Wildlife and Nature

- Geography
- Mountains and Streams
- Geology
- Forests and Vegetation
- Climate
- Endangered Species
- Hunting and Fishing
- Astronomical Phenomena

Location of Oklahoma

This section was compiled using data from the following sources: *The Atlas of Oklahoma, Classroom Edition*, published by the Department of Geography, Oklahoma State University, October 1991, Tom Wikle, Editor; U.S. Government Information Division, Oklahoma Department of Libraries, Steve Beleu, Administrator; Charles Mankin at the Geological Survey; State Geographer Bob Springer; Mark Shafer at the Oklahoma Climatological Survey; Mark Harrison at the Oklahoma Conservation Commission; Wayne Wyrick at the Kirkpatrick Planetarium; Nels Rodefeld at the Department of Wildlife; Caryn Vaughn at the Oklahoma Biological Survey; and Kurt Atkinson, Forestry Services Division of the Oklahoma Department of Agriculture.

Location and Size

Oklahoma is surrounded by six other states: Texas to the south and west, New Mexico to the west, Colorado and Kansas to the north, and Missouri and Arkansas to the east. Oklahoma City serves as the state's capital. It is located very near the geographic center of the state. Geographic center is approximately eight miles north of Oklahoma City.

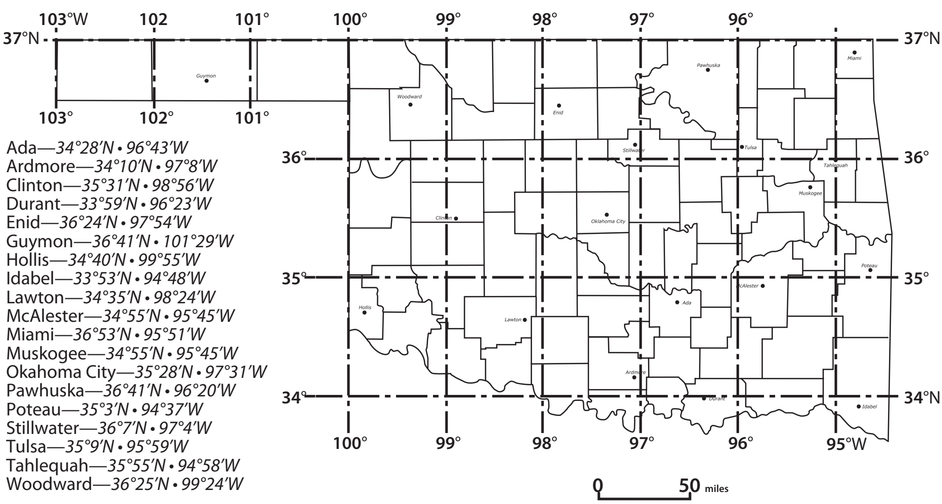
Lines of longitude and latitude form a grid system on the earth's surface. These reference lines are used to pinpoint the position of any spot on Earth. Oklahoma extends across north latitudes and west longitudes.

Latitude is distance measured north and south of the equator. Lines of latitude, also called parallels, are established by the angle between a radius from a point at the center of the earth in relation to the equatorial plane. Latitude ranges from 90 degrees at each pole to zero degrees at the equator. For greater precision, degrees of latitude can be broken up into minutes and seconds. There are sixty minutes in a degree and sixty seconds in each minute. One degree of latitude equals roughly sixty-nine miles because the Earth is not a perfect sphere.

Longitude is the other component of the Earth's grid system. Lines of longitude, called meridians, run north and south and help to pinpoint locations east and west. Longitude is also measured in degrees, minutes, and seconds. The most important reference line used for longitudinal reference is the Prime Meridian established in 1884 by international agreement. The Prime Meridian runs through the Royal Observatory at Greenwich, England, and represents a longitude of zero degrees. Longitudes to the east of the Prime Meridian are called east longitudes and those to the west, west longitudes. On the opposite side of the earth is the International Date Line that represents a longitude of 180 degrees.

Oklahoma is situated between ninety-four degrees, twenty-nine minutes, and 103 degrees west longitude; and thirty-three degrees, forty-one minutes, and thirty-seven degrees north latitude.

Longitude and Latitude



Ada—*34°28′N • 96°43′W*
Ardmore—*34°10′N • 97°8′W*
Clinton—*35°31′N • 98°56′W*
Durant—*33°59′N • 96°23′W*
Enid—*36°24′N • 97°54′W*
Guymon—*36°41′N • 101°29′W*
Hollis—*34°40′N • 99°55′W*
Idabel—*33°53′N • 94°48′W*
Lawton—*34°35′N • 98°24′W*
McAlester—*34°55′N • 95°45′W*
Miami—*36°53′N • 95°51′W*
Muskogee—*34°55′N • 95°45′W*
Okahoma City—*35°28′N • 97°31′W*
Pawhuska—*36°41′N • 96°20′W*
Poteau—*35°3′N • 94°37′W*
Stillwater—*36°7′N • 97°4′W*
Tulsa—*35°9′N • 95°59′W*
Tahlequah—*35°55′N • 94°58′W*
Woodward—*36°25′N • 99°24′W*

By the time Oklahoma was granted statehood in 1907, it had been divided into seventy-five counties. New counties were created when Harmon County was separated from Greer County, and Cotton County broke away from Comanche County. With these additions in 1910, the number of counties was elevated to the present total of seventy-seven. Since statehood, only eight counties have relocated their county seats.

Osage is the state's largest county with an area of 2,293 square miles, while Marshall is the smallest county in the state with only 360 square miles. Cimarron County is the only state county in the nation that borders four other states (Kansas, Colorado, New Mexico, and Texas).

The five largest counties by population, according to the U.S. Census 2003 estimates are: Oklahoma (676,066), Tulsa (570,313), Cleveland (219,966), Comanche (113,890), and Canadian (92,904). In contrast, the five smallest counties by population are: Cimarron (2,961), Harmon (3,053), Roger Mills (3,201), Harper (3,398), and Ellis (3,996). For more information, visit **www.census.gov**

Trends in County Populations

Five Largest		
County	1991 Population	2003 Pop. Est.
Oklahoma	636,539	676,066
Tulsa	548,296	570,313
Cleveland	203,449	219,966
Comanche	106,621	113,890
Canadian	86,498	92,904
Five Smallest		
Cimarron	2,922	2,961
Harmon	3,336	3,053
Roger Mills	3,593	3,201
Harper	3,580	3,398
Ellis	4,194	3,396

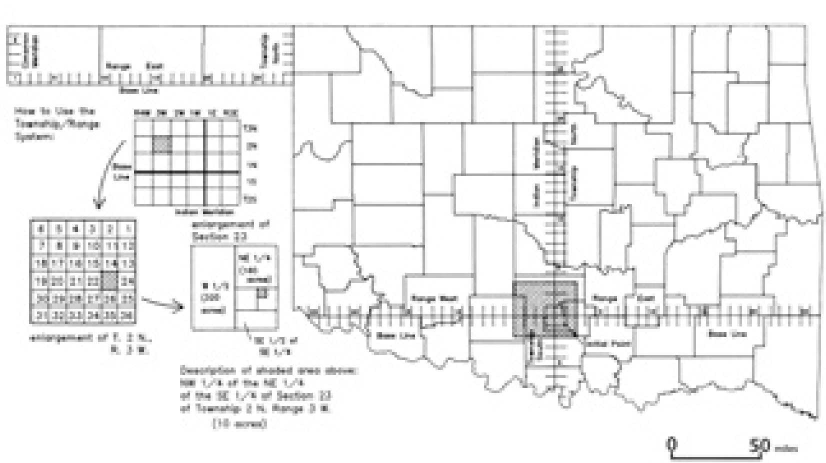
(U.S. Census Bureau data)

Locating property in Oklahoma can be accomplished by using a reference system known as Township and Range. The system was adopted by the federal government as a part of the Northwest Ordinance of 1785 to prevent conflicting titles of land as pioneers claimed irregularly shaped plots to acquire the most fertile lands. It was also initiated to assist in the orderly survey and sale of public land. The Township and Range System uses an initial point from which all locations are referenced. The primary initial point used for land in Oklahoma is located about one mile south of Fort Arbuckle in Murray County (in south central Oklahoma). This point was established by Ehud N. Darling in 1870 to aid in the dispersion of Indian lands. Running through the initial point are two lines: a base line that corresponds to an east/west parallel, and a north/south meridian. All areas to the north of this point are referred to as township north and areas to the south are called township south. The meridian associated with the initial point is called the "Indian Meridian" and is used to designate range east from range west.

The base line and meridian are divided into six-mile segments forming a grid of individual township/range units. These units are again divided into thirty-six, one-square-mile sections that are numbered consecutively beginning in the northeast corner of the township/range. These sections (640 acres each) are then divided into half-sections, quarter-sections, etc.

Excluding the Panhandle, there are thirty-eight township lines running east and west and fifty-three range lines running north and south. A separate initial point was used for the panhandle and is located at the southwest corner of Cimarron County.

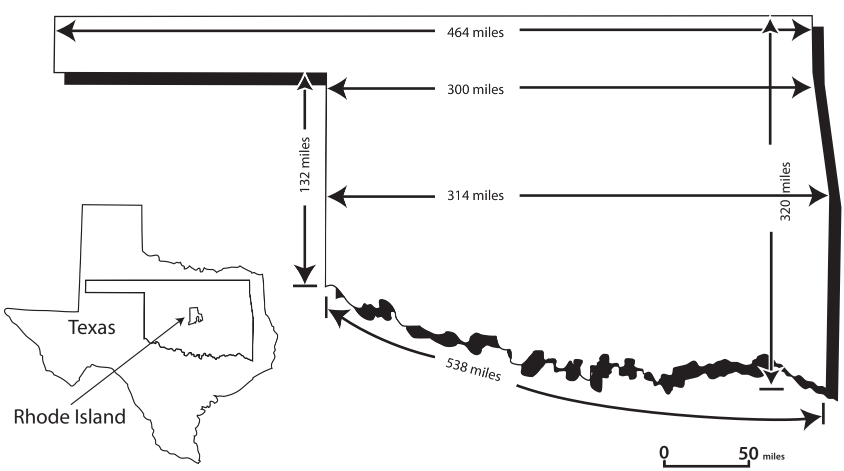
Townships and Ranges



Oklahoma is located farther west than any country in South America. Traveling due south from Oklahoma City, one would cross Texas and the country of Mexico before reaching the Pacific Ocean. All of South America would be located to the east. Oklahoma covers an area of 69,903 square miles (68,679 in land and 1,224 in water).

Oklahoma ranks eighteenth in size in the United States and is considered one of the larger states when compared to those of the East Coast. The combined area of Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, and Connecticut are smaller than the area of Oklahoma. Oklahoma is more than fifty times larger than the state of Rhode Island and has about the same area as the South American country of Uruguay. Only Montana, Tennessee, Texas, and Alaska have greater east-west distances than Oklahoma. With 277,340 square miles, Texas is almost four times larger than Oklahoma. When compared to other states in the West, Oklahoma is larger than Washington and Hawaii.

State Dimensions



Demographics

Population

According to the U.S. Census Bureau, Oklahoma's population for 2000 was 3,450,654. This represents an increase of 9.7 percent from 1990 to 2000, or 305,069 persons. For 2004, Oklahoma's population is estimated to be 3,523,553. In 1990, population density was 46.1 persons per square mile; in 2000, the density was 50.3. Trends in Oklahoma continue to show people leaving rural areas of the state in favor of urbanized areas. The two biggest concentrations of people in the state are in the metropolitan areas of Oklahoma City and Tulsa. In the Trends in County Populations table, each of the state's largest counties grew in population between 1991 and 2003, while all but one of the smallest counties became smaller during the same time period. U.S. Census Bureau population predictions state that by 2015, Oklahoma's population is estimated to be 3,789,000; and will increase to 4,057,000 by 2025.

Vital Statistics

In 2003 Oklahoma had 50,040 births and 35,325 deaths. By comparison, in 2000, there were 49,782 births and 35,079 deaths. The birth rate per 1,000 population was 14.4 in 2003 and the infant mortality rate was 7.4 deaths per 1,000 live births. The number of births to teenagers, age ten to seventeen in Oklahoma in 2003 was 2,213, and the number of births to unmarried mothers was 18,869. From April 1, 1990, to July 1, 1999, according to the U.S. Census, there were 437,373 births in Oklahoma, and 298,499 deaths.

