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CREATING THE BLUEGRASS ENVIRONMENT

Kentucky's Physical Regions and the Inner Bluegrass

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Kentucky's physical geography is diverse. Within its boundaries one may find forested mountains of the Appalachian Plateau, rocky gorges and tumbling waterfalls, broad valleys framing several major rivers, and fertile plains that support an array of agricultural activities. Kentucky's weather is equally diverse. The summer heat may bring temperatures above 100°F, whereas winter lows often reach below zero. Thunderstorms result in torrential rain, hail, and tornadoes, and winter ice storms and deep snow are not uncommon. Yet the climate is generally mild, with fewer than 86 days out of the year having any form of precipitation, and for much of the year the skies are fairly clear. All of these characteristics have long worked in concert first to attract, and subsequently support, both people and commerce. Gilbert Imlay, an early traveler to the area, wrote in 1792, "Everything here assumes a dignity and splendor I have never seen in any other part of the world." Residents and visitors from that time forward have shared a similar sentiment.

North-central Kentucky serves as a perfect home base for exploring the state's many physical features; this guide will focus primarily on the Bluegrass Region, near the center of which is Lexington. We begin with an overview of Kentucky's geologic origins, fundamental to the existence of myriad surface and subsurface features. Next is a survey of the karst landscapes of the Inner Bluegrass, and we end with a glimpse of a few environmental issues that emerge from the area's unique physical geography.

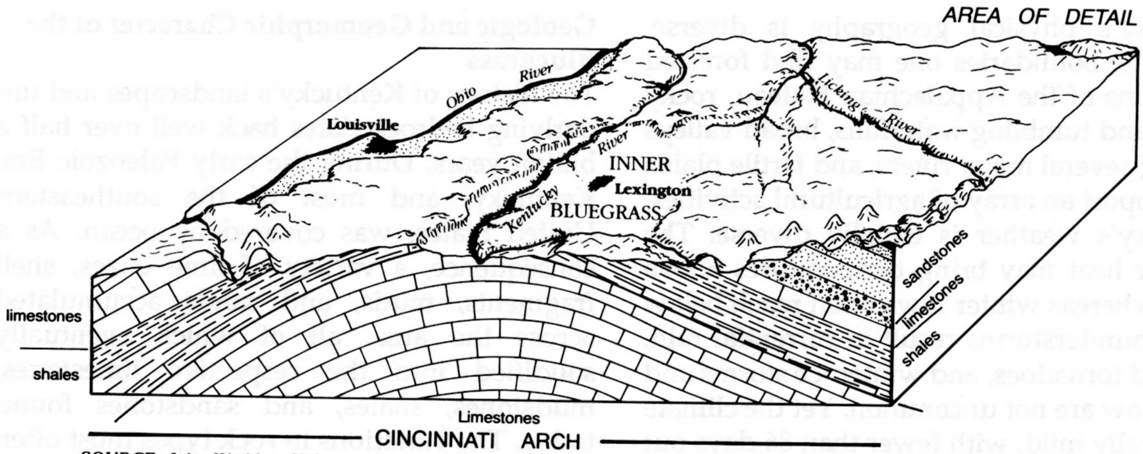
Geologic and Geomorphic Character of the Bluegrass

The history of Kentucky's landscapes and underlying bedrock dates back well over half a billion years. During the early Paleozoic Era, Kentucky, and most of the southeastern United States, was covered by ocean. As a consequence, a variety of lime oozes, shell fragments, muds, and sands accumulated across the area, all of which eventually solidified into the respective limestones, mudstones, shales, and sandstones found today. The variations in rock types most often reflect periodic changes in sea level, which influenced both the sediment particle size (such as silts, sands, and gravels) and the extent of chemical precipitates (such as the calcium carbonate of limestone) that were deposited. Within many of these rocks can be found a host of fossilized marine life, and the Falls of the Ohio (located at Louisville but accessible from Indiana) is well known because of its exposed coral reef limestones—and abundant fossils—dating back to the Devonian and Silurian periods (400 to 430 million years ago).

