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Evaluating Land Resource Potentials in Kentucky

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The most successful land use decisions are those where the intended use matches the capabilities of the land. Determining the capability of the land begins with a visual assessment of the landscape such as topography (percent slope) and surface drainage patterns followed by a closer examination of the soil physical and chemical characteristics. The purpose of this publication is to provide a basic understanding of the relationship between these landscape and soil properties to facilitate wise land use decisions. Topics such as soil testing to determine plant nutrient supply, plant species selection, and management are not covered in this publication. Some selected references are provided at the end of this publication or can be found by contacting your local extension office. Much of the information contained in this publication was adapted from University of Kentucky Extension publication 4BA-08MG, *4-H Land Judging in Kentucky*, as the topics are similar but focused toward a different audience and end use.

Soil Profile and Horizon Description

Soil is a mixture of weathered rock fragments (minerals) and organic materials that accumulate at the Earth's surface. Soil is both chemically and biologically active, stores water, and provides oxygen and nutrients to plant roots. Soil is also the medium used to support foundations for buildings and roads. So it is important to understand what soil properties are more ideal for supporting buildings and roads and those more ideal for growing plants.

Soils form and develop in layers. Each layer is called a horizon and a group of soil horizons is called a soil profile (Figure 1). Each horizon in a soil profile has unique properties that are related to their proximity to the surface or parent material (bedrock), land use, and environmental conditions.

Not all horizons will be present in all soil profiles. For example, the O Horizon can be found in undisturbed systems (forested or pastured soils), but not in tilled systems due to this horizon being mixed into the A Horizon when subjected to recent tillage operations. If the soil is tilled, the A Horizon becomes an Ap Horizon to indicate mixing of the organic and topsoil layers. The thickness of the A (or Ap) Horizon will vary depending upon the amount of soil erosion that has occurred and other management operations used. In some cases, the original topsoil or A Horizon may not be present and the soil at the surface may actually be the subsoil B Horizon. Learning how to recognize differences in soil color, texture, and structure is helpful when differentiating between soil horizons and potential land uses.

Figure 1. Soil profile and major soil horizons.

Horizon	Profile
O	**Organic layer:** Dominated by weathering organic materials.
A	**Topsoil:** The upper part of the soil, influenced by growing vegetation and use. Darker in color than the soil below, the most important horizon agronomically.
B	**Subsoil:** The soil immediately below the topsoil, lighter in color and contains a greater concentration of clay than the topsoil.
C	**Unconsolidated material** below the B horizon that has had little influence from biological activity.
R	**Bedrock:** Consolidated rock below the C horizon with no evidence of weathering.

Landscape Factors Influencing Land Use

The depth in which roots are able to grow and extract soil water and plant nutrients is an important feature if plant production is the intended land use. The depth of root zone can be influenced by highly compacted soil, bedrock, and even the depth to the water table. Another feature that can limit rooting depth in some Kentucky soils is called a "fragipan." Fragipans are natural soil formations that are dense, brittle soil layers found in the subsoil horizon that are cemented together and restrict root growth and water infiltration. Fragipans were formed thousands of years ago and can be found in different types of parent material. Fragipans in Kentucky are typically found in loess-derived soils.

The depth of the root zone (Figure 2) can be hard to determine in some instances. For example, plant roots can penetrate fractured bedrock or thin fragipans that may create enough of a barrier to make it difficult to force a probe or shovel through these layers. The depth to the water table will also change seasonally and is usually higher in the winter and spring than in the summer and fall. Further, some soils can be artificially drained to improve soil/water relationships and allow for improved use in some situations.

Depth to the root zone is grouped into three categories: deep, medium, and shallow.

Figure 2. Depth to the root zone.

Category	Depth to a limiting layer
Deep	Over 40 inches
Medium	Between 20 to 40 inches
Shallow	Less than 20 inches

Depending of the proposed use of the soil or landscape in question, this soil physical characteristic may or may not be a factor which limits land use.

Texture and Workability

Texture and workability (Figure 3) are important physical characteristics of the soil. Soil texture is a function of the sand, silt and clay composition of a soil. Soil workability is a qualitative term that's directly related to soil texture and organic matter content. Soils with poor workability in the surface horizon typically have more clay and less organic matter present, requires more energy for tillage, and results in slower water infiltration which subsequently reduces plant growth.