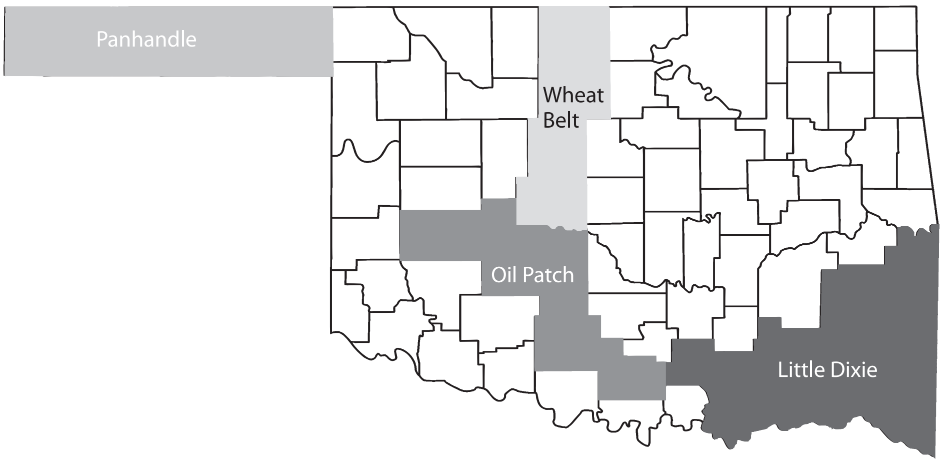
Previous editions of the *Oklahoma Almanac* have included marriage and divorce statistics. The 2001–2003 *National Vital Statistics Report* does not list the number of marriages and divorces for Oklahoma. The problems associated with collecting this data also resulted in the deletion of these statistics from the "County" pages in this edition of the *Oklahoma Almanac*. See **www.cdc.gov** or **www.census.gov**

Vernacular and Cultural Regions

Vernacular regions are areas that have a unique cultural identity among their residents. R. Todd Zdorkowski and George O. Carney's map [top right] was constructed using a survey of past and present Oklahoma place names that respondents had heard or used. The regions shown reflect local customs and economic histories. The area known as "Little Dixie" is dominated by a non-Indian population; however, the Indian population of this region responded to the survey with the name "Kiamichi," which is also the Oklahoma Tourism Department's name for the area (although pronunciations differ). A uniformity among responses concerning the Panhandle region suggests it is the most widely accepted vernacular region. Other region names are derived from economic terms, suggesting local experience and public involvement may be the keys to regional perception.

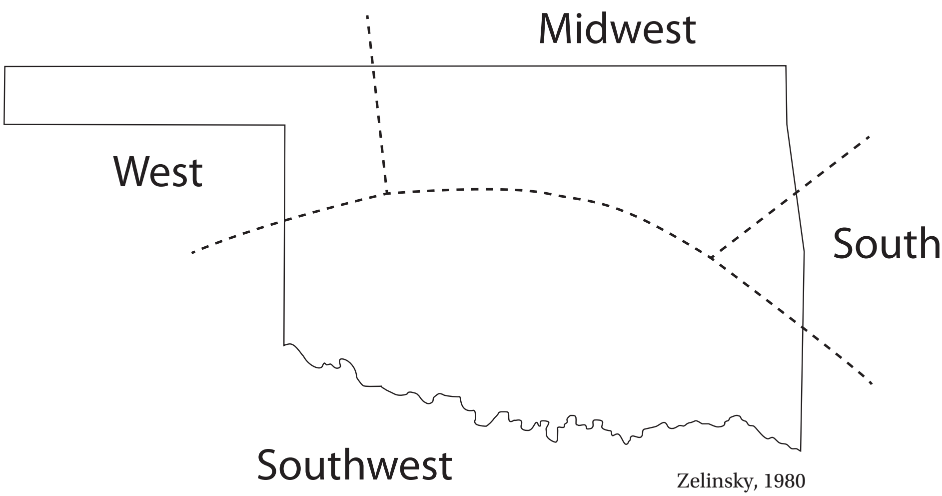
Wilbur Zelinsky's map [right bottom] is an excerpt from a national map of cultural geography. Oklahoma is at the center of three cultural regions of the nation: the Middle West, the South and the West. The influx of Indians from the East and the settlement of Europeans add to uncertainty in the national cultural identity of Oklahoma.

Vernacular Regions



Zdorkowski and Carney, 1985

Cultural Regions



Zelinsky, 1980

Climate

Oklahoma's weather is driven largely by its topography. Elevations in the state range from less than 500 feet in the southeastern corner of the state to more than 4,000 feet in the far western Panhandle. Because of the general upward slope of the state, moisture tends to be more concentrated in the east, driving annual precipitation, temperature, and severe weather cycles.

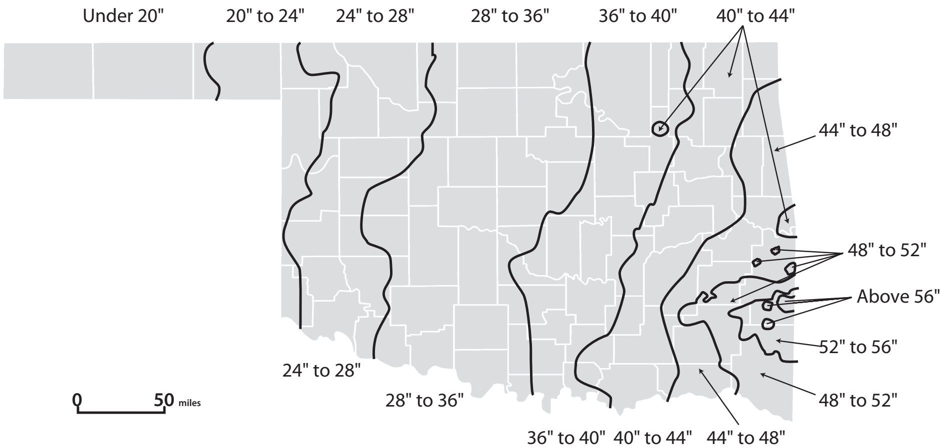
Average temperature decreases across Oklahoma generally from the south to the northwest. Mean annual temperature along the Red River, Oklahoma's southern boundary, is about sixty-two degrees and is about fifty-eight degrees along its northern border with Kansas. Temperatures continue to decrease westward across the Oklahoma Panhandle to a state low of fifty-six degrees in the far west. Annual temperatures show a great variability in Oklahoma; almost everywhere has an annual temperature range of one hundred degrees or more. For any place in the state, temperatures near 110 are common about two out of ten years, as are temperatures slightly below zero. State extreme temperatures range from 120 degrees (recorded six times) to twenty-seven degrees below zero (twice). Most of the state has a growing season of more than 200 days, except in the western Panhandle where the growing season only lasts about 175 days.

Annual precipitation shows a strong east-to-west gradient across Oklahoma. Eastern portions of the state average up to fifty-six inches of precipitation annually, while portions of the Panhandle receive less than seventeen inches, on average. The typical peak in precipitation comes in the spring for most of the state, except the Panhandle which has a summertime maximum. A secondary peak occurs during early autumn, and is especially pronounced in eastern Oklahoma. Measurable precipitation is recorded on about forty-five days per year in western Oklahoma to about 115 days near the Arkansas border. Most precipitation falls at night, while the maximum rainfall intensities are usually during late afternoon. The state records for annual precipitation are 84.47 inches, recorded in southeastern Oklahoma in 1957, and a meager 6.53 inches, recorded in the Panhandle the previous year. The state's record for single-day rainfall is 15.68 inches, but unofficial total of over twenty inches have been recorded. Snowfall is frequent across northwestern Oklahoma, which averages nearly thirty inches of snow, but areas of southeastern Oklahoma may go several years between events. The state's record snowfall is 87.3 inches, during the winter of 1911–1912. A more common threat to the state is ice. Two major ice storms struck Oklahoma during consecutive winters: December 2000 and January 2002, causing a combined $270 million in damages.

In addition to ice storms, the primary threats to safety and economy in Oklahoma are severe storms, floods, and droughts. Large and damaging tornadoes are a threat in almost any part of Oklahoma, but recent advances in technology and preparedness have reduced the loss of life. Oklahoma averages fifty-four tornadoes per year, fifteen of them rating F2 or higher. Most tornadoes occur between late March and mid-June, although tornado outbreaks are sometimes associated with the secondary precipitation maximum in autumn.

Flood control projects stemmed many of the most devastating floods in the early twentieth century, but flash flooding remains a serious threat. Much of Oklahoma's precipitation comes in the form of intense, but short-lived, convection, causing excessive runoff, especially in urban and suburban areas. While not a threat to life, drought can be devastating to Oklahoma's economy. Precipitation variability is highest in the agricultural-intensive areas of the west, meaning droughts are a frequent nuisance. Droughts may last from several months to several years. Major drought episodes occurred from 1909–1918, 1930–1940, 1952–1958, and 1962–1972. Several recent years, beginning in the mid–1990s, have experienced short-duration but intense drought episodes.

Normal Annual Precipitation



Extreme Weather Records

Temperature

Lowest	Vinita	-27 degrees	2/13/05
	Watts	-27 degrees	1/18/30
Highest	Altus	120 degrees	7/19/36 & 8/12/36
	Alva	120 degrees	7/18/36
	Poteau	120 degrees	8/10/36
	Tishomingo	120 degrees	7/26/43
	Tipton	120 degrees	6/27/94

Rainfall

Wettest Year	Entire state	48.21 inches	1957
Driest Year	Entire state	18.95 inches	1910
Most Annual	Kiamichi Tower	84.47 inches	1957
Least Annual	Regnier	6.53 inches	1956
Most Daily	Enid	15.68 inches	10/11/73

Snowfall

Most/Season	Beaver	87.3 inches	1911–12
Most/Month	Buffalo	36.5 inches	February 1971
Most/24 hrs.	Buffalo	23.0 inches	2/21/71
Max. Depth	Buffalo	36.0 inches	2/22/71

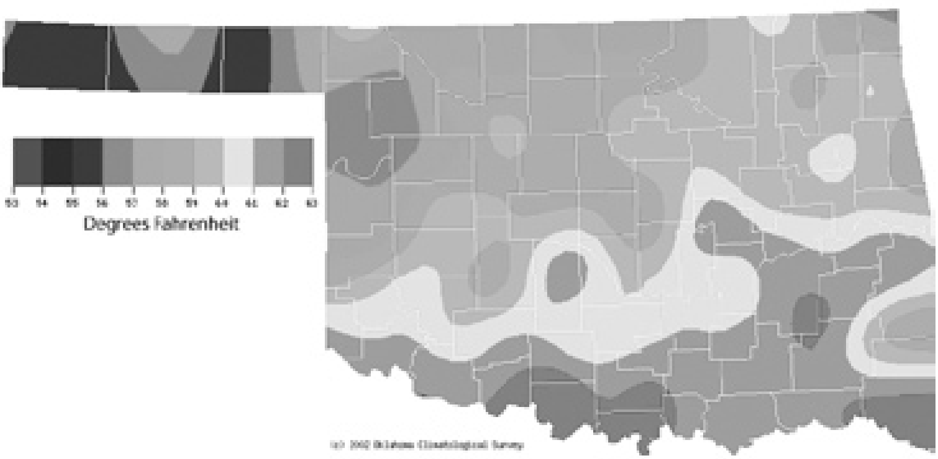
Monthly, Statewide-Averaged Temperature & Precipitation

1892–2004

Month	Highest Temp.		Lowest Temp.		Most Precip.		Least Precip.	
January	1923	47.5	1930	24.9	1949	5.23	1986	0.04
February	1954	51.8	1899	27.9	1938	4.66	1996/1947	0.20
March	1907	59.6	1915	39.2	1973	7.46	1971	0.38
April	1954	66.5	1983	54.0	1942	8.50	1989	0.58
May	1896	75.8	1907	62.3	1957	10.68	2004	1.10
June	1953	85.1	1903	70.3	1908	8.73	1933	0.46
July	1954	88.6	1906	76.4	1950	9.26	1980	0.41
August	1936	87.9	1915	73.9	1906	6.54	2000	0.14
September	1931	80.6	1974	65.4	1945	7.86	1956	0.27
October	1963	70.7	1925	55.3	1941	11.32	1952/1917	0.14
November	1999	56.2	1929	42.6	1909	5.72	1910	0.12
December	1965/1933	46.5	1983	26.5	1984	4.98	1908	0.07

Normal Annual Temperatures

1971–2000



Observing the Weather

Howard L. Johnson, Oklahoma Climatological Survey

The climatology of an area is determined from regular observations of pertinent climatic features over a period of many years. The most widely measured, and arguably the most important weather variables, are precipitation and temperature. The National Weather Service (NWS) and its predecessor organizations have provided rain gauges and thermometers to thousands of volunteer citizens in all parts of the United States. These volunteers, known as cooperative observers, maintain records of daily temperature and measurements of precipitation, which are then given to the NWS at the end of each month for processing and eventual publication.

More detailed observations of weather conditions are made at airports by the National Weather Service, Federal Aviation Administration, or Department of Defense. Observations supporting aviation include measurements of temperature, humidity, air pressure, winds, clouds, visibility, and others. Observations by humans have mostly been replaced by automated observing platforms. The most sophisticated of these systems, the Automated Surface Observing System (ASOS), is in place at all major airports in the United States.

Annual Temperatures (Degrees Fahrenheit)

"Normals" and extremes of the features of climate are used to characterize the climatology. The term "normal" is used to indicate the characteristic value of a parameter. Although the value of the parameter may change in a matter of seconds, as does the speed of the wind, or over a longer period of time, as does the frequency of precipitation, fluctuations will be around the value of the normal. Climatologists have defined normals of temperature and precipitation to be thirty-year averages, using the most recent three complete decades. Therefore normals in current use are average values during the period from 1971 to 2000.