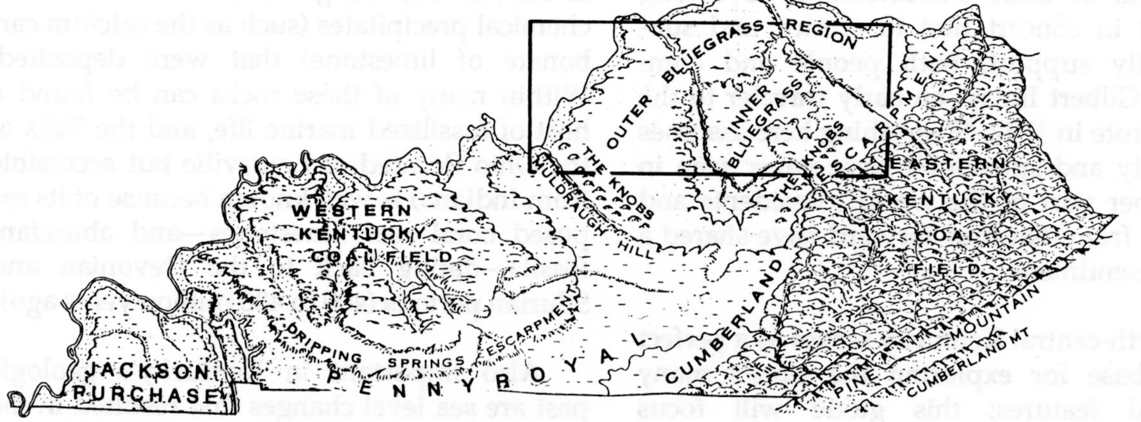
Also important in Kentucky's geologic past are sea level changes that resulted in the emergence of land surfaces. During such periods (primarily about 335 years ago during the Pennsylvanian Period), land-dwelling animals and plants thrived. Several wetland areas accumulated organic matter with the warm humid climates of the time, and later rises in sea level covered this material with fine sediments that effectively stopped decomposition. Today we see the geologic results of this sequential exposure and inundation in the coal fields of eastern and western Kentucky.

The Bluegrass Region comprises the north-central portion of the state, formed through the processes of broad warping and erosion. During the middle Paleozoic era (approximately 415 million years ago during the Silurian age) the pressures of crustal movement caused a major uplift extending from what is now Cincinnati southwest towards Nashville, Tennessee. This uplift, called the Cincinnati Arch, temporarily divided the major eastern and western geologic basins with respect to marine and terrestrial deposits. Warping continued for approximately another 15 million years, and because this arch was exposed to atmospheric forces, upland strata were the first to be broken down through the processes of weathering. Today, the uppermost sandstone layers have locally been eroded to reveal much older shales and limestones that characterize the region's bedrock, exposed along roadcuts and stream valleys (Fig. 2). Continued lowering of sea level and continental uplift eventually exposed the entire state, and the processes of weathering,

Figure 2: Physiographic Diagram of Kentucky and the Bluegrass Region



SOURCE: John Watkins, University of Kentucky, 1994



SOURCE: *The Geological Story of Kentucky*, by Preston McGrain, 1983 especially stream erosion, then became major players shaping the landscape statewide.

Three distinct areas comprise the Bluegrass Region: the Outer Bluegrass, the Inner Bluegrass, and the Eden Shale Hills. These areas become quite apparent when driving in virtually any direction away from Lexington, which stands in the approximate center of the Inner Bluegrass. The gently rolling landscape immediately surrounding Lexington is based on Middle Ordovician Limestones, which are among the oldest rocks found in the state. These limestones happen to have relatively high levels of phosphorus, and the soils that have developed in the area tend to be deep and quite fertile. Consequently, agriculture here has been very successful. So too has the horse industry, which relies on the supplemental nutrition provided by grasses grown in local soils.

Traveling west or south away from Lexington one soon encounters the Kentucky River, which crosses the Inner Bluegrass and has carved a deep meandering valley. The river can be seen in many places, including U.S. Highways 25, 27, 62, and 68, and Clays Ferry (accessible off Interstate 75 south of Lexington). The river has entrenched itself 300 to 400 feet below the level of the central Kentucky limestone plain and the resulting valley palisades are quite dramatic.