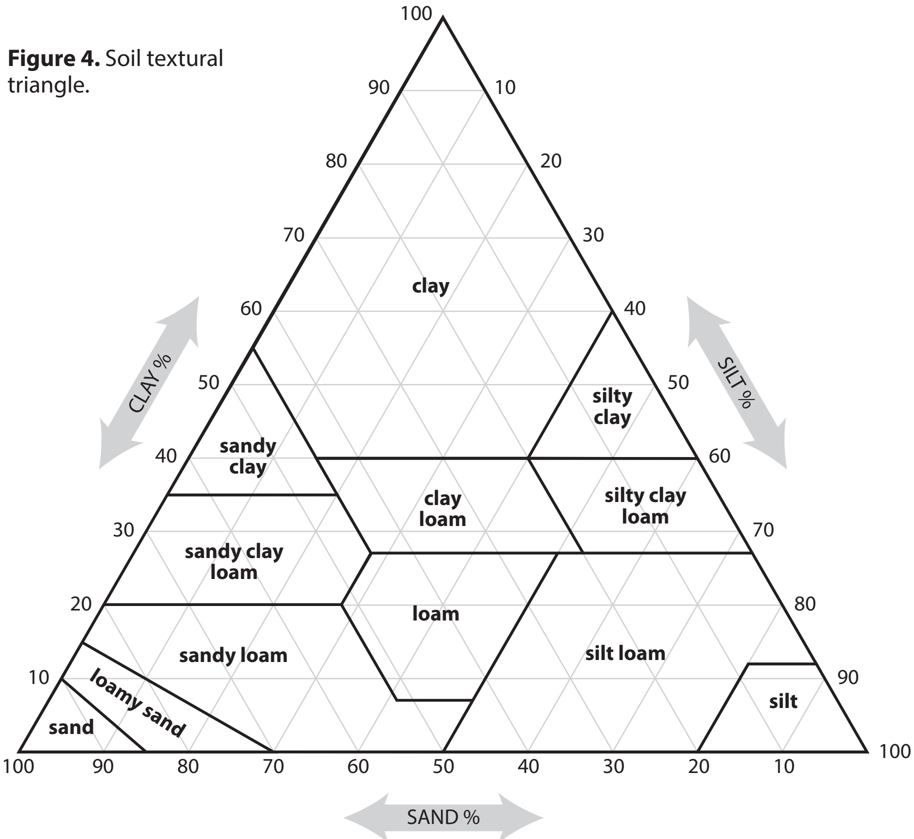
Sand is the largest soil particle that is taken into account when determining soil texture. Sand can be seen without magnification and is that portion of soil that makes it feel "gritty." Sand has limited ability to hold moisture and nutrients, but does contribute to faster water movement through soils because of the large pore space between individual sand particles.

Silt is smaller than sand, and magnification must be used to see the individual particles. Silty soils are highly erodible. Thousands of years ago, winds from the west blew in silt sized particles (loess) after the occurrence of glacial activity to the north and east that covered the Kentucky landscape. The deepest silt deposits are in the western part of the state and decrease as you move east. Much of the topsoil in Kentucky had a silt layer at one time, but years of cultivation coupled with subsequent erosion have reduced the amount of silt covering many of our Kentucky landscapes. Soils dominated by silts have the ability to retain water and to a lesser extent, hold nutrients, but provide easy workability.

Figure 3. Texture and workability.

Category	Description
Good	Soil crumbles readily with little surface crusting (e.g. silt loams, loams).
Medium	Soil is somewhat difficult to crumble and tends to form a surface crust and small clods (e.g. silty clay loams, clay loams, and sandy clay loams).
Poor	Soil is sticky when wet, can make a "ribbon" when forced between fingers indicating a high clay content, usually cloddy and hard when dry, and forms hard surface crust (e.g. clay, silty clay, and sandy clay).

Figure 4. Soil textural triangle.



Clay is the smallest of the three particle sizes of soil requiring the use of powerful microscopes to see individual particles. Because clay particles are so small, the pore space between particles is also small making it difficult for water to move between the clay particles. Therefore, soils dominated by clay have slower infiltration rates compared to more sandy textured soils. So is a sandy or silty soil better than a clayey soil? It all depends on the intended land use. For growing plants, a silty or sandy textured soil is probably better than a clay soil. But for building a pond that will hold water, a clayey soil would work best.

The amount of sand, silt, and clay present in the soil determines its textural classification (Figure 4). Ideally a soil used for crop production will have a good mixture of sand, silt, and clay. Generally the most productive soils in Kentucky are silt loams and loams. These soils have enough clay to retain nutrients, but not so much to restrict water infiltration. Further, they are able to provide the most available water for plant growth. Texture and workability can be grouped into three categories: good, medium, and poor.