In 2002 there were 202 active cooperative observers in Oklahoma. Each of them reports daily precipitation measurement with 114 also reporting daily maximum and minimum temperatures. Precipitation amounts are determined by measuring the depth of rainfall or melted snow, sleet or freezing rain in a standard rain gauge. Nearly all of the precipitation measurements are taken near sunrise. Daily temperature extremes are read from an electronic sensing device that retains the highest and lowest temperature since the unit was last reset. Thermometers capable of indicating the highest and lowest value of temperature were used before the deployment of the electronic sensors and are still used by a few observers. Most of the temperatures are read in the morning at the same time as the rain gauge although about a third of the observers report temperatures in late afternoon, near sundown. Six other sites in Oklahoma—all airport locations acting in support of aviation—contribute temperature and precipitation measurement to the cooperative network. Temperature extremes and precipitation measurements are taken at midnight, yielding values for the calendar day.

Oklahoma has acted to enhance its environmental monitoring through implementation of the Oklahoma Mesonetwork (Mesonet, for short). The Mesonet is a collection of 115 towers, at least one in each county, equipped with sensors and configured to automatically relay data to a central collection point. Operated by the Oklahoma Climatological Survey in partnership with the University of Oklahoma and Oklahoma State University, the Mesonet monitors air and soil temperature, relative humidity, wind speed and direction, solar radiation, and precipitation at each of its sites. Many of the sites measure other information of agricultural or other scientific interest. Observations are made every five minutes and transmitted every fifteen minutes. Reports are carried from the field sites to the central processing computer by a combination of radio and the dedicated high-speed telephone lines of the Oklahoma Law Enforcement Telecommunications System (OLETS). Processed observations are available via various electronic media, including a dial-in bulletin board and Internet. The network has been operational since early 1994.

Oklahoma Monthly Temperature Extremes

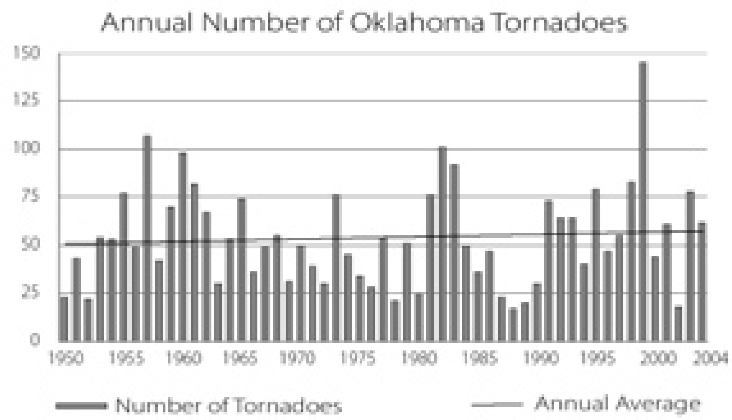
Volunteer observers, recruited and supported by the National Weather Services offices that serve their areas, provide daily reports of precipitation and temperature extremes. They forward those reports to the appropriate Weather Service office, from which they are sent to the National Climatic Data Center in Asheville, North Carolina, for inclusion in the nation's climatic records. This network of volunteers, known collectively as the Cooperative Observers Network, has monitored the climate within the current boundaries of Oklahoma since 1890. It is from the records provided by this group of dedicated volunteers that detailed records of Oklahoma's climate during the past 111 years are known.

The United States Weather Bureau (which has evolved into the present-day National Weather Service) established an office in Oklahoma City to provide meteorological services to resident of the Oklahoma and Indian territories and other associated lands. Prior to that time weather observations were taken and records kept at the various forts and a few other locations under the auspices of the U.S. Army. The oldest known sequence of daily weather observations in Oklahoma was recorded by the post surgeon at Fort Towson, from September 1824 through December 1855. For many years, the Federal Aviation Administration and its predecessor organizations took hourly weather observations at several state airports. Automated observations under the auspices of the National Weather Service have largely replaced those manual observations. The various military bases in Oklahoma provide their own weather observations in support of military aviation activities. Reports from the Oklahoma Mesonet have supplemented the National Weather Service data and provided detailed, continuous measurements of other meteorological data since 1994. Monthly extreme temperatures in Oklahoma according to available records are as follows:

Month	High temp.	Location	Date	Low Temp.	Location	Date
January	92	Cloud Chief	01/31/1911	-27	Watts	01/18/1930
February	99	Arapaho	02/24/1918	-27	Vinita	02/13/1905
March	104	Frederick	03/27/1971	-18	Kenton	03/06/1948
				-18	Hooker	03/07/1920
April	106	Mangum	04/12/1972	06	Boise City	04/02/1936
May	114	Weatherford	05/25/2000	19	Hooker	05/01/1909
June	120	Tipton	06/27/1994	34	Kenton	06/13/1919
July	120	Tishomingo	07/26/1943	41	Goodwell	07/05/1915
	120	Altus	07/19/1936			
	120	Alva	07/18/1936			
August	120	Altus	08/12/1936	38	Bartlesville	08/31/1915
	120	Poteau	08/10/1936			
September	115	Alva	09/03/1947	25	Boise City	09/30/1985
	115	Alva	09/03/1939			
October	110	Waukomis	10/02/1898	06	Kenton	10/30/1993
November	95	Coalgate	11/01/1937	-15	Kenton	11/28/1976
	95	Mutual	11/01/1914			
December	92	Ardmore	12/30/1951	-19	Goodwell	12/12/1932

Tornadoes

Oklahoma ranks second in the nation (behind Texas) in its total number of tornado sightings. Although tornadoes can occur at any time, they appear most often in the spring months, especially April and May. The vortex of a storm capable of producing a tornado originates a few hundred yards above the ground. This rotating cyclone usually (but not always) becomes visible when upswept water vapor condenses into a funnel-shaped cloud that dangles downward. When this twisting funnel touches the ground, it can display dust and debris sucked from below. Tornadoes normally move from southwest to northeast, associated with large systems of thunderstorms. Tornadoes have the most extreme naturally occurring pressure gradients known. The most destructive of all atmospheric disturbances, winds in a tornado may reach speeds of 300 miles an hour, and the storm can track along the ground at twenty-to-seventy miles an hour. Tornadoes usually measure less than a quarter-mile (800mm) in diameter, however, some have measured more than two miles wide. The storms are erratic and may move without warning.



Annual Number of Tornadoes in Oklahoma, 1950–2004

A record number of tornadoes, 146, struck in Oklahoma in 1999, seventy-three of them occurring during a 24–hour period beginning on the afternoon of May 3. A total of forty-two deaths resulted from tornadoes during that year, the most tornado-related deaths in any year since 1947 when the Woodward tornado of April 9 took 116 lives. The enhanced warning capabilities, made possible by the effectiveness of the current generation of weather radar, an aware citizenry, conscientious local emergency management personnel, and an active and responsible media all share credit in keeping the 1999 death toll from being comparable to, or greater than that of 1947. From 1950 to 2004, the 2,973 tornadoes that have been documented in Oklahoma have resulted in 272 deaths.

Earthquakes and Faults

Faulting takes place where rocks are forcefully broken and displaced within the earth. They occur vertically, horizontally, or in combination. Faults are found along weak areas in the earth's crust called fault zones or fault planes. Oklahoma's geology, earthquakes, and structural evolution are linked to regional tectonics and shifting of the earth's crustal plates. Earthquakes are a result of slippage along faults. The energy released from this movement travels through the earth in waves.

The most common scale for measuring the magnitude of earthquakes is the Richter Scale. This scale was devised by Charles F. Richter in 1935 to describe the amount of energy released by earthquakes. The scale is logarithmic–each successively higher number represents an energy release that is ten times greater than the preceding number. Scale numbers range from zero to nine, but theoretically have no upper limit. Any earthquake with a Richter measurement of eight or above is considered catastrophic, but, lower-numbered shocks can cause immense damage under certain conditions. As a comparison, the San Francisco earthquake in 1906 was estimated at 8.3 on the Richter Scale, while the southern Alaska earthquake of 1964 measured 8.5. The largest earthquake in North America, measuring 9.2, was in 1964 at Prince William Sound, Canada. The quake had a seismic sea wave 50 feet high traveling 8,445 miles at more than 450 miles per hour.

Earthquakes tend to occur in belts or zones. For example, narrow belts of earthquake epicenters coincide with oceanic ridges where plates separate, such as the mid-Atlantic and east Pacific oceans. Earthquakes also occur where plates collide and/or slide past each other. Although most earthquakes originate at plate boundaries, a small percentage occurs within plates. The New Madrid earthquakes of 1811–12 are examples of large and destructive intraplate earthquakes in the U.S.

The New Madrid earthquakes of 1811–12 are probably the earliest historical earthquake tremors felt in Oklahoma (Arkansas Territory) by residents in southeastern Oklahoma settlements. Before Oklahoma became a state, the earliest documented earthquake occurred October 22, 1882, probably near Fort Gibson, Indian Territory, although it cannot be located precisely. The *Cherokee Advocate* newspaper reported that at Fort Gibson "the trembling and vibrating were so severe as to cause doors and window shutters to open and shut, hogs in pens to fall and squeal, poultry to run and hide, the tops of weeds to dip and cattle to lower."

The next documented earthquake in Oklahoma occurred near Jefferson, Grant County, December 2, 1897. The next known Oklahoma earthquake happened near Cushing, Payne County, in December 1900. This event was followed by two additional earthquakes in the same area in April 1901.

The largest known Oklahoma earthquake (with the possible exception of the 1882 event) occurred near El Reno, Canadian County, April 9, 1952. This magnitude 5.5 (mb, Gutenberg-Richter) earthquake was felt in Austin, Texas, as well as Des Moines, Iowa, and covered a felt area of 362,000 km^2. In Oklahoma each year, approximately sixty to ninety small earthquakes, with magnitude values that range from 1.8 to 3.3, are located by the Oklahoma Geological Survey.

Geology

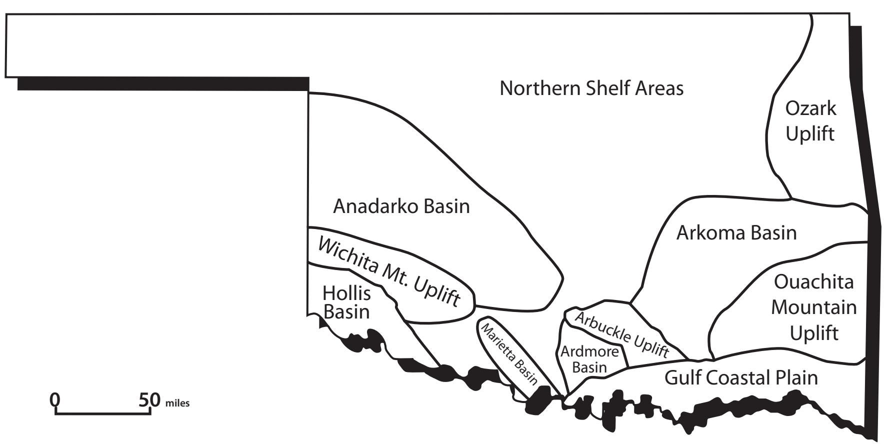
Oklahoma is a region of complex geology where several major sedimentary basins are set amongst mountain ranges and uplifts. The state contains many classic areas where fundamental concepts of geology, petroleum exploration, and minerals production have been formulated during the years. Because of its geologic history, Oklahoma has abundant mineral resources that include petroleum (crude oil and natural gas), coal, nonfuel minerals (lead, zinc, gypsum, limestone, sand and gravel), and water.

Geologic forces deep within the earth's crust hundreds of millions of years ago caused portions of Oklahoma to subside as major sedimentary basins, while adjacent areas were folded and thrust upward as major mountain uplifts. Most of the outcropping rocks in Oklahoma are of sedimentary origin, and they consist mainly of shale, sandstone, limestone, and gypsum. These sedimentary rocks typically are 2,000 to 10,000 feet thick in the northern shelf areas, and they increase sharply to 30,000 to 40,000 feet thick in the deep basins of the south. These sedimentary rocks contain most of the states' mineral resources including petroleum, coal, water, and most of the nonfuel minerals. Sedimentary rocks rest upon a "basement" of igneous and metamorphic rocks that underlie all parts of the state.