Beyond the river there is an evident increase in elevation that marks the Eden Shale Hills, which is a transition to the Outer Bluegrass area. The rocks of this area are, like those in the Inner Bluegrass, also Ordovician in age, but are somewhat younger and quite different in lithology. Comprised of thinly bedded shales and limestones, these rocks are less resistant to erosion. This means that the Eden Shale rocks have been eroded into hills and steep slopes, and soils are infertile yellowish clays. Although the shale area was cleared and farmed as recently as the 1930s, most slope land has reverted to woodland and the few remaining farms raise tobacco or pasture stock on narrow valley bottom fields. Farther west and south (or east) the shale gives way to younger Ordovician limestones and a gently rolling plain with fertile reddish soils. This is the Outer Bluegrass. Although farming in the Outer Bluegrass is not as profitable as it is in the Inner Bluegrass, significant amounts of tobacco, corn, grains, cattle, hogs, and dairy products are produced.

Moving west, south, or east, one can immediately identify the outermost boundary of the Bluegrass by the presence of the Knobs, an irregular belt of relatively isolated tree-covered conical hills. The knobs are remnants of the retreating Pottsville Escarpment on the east and south, and Muldraugh's Hill on the west. They are capped by highly resistant conglomerate or limestone that protects them from erosion. They can be viewed at Cave Run Lake (south of Interstate 64 near Morehead), just east of Berea, or south and west of Louisville. The southern Knobs are especially rich in geodes. Beyond the Knobs stand limestone and conglomerate-capped escarpments that mark the transition into the state's dissected plateau regions.