Slope

Slope (Figure 5) is the landscape feature that has the greatest influence over many of the other important soil properties that are considered when making land use decisions. For agricultural uses, slope is commonly reported as a percentage (%) while in engineering settings, slope is commonly reported in degrees. Basically, slope is a measure of elevation change over a uniform 100 foot distance. For example, a 3-foot rise in elevation over a distance of 100 feet would be a 3% slope. A 45-degree slope is equivalent to a 100% slope.

Slope dictates the speed and direction of surface water movement. The steeper and longer the slope, the faster water moves across the soil surface, which increases the potential for soil erosion to occur. The faster water moves across the soil surface, the less likely it is to move into the soil (infiltration) and decreases the soils ability to supply water to plants. Slope should always be determined in the direction of natural surface water drainage. A clinometer or transit can be used to get an accurate measure of slope, but a good estimation of slope can easily be obtained by sight and a tape measure. Slope ranges and their letter designations (A to F) are defined below.

Figure 5. Slope ranges.

Designation		Rise (%)
A	Nearly level	0 to 2
B	Gently sloping	>2 to 6
C	Strongly sloping	>6 to 12
D	Moderately sloping	>12 to 20
E	Steep	>20 to 30
F	Very steep	>30 to 50

Erosion

Erosion is the detachment and transport of soil by water or wind. Most soil erosion in Kentucky is the result of soil movement by water, generally over sloping land without adequate surface cover. Disturbing the soil surface of sloping land by tillage or construction will increase the risk of soil erosion (Figure 6). Agronomically, topsoil is the most important soil horizon and a substantial amount can be lost during the erosion process. The loss of topsoil will take many years to replace through natural processes. Class I soils have 7 inches or more topsoil present. Some soils that formed on steeply sloping ground (i.e. classes VII and VIII) may have never formed this much topsoil. Topsoil is the profile horizon where the majority of the water and nutrients are held for plant use. The loss of topsoil significantly reduces soil productivity. The amount of topsoil present in the surface 7 inches is also a good indicator of past soil erosion.

Figure 6. Loss of topsoil.

Designation	Topsoil in top 7" of soil
None to slight	At least 75% (no more than 25% subsoil in the top 7 inches of soil
Moderate	25% to 74%
Severe	Less than 25%

The erosion **hazard** of a site is based on the steepness and length of the slope, type and intensity of tillage, depth of the root zone, land use (e.g. pasture versus row crop production), type and amount of surface cover, and the amount of erosion that previously occurred. In general, the greater the slope and the more shallow the soil depth, the greater the erosion potential. The erosion hazard of a site will have an impact on the land use and/or management practices that will be needed to protect and sustain the productivity of the land. The intended use of the soil will determine how much the erosion potential should be considered. For example, a house, with the proper engineering, can be constructed on a severe erosion hazard site that would not be recommended for continuous crop production.

Aeration and Drainage

Aeration and drainage are related to each other and if drainage improves so will aeration. **Aeration** is the exchange of air in the soil with air in the atmosphere. Good aeration is critical for good root and plant growth for most plants. Soil **drainage** influences how long water will stay on the soil surface and in the soil profile after a rainfall event occurs. The depth to a restricting layer will also influence soil drainage. In general, the more solid and the closer to the surface the restricting layer is located, the less drainage will occur. Soil color is a very useful indicator of how well the soil drains. When soils become saturated, the oxygen in the soil is used by plant roots and soil organisms. If soils become saturated frequently or for long periods of time, soil oxygen can become depleted and plant growth will suffer. Soils with good drainage will be brown or red and soils with poor drainage are gray in color. **Mottles** are spots or blotches of different colors that are interspersed with the dominant soil color and also indicate poor drainage and aeration (Figure 7). Other factors such as soil parent material will influence soil color and mottling to some extent, but when soil color is coupled with other factors (depth to restrictive layer, plant types present, landscape position, etc.) then good inferences can be made from soil color and mottling on drainage.

Drainage conditions fall into four categories:

Figure 7. Drainage conditions.

Category	Gray drainage mottling
Good	None above a 30-inch depth; subsoil color is usually dark brown, brown, or red, depending on the parent material
Moderate	Subsoil shows mottling between 20 and 30 inches, which might be indicative of a fragipan
Poor	Mottling or solid gray color develops between 10 and 20 inches
Very Poor	Within the upper 10 inches

A soil's **ability to supply moisture** for plant growth is affected by a combination of soil texture, root zone depth, and percent slope. A lack of soil moisture is typically the most limiting factor in crop production for Kentucky soils despite the fact that Kentucky receives around 50 inches of rainfall per year.