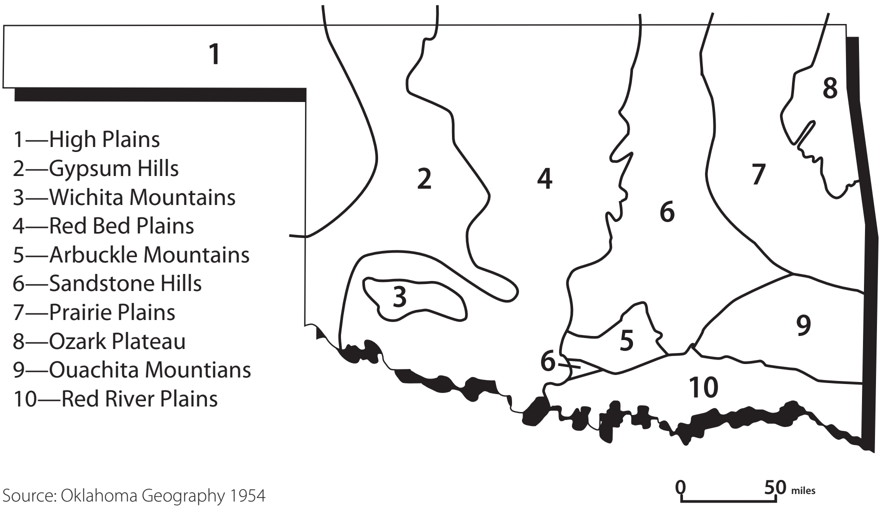
Exposed in the southern Oklahoma mountain belts are a great variety of sedimentary and igneous rock units seen at few other places in the entire mid-continent region. Steeply dipping strata, such as those exposed along Interstate 35 through the Arbuckle Mountains, attest the strong geologic forces that folded and raised the mountain blocks. Outcropping rocks outside the mountain regions are essentially horizontal, with dips of less than one degree being most common. These strata typically form gently rolling hills and plains: thick shale units form broad, flat plains and valleys, whereas resistant layers of sandstone and limestone cap mesas, cuestas, and hills 100 to 500 feet high. Rocks and soils of western Oklahoma typically are red in color, due to iron oxides present in the bedrock, whereas rocks and soils elsewhere are shades of brown, gray, and black.

In the Wichita Mountain Uplift, peaks of Cambrian granite and related igneous rocks tower 500 to 1,200 feet above surrounding plains. The province is composed mostly of granite, rhyolite, gabbro, and limestone. In the Hollis Basin, located in the extreme southwest corner of the state, thick formations of gypsum, shale, and sand are found. In the northeastern corner of the state, the Ozark Uplift is deeply dissected with Mississippian limestone and chert, shale, sandstone,

Major Geological Provinces



Physiographic Regions



Source: Oklahoma Geography 1954

and dolomite are also found in this area. The Arkoma Basin, in east central Oklahoma, is composed primarily of sandstone, shale, and limestone. The Ouachita Mountain Uplift consists of tightly folded sedimentary rock types, varying in age from Ordovician to Mississippian. The mountain ridges are folded Mississippian and Pennsylvanian sandstones that tower above valleys formed in shale.

The Gulf Coastal Plain is located in the southeast part of the state. Shale, limestone, sandstone, and large amounts of sand are present in this geological province. The Arbuckle Uplift is totally enclosed in Oklahoma. Thick limestone and dolomite units, varying in age from Cambrian to Mississippian, are found in addition to some sandstone and granite deposits. The Ardmore Basin is also located completely within Oklahoma's borders. It is composed mainly of Pennsylvanian sandstone and shale. The Marietta Basin consists mainly of outcrops of sandstones and shales of Pennsylvanian and Permian age.

Physiographic Regions

Oklahoma lies mostly in the Great Plains physiographic region and is characterized by low rolling plains that slope eastward. Although the state is often described as flat, local hilly areas rise a few hundred feet to more than 1,000 feet above the surrounding prairies. Three mountain ranges are present in the state: the Wichita Mountains in southwest Oklahoma, the Arbuckle Mountains in south central Oklahoma, and the Ouachita Mountains in the southeastern portion of the state. The highest vertical relief in Oklahoma occurs in the Ouachita Mountains and the southeast part of the prairie plains, with some peaks reaching more than 2,000 feet above their base elevations.

The major rivers of Oklahoma generally flow eastward. Listed from north to south these rivers are: the Arkansas, Cimarron, North Canadian, Canadian, Washita, and the Red. The Arkansas and its tributaries drain the northern two-thirds of the state, while the Red River and its tributaries drain the southern third.

Oklahoma can be divided into ten distinct regions, based on physical characteristics. Many of these areas are extensions of those found in surrounding states and extend to areas as far away as the Gulf of Mexico. The sharp contrasts between the regions give a broad overview of what to expect on a tour of the state.

The state's most level areas are those of the High, Red Bed, and Prairie Plains (regions 1, 4, and 7). Within these areas, the majority of Oklahoma's crops are produced and a great variation in population can be found. The Red River Plains (region 10) is located in the southern portion of the state and is endowed with fertile soil and low, rolling hills. Most of the rock in this region is composed of shale, sandstone, and limestone. A large portion of this area is located below 500 feet in elevation.

Interrupting the plains are the Sandstone and Gypsum Hill regions (regions 2 and 6). The hills in these regions are aligned north to south. The Sandstone Hills resist general weathering because they are capped by resistant sandstone layers. The Gypsum Hills of western Oklahoma are known for the thick layers of white gypsum that cap mesas, buttes, and hilltops, and overlie layers of shale and sandstone that tend to erode easily.

The Arbuckle and Wichita Mountain regions (regions 3 and 5) were formed through geologic uplift and folding. The Arbuckle Mountains contain limestone, sandstone, shale, and granite that have become important mineral sources to the mining industry. The Wichita Mountains, on the other hand, were formed from intrusive and extrusive igneous rocks that are very resistant to erosion. Granite and rhyolite remain where overlying rocks have been eroded.

The most pronounced of the mountain areas is the Ouachita Mountains (pronounced WA-she-taw) found in the southeastern section of the state (region 9). The rough terrain allows for farming only in the valleys, while some hillsides are grazed by cattle.

At one time the Ozark Plateau (region 8) was shaped like a large dome that rose high above the surrounding plains. It is now a hilly region with deeply dissected valleys as a result of the action of northeastern Oklahoma's numerous streams and rivers.

Generalized Topography

Oklahoma lies between the lower elevations of the Coastal Plain and the higher elevations of the Rocky Mountain foothills. The land surface of Oklahoma slopes gently from its northwest corner to the southeast with the steepest gradient of about twelve feet per mile in the Panhandle. Throughout the rest of the state, the slope averages about five feet per mile.

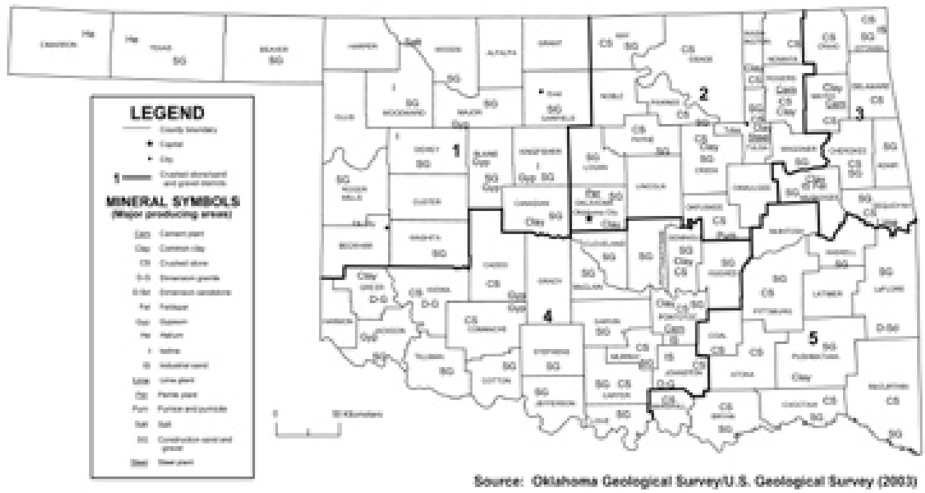
The contour lines shown in the diagram on previous page ("Physiographic Regions") connect points on the land surface having the same elevation. When contour lines are close together, they indicate that the slope of the land is steep.

Southeastern Oklahoma has many steep slopes and high mountains, while western Oklahoma has gentle slopes. In the extreme northwestern part of the state is Black Mesa, the highest point in Oklahoma, with an elevation of 4,973 feet above sea level. The lowest point, at 287 feet above sea level, is in the flood plain of the Little River near the state's southeastern corner. Oklahoma's best-known peak is Mount Scott in the Wichita Mountains.

Minerals

The United States Geological Survey estimated the value of nonfuel mineral production in Oklahoma was $453 million in 2000. That represents a 2.7% increase from the final figures for 1999. Crushed stone leads the state in the value of nonfuel mineral production exceeding $140 million. Based on value, crushed stone was followed by cement (masonry and portland), construction sand and gravel, industrial sand and gravel, gypsum, iodine and lime. Almost 48 percent of the total value is due to the combined values of three of Oklahoma's four major construction materials: crushed stone, construction sand and gravel, and gypsum (descending order of value). All nonfuel minerals showed increases in value in 1999 except for Grade-A and

Mineral Resources



Source: Oklahoma Geological Survey/U.S. Geological Survey (2003)

crude helium, crushed stone, and common clay. Oklahoma leads the U.S. in the production of gypsum; ranks fifth in feldspar production; ranks second of four states producing tripoli; ranks third of three states producing helium and is the only state producing iodine.

Oklahoma's enormous mineral reserve can be divided into three types of mineral products: mineral fuels, metals, and non-metals. Mineral fuels are materials that can be burned, such as petroleum (crude oil and natural gas), and coal. These account for more than 90 percent of Oklahoma's annual mineral output. Metals are substances that can be melted and molded into any shape desired and are usually hard and heat resistant. There presently are no metals mined in Oklahoma. Zinc and lead are the principal metals previously mined in Oklahoma, but copper, manganese, iron, and uranium also were produced. A non-metal (industrial mineral) is any rock, mineral or other select naturally occurring or synthetic material of economic value often used in combination with other materials, such as sand and stone used in concrete. The principal industrial minerals produced in Oklahoma include crushed stone, portland cement, construction sand and gravel, industrial sand and gravel, iodine, and gypsum. Other Oklahoma non-metals include tripoli, feldspar, helium, common clay, granite, salt, volcanic ash, and lime.

Nonfuel Mineral Production, 2003

Mineral	Quantity (in metric tons)	Value (in thousands)
Cement	*	*
Common Clay	1,030,000	$2,250
Gypsum	2,410,000	$18,700
Iodine	1,750	$19,700
Sand & Gravel	11,120,000	$68,100
Stone	45,817,000	$204,100

* Data withheld to avoid disclosing company proprietary data.

Note: Total value presented in Table does not equal the total value of nonfuel mineral production in Oklahoma for 1999. The difference is in mineral values not released for public distribution.

Forests and Vegetation

Oklahoma's forests are vital to the economy and environmental quality of the state, providing a diverse scenic panorama, a wealth of intangible benefits, and a significant forest products industry. Forests protect our high quality waters, provide habitat for wildlife, supply opportunities for recreation, and enhance the environment.

Our forests have been shaped and altered by natural disturbances and human influences. Native Americans worked the forest for their own needs. They burned the forest floor to stimulate brushy growth favored by game species, cleared land for settlements, and used wood for their primary cooking fuel. The first European settlers found forests dominated by white and red oaks, shortleaf and loblolly pine, black walnut, maple, hickory and pecan, elm, ash, cottonwood, baldcypress, and many other species.

As logging dried up the forests of New England and the Great Lakes, the extensive pine and oak resources of the South beckoned. Although small "peckerwood" sawmills were scattered across southeastern Oklahoma by the late 1800s, intensive logging began in earnest around 1900. By 1930, much of Oklahoma's most valuable virgin pine timber had been removed to support the industrial growth of the upper midwest. Forests were cleared for cotton farming or livestock grazing. As the southern forests began to wane, loggers moved west, leaving behind an overcut forest plagued by wildfire.

The forest underwent extensive cutting, concerned citizens and private companies helped establish the Oklahoma Forestry Association and a State Forest Service by 1925. Protection reduced wildfire damage and regeneration took hold. In western Oklahoma, President Franklin D. Roosevelt's Prairie States Forestry Project planted its first tree in a Greer County shelterbelt. The forest industry languished during the Great Depression, but the war brought renewed activity, relying on the growing "second forest." After World War II, social shifts in our population also affected the forests. The 1940s and 1950s saw urban dwellers leave inner cities in large numbers. Suburban developments cut into forest land and woodlots became more important as sources of recreation than income.

Oklahoma is often thought of as a state with only wide open prairies, wheat fields, and ranch land, but nearly ten million acres—20 percent of the land—is forest. More than six million forest acres are commercial–capable of growing wood as a crop. More than 90 percent of Oklahoma forests are owned by individuals, corporate owners, and the forest industry. Six percent is publicly owned.

Considerable value is also placed on forests in urban and community areas. Three-fourths of Oklahomans are now considered "urban" residents, which represents a significant change from the rural roots and image of the state. Forests are also highly valued outside traditional commercial areas, providing many environmental benefits.