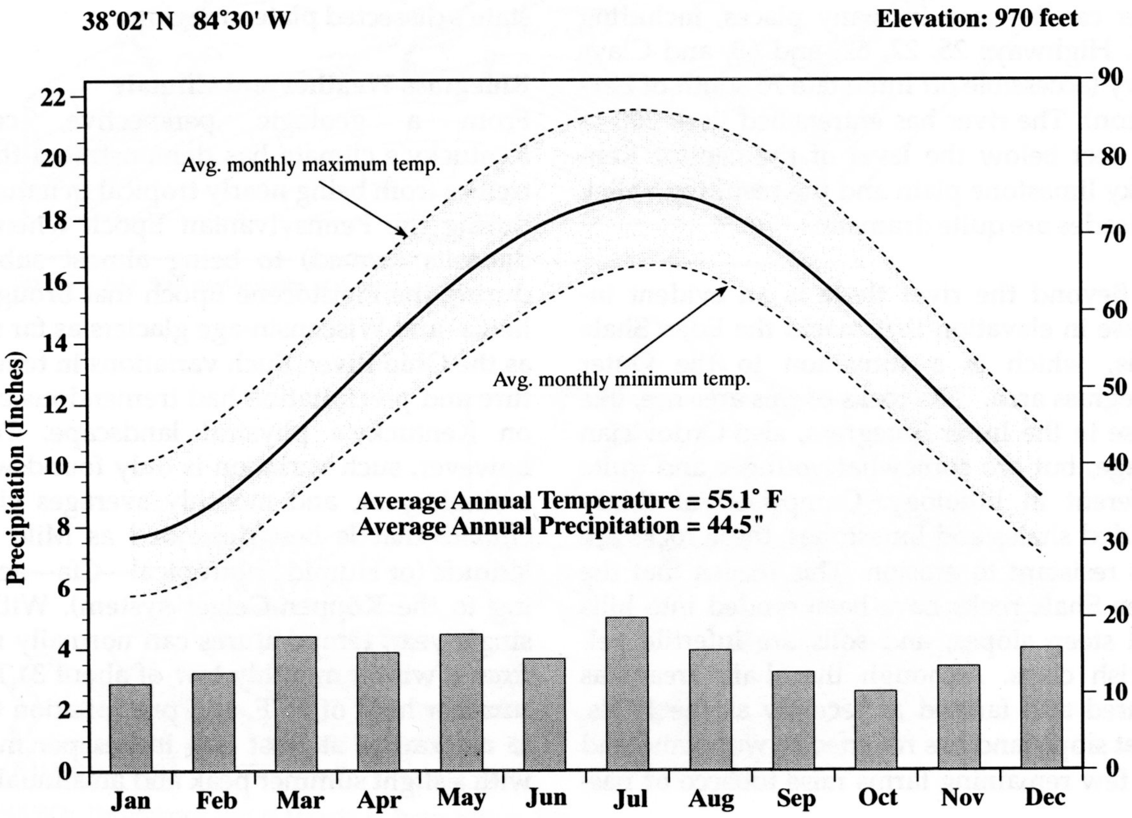
Bluegrass Weather and Climate

From a geologic perspective, central Kentucky's climate has demonstrated the extremes from being nearly tropical in nature (as during the Pennsylvanian Epoch when coal deposits formed) to being almost subpolar during the Pleistocene Epoch that brought Illinois- and Wisconsin-age glaciers as far south as the Ohio River. Such variations in temperature and precipitation had tremendous effects on Kentucky's physical landscape. Today, however, such variation is only found within a single year, and monthly averages yield a climate that is best described as Mild Midlatitude (or Humid Subtropical—Cfa—according to the Köppen-Geiger system). Within a single year, temperatures can normally range from a winter monthly low of about 31°F to a summer high of 76°F, and precipitation tends to amount to at least two inches per month, with a slight summer peak and an annual total of just over 44 inches (Fig. 3). Overall there is an annual moisture surplus in the Bluegrass, and only the exposed limestone bedrock prevents local soils from becoming acidic, a characteristic of most mid-latitude soils.

Like other mild mid-latitude climates, the Bluegrass experiences a diversity of weather. With a location of about 38° north of the equator, the Bluegrass is positioned in a virtual battleground of contrasting air masses. During the summer months warm, moist air masses move north from the Gulf of Mexico and dominate the region, whereas winter months experience the influence of cool, dry air masses from the north. An important fact is that each of these air masses usually tends to be moderated by the time they approach Kentucky and temperatures are commonly warm—not hot, or cool—not cold. As a consequence, the normal weather of the Bluegrass is quite comfortable. Yet winter or summer extremes occur and often produce frozen water pipes or high air conditioning bills.

An important feature of an eastern continental mid-latitude location such as the Bluegrass is that relatively small changes in the atmosphere can cause dramatic changes in local weather. Slightly stronger contrasts in air masses, for example, may result in severe storms along cyclonic fronts, and numerous ice storms and tornado outbreaks during the transition months between winter and summer attest to this influence. Indeed, close observation of Lexington trees will clearly show the effects of the early spring ice storms of 1994, during which nearly 15,000 Lexington households were left without power for three days. Slight changes in upper atmosphere jet stream location can also cause extremes in temperature; the record low temperature is -21°F (recorded in January of 1963) when an Arctic air mass reached the Bluegrass during

Figure 3: Climograph for Lexington, KY



SOURCE: NOAA, U.S. Dept. of Commerce

an unusual southerly track of the polar jet. Monthly highs broke records during June and July of 1988 when the polar jet was far to the north and a high pressure cell brought 100+ °F temperatures and drought conditions to the region.

Inner Bluegrass Karst Landscapes

Weather and climate characteristics across millennia have caused dramatic alteration of the Bluegrass landscape. Perhaps the most visible alterations, within the Inner Bluegrass at least, has been the development of a distinct karst topography. Surface features associated with karst landscapes are principally attributed to solution weathering of calcium-based rocks such as limestone. For these features to have developed, precipitation and groundwater must be slightly acidic in order to react with—and break down—limestone. This acidity is attained first as rainfall absorbs atmospheric carbon dioxide, and second as moisture absorbs carbon dioxide concentrated in the open spaces of soils. The absorption of this gas by water results in a weak carbonic acid, which readily decomposes limestone.