Silt loam and loam soils have the greatest ability to store plant available moisture. Sandy soils have large pore space between soil particles so water moves through them rapidly but are not able to retain much water for future plant use. Conversely, a clay soil is able to hold a substantial amount of water in their very small pore spaces. However, the water in clay is tightly held between the pore spaces and limits the ability of plants to easily extract this water.

The depth of the root zone influences the amount of water available to the plant by volume of soil that roots can explore. For example, if a silt loam soil can provide 2 inches of water for every foot of soil, then doubling the depth of topsoil should double the amount of plant available water.

Slope and slope length influences the speed at which rainfall moves across the soil surface. For soils under similar management systems, steeper land (or higher slope) will result in greater runoff. Greater runoff will result in less infiltration and less stored plant available moisture within the soil profile.

Land Capability Classes and Potential Uses

Landscapes are grouped into capability classes based first on slope and then other soil properties that may pose a land use risk or failure (Figure 8). The primary soil limitations that affect land capability classification are current and potential soil erosion, depth of root zone, aeration and drainage, and the ability to supply moisture to plants. Land capability classes were developed by U.S. Department of Agriculture-Natural Resource Conservations Services (USDA-NRCS) to determine the best use of land and recommended management practices to maintain the productivity of that land over a long period of time. Although originally developed for agricultural use, these capability classes also identify limitations important in making many other land use decisions. There are eight land capability classes, although only six are commonly recognized in Kentucky. Class I land has an "A" slope (0% to 2%), has no erosion hazard, is 40 or more inches deep, has good aeration and drainage, good texture and workability, and good water holding capacity. In contrast, Class VII land has an "F" slope (>30%-50%), severe erosion hazard, and poor water holding capacity. Other limitations such as poor aeration and drainage and shallow depth of root zone can lower the land capability class. The classifications are defined by the USDA technical handbook in the table that follows.

Figure 9 shows the common landscape positions where the different land capability classes can be found.

Figure 8. Capability classes.

Class	Description
I	Soils have no to slight limitations that restrict their use.
II	Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices to minimize soil erosion losses.
III	Soils have severe limitations that reduce the choice of plants or require very careful management, or both to minimize soil erosion losses.
IV	Soils have very severe limitation that restrict the choice of plants or require very careful management, or both to minimize soil erosion losses.
V	Soils have little or no hazard of erosion but have other limitations impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
VI	Soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to grazing, forestland, or wildlife food and cover.
VII	Soils have very severe limitations that make them un-suited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.
VIII	Soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, water supply or for aesthetic purposes.

