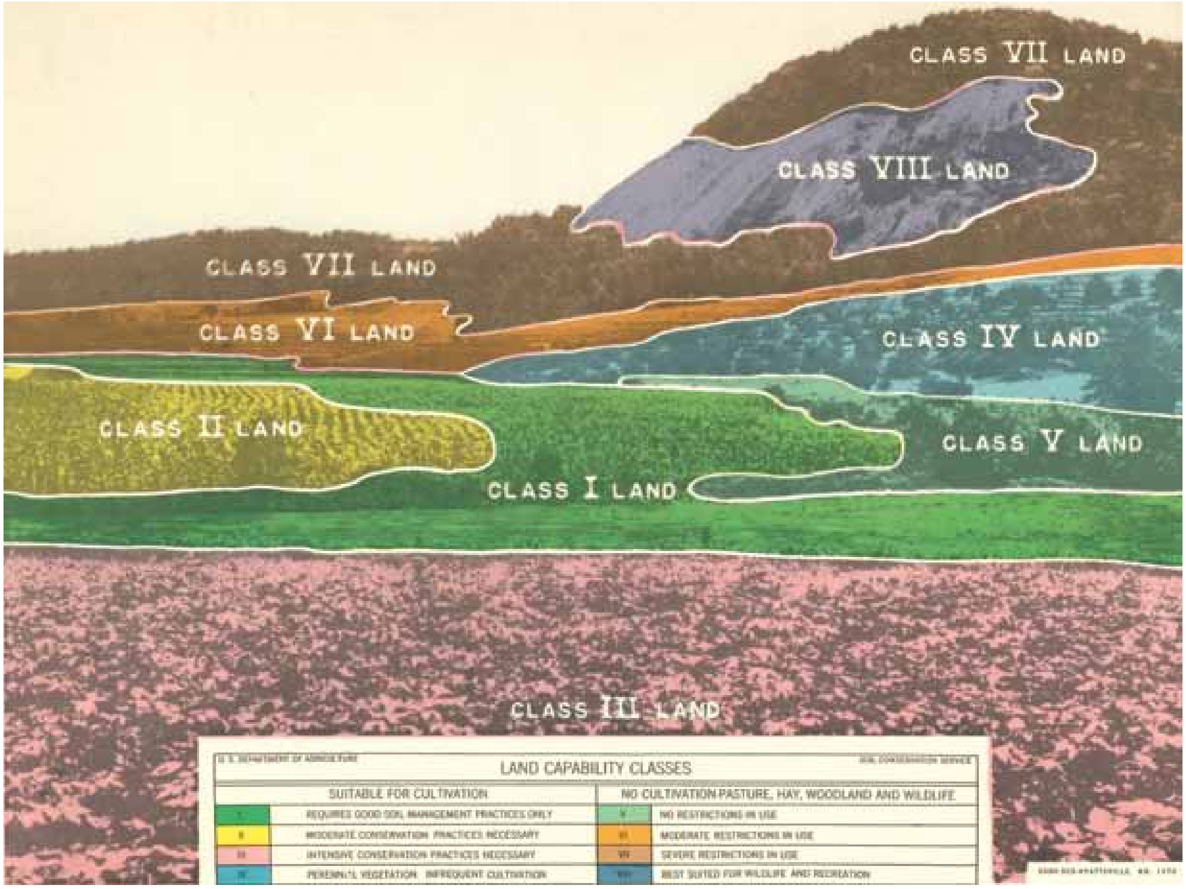

Figure 10. An illustration showing land belonging in each of the eight Land Capability Classes (adapted from Natural Conservation Resources Service USDA).

Class VII land has severe limitations for pasture or woodland use. The hazard may be from a slope gradient of 30 to 60 percent or some other equally serious limitation. Much class VII land is shallow and stony, but the stoniness may not be very important because there are other more severe problems. The land may be useful for grazing or forestry, but great care is required to avoid damage to the soil. Use of class VII land is restricted largely to minimal grazing, woodland, wildlife, or recreation. Class VII land is colored brown on land capability maps.

CLASS VIII land is unsuitable for agriculture but it may have value for recreational, wildlife, or watershed protection. Non-vegetated land such as bare rock outcrops, sand dunes, or river sandbars are included. Also, much land with sparse vegetation that should not be disturbed is in class VIII because it is extremely steep, rough, swampy, or arid. Class VIII land is colored purple on land-use capability maps.