Approximately fifty percent of Kentucky has limestone or dolomite at, or very near, the surface, and virtually all of the Inner Bluegrass has this type of bedrock. Limestone is not permeable to water, yet tends to have both horizontal weaknesses (bedding planes) and vertical openings (fissures and faults) through which water passes. Over time these pathways become enlarged by chemical dissolution, which, in turn, allows increasing water flow. The limestone becomes a vast plumbing system of tubes and conduits that carries water under the influence of gravity to lower elevations.

Surface streams in karst regions, including the Bluegrass, are often limited in extent or even absent. The water that would normally be carried by surface streams instead flows underground, out of sight and often out of reach. Only major streams flow across the surface and many, like the Kentucky River, are fed more by underground sources than surface tributaries. A number of surface stream networks disappear within a short distance, as water either gradually drains into bedrock fissures within the streambed or disappears altogether into swallets and sinkholes that lead directly to deeper bedrock conduits.

The notion of caves as features resulting from solution processes is a concept of human perception, defined in terms of human body dimensions. As water in the karst landscape flows through conduits of all sizes from narrow cracks to passages tens-of-feet high and wide, the proportion of these conduits that we call caves are simply those large enough for humans to walk, crawl, or painfully squirm into. Most conduits are far too small to permit human entry and so we do not perceive them as caves. Nevertheless, they are the most important drainage mechanism in karst landscapes. Underground drainage ultimately emerges as springs at the level of the nearest surface stream that is large and deep enough to avoid underground capture. This is known as local base level. The regional base level for groundwater in the Inner Bluegrass is the Kentucky River, trenched in its steep-sided gorge nearly four hundred feet below Lexington's elevation.

Groundwater emerges as springs along the banks of Kentucky River tributaries such as North and South Elkhorn Creeks, Hickman Creek, Jessamine Creek, and other streams. The region's first explorers and settlers were impressed by the number of free-flowing springs that watered the countryside. Many of the larger springs became landmarks and were used to navigate through the sparsely-settled frontier wilderness. Since settlers would make their living by agriculture, a good water supply was of paramount importance for livestock, crops, and domestic use. Springs were thought to provide the very finest sort of water, and land claims were often based around a good spring.

A farm's residence was usually built near the best spring for easy access. Protective enclosures, or spring houses, could be very simple or as elaborate as the owner's taste and budget permitted. One spring house in residential Lexington in the early nineteenth century was a two-story structure of brick, 10 by 20 feet; the upper story was used as a smokehouse. The rural Bluegrass region today is dotted with hundreds of stone spring houses, now primarily used for watering stock.

Community site selection in the Inner Bluegrass was often influenced strongly by the presence of a large spring. Inner Bluegrass communities founded in the 1770s at spring locations include Lexington, Georgetown, and Harrodsburg. Although most cities and towns in the state are today served by municipal water supplies derived from surface water, a few are still dependent upon the same spring that marked their original site.

Karst features have also played an economic role in the region's history. During the War of 1812, Lexington became the market center for saltpeter mined from caves and rock shelters in the Mississippian limestone belt and this became the bases for local gunpowder manufacturing. A number of early industries used springs, either for water-powered mills or as a source of water. The best-known example of a spring-dependent, early Kentucky industry is bourbon whiskey distillation. The first bourbon whiskey made in the state was reported to be that made in 1789 by Craig and Parker at Georgetown's Royal Spring.

Today, with increased citizen concern about the purity of drinking water, national sales of bottled water have dramatically increased. The image of pure spring water (as we shall later see, an image far from the truth) has supported a growing number of bottling companies in this country and abroad, including one in the Inner Bluegrass south of Lexington. The water they distribute is pure, but has been reconstituted and is natural only in a general sense.

The Central Kentucky karst is identified by place names. Many towns have a Spring Street. Lexington has its own Spring Street, as well as Russell Cave Road, Cave Hill Lane, Boiling Springs Drive, Cave Creek, Deep Springs Subdivision, the Springs Motel, and other similar names. In the countryside are two Cave Spring Farms and one Caveland Regional Farm.