Major forests are located in the Ouachita Mountains and the Ozark Plateau, in the eastern portion of the state, where rainfall is sufficient for tree growth. Also, the local topography in these areas is rough, which discourages the removal of forests for agricultural use. The Ozark Plateau is dominated by oak and hickory trees, while pine trees dominate the higher elevations of the Ouachita Mountains. There is, however, some mixing of these two types at all levels. Some sections of the Sandstone Hills, the Red River Plains, and the Prairie Plains are also covered by forests. The state has 144 native species of trees with common varieties including shortleaf and loblolly pine, sweetgum, pecan, several types of oak, cottonwood, and walnut.

Natural Vegetation

Oklahoma is situated in a transition zone between the humid eastern forests and the drier western grasslands. The state can be divided into three main types of vegetation: grassland, savannah and woodlands, and forests. Grass areas are abundant within Oklahoma's boundaries and are used for grazing. Grasses in the western sections are primarily short and mixed. In the Panhandle, the soil is often parched and only the surface is moistened by rain. Tall grasses are found in the eastern section of the state. Savannah and woodland areas exist in all parts of the state with the exception of the rough terrain of the Ouachita Mountains in southeastern Oklahoma. The Cross Timbers of central Oklahoma is the largest woodland-savannah region and supports some the state's oldest known trees. Juniper-Pinyon is the least abundant vegetation type, found only in the state's far northwest corner.

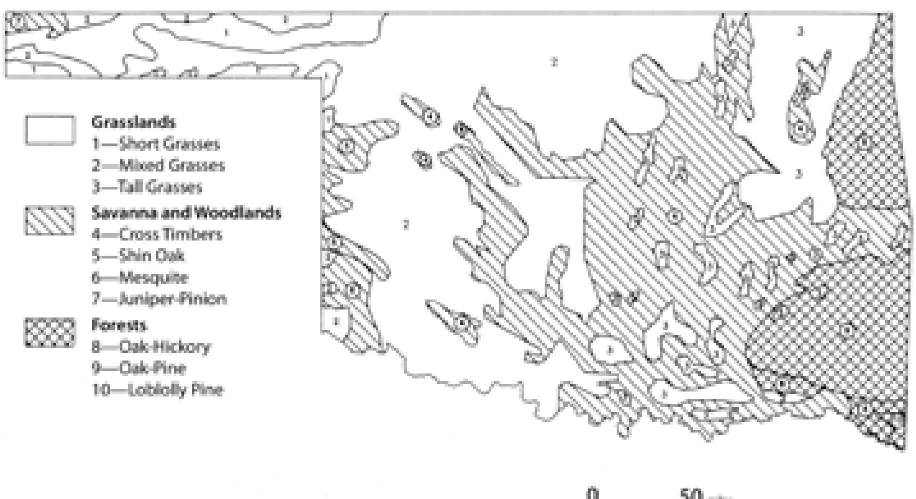
Large expenses of forest are found primarily in eastern Oklahoma where rainfall is abundant. The Ouachita Mountains are home to the largest forested area in the state and this is an extremely important area to the lumber and tree farming industries.

Generalized Soils

Soil is a combination of loose rock material, organic matter, air, and water. Oklahoma has a great diversity of soils ranging from the rich limestone soils of the dark prairie lands to the alluvial soils of river valleys, to thin sandy soils and poor red-clay soils. There are seven major soil groups in Oklahoma. The following is a breakdown of these groups:

Alfisols are found in central, south central, eastern, and western Oklahoma. They occur in climates that have a period when evapotranspiration (the rate at which water evaporates from the soil or is removed by plants) exceeds precipitation. Mollisols are commonly dark colored, base-rich soils of the grasslands that are found in central, western (including the central panhandle), eastern, and northeastern Oklahoma. They cover a larger area of Oklahoma than any other soil type.

Natural Vegetation



Source: Oklahoma in Maps, 1979

Generalized Soils

Source: Oklahoma in Maps 1979

Utisols occur only in eastern Oklahoma. They are usually found in warm and humid climates and are associated with a seasonal deficiency of rainfall. Low fertility and low base saturation in these soils are the major limitations to agricultural use. Inceptisols occupy a large portion of western Oklahoma and are found in climates where there is some leaching (filtering out) of soil nutrients. Vertisols occur mostly in southeastern Oklahoma and extend into Texas. They are clay soils that develop deep, wide cracks that allow the soil to be moistened from both above and below. Entisols occur mostly in floodplains and on steep slopes throughout the state. They show little or no evidence of active soil formation. Entisols found in western Oklahoma are shallow soils that show limited evidence of weathering processes. Stony Rockland areas, which are actually surface features and not a soil, are located in southwestern and south central Oklahoma and can be found in three small areas that boast a very rocky soil type.

Congress created the Soil Conservation Service in 1935 to protect topsoil from becoming badly eroded by poor agricultural practices. Oklahomans were among the first to take advantage of the Soil Conservation Service, establishing the first soil conservation district in the United States.

Through the years, prior to statehood and even to the present, Oklahoma's most valuable resource has been its resourceful and imaginative people. For as many years, they have chosen numerous and varied official state symbols to recognize their special interests. Many of the state symbols come with stories as colorful and unusual as the symbols themselves. One of the more recently adopted state symbols was the selection of Port Silt Loam to represent the state soil for Oklahoma. This state soil was added to the list of state symbols by the state legislature in 1987.

Why have a state soil? The citizens of Oklahoma should have a keen awareness that soil is one of the most valuable resources. Food and much clothing and shelter come from plants growing in the soil. Individual and group action since statehood shows better care of this resource is important to the livelihood and well being of Oklahomans. More than 100 million tons of topsoil wash or blow away each year. Therefore, naming a state soil provides an educational purpose. It brings attention to the importance of soils and to the importance of conservation.

Oklahoma has a variable climate and many kinds of geologic materials. These factors greatly influence the formation of different kinds of soil. More than 2,500 different kinds of soil are found in Oklahoma. Some soils are naturally fertile, and others are very limited in productivity. No one individual soil occurs throughout the state.

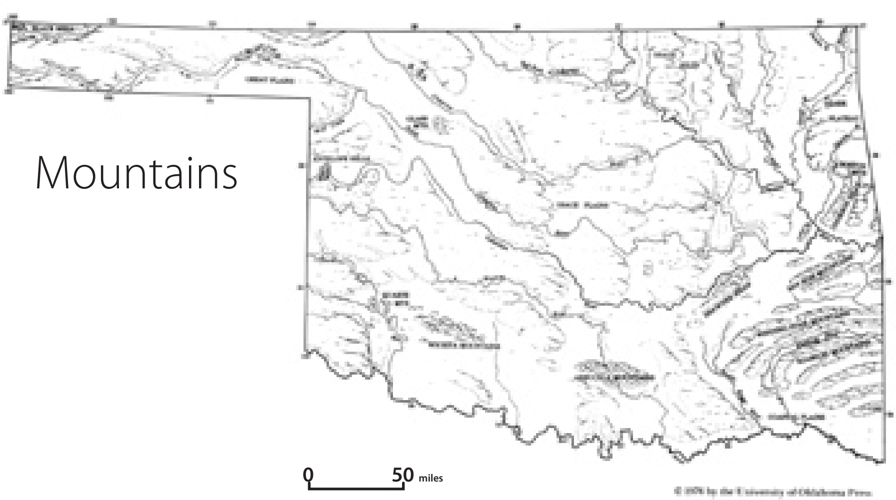
Port Silt Loam, the state soil, was selected because it occurs in more counties (thirty-three), and in about one million acres, more than any other particular soil. The Port soil is deep, well drained, and has a high productivity potential. It is suited for the production of alfalfa, cotton, wheat, sorghum, oats, and other sown crops. Port soil is usually dark brown to dark reddish brown, with the color derived from upland soil materials weathered from reddish sandstones, siltstones, and shales of the Permian Geologic Era. The natural soil supports a native, undisturbed vegetation of tall prairie grasses, with an overstory of pecan, walnut, bur oak, and cottonwood trees. This native condition offers a very desirable habitat for most of Oklahoma's wildlife species.

Soils are often named after an early pioneer, town, county, community, or stream in the vicinity where they are found. The name "Port" comes from a small community located in Washita County. The name "silt loam" is the texture of the topsoil. This texture consists mostly of silt-sized particles (.05 to .002mm) and when the moist soil is rubbed between the thumb and forefinger, it is loamy to the feel, thus the term "silt loam."

Mountains and Streams

Kenneth S. Johnson, Oklahoma Geological Survey

Mountains and streams have defined the landscape of Oklahoma in the geological past, and have helped create a beautiful landscape. Resistant rock masses have been folded, faulted, and thrust upward to form the mountains, while the streams have persisted in eroding less-resistant rock units and lowering the landscape to form the broad valleys, hills, and plains so typical of Oklahoma.



Mountains

Mountains are important not only because they expose much of the mineral wealth needed for the state's growth and industrial development, but, along with lakes and streams, they provide the unexpected beauty of Oklahoma's recreational areas. Although the three principal mountain systems —**Wichitas, Arbuckles, and Ouachitas**—occur in southern Oklahoma, other mountainous and hilly areas extend across many parts of the state.

The **Wichita Mountains** in the southwest consist of a core of granite, rhyolite, and other igneous rocks emplaced during the Cambrian Period of geologic time, about 525 mya (million years ago). On the northeast they are flanked by thousands of feet of folded and steeply dipping marine limestones and other sedimentary rocks deposited during Late Cambrian and Ordovician time (515–425 mya). The relief between the hilltops and nearby lowlands generally ranges from 400 to 1,100 feet, and the highest elevation, about 2,475 feet above sea level, is on an unnamed peak four miles east, southeast of Cooperton. The best-known peak, Mount Scott, with a summit of 2,464 feet, can be reached by car or bus and commands the most spectacular view of the area. Important mineral resources produced here are granite, limestone, sand and gravel, and oil and gas. The mountains have been prospected, with limited success, for gold, silver, copper, lead, zinc, aluminum, and iron ores.

The **Arbuckle Mountains***,* an area of low to moderate hills in south-central Oklahoma, contain a core of Precambrian granite and gneiss (a metamorphic rock) formed about 1,300 mya. Most of the Arbuckles consist of 15,000 feet of folded and faulted limestones, dolomites, sandstones, and shales deposited in shallow seas from Late Cambrian through Pennsylvanian times (515–290 mya). Relief in the area ranges from 100 to 600 feet, with the highest elevation, 1,415 feet, in the West Timbered Hills, about seven miles west of Interstate 35. Although low, the relief is still impressive, as it is six times greater than any other topographic feature between Oklahoma City and Dallas, Texas. Two significant features in the mountains are the deep roadcuts on I-35, and the "tombstone topography," which looks like rows of tombstones in a field, and is the result of differential weathering and erosion of alternating layers of hard and soft limestone. The Arbuckles contain the most diverse suite of mineral resources in Oklahoma. Limestone, dolomite, glass sand, granite, sand and gravel, shale, cement, iron ore, lead, zinc, tar sands, and oil and gas are all minerals which are being produced or have been produced here.

The **Ouachita Mountains** (pronounced "Wa-she-tah"), in southeast Oklahoma, are made up of rocks deposited in a deep sea that covered the area from Late Cambrian through Early Pennsylvanian time (515–315 mya). The area was then folded and faulted in such a manner that resistant beds of sandstone, chert, and novaculite (a fine-grained silica rock, like flint) now form long, sinuous mountain ridges that tower 500–1,500 feet above adjacent valleys formed in easily eroded shales. The highest elevation is 2,666 feet on Rich Mountain. Major individual ridges within the Ouachitas are Winding Stair, Rich, Kiamichi, Blue, Jackfork, and Blackjack mountains. Mineral resources include limestone, quartzite, sand and gravel, asphaltite, lead, oil, and gas.

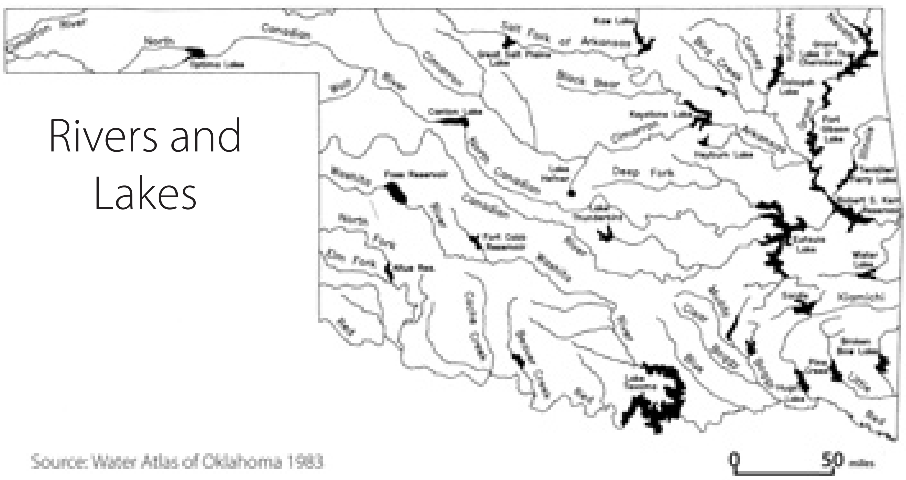
Mountains of the Arkansas River Valley are another group of high hills and mountains scattered in the Arkansas River Valley of east-central Oklahoma. They include Sans Bois, Cavanal, Sugar Loaf, Poteau, Beaver, Hi Early, and Rattlesnake mountains, among others. These mountains typically are broad featured, capped by thick and resistant sandstones that stand 300–2,000 feet above the wide, hilly plains formed on thick shale units. These sandstones and shales, deposited in the shallow seas and coastal areas covering eastern Oklahoma in Early and Middle Pennsylvanian times (330–310 mya), were broadly uplifted and folded during the Middle and Late Pennsylvanian uplift of the Ouachita Mountains. The largest mountain area is the Sans Bois Mountains, north of Wilburton and Red Oak. The highest summit, Sugar Loaf Mountain, is eight miles east of Poteau, and, at 2,568 feet, rises 2,000 feet above the surrounding plains. Principal mineral resources of the area are coal, oil and gas, clay, building stone, sand and gravel, and volcanic ash.