Land Capability Subclasses

Classes II through VIII are assigned subclasses on the basis of the type of hazard or limitation restricting their use. Four subclass symbols are used to designate the problem as erosion, wetness, soil, or climate. Some soils may have two or three types of limitations but only the most severe one is used as a subclass. The subclass coming first in the list is given preference if two or more of these limitations would restrict the soil to the same capability class. The four subclasses are defined as follows:

e. Erosion hazard or limitation related to either water or wind erosion.

w. Wetness problem from either surface or subsurface drainage problems.

s. Soil limitations related to unfavorable physical or chemical characteristics such as shallow depth, sandy or clayey textures, stoniness, acidity, or alkalinity.

c. Climatic limitations such as being too cold or too dry (not used in Iowa but occurs in other places).

In soil judging, the student will classify the soil into one of the eight land capability classes on the basis of its suitability and limitations for various uses. Also, the student will assign a subclass symbol, e, w, s, or c to any soil that is not in Class I.

Soil Productivity Potential

Soil productivity indexes or soil ratings have become widely used in several midwest states. Productivity indexes reflect the physical and chemical properties of the soil in terms of soil productivity for commonly grown crops such as corn and soybeans. In Iowa, the productivity index is called Corn Suitability Rating (CSR).

The Corn Suitability Ratings reflect the integrated effects of numerous factors that influence the yield potential and use of the soil for row-crop production. Soil properties, topography, and weather conditions are the dominant factors that affect yield potential. Topographic characteristics are major factors that determine the intensity of land use for row-crop production. Slope gradient and length affect erosion rates, water infiltration, and ease and efficiency of machine operation.

Other factors that affect the productivity of a tract of land are the size and shape of the individual soil map units and the combination of these units within a given tract.

Corn Suitability Ratings are designed for rating the inherent productivity potential of each soil map unit identified in the soil survey. A soil map unit identifies the soil name to include the texture of the surface horizon and the slope and erosion class. An example of a soil map unit is: Tama silty clay loam, 5 to 9 percent slopes, moderately eroded.

An index system for rating soil productivity has several advantages over estimated yields because the index system:

a. Accounts for the estimated yield as well as the intensity and frequency that a given soil map unit may be used for row crop production.

b. Provides a system for ranking a soil map unit against other soil map units within the confines of the state for which the index system was designed.

c. Provides for the index of a given soil map unit to be relatively constant over time. New technology may make estimated yields obsolete, but the index value of a given soil map unit and its relationship to other soil map units should remain constant.

d. Provides for a method to evaluate the productivity of a tract of land and compare the tract of land against other tracts of land. The productivity of a tract of land can be calculated by determining the acreage of each soil map unit and multiplying the acreage by the productivity index of the soil map unit. The sum of the products for all soil map units in the tract divided by the total acreage results in an average productivity index for the tract.

Corn Suitability Ratings assume an adequate level of management. The Corn Suitability Rating scale ranges from 100 (the best) to 5 (the poorest). An index of 100 is reserved for soils that:

a. are located in areas of most favorable weather conditions for Iowa;

b. have high yield potential;

c. can be continuously row cropped without degradation due to erosion; and

d. have adequate surface, subsurface drainage, or have drainage installed that allows for timely field operations to occur throughout the growing season.

In Iowa the assignment of Corn Suitability Ratings for soil map units specifies the following conditions:

a. natural weather conditions (not irrigated);

b. surface or subsurface drainage installed where needed,

c. soils on lower landscape positions not subject to frequent damaging floods; and

d. no land leveling or terracing.

In the soil judging contest, the soil will be rated for its productivity potential in terms of how intensively the land can be row cropped without causing excessive erosion or other soil degradation. Basic physical properties such as slope, texture, distribution of texture in the soil profile, topsoil thickness, soil depth, internal drainage, and parent material will be considered in this classification.

The soil will be rated in one of four classes based on its potential for intensive row cropping. Adequate management includes tillage management, crop sequences, and drainage practices if needed for intensive row cropping. These practices include crop residues on the ground surface following planting of the current crops, contouring, strip cropping, sod based crops used in rotation with corn and soybeans, and surface and/or subsurface drainage that allows for conducting timely field operations.