Environmental Issues

Historically, builders and city planners have given little attention to the special problems of development on karst landscapes. Lexington is sited atop a fairly well-developed karst terrain. Over two centuries of city growth many karst features have been indiscriminately covered up during construction or used as inlets for storm drainage disposal. These and other practices have produced various problems including surface and groundwater pollution, building foundation instability, and localized flooding.

Groundwater in conduit flow systems tends to move rapidly close to the surface, almost at surface rates, and to undergo little filtering effect during its passage underground. Introduced contaminants can end up ten miles (16.1 km) away in a day, with little reduction in impurities. During the nineteenth century, ignorance of the relationship between contaminated water and disease led to several cholera epidemics. At present we consider ourselves less at risk to water-borne diseases because of modern water treatment facilities, but a number of contaminants are difficult to remove. In addition, groundwater supplies 90 percent of Kentucky's rural residents. Obviously, much is at stake in maintaining groundwater quality.

Groundwater contamination in an urban area takes many forms. Fayette County, for example, receives mixed contaminants from both agricultural and urban sources. The usual form of pollutant entry into groundwater is directly through sinkholes and stream bed swallets, and by soil infiltration.

Sinkholes seem to invite abuse. People fill them in to make the ground level. This is often accomplished by dumping junk automobiles, dead animals, and trash and refuse of all kinds. On the grand scale, sinkholes have been erased *en masse* by large subdivision developments where the natural land form is altered to conform to the design of developers. Yet, the sinkholes remain functional, regardless of how the surface has been rearranged. Over time filled sinkholes often redevelop, at the expense of whatever structures may be situated above. A building erected over a sink that has been artificially leveled may have a portion of its foundation resting in deeper soil than other parts. The foundation will inevitably settle unevenly and may crack and shift. In karst landscapes, the ground can collapse. Visualize a vertical shaft in the limestone bedrock, thirty feet deep and eight feet in diameter. Sitting on top of the shaft, hiding it from view, is a thick plug of clay and sod, like a cap on a milk jug. From the surface it looks just like the rest of the land. After a heavy rain, the soil bridge may cave in, leaving a gaping chasm. The city of Bowling Green in western Kentucky is plagued by such events forty or fifty times each year. In Lexington this phenomenon is much less frequent. Some sinkhole collapses are natural. Others are brought on by increased runoff, the result of covering the surface with asphalt or houses.

Grading the landscape to suit the needs of a particular development may adversely affect area drainage patterns. Sinkholes, especially sinking streams, are often used as convenient inlets for storm drainage. They often have runoff diverted to them far in excess of their flow capacities. Flooding occurs as storm water piles up faster than it can penetrate into the aquifer. This has occurred in several Lexington neighborhoods. Many people have unknowingly bought homes in flood zones.

In 1985, Lexington enacted a Sinkhole Ordinance, and as a result, land development must take karst features into account. Sinkholes and adjacent land may be classified to exclude any surface development in the form of structures or even the filling in of low areas. Most significant, sellers are required to give notice to a potential purchaser or lender that a particular property may be subject to future sinkhole problems.

Lexington, like many cities nationwide, demonstrates a high level of concern for environmentally sound land use. This concern is especially evident in zoning that requires certain amounts of open space within the various land use categories. Indeed, this zoning blends very well with the city's efforts to reduce the sinkhole problem. Within several subdivisions, for example, sinkhole areas are used as a common space for recreation or simple enjoyment of their aesthetic qualities.

Solution processes and the resulting karst landscapes of the Bluegrass provide a valuable field laboratory for both students and instructors of geography. Few places have such a variety of active cave systems, sinkholes, and drainage features in such close proximity to a large urban area, and there is no question that Lexington represents an excellent case study of the interaction between humans and their physical environment. Caving is a popular past-time for a growing number of central Kentucky residents, and a surprising number of natives have grown up in and around caves and have relied almost solely on springs or wells for their water. Despite the benefits, either for recreation or as a source of water, the Bluegrass karst landscape will continue to cause problems that can be solved only through responsible action at both the individual and community level.