The **Ozark Plateau**, or the Ozarks of northeast Oklahoma, is best described as a deeply dissected plateau. Bedrock units in the area are mostly flat-lying limestones and cherts deposited in shallow seas during the Mississippian Period (365–330 mya).

To the south and southwest, the Ozarks include outcrops of sandstones and shales deposited in shallow seas and coastal areas during Early Pennsylvanian time (330–315 mya). The Ozarks, including the Brushy or Boston mountains, were broadly uplifted during, and since, Pennsylvanian time causing streams to be incised into the bedrock. Relief in the Ozarks is 50 to 400 feet, typically, and the highest elevation, 1,745 feet, is on Workman Mountain, eight miles east, southeast of Stilwell. The beauty of the Ozarks and the abundant clear-water lakes have spawned many state parks. Important mineral resources being produced are limestone, shale, cement, tripoli, sand and gravel, oil, and gas. In the north is the world-famous Tri-State lead-zinc mining district (Miami-Picher area), which led the United States in zinc production almost every year from 1918–1945, and finally was closed in 1970.

The **Glass Mountains**, in north-central Major County, about six miles west of Orienta, are an area of badlands topography, and are a prominent feature of the Blaine escarpment that extends southeast to northwest across northwest Oklahoma. Outcropping rocks are red-brown shales and siltstones, capped by several beds of resistant white gypsum; all were deposited during the Permian Period (about 270 mya). Much of the gypsum looks like glass fragments, and hence the name, "Glass Mountains." "Mountains" is a misnomer; they are actually prominent mesas, buttes, and escarpments. Flat-lying beds of caprock gypsum and underlying shales originally extended far to the north and east, but have been eroded back to the south and west to their present position. The local relief generally ranges from 150 to 200 feet, and the elevation at the top of the high buttes is about 1,585 feet.

Black Mesa, in the northwest corner of the Oklahoma Panhandle, is the highest point in the state, with an elevation of 4,973 feet. It is a plateau that rises about 600 feet above the adjacent Cimarron River and North Carrizo Creek. In Oklahoma, Black Mesa is 0.5 to one mile wide and three miles long, and is the erosional remnant of a finger-like basaltic lava flow extruded from a volcano in southeast Colorado. The lava flow formed during Tertiary time, about two to four mya, and occupied what was then a broad valley.



Streams

Oklahoma's stream systems, in terms of geologic time, are temporary as to location and flow rates. Eventually, streams will cut deeper, and their tributaries will erode nearby uplands, thereby shifting their positions. Major drainage systems in Oklahoma were initiated during the Pleistocene Epoch of geologic time (the last 1.65 million years or so), a time characterized by erosion in Oklahoma. Pleistocene terrace deposits, one hundred feet to more than 300 feet above modern flood plains, attests to the great erosion and downcutting performed by major rivers in this period.

Oklahoma's two major river basins are the **Red River** and **Arkansas River** basins. Flowing into Oklahoma from six neighboring states, all the surface water leaving the state flows into Arkansas via the Red, Arkansas, and Little rivers, and Lee Creek. The major rivers and their tributaries flow to the east and southeast across Oklahoma.

Red River and its tributaries drain about 23,000 square miles in the southern third of the state. The westernmost headwaters of Red River is a small tributary, Frio Draw, which begins about thirty miles south of Tucumcari, New Mexico. It flows across the Texas Panhandle through Palo Duro Canyon, and then marks Oklahoma's southern border (517 river miles) with Texas. From there it flows through Arkansas into Louisiana, where it joins the Atchafalaya River and enters Atchafalaya Bay and the Gulf of Mexico.

At the southwest corner of Oklahoma, the main stem is called Prairie Dog Town Fork Red River (PDTFRR); it is joined by Buck Creek two miles farther east, and from that point eastward, it is officially called Red River. Lake Texoma is the only reservoir on the main stem of Red River in Oklahoma; it holds the largest volume of water, 2.6 million acre feet, in the state, and has the second largest surface area of 88,000 acres. The tributaries to Red River have many other important lakes and reservoirs, such as Altus, Foss, Ellsworth, Waurika, Arbuckle, McGee Creek, Sardis, Hugo, Pine Creek, and Broken Bow.

Major Oklahoma tributaries to Red River include Salt Fork Red River, North Fork Red River, and Washita River, all of which contribute flow into Lake Texoma. Other tributaries are Muddy Boggy Creek, and Kiamichi and Little rivers, each having its own tributary system. There are also many other rivers and creeks that flow directly into Red River. At the southeast corner of the state, Red River has an elevation of 305 feet. The lowest elevation in the state, 287 feet, is twenty miles to the north where Little River enters Arkansas.

The **Arkansas River** and its tributaries drain the northern two-thirds of Oklahoma, nearly 47,000 square miles. The source of the Arkansas River is near the town of Leadville, Colorado. The river flows eastward across southeast Colorado and western and central Kansas, turning south to enter Oklahoma at Kay County, north of Ponca City. It crosses northeast Oklahoma to leave the state at Fort Smith, Arkansas.

Much of the Arkansas River has a series of locks and dams, the McClellan-Kerr Navigation System, that link Oklahoma with barge traffic to the Mississippi River. Major lakes and reservoirs on the main stem of the Arkansas River include (from the southeast) Robert S. Kerr, Webbers Falls, Keystone, and Kaw. On the Canadian River, a major tributary to the Arkansas in eastern Oklahoma, Eufaula Lake has the largest surface area in the state, with 105,500 acres, and the second largest volume with 2.3 million acre-feet. Many tributaries to the Arkansas River have important lakes and reservoirs, such as Canton, Great Salt Plains, Hefner, Overholser, Thunderbird, Carl Blackwell, Hulah, Skiatook, Oologah, Fort Gibson, Hudson, Tenkiller Ferry, and Wister.

Major tributaries to the Arkansas River include the Canadian, North Canadian (named Beaver River in the Panhandle, above Wolf Creek), and Deep Fork rivers, all flowing into Eufaula Lake. Others are the Cimarron, Salt Fork, Caney, Verdigris, Neosho (Grand), and Illinois rivers, each having its own tributary system. Many other rivers and creeks flow directly into the Arkansas River. The lowest elevation, 385 feet, is where the river flows into Arkansas at Fort Smith.

The **Scenic Rivers** of Oklahoma have such exceptional beauty and recreational value that six of them have been officially designated as "scenic rivers," and are protected by the state legislature. One scenic river is in the Red River System—the upper part of Mountain Fork, which flows into Broken Bow Lake in the Ouachita Mountains. The other five scenic rivers are in the Arkansas River System, in the Ozark Plateau, and include parts of the Illinois River and parts of Flint, Baron Fork, Lee, and Little Lee creeks.

The **Salt Plains and Saline Rivers** are an unusual feature of the Oklahoma landscape. Natural dissolution of bedded salt (deposited during the Permian Period, about 270 mya) occurs at shallow depths in several parts of northwest and southwest Oklahoma. The resultant high-salinity brine seeps to the surface in some of the state's rivers. In the Arkansas River drainage, Great Salt Plains on Salt Fork covers about twenty-five square miles and is the largest salt flat. Others are Big Salt Plain and Little Salt Plain on Cimarron River, and Ferguson Salt Plain just north of Watonga in Blaine County. In the Red River drainage, the Caney, Kiser, and Robinson Salt plains are on Elm Fork in northern Harmon County, south of Erick. All of these Oklahoma salt plains discharge brines to the Arkansas and Red River systems, thus degrading the river waters and making them generally unsuitable for industrial, municipal, or irrigation uses in parts of western and central Oklahoma. The saline river waters are diluted by fresh-water inflow downstream from the salt plains, and thus the water is mostly usable by the time it reaches Keystone Lake and Lake Texhoma. Although the salt plains degrade the river waters, like most of nature's checks and balances they are a necessary part of the environment for the area's inhabitants, and they provide yet another aspect of the beautiful geological areas of the state of Oklahoma.

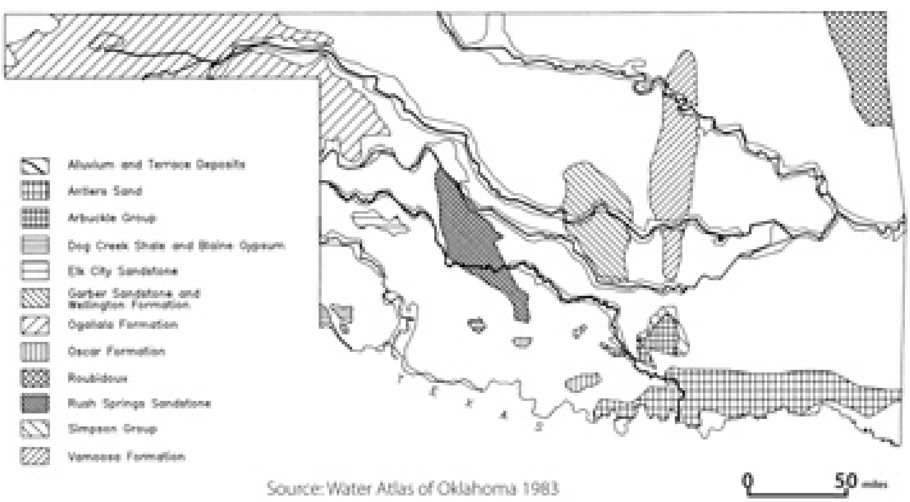
Water

Oklahoma contains thirty-four major reservoirs with a combined surface area of 543,450 acres and storing more than 13 million acre-feet of water. The state's largest lake in surface area is Eufaula (105,000 acres); Lake Texoma is second (88,000 acres). The state's largest lake in conservation storage is Texoma (2.6 million acre-feet of water); Eufaula is second (2.3 million ac-ft). Evaporation and percolation preclude immediate use of approximately 80 percent of Oklahoma's water. Average annual lake evaporation ranges from forty-eight inches in the extreme east to sixty-five inches in the southwest, numbers that far exceed the average yearly rainfall in those areas.

Groundwater is the prevalent source of water in the western half of the state, accounting for almost 90 percent of the total irrigation water use in Oklahoma. Underneath the state are twenty-three major groundwater basins containing 320 million acre-feet of water in storage, though only one-half of that amount may be recoverable.

According to the Oklahoma Water Resources Board, irrigation is the number one use of water in Oklahoma; water supply is a close second, followed distantly by livestock watering. The majority of the state's surface water (approximately 60 percent) is used for public water supply, followed by thermoelectric power generation and irrigation. The largest total amount of freshwater withdrawn for irrigation purposes was in Texas County, followed by Cimarron and Beaver counties, all in the Oklahoma Panhandle. The largest amount of water withdrawn for water-supply purposes is in Cleveland County, followed by Comanche and Oklahoma counties. Livestock withdrawals are largest in Texas County, followed by Cimarron and Alfalfa counties. The largest total amount of freshwater withdrawn for thermoelectric-power generation purposes is in Muskogee County, followed by Rogers and Seminole counties.

Groundwater



Source: Water Atlas of Oklahoma 1983

Wildlife

From the time the Oklahoma Department of Wildlife Conservation was created as a one-man agency in 1909, department personnel have been working to provide quality hunting, fishing, and a variety of other outdoor recreational opportunities for outdoor enthusiasts. During these years, Oklahomans have seen deer and turkey populations rebound, pheasants become abundant, and even controlled hunts for elk have become a reality. Native sport fish are thriving, and introduced species have provided exciting fishing and economic boosts in many parts of the state.

Since its beginning, the department has become increasingly complex, employing the best qualified personnel and modern equipment in accomplishing its task of conserving the state's wildlife. The Fiscal Services section of the Oklahoma Department of Wildlife Conservation is responsible for selling licenses for hunting, fishing, and trapping in Oklahoma. About fifty different types of licenses are sold annually to resident and nonresident sportsmen, amounting to 40 percent of the department's total income. License personnel sell licenses at the central office in Oklahoma City, and through more than 1,200 license dealers statewide.

Hunting License Costs

For information call the Wildlife Division at 405/521–2739.