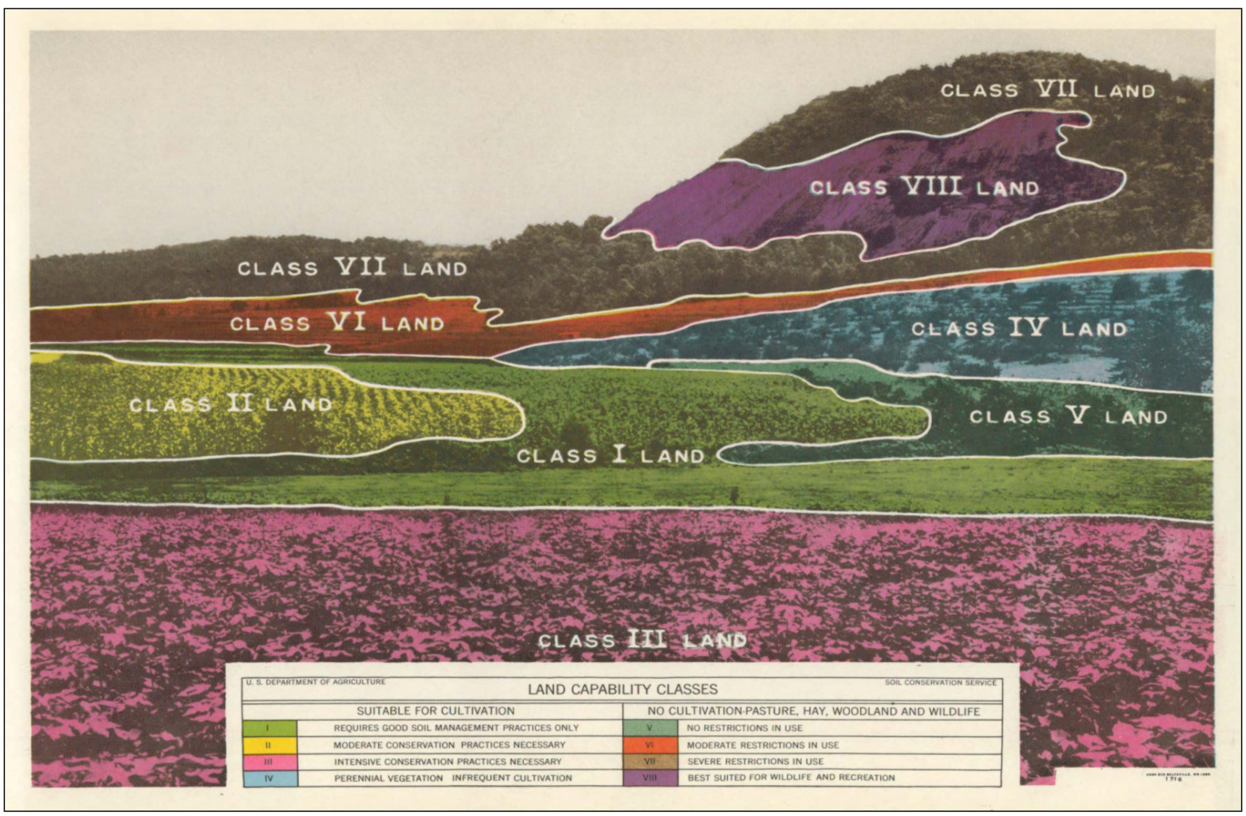


Figure 9. Land capability classes. Source: USDA-Soil Conservation Services

Tools and Resources for Determining Land Use Capabilities

General suitability for a potential land use can be evaluated without expensive tools or equipment. For example, a commercial hand soil probe or common shovel can be used to collect soil for determining soil texture, estimating rooting depth, and evaluating the internal drainage capability of the profile. With practice, slope ranges (i.e. 0% to 2%) can easily be estimated by eye. For, more accurate slope estimates a $100 clinometer works well. A tiling rod, or sharpened ⅜-inch rod with a T-handle can also be used to detect the depth to a root limiting layer.

Another valuable resource that should be used for a site evaluation is a county soil survey. Printed copies are still available in some areas, but this resource is also available online (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) and as an iPhone app. Information specific to each soil type such as physical, chemical, engineering properties, land use limitations, management concerns, and potential productivity can be found in this resource. Although the information contained in a soil survey is accurate for each soil type, an on-site investigation may be necessary depending upon the degree of accuracy required for the proposed land use. Not every acre in the state was examined and mapped, so inferences and assumptions were made on the surrounding areas based on landscape position, vegetation, and visual observations by the soil scientist doing the mapping. Video tutorials can be viewed online that will orient the user with the Web Soil Survey. Video links are provided in the additional resource section found at the end of this publication for two example scenarios.

County Extension agents and NRCS personnel are also valuable resources that can be utilized. These personnel often have inherent knowledge of the area and can provide valuable insight into the decision making process. Each county in Kentucky has an Extension office that is funded by taxpayers. NRCS offices are regionally based and are also able to assist in the decision making process.

Now that the basic concepts have been explained and common resources have been provided, how can they be utilized? The first question that should be addressed is "what is the intended use of the land?" Answering this question will help focus the decision in the correct direction. In Table 1 are some specific examples to guide the use of this publication.

Resources

Kentucky Local Health Departments (site inspection for septic systems): http://chfs.ky.gov/dph/LinkstoLocalHealthDepartments.htm

University of Kentucky Extension Publications

- 4-H Land Judging in Kentucky (4BA-08MG): http://www2.ca.uky.edu/agc/pubs/4ba/4ba08mg/4ba08mg.pdf
- Kentucky Master Gardener Manual: http://www2.ca.uky.edu/ANR/Master%20Gardener%20Publication.htm
- Lime and Nutrient Recommendations (AGR-1): http://www2.ca.uky.edu/agc/pubs/agr/agr1/agr1.pdf
- Taking Soil Test Samples (AGR-16): http://www2.ca.uky.edu/agc/pubs/agr/agr16/agr16.pdf
- University crop/plant production guides (search by name): http://www2.ca.uky.edu/agcomm/pubs.asp
- Web Soil Survey demonstration videos: http://video.ca.uky.edu/videos/video/756/in/channel/1/ http://video.ca.uky.edu/videos/video/757/in/channel/1/

Table 1. Features to evaluate and resources to utilize.*

Primary use	Slope	Erosion potential	Soil type/ texture	Depth of root zone	Aeration drainage	Soil survey manual
Field crop production	X	X	X	X	X	X
Garden production	X	X	X	X	X	
Building site (house)			X		X	X
Building site (yard)	X	X	X	X	X	X
Septic system	X		X	X	X	X
Pond	X		X		X	X
Trees/forest/pasture		X	X	X	X	
Recreational use	X	X				

*County Extension agents and NRCS personnel are good resources to consult.

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