Terraces and other structural practices on upland soils are considered as part of a high level of management and are not included in consideration of adequate management. Structures to prevent flooding and overflow for soils on floodplains or terraces are considered as part of average management. The four classes indicating the potential of land for the continuous growing of row crops are:

HIGH. Soils can be used for growing continuous row crops such as corn and soybeans. Soil degradation is not expected to occur due to erosion with use of adequate management practices. Adequate surface and/or subsurface drainage has been installed, if needed, to allow for timely field operations to occur throughout the growing season. Most soils with 0 to 5 percent slopes may be included in this class except those soils with excessive or very poor internal drainage.

MEDIUM. Soils can be used for growing row crops at least half of the time but not continuously with use of adequate management practices. Small grains or sod based crops such as alfalfa or other legumes or legumes in combination with grasses are needed to maintain potential soil losses at or below the established levels of tolerance. In a 5-year rotation the growing of corn and soybeans 3 of the 5 years would be acceptable for soils in this class. Most soils with 5 to 9 percent slopes may be included in this class and nearly level soils in Land Capability Class IIIw. Included are those soils occurring on 0 to 5 percent slope that do not qualify for the High class.

LOW. Soils can be used for growing row crops less than half of the time with use of adequate management practices. Small grains or sod based crops such as alfalfa or other legumes or legumes in combinations with grasses are needed to maintain potential soil losses at or below the established levels of tolerance. In a 5-year rotation the growing of corn and soybeans 2 of the 5 years would be acceptable for soils in this class. Soils with 9 to 18 percent slopes may be included in this class.

UNSUITED. Soils are not suited for row crops. Soils should be limited to sod based crops, permanent pasture, or woodland in order to maintain soil losses at or below the established levels of tolerance. Soils in the class have physical properties that prevent the growing of corn or soybeans to be established as a viable crop. Soils on slopes greater than 18 percent may be included in this class.

Part IV. Evaluation of Land Use and Management Practices

Decisions regarding land use and management are based partly on the desires of the person using the land and partly on the nature of the soil. Most land is adaptable to several different uses, and its needs may be met in several ways. The landowner or operator should choose a suitable use and management combination that will maintain the long-term productivity of the land and minimize soil degradation.

This section deals with the needs of the land and the restrictions those needs impose on land use and management. It does not include management decisions that involve personal preference. Such decisions are left to the person using the land.

Practices to Overcome Soil Limitations

It need not be assumed that all land will be used as intensively as possible. Some land owners and operators will want to use some or all of their land at a lower intensity than its potential. On the other hand, some may want to use special practices to increase the potential of their land. Iowa's climate and much of its soil are well adapted for growing corn and soybeans and make these crops especially profitable. Many farmers therefore want to maximize their production of these crops. Use of erosion control practices and drainage practices often make it possible to overcome soil limitations and increase the frequency of row crops.

Practices listed in Part IV can be used to overcome soil limitations. In Iowa, soils classified as Land Capability Class VI, VII, and VIII are unsuited for cultivation. Contouring, strip cropping, terracing, and conservation tillage are not considered to be effective erosion control measures to limit soil erosion on soils in these capability classes. For purposes of the soil judging contest, the student should check "no" for questions 27, 28, 29, and 30 when the soil area is judged to be in Land Capability Class VI, VII, or VIII.

Certain good management practices such as planting high quality seed in narrow rows are not included here because they are applicable to all cropland. Using adequate fertility and good pest control practices are also assumed to apply to all cropland. The factors to be indicated here are those that would be especially beneficial to the soil being judged.

The contestant should indicate on the score card whether or not each of the following practices would be suited to the area and would significantly improve the potential of this particular land for growing row crops. Each practice should be considered on its individual merits and adaptation to the area. Some sites will have more practices marked "yes" on the score card than would actually be applied. For example, conservation tillage, terracing, and strip cropping are often good alternatives for the same land and should be marked on the score card even though they may not necessarily be required to be used together on a given soil or field. Practices selected are considered independent of land capability classes and productivity potentials that were addressed in part III, except for land capability classes VI, VII, and VIII as discussed in the previous paragraph or unless noted in the following description.

1. SURFACE DRAINAGE—practices that dispose of surface water to keep an area from being too wet for use, including diversions to keep water from running onto areas and ditches or land smoothing to help remove excess surface water from the area. These practices are often needed for land on level and nearly level landscapes with slopes less than 2 percent, but the practices also may be needed on steeper landscapes.