(As of 01/01/05)	Resident	Nonresident
Annual Hunting	$12.50	$85.00
Hunting & Fishing Legacy Permit	5.00	5.00
Lifetime Hunting	625.00	450.00
Lifetime Hunting and Fishing	775.00	650.00
Lifetime Hunting over 60	225.00	
Nonresident Five-Day Hunting License		42.50
Senior Citizen Hunting License	6.00	
Senior Citizen Hunting-Fishing License	10.00	
Turkey Tag	10.00	10.00
Deer—Gun Tag (Antlered and Antlerless)	20.00	201.00
Deer—Archery Tags	20.00	201.00
Deer—Primitive Firearms Tag	20.00	201.00
Youth Deer (Antlered and Antlerless) (Gun Only)	10.00	201.00
Trapping (General)	10.00	–
Bobcat–Raccoon–Gray Fox	10.00	51.00
Oklahoma Waterfowl Stamp	10.00	10.00
Lifetime Waterfowl Stamp	50.00	50.00
Federal Duck Stamp (Available at U.S. Post offices)	15.00	15.00

Oklahoma Fishing Regulations

For information about Oklahoma fishing, call the Fisheries Division at 405/521–3721.

	Resident	Nonresident
Annual Fishing	$20.00	$37.50
Lifetime Fishing	225.00	275.00
Fishing & Hunting Legacy Permit	5.00	5.00
Fishing (Non-resident 5 day)		18.50
Senior Citizen Fishing	6.00	
Senior Citizen Combination Fishing-Hunting	10.00	
Trout License	12.00	12.00
Lake Texoma License	12.00	12.00
Disability Fishing License	10.00	

Call 800/223–3333 from anywhere in the country, 24 hours a day, 365 days a year for instant Oklahoma Hunting and Fishing licenses.

Source: Oklahoma Department of Wildlife Conservation—www.wildlifedepartment.com

Natural Resources Programs

The natural resources section of the Department of Wildlife Conservation coordinates the Environmental, Wildlife Diversity, and Biodiversity programs in Oklahoma. The section works directly with the public to promote habitat improvement, environmental quality, and conservation management. The Wildlife Diversity Program coordinates research and inventories works on rare and endangered species such as least terns, Texas horned lizards, and red-cockaded woodpeckers; coordinates the Oklahoma Wildscapes program to encourage urban wildlife management; and conducts a number of wildlife observation activities, including the winter bald eagle tours, spring Watchable Wildlife Weekends, and summer Selman bat viewing. Call 405/521–4616 for information.

Conservation Education Program

The goal of the Conservation Education Program at the Oklahoma Department of Wildlife Conservation is to educate the citizens of Oklahoma concerning wildlife conservation issues and to help these citizens become more environmentally literate.

The largest program within Conservation Education is Project WILD (Wildlife in Learning Design), an interdisciplinary, supplementary, K-12 environmental education curriculum that emphasizes wildlife, habitat, and the importance of the interrelationship between humans and other animals and the environment. Project WILD is a cooperative program of the Oklahoma Department of Wildlife Conservation and the Oklahoma Conservation Commission, who distributes the materials via activity-oriented workshops. Workshops are given across the state for classroom and pre-service teachers, scout and 4-H leaders, daycare personnel, and other youth leaders.

The OK WILD School Site Grant Program provides funding for K-12 public and private schools to develop or improve an outdoor education site. Recipients are eligible to receive up to $500 and are encouraged to have the students participate in the actual planning and implementation of the site as well as use the outdoor learning area in the traditional manner.

The Oklahoma Resource Trunk Program provides educators with materials about four subject areas: arthropods, water, endangered species, and outdoor classrooms, that they may normally not have funds to purchase for use in their classrooms. The trunks can be checked out for three weeks for little or no cost. The Conservation Education program also provides free information, such as teaching units and posters. Call 405/521–3855 for information.

Fisheries

Boasting a landscape dotted by reservoirs, lakes, and ponds, and threaded with rivers, Oklahoma offers top fishing opportunities to thousands of anglers in the state. Seventy reservoirs equaling nearly 600,000 acres, one-half million acres of farm ponds, and 23,000 miles of rivers and streams place Oklahoma high in the state rankings for total surface acres of water. And not only does the state have the available water for good fishing, but fish species–both native and introduced–abound for Oklahoma anglers. Largemouth bass, crappie, channel catfish, white bass, sunfish, flathead catfish, blue catfish, sauger, paddlefish, spotted bass, and smallmouth bass all are native sport fish to Oklahoma waters.

The striped bass, a native to salt water, has been stocked in Texoma, Kaw, Keystone, Foss, and Canton reservoirs and has provided good fishing along with an economic boost in several areas. More recently, a hybrid between striped bass and the native white bass has been introduced and has become popular. Additionally, the walleye, introduced in the late 1960s, is another popular sport fish. And a cross between the walleye and sauger – called the saugeye – was introduced in the state.

In addition to the above introduced species raised in hatcheries, eight put-and-take rainbow trout fishing areas are maintained in the state. These areas are the Illinois River below the Tenkiller dam, the lower Mountain Fork River Trout Area below Broken Bow Dam, Lake Etling in Black Mesa State Park, below Carlton Lake in Robber's Cave State Park, the Quartz Mountain Trout Area, the Blue River Public Fishing and Hunting Area, Lake Watonga, and Lake Pawhuska. Also, brown trout have been introduced in the lower Mountain Fork River and the Illinois River. Call 405/521–3721 for information.

Game Species

Oklahoma sportsmen spend about 3.5 million man-days a year hunting for a variety of game species, including deer, elk, waterfowl, turkey, pheasant, and quail. In the fall of 2001, Oklahoma deer hunters had a harvest of more than 101,635 animals. Each year 1.5 to 2 million quail are harvested in Oklahoma. Call 405/521–2739 for information.

Conservation Districts

Oklahoma's eighty-eight conservation districts are legal subdivisions of state government organized by local residents. The entire state is divided into conservation districts, often but not always along county lines. Each conservation district office offers a variety of natural resource information including soil surveys. Conservation districts provide services to large segments of the public, including farmers, ranchers, community planners, public health officials, developers, educators, students, and rural and urban citizens. A directory of district offices, addresses and telephone numbers is available on the Conservation Commission's web site at **www.okcc.state.ok.us**.

Astronomical Phenomena for Oklahoma—2005 and 2006

Wayne Harris-Wyrick, Director, Kirkpatrick Planetarium

Eclipses

An eclipse occurs whenever the sun, Earth, and the Moon align in space. If the Moon is between the sun and Earth, a solar eclipse occurs. Whenever the Moon completely covers the sun, we get a total solar eclipse. Total solar eclipses are rather common. One or two occur every year somewhere on our planet. They are quite rare, however, for any given location. A total solar eclipse is visible only over a very narrow path on Earth's surface, although everyone for hundreds of miles either side of the path of totality sees a partial eclipse. During a partial solar eclipse, the Moon only covers a part of the sun's disk. They are more common from a given location, but much less spectacular.

On rare occasions, Earth experiences an annular solar eclipse. Since the Moon's distance from Earth varies slightly, it sometimes looks slightly smaller than the sun. The Moon is always nearly four hundred times smaller than the sun in actual size, but being four hundred times closer, it normally appears slightly larger. If a solar eclipse occurs when the Moon is farthest from Earth, it won't quite cover the sun. An "annulus," a ring of fire from the sun's edge, surrounds the Moon like a celestial donut in the sky. The rarest type of eclipse is a combination annual-total solar eclipse. During such an event, the Moon moves ever so slightly closer to Earth and what starts as an annular eclipse becomes a total eclipse during the middle of the event. Or it may begin as a total eclipse then become an annular eclipse as the Moon inches away from Earth.

If Earth passes between the sun and Moon, our planet blocks the sunlight striking the Moon's surface, and we see a lunar eclipse. A lunar eclipse, whether partial or total, is visible from most parts of Earth where it is night at the time of the eclipse.

The Moon's color and brightness both change dramatically during an eclipse. The overall brightness decreases by a factor of a hundred or more. During a total lunar eclipse, the color changes can appear rather bizarre. The brilliant white Moon may become copper-colored or turn deep blood red. No wonder such sights frightened ancient civilizations.

During 2005 and 2006, Earth will witness four solar eclipses, one total, two annular eclipses, and one rare annular-total eclipse. Only one of these solar eclipses will be visible from Oklahoma, and only barely so. The dramatic and rare annular-total eclipse, the first of the two-year period, happens April 8, 2005, in the middle of the Pacific Ocean. Oklahomans will witness less then ten percent of the sun covered beginning at 7:45 p.m. The total solar eclipse occurs March 29, 2006, but only observers in Africa and parts of Europe and Asia will get to witness it. The first annular eclipse takes place on October 3, 2005, and you will have to travel to Europe, Africa, or the Middle East to see it. For the other annular eclipse, you will have to travel to the middle of the Atlantic Ocean on September 22, 2006.

A lunar eclipse generally occurs at the full Moon either before or after a solar eclipse, and rarely on both such full Moons. Four lunar eclipses occur over the next two years, none of them full, one associated with each of the four solar eclipses. Oklahomans can observe two of them, but neither is very good. Those visible from Oklahoma include: April 24, 2005, at 4:54 a.m.; October 17, 2005, at sunrise (only the tail-end is visible from Oklahoma). The other partial lunar eclipses for the two-year period occur on March 14, 2006, visible from Africa and

Europe and September 7, 2006, which can only be observed from parts of Africa, India, and most of Asia and Australia.

Seasons

A common misconception holds that seasons come about because varying distance between Earth and the sun. Actually, Earth is closest to the sun in early January and at its most distant in early July. Seasons occur because our planet's north-south axis leans over a bit compared to our orbit around the sun. During summer, the North Pole slants toward the sun. We receive more direct sunlight and enjoy longer days. During winter, the North Pole tilts away from the sun. We receive less direct energy from the sun, and the shorter days mean colder temperatures. See the section *Determining the Sun's Position and Number of Hours of Sunlight Per Day*. The chart below lists the beginning time of the seasons for 2005 and 2006.

Year	Spring	Summer	Fall	Winter
2005	20 Mar, 6:34 am	21 Jun, 12:47 am	22 Sep, 5:24 pm	21 Dec, 12:36 pm
2006	20 Mar, 12:26 pm	21 Jun, 7:27 am	22 Sep, 11:04 pm	21 Dec, 6:23 pm

Moon Phases

The table below lists the phases of the Moon for 2005 and 2006. A full Moon rises at sunset. A new Moon is between Earth and the sun, and not visible. The quarter phases occur between the new and full phases. A Blue Moon refers to the second full Moon in the same calendar month. They happen, on average once every two and one-half years. Since February has only twenty-eight or twenty-nine days in it, and the full lunar cycle takes 29–1/2 days, February occasionally contains only three of the four lunar phases. The next three-phase February occurs in 2012. About every two or three decades, February's missed full Moon occurs on January 31, the second one in January, making another Blue Moon in March, a double Blue Moon year. The next double Blue Moon won't happen until 2018.

2005		2006	
New	Full	New	Full
Jan 10	Jan 25	Jan 29	Jan 14
Feb 8	Feb 24	Feb 28	Feb 13
Mar 10	Mar 25	Mar 29	Mar 14
Apr 8	Apr 24	Apr 27	Apr 13
May 8	May 23	May 27	May 13
Jun 6	Jun 22	Jun 25	Jun 11
Jul 6	Jul 21	Jul 25	Jul 11
Aug 5	Aug 19	Aug 23	Aug 9
Sep 3	Sep 18	Sep 22	Sep 7
Oct 3	Oct 17	Oct 22	Oct 7
Nov 2	Nov 16	Nov 20	Nov 5
Dec 1	Dec 15	Dec 20	Dec 5
Dec 31			

Meteor Showers

On any dark, clear night away from city lights, you occasionally see a brief streak of light zip across the sky. We often call them "falling stars" or "shooting stars." They are actually meteors, tiny bits of space rock that enter our atmosphere at speeds up to 150,000 miles per hour. At such speeds they heat the surrounding air to incandescence from friction and pressure, creating the streak of light we see.

Several times a year we see greater numbers of meteors for a few nights. These events are called meteor showers. Meteor showers come from comets. Comets are huge, dirty snowballs that orbit our sun like the planets. The sun's heat constantly boils the comet's icy body, freeing the trapped dirt and rock. The debris remains in the comet's orbital path around the sun.

As it revolves around the sun, Earth may cross a comet's orbital path. Earth will encounter the comet's orbit on or near the same day each year. Our planet slams into the debris trail, and we see a meteor shower.

Several meteor showers occur throughout the year. Meteor showers are named for the constellation they appear to radiate from. The list below contains the most active meteor showers. A typical shower produces only one meteor every minute or two, so perhaps "meteor drizzle" is a better term.