2. SUBSURFACE DRAINAGE—use of tile drains or other means to remove excess subsurface water either from level or nearly level land or from seep spots on slopes. Soils with low permeability usually need surface drainage either with or in place of subsurface drainage. Tile drainage may be needed on somewhat poorly drained soils as well as poorly and very poorly drained soils. Tile drainage is often needed to allow for timely field operations on soils that have relatively minor wetness problems; therefore, some areas of Class I soil may benefit from subsurface drainage.

3. GRASS WATERWAYS—permanent grass vegetation to prevent rills and gullying in places where water flows quickly enough to erode unprotected soil drainageways. This practice is effective in controlling erosion only from such channels or waterways.

4. CONTOURING—tillage and crop rows oriented across slopes to reduce the velocity of runoff. Contouring may reduce erosion as much as 50 percent where it is adapted, but it does not work well as a single practice where slopes are irregular or on steep topography. Contouring is recommended for slopes from 2 to 9 percent.

5. STRIP CROPPING—strips of an erosion reducing crop placed to catch the soil that erodes from a cropped area. Usually there are alternating strips of each crop in the rotation placed either across the slope as in contour strip cropping or across the prevailing wind as in wind strip cropping.

Another form, called border strip cropping, uses a single strip of meadow to keep silt out of a pond or other area to be protected. Strips are best adapted to areas where sod-based rotations can be used on slopes ranging from 2 to 14 percent excluding grass waterways. In addition, strips are an effective practice to reduce wind erosion on level and gentle slopes as well as areas adjacent and parallel to streams and rivers where a minimum width of 66 feet or more of nearly level slopes are present.

6. TERRACING—the practice of constructing ridges and channels across the slope to intercept runoff water and dispose of it safely or hold it until it infiltrates. Terraces reduce erosion by shortening the effective slope length, thereby preventing large volumes of water from flowing down the slope. Terraces need not follow the exact contour. They are best adapted where slopes are long and relatively uniform and are more effective on steep slopes for erosion control than strip cropping and contouring. Terraces may be constructed on slopes of 2 percent gradient and steeper up to 14 percent. The kind of terrace installed will depend on the slope gradient, kind of parent materials, and projected land use.

7. CONSERVATION TILLAGE—the practice of leaving plant residues on the ground surface or leaving ridges and surface roughness to reduce the loss of soil and water as contrasted to tillage systems that bury all residue and leave a smooth surface. Conservation tillage is considered the single most effective and least costly system to reduce soil erosion on level and gently sloping lands. On steeper landscapes, conservation tillage can enhance the effectiveness of other erosion control practices.

Part V. Suitability of Soils for Nonagricultural Uses

People use soils for many different purposes and find that each purpose has its own special requirements. The ability of soil to support weight is important when a structure is built on it. The permeability is important where a septic tank absorption field is needed. Resistance to compaction is needed where vegetation must grow in spite of people walking across an area. These examples are only a sampling of factors that influence the suitability of land for various uses.

Table 3. Shrink-swell ratings and values for Percent Volume Change*.

RATINGS USED IN SOIL SURVEY REPORTS	TEXTURAL GROUPS (CLASSES) FOR IOWA SOILS	PERCENT VOLUME CHANGE
Very low	Coarse, mod. coarse	0-3
Low	Mod. coarse, medium (loams)	3-9
Moderate	Medium (silt loams, silts), mod. fine	9-19
High	Mod. fine, fine	19-33
Very high	Fine	> 33

** George R. Hallberg. The Use of COLE values for sell engineering evaluation. Soil Sci. Sec. Amer J. 41 775-77T 1977.*

Table 4. Soil properties for evaluating building sites for houses with basements.

SOIL PROPERTY	NO LIMITATION	LIMITATION
Bedrock	Hard – ≥ 60 inches Soft – ≥ 36 inches	< 60 inches < 36 inches
Evidence of water table	≥ 40 inches	< 40 inches
Flooding	None	Possible
Shrink-swell	< 9 percent volume Change on wetting and drying	≥ 9 percent volume Change on wetting and drying

Table 5. Soil properties for evaluating conventional septic tank absorption fields.

SOIL PROPERTY	NO LIMITATION	LIMITATION
Bedrock	≥ 72 inches	< 72 inches
Flooding	None	Possible
Evidence of water table	≥ 40 inches	< 40 inches

Table 6. Soil properties for evaluating use of material as a source of topsoil.

SOIL PROPERTY	NO LIMITATION	LIMITATION
Texture group (0 to 40 inches)	Medium	Coarse, moderately coarse, moderately fine, fine, muck peats
Thickness of A horizon	≥ 14 inches	< 14 inches
Evidence of water table	≥ 12 inches	< 12 inches

Economic, social, and political considerations enter into land-use planning, but the type of soil present should be a major factor. Usually, there are several potential uses for each area of land and several alternatives for locating each type of land use, but these alternatives are not all equal. Careful planning to locate each land use in a suitable place can eliminate problems and significantly reduce costs. Furthermore, the benefits derived from land may be considerably enhanced where uses are chosen to be compatible with soil.

Matching land use with the soil requires an evaluation of various soil properties because these properties relate to particular uses. The degree of limitation or potential for each use should be evaluated in terms of specific soil properties. It should be recognized that some areas must be used for certain purposes in spite of soil limitations for those purposes. There may not be soil properties in the area that would have limitations for an intended use, or there may be higher priority uses for the better land. Even so, the limitations must be recognized so that appropriate allowances can be made for them. The evaluation in the soil judging contest is made independently of whether any better land is available or not.

Contestants will rate each soil property in terms of whether the property will be a limiting factor for the uses described. The extent or severity of the limitation will not be judged, only whether the soil or landscape property has the potential to be a limiting factor in terms of the intended use. Some soil properties will be more limiting and will require greater design technique and engineering to overcome than will other soil properties.

Mark the appropriate yes or no answer on the score card for each use even if the site is not likely to be used for some of the specified purposes.

Limitations for Building Sites for Houses with Basements

A building site needs to have soil that will support the weight of the structure without undue settling. The soil should be deep enough to permit excavation for a basement without major rock blasting and removal as well as permitting the reshaping of the area for landscaping. The soil should be deep enough to grow grass, trees, and garden plants.

Shrink-swell of the soil relates to the percent of volume change during wetting and drying. Table 3 shows shrink-swell ratings and values for percent volume changes. Soils whose volume changes by more than 9 percent will affect the stability of basement walls, the foundation, patio, sidewalks, and concrete floors anchored to the ground.

Both external and internal soil drainage are important factors. A tendency toward shallow ponding is considered a limitation and occasional flooding is a major limitation. Internal drainage influences the weight the soil can support, the likelihood of wet basements, and the suitability of the soil for growing trees and shrubs. Evidence of water in the soil profile will be determined by identifying the presence of redox features within the upper 40 inches of the soil profile.

The properties listed in table 4 determine whether limitations occur for houses with basements. The properties listed are not inclusive for arriving at an overall evaluation as to the suitability of a building site for houses with basements.

Limitations for Conventional Septic Tank Absorption Fields

Homes with septic tanks require suitable soil absorption fields to treat the effluent. An absorption field is an area in which effluent from the septic tank is distributed into the soil through tiles or perforated pipes that are installed below the ground surface. The purpose of a septic tank absorption field is to treat the organic constituents in the effluent before the effluent is diffused with the water table that occurs below or adjacent to the absorption field.

A conventional septic tank absorption field has the laterals placed at a depth of 24 to 30 inches below the ground surface. The conventional system is designed in accordance with criteria described by the Environmental Protection Division, Iowa Department of Natural Resources. These criteria require the total lineal footage of laterals to be calculated based on the soil percolation rate and number of bedrooms in the home.

Adequate treatment of effluent in the absorption field is difficult to achieve if the soil is shallow to bedrock, has a seasonal high water table, is subject to periodic flooding, or is slowly permeable. Soils best suited for treatment are those that occur on upland landscapes, that are more than 72 inches deep, are well drained, and have good water and air relationships in both the topsoil and subsoil.

An estimate of the rate and direction of water movement in the soil profile can be made based on soil texture and structure. Medium and some moderately fine as well as some moderately coarse textured soils with well-developed open structure are most favorable for absorption fields.

Soils with fine texture and well developed dense structure have slow rates of water movement that result in surface ponding and high water tables. Adequate treatment of the effluent will not occur in these soils. Coarse and some moderately coarse textured soils also will not provide for adequate treatment of effluent because the liquid will move through the soil at a fast rate. Sufficient filtering of organic constituents and chemical exchange will not occur due to low organic matter and clay content in coarse and some moderately coarse textured soils.

Soil properties listed in table 5 will be used in the contest to determine whether limitations occur for conventional septic tank absorption fields. Evidence of water in the soil profile will be determined by identifying the presence of prominent redox features within the upper 40 inches of the soil profile. A few faint casts or tints composing less than 5 percent of the soil matrix are acceptable. The properties listed are not inclusive for making an overall evaluation as to suitability for conventional septic tank absorption fields.

Source of Topsoil

Construction activities require the movement and placement of soil materials. Topsoil is used to cover either a disturbed or undisturbed area so that vegetation can be established and maintained on the site. In the soil judging contest, the upper 40 inches of the soil profile will be evaluated for use as topsoil. The surface layer or the A horizon of most soils is preferred for topsoil because of the organic matter content. This layer must be sufficiently thick for cost-effective removal and use as a topsoil material. Organic matter increases the absorption and retention of moisture and nutrients for plant growth, enhances structural development and stability of soil aggregates, and provides a more favorable soil tilth quality than occurs in soils low or very low in organic matter content.

Soils suited for a source of topsoil generally have more than 40 inches of total soil profile depth, have textures in the medium textural group, have dark or black A horizons greater than 14 inches thick, and are somewhat poorly or better drained in their natural internal drainage class. These soils are free of stone and cobbles and have little or no gravel.

Soil properties listed in table 6 will be used in the contest to determine whether the material is suitable for use as a source of topsoil. Presence of redox features at or below 12 inches of the surface will be used to determine evidence of a water table. Rust colored redox features are usually visible if a seasonal high water occurs within the upper 12 inches of the black A horizon. These redox features may be few in quantity. Poorly and very poorly drained soils have limitations for this use. The properties listed are not inclusive for making an overall evaluation as to the suitability for a source of topsoil material.

Grading the Score Card

Contest judges will examine each field site and soil profile before the contest begins. The judges will evaluate each site and mark the score cards in the same manner as the contestants. These official score cards will be used for validating the scoring of the contestants.

The score card is divided into five major parts and contains 40 questions. Each question has one best answer of the alternatives listed. The score card is designed so that each question has equal weight. However, the contest judges can decide before the contest whether any of the other answers are so nearly right that part credit can be allowed. In addition, the contest judges can decide before the contest if all questions will be considered for the contest.

Contestants should mark only one answer per question. A wrong answer (more than one answer marked per question) will result in zero credit even if the correct answer is marked for the question.

The official scorers will tabulate each contestant's points for each part of the score card and determine the total number of points earned as shown on the score card. Most contests will require contestants to judge four soil pits and complete a written test, so a contestant's soil judging score will be a sum of the soil pit points and the written test points.

Team and individual ties in the total score shall be broken by giving preference to the team and contestant with the higher score at site number 1. If there is also a tie at site number 1, then site 2 may be used, and so forth. If any ties are still unbroken, the sites shall be given priority in order of sites 1 through 4, with preference given successively to question 1, 2, 3 and so forth to question number 40.

In all cases such requirements and other projected decisions should be reviewed by the official judges prior to the soil judging contest.

The score card is designed to be used in conjunction with mechanical tabulating and scanning machines for facilitating time and personnel needed.

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At: https://store.extension.iastate.edu/ProductList.aspx?CategoryID=94 and
http://soils.usda.gov/survey/printed_surveys/state.asp?state=Iowa&abbr=IA and
http://websoilsurvey.nrcs.usda.gov/app/

Appendix A.

A Comparison of Soil Horizon Nomenclature

Procedures for identifying and assigning soil horizon designations were changed by the National Cooperative Soil Survey in 1981. In Iowa, all county soil survey reports published since April 1983 contain soil profile descriptions utilizing the revised horizon nomenclature.

The following principles are used in both the old and new system of designations for soil profile horizons.

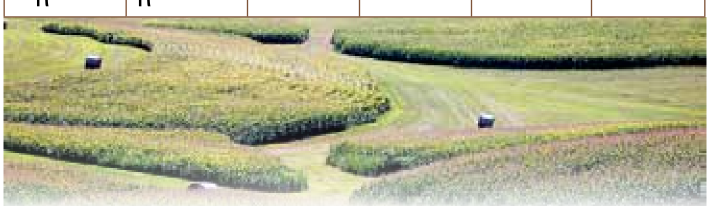
a. Capital letters are used to designate master horizons.
b. Lowercase letters are used as suffixes to indicate specific characteristics of the master horizon.
c. Arabic numerals are used as suffixes to indicate subdivisions within a horizon.

In the new system, Arabic numerals also are used as prefixes to identify major changes in soil materials within the profile. This is a change. In the old system, Roman numerals are used as prefixes to separate major changes of soil materials within the profile.

The following is a comparison of the old and new system for naming and identifying soil profile horizons and subhorizons.

Master Horizons and Layers

		THICK HORIZONS		MORE THAN ONE PARENT MATERIAL	
OLD	NEW	OLD	NEW	OLD	NEW
O	O				
O1	Oi, Oe	A11	A1	A1	A
O2	Oa, Oe	A12	A2	A3	AB
A	A	A31	A3	B2	B
A1	A	B21g	Bg1	IIB3	2BC
A2	E	B22g	Bg2	IIc	2C
A3	AB or EB	B21t	Bt1		
AB		B22t	Bt2		
A & B	E/B	B21	Bw1		
AC	AC	B22	Bw2		
B	B	C1	C1		
B1	BA or BE	C2	C2		
B & A	B/E				
B2	B or Bw				
B3	BC or CB				
C	C				
R	R				



Subordinate distinctions with master horizons that are used in Iowa soil survey reports. (Used as suffixes.)

OLD	NEW	
–	a	highly decomposed organic matter
b	b	buried soil horizon
–	e	intermediately decomposed organic matter
–	d	dense unconsolidated sediments
9	9	strong gleying
–	i	slightly decomposed organic matter
ca	k	accumulation of carbonates
p	p	plowing, tillage, or other disturbance
r	r	weathered or soft bedrock
t	t	accumulation of clay
–	w	color or structural B
cs	y	accumulation of gypsum
sa	z	accumulation of salts

Appendix B.

Suggested procedures for conducting soil judging contests in Iowa

1. Dig four soil pits to a minimum depth of 60 inches where possible. Slope one end of the pit for entry and exiting, and prepare a vertical face at the other end of the pit. A minimum of 60 inches in width is recommended for the soil pit.

2. Locate and mark the area of the soil pit that will be used for judging the soil profile. Mark this area by driving stakes in the ground surface outside the soil pit. Tie string or engineer tape to each stake and the adjacent stake, thus delineating the area to be judged.

3. Clean the vertical face of the soil pit in the area of the soil profile that is to be judged. A small shovel, trowel, or large pocket knife will work satisfactorily for cleaning the vertical face of the soil pit.

4. Place the soil to be judged for each horizon in buckets or small tubs and locate these containers outside the soil pit.

5. Place four or more wood lathe or stakes in the ground for the purpose of marking the landscape area to be judged for Parts III and IV on the score cards. Connect these stakes with string or engineer tape. This area can be a rectangle, square, triangle, trapezoid, or other shape that adequately delineates the land surface to be judged.

6. Soil judges must use and follow the guidelines described in the soil judging pamphlet for the official judging of each site. Personal experience, bias, and agency policies cannot be substituted for guidelines outlined in this pamphlet.

7. The judge(s) for Parts I, II, and V must meet the qualifications required for a soil scientist. Judge(s) for Parts III and IV must meet the qualifications required for a soil conservationist.

Iowa Soil Judging Score Card

See Soil Judging in Iowa, PM 1106, for interpretation of this form. Mark only one box per question.

Soil Site No. ____________ Contestant Name ____________

Contestant No. ____________ School Name ____________

Part I. Surface Features (2 points)

1. Landscape Position	Upland	a	
	Intermittent drainageways	b	
	Footslope	c	
	Terrace	d	
	Bottomland	e	
2. Slope	Nearly level, 0-2%	a	
	Gently sloping, 2-5%	b	
	Moderately sloping, 5-9%	c	
	Strongly sloping, 9-14%	d	
	Steep, greater than 14%	e	

Part I Total ☐

Part II. Soil Features—The Profile (17 points)

3. Moist Color of A1 or Ap	Dark	a	
	Moderately dark	b	
	Light	c	
	Very light	d	
4. E Horizon Present	Yes	a	
	No	b	
5. Thickness of A Horizon or A+E Horizons	Thick, more than 12"	a	
	Moderately thick, 7-12"	b	
	Moderately thin, 3-7"	c	
	Thin, less than 3"	d	
6. Texture of A Horizon	Coarse	a	
	Moderately coarse	b	
	Medium	c	
	Moderately fine	d	
	Fine	e	
7. B Horizon Present	Yes	a	
	No	b	
8. Moist Color of B Horizon (or C Horizon if B is absent)	Uniform brown or dark brown or strong brown	a	
	Uniform brown or dark brown or strong brown. Includes olive or yellowish or reddish cast or tints or other redox features	b	
	Grayish brown or olive gray, no redox features	c	
	Grayish brown or olive gray with gray or rust redox features	d	
	None of the above	e	
9. Moist color of B Horizon (or C Horizon if B is absent)	Gray with redox features	a	
	Uniform gray. May have bluish or greenish cast or rust redox features around roots or small pores	b	
	Black. May contain few rust redox	c	
	None of the above	d	

Part II. (continued)

10. Texture of B Horizon (or C Horizon if B is absent or buried A if 24" overwash)	Coarse	a	
	Moderately coarse	b	
	Medium	c	
	Moderately fine	d	
	Fine	e	
11. Soil Depth	Deep, more than 40"	a	
	Moderately deep, 30-40"	b	
	Moderately shallow, 20-30"	c	
	Shallow, less than 20"	d	
12. Soil Parent Material	Glacial drift or local sediments from glacial drift	a	
	Loess	b	
	Alluvium or colluvium	c	
	Residuum	d	
	Peat or organic	e	
13. Native Vegetation	Forest	a	
	Transition	b	
	Prairie	c	
	Marsh	d	
14. Surface Drainage	Rapid	a	
	Medium	b	
	Slow	c	
	Ponded	d	
15. Internal Drainage	Excessively drained	a	
	Well drained	b	
	Somewhat poorly drained	c	
	Poorly drained	d	
	Very poorly drained	e	
16. Erosion Class	Overwash	a	
	Uneroded or slightly eroded	b	
	Moderately eroded	c	
	Severely eroded	d	
	Gullied land	e	
17. Calcareous Surface Soil	Yes	a	
	No	b	
18. Calcareous B Horizon (or C Horizon if B is absent)	Yes	a	
	No	b	
19. Stoniness or Rockiness	Yes	a	
	No	b	

Part II Total ☐

Part III. Land Capability Classification and Productivity Potential (4 points)

20. Land Capability Class	I. Few limitations	a	
	II. Some limitations	b	
	III. Severe limitations	c	
	IV. Very severe limitations	d	
	None of the above	e	
21. Land Capability Class	V. Noncropland	a	
	VI. Unsuited for cultivation	b	
	VII. Restricted for agric.	c	
	VIII. Nonagricultural	d	
	None of the above	e	
22. Land Capability Subclass	None	a	
	e erosion	b	
	w wetness	c	
	s soil	d	
	c climate	e	
23. Productivity Potential	High	a	
	Medium	b	
	Low	c	
	Unsuited	d	

Part III Total ☐

Part IV. Evaluation of Management Practices (7 points)

Practices to overcome soil limitations

24. Surface drainage	Yes	a	
	No	b	
25. Subsurface drainage	Yes	a	
	No	b	
26. Grass waterway	Yes	a	
	No	b	
27. Contouring	Yes	a	
	No	b	
28. Strip cropping	Yes	a	
	No	b	
29. Terracing	Yes	a	
	No	b	
30. Conservation tillage	Yes	a	
	No	b	

Part IV Total ☐

Part V. Suitability of Soils for Nonagricultural Uses (10 points)

Limitations for building sites for houses with basements

31. Bedrock	Yes	a	
	No	b	
32. Evidence of water table	Yes	a	
	No	b	
33. Flooding	Yes	a	
	No	b	
34. Shrink-swell	Yes	a	
	No	b	

Limitations for conventional septic tank absorption fields

35. Bedrock	Yes	a	
	No	b	
36. Flooding	Yes	a	
	No	b	
37. Evidence of water table	Yes	a	
	No	b	

Source of topsoil

38. Texture group	Suitable	a	
	Not Suitable	b	
39. Thickness of A horizon	Suitable	a	
	Not Suitable	b	
40. Evidence of water table	Suitable	a	
	Not Suitable	b	

Part V Total ☐

Scoring Summary

Part I	
Part II	
Part III	
Part IV	
Part V	
Total Score	

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Extension and Outreach

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