The Leonid meteor shower occurs on November 17. Its parent comet, Tempel-Tuttle, orbits the sun every thirty-three years. The debris is heavily concentrated behind the comet, so every thirty-three years we see a spectacular Leonid meteor shower. The comet passed by in 1966. That year the Leonids set the record for meteor shower activity with as many as 140 visible per second. The Leonids in 1998 peaked at around 1000 per hour. In 1999 through 2002, Leonid meteor shower displayed dramatic activity, but has decreased steadily ever since. While none of these showers were as active as the 1966 Leonids, they displayed numerous and bright fireballs. However, on the last outbound leg, the comet and its debris trail passed very close to Jupiter. Jupiter's massive gravity altered the orbital path of the comet and its debris, possibly ending Leonid meteor storms forever. That may not be the end of meteor showers from Comet Tempel-Tuttle, though. In another one hundred years or so, the comet will again pass near Jupiter, bending its course back close to Earth's orbit. Since the meteor shower will appear to come out of a different constellation, it will have a new name.

Generally, the best viewing time for a meteor shower is from midnight to six a.m. The farther away from city lights, the more meteors you can see. A full or third quarter moon (see Moon Phases) will also hinder meteor observations. The date listed for each shower is the evening before the a.m. peak. For example, to see the Perseid shower, stay up past midnight on August 11 to the early morning hours of the 12.

Meteor Shower	Date	# per hour
Quadrantids	3 Jan	50
Eta Aquarids	4 May	20
Delta Aquarids	28 July	20
Perseids	12 Aug	56
Orionids	21 Oct	25
Leonids	17 Nov	15
Geminids	14 Dec	50
Ursids	22 Dec	20

Planet Visibility

The closer a planet orbits the sun, the faster it moves. Mercury and Venus orbit so rapidly, changes in their positions can be noted almost night to night. While Mars moves more slowly than either Mercury or Venus, an "optical illusion" occasionally makes Mars appear to really zip across the night sky. When Earth and Mars are on the same side of the sun, Earth's orbital motion makes Mars appear to move much faster than normal, sometimes even backward. This is much like passing a slower moving car on the highway. From your point of view, that slower car appears to be moving in reverse. The same apparent reverse motion also happens with all of the planets beyond Earth, but for Mars the effect is most obvious. While Mars, Jupiter, and Saturn never actually backtrack in their orbits around the sun, they do appear to back up once in a while. The effect is similar to riding in a car and passing another car. From your point of view, the other car appears to go backward. It is an illusion due to the fact that you are faster than the other car.

It is generally not difficult to distinguish planets from stars. You've never sung the song "Twinkle, Twinkle Little Planet" because planets don't twinkle, stars do. Also, the visible planets Mercury, Venus, Mars, Jupiter, and Saturn are brighter than most or all of the stars in the night sky. Bright non-twinkling "stars" are most likely planets.

Mercury orbits the sun at one-third the distance Earth does. Most of the time it is too close to the sun to be visible from Earth. When we can see it, it is always low in the west immediately after sunset, or low in the east just before sunrise. You'll need to find an observing location free of hills, trees, buildings and other horizon obstructions. A view over a large lake should be helpful.

At best, Mercury rises little more than an hour before the sun or sets barely an hour after. As a result, Mercury is never seen in a dark night sky. It always floats in the twilight's glow, making it difficult to find. Mercury remains visible for generally no more than two or three weeks at a time. Binoculars help to locate Mercury in the twilight glow.

The best chances to see Mercury in 2005 and 2006 in the predawn hours occur for a week either side of August 20 and December 9 in 2005 and March 24, August 10, and November 22 in 2006. Evening twilight appearances of Mercury happen for about two weeks centered on March 24 and June 23 in 2005 and February 26 and June 9 in 2006.

Venus is the brightest celestial object after the sun, the Moon, and an occasional bright meteor. It is also the planet that comes closest to Earth. Like Mercury, it is only visible after sunset or before sunrise. Venus can be more than three times as far from the sun as Mercury, well above the sun's twilight glow. At such times, Venus shines like a brilliant searchlight in the night sky.

Because Venus orbits closer to the sun than Earth, it goes through phases like our Moon. Remember, planets don't make any light of their own. We see them only by reflected sunlight. As it approaches its closest point to Earth, between us and the sun, we see only a thin crescent. When it is on the far side of the sun, we see it nearly full. While our moon takes only a month to go through its phases, Venus takes a year and a half.

As the closest planet to Earth, it appears to be the largest. It is not, but its proximity makes it look big. At such times, a good pair of binoculars or any small telescope reveals the crescent shape of the planet, like a tiny Moon.

Because of its brilliance, Venus is often called the "Morning Star" when seen rising before the sun in the east and the "Evening Star" when in the west after sunset.

Venus begins 2005 visible in the morning hours just before dawn's rays begin lighting the eastern horizon. It quickly dives towards the sun, disappearing around the first of March. Over the remainder of the next two years, Venus makes two extended visits to our nighttime sky. It will be visible in the evening beginning in late April 2005 and will remain the "Evening Star" throughout the year. Venus rapidly dives into the evening twilight to disappear around January 15, 2006, only to reappear as the "Morning Star" very soon after. Venus graces the pre-dawn skies through September 2006 when it again passes behind the sun to make another evening appearance in late November.

Mars shines with a distinctive reddish-orange hue, unlike any of the other planets. In fact, Mars's color most resembles the star Antares in Scorpius (see Summer Star Chart). And since Mars and Antares shine with about the same brightness, it certainly makes sense that Antares is Greek for "the rival of Mars." Mars is visible in the morning skies as 2005 begins, and remains there rising earlier and earlier through mid-July, when it begins rising before midnight, moving into the late evening sky. It remains an evening object, moving slowly from the southeast towards the western horizon, throughout the remainder of 2005 and until late August 2006, where it finally succumbs to evening twilight. By the end of 2006, Mars has crept from behind the sun and becomes visible again in morning twilight by the first of December.

Jupiter, our solar system's largest planet, could swallow 1,300 Earths. Jupiter and the other outer planets move very slowly as they orbit the Sun, so slowly that these planets may spend an entire year, perhaps even a decade, within the same constellation. Jupiter begins 2005 in Virgo, rising about 1:00 a.m. It remains a morning object until it moves into the late evening sky in early March. It rises earlier and earlier in the evening sky, where it lingers until near the end of September. Jupiter then passes behind the sun and reappears in the morning twilight near the Virgo-Libra border in early November. The giant planet moves into to Libra and remains visible in the morning skies through early August 2006, but by late March when it slides into the late evening skies by rising before midnight. By late October, Jupiter disappears behind the sun again to reappear in Scorpius in early December's pre-dawn skies.

Saturn, moving even slower than Jupiter, begins 2005 high in the east after sunset in Gemini, but by July, as it moves behind the sun, the ringed planet also moves towards Cancer. Look for its soft, yellowish glow during the cold evenings of late winter and spring. When Saturn reappears in morning twilight it is fully into Cancer, where it will remain until September 2006, when it majestically glides into Leo. Saturn remains in the morning sky until it crosses into late evening in early February 2006. It will remain an evening object until it is again swallowed by the sun at the end of June, reappearing in the morning sky and in Leo in early August 2006.

Uranus, **Neptune** and **Pluto** all are so far from the sun they seem to barely creep along in the sky, moving very little over the course of two years. Uranus, just barely visible to the unaided human eye from a dark location, spends 2005 and 2006 in Aquarius. Neptune spends the entire period of time in Capricorn, and faint Pluto sits on the border of Serpens and Sagittarius. You will need a telescope to see either of these two faint planets.

Both Uranus and Neptune begin 2005 close to the sun, low in the west. They disappear in evening twilight glow early in the year and reappear as morning objects by early April where they remain until they slip into the late evening sky in July, where they remain for the remainder of 2005. The same visibility pattern repeats in 2006.

Pluto, visible only through a large telescope, rises an hour before the sun to begin both 2005 and 2006. It drifts higher in the morning sky until early May when it drifts into the late evening sky, where it remains until it is too close to the sun in mid-November. It is blocked by the sun for almost two months and reappears as a morning object around December 20. This same pattern holds for both 2005 and 2006.

A **Conjunction** occurs whenever two or more objects in our solar system appear close together in our sky with one due north of the other. Many millions of miles separate the bodies in space, but from our viewpoint on Earth they seem to be very close. Two planets very rarely "line up," appearing as one bright object, but several conjunctions occur over the two-year period including some very close ones. While the table below lists times when two or more bodies within our solar system appear close together as seen from Earth, the planets, Moon and Sun move constantly, changing their relative positions nightly. On an even longer time frame, the stars themselves slowly move in their individual orbits around the Milky Way galaxy. Every night, every hour, every minute presents an unique astronomical sight, never exactly the same as any other instant of time, ever.

The conjunction between the Moon and Jupiter on May 19, 2005, provides a rare opportunity to study a planet in the daytime. The Moon passes within half a degree, one Moon diameter, of Jupiter at 3:30 pm on that day. But the two objects are just below the eastern horizon then. By 4:50, they are well above the horizon. The 82 percent full moon will be easily spotted in the afternoon daylight, and Jupiter will still be one degree above the Moon. Jupiter shines brightly enough to be spotted in daylight, and if you know where to look, the Moon can lead you to Jupiter.

The table below lists the good conjunctions to watch for in 2005 and 2006. For conjunctions between the Moon and a planet to be listed, the two objects appear no more than two Moon diameters, one degree, apart. Planet-planet conjunctions are listed when the two planets are within three Moon diameters or one and a half degree of each other. In all cases, the pair must be at least six degrees above the horizon, roughly the width of a fist held at arm's length, and the sun is at least six degrees below the horizon. Three-way conjunctions (not true conjunctions: only two are north-south at any given time) are listed if the objects are within four Moon diameters or two degrees of each other. "Time" indicates the best time to view the conjunction, not necessarily the closest approach of the two bodies. The closest spacing between the two objects may occur in daylight or when they are below the horizon. Unless one of the objects is the Moon, a few hours difference in time will not make a great difference in the proximity of the two objects. Only those conjunctions of objects visible to the unaided human eye are listed. Neptune and Uranus are so faint, you will need at least a pair of binoculars to see them, and you will need a large telescope to see Pluto. A "syzygy" is a relatively grouping of several astronomical bodies but not a true conjunction.

Planet Visibility

Objects	Date	Time	Comments
Moon and Mercury	Oct 4, 2005	7:30 pm	Very low in west
Moon and Venus	Aug 8, 2005	8:30 pm	Closest after objects set
	Sep 6, 2005	8:30 pm	Closest after objects set
	Apr 24, 2006	6:00 am	Closest after objects rise
Moon and Mars	No close Moon-Mars conjunction occur in the period		
Moon and Jupiter	May 19, 2005	6:00 am	Closest after objects rise
Moon and Saturn	No close Moon-Saturn conjunction occur in the period		
Mercury and Venus	Jan 14, 2005	7:00 am	Very low in east
	Jun 27, 2005	9:20 pm	Closest conjunction of year
Mercury and Mars	Sep 15, 2006	7:30 pm	Very low in west
	Dec 10, 2006	7:20 am	Very low in east

Mercury and Jupiter	Oct 5, 2005	7:00 pm	Very low in west
	Dec 10, 2006	7:20 pm	Very low in west
Mercury and Saturn	Jun 26, 2005	9:30 pm	Best before sunset
Venus and Mars	No close Venus-Mars conjunction occur in the period		
Venus and Jupiter	Sep 1, 2005	8:30 pm	Low in west
Venus and Saturn	Jun 25, 2005	7:20 pm	Low in west, with Mercury
Mars and Jupiter	June 11, 2006	7:30 am	Low in east, with Mercury
Mars and Saturn	Jun 17, 2006	10:00 pm	Beehive star cluster nearby
Jupiter and Saturn	No close Jupiter-Saturn conjunctions occur in period		

Three-way Conjunctions

Mercury and Venus and Saturn	Jun 25–27, 2005	Low in west after sunset	
Moon and Venus and Mercury	Sep 7, 2005		Low in west after sunset
Moon and Mercury and Jupiter	Oct 4, 2005		Low in west after sunset
Mercury and Mars and Jupiter	Dec 10–11, 2006	Low in east before sunrise	

Daytime Syzygies

Venus and Sun and Jupiter and Mars and Mercury	Nov 29, 2006	27.50 total spread at noon	

Determining the Sun's Position
and the Number of Hours of Sunlight Per Day

Because of Earth's daily rotation, the sun, moon, and the stars appear to move slowly across the sky. They "rise" in the east and "set" in the west. Of course they do not really move; we do. Earth rotates from west to east, so the sun, moon, planets and the stars appear to move from east to west. Really, we are moving out from under them.

Over the course of a year, Earth orbits the sun, creating our seasons. This causes the sun's daily motion across the sky to vary at different times of the year. During summer, the sun passes nearly overhead. In winter, the sun arcs low across the sky in the south. The number of hours of daylight also varies with the seasons. Indeed this varying height of the sun, caused by Earth's tilt, and the subsequent varying number of daylight hours is the cause of our seasons. If Earth were not tilted, we would not have seasons and the amount of daylight would be constant.

The chart *Altitude and Azimuth of the Sun* (right) gives the sun's location in the sky for any day and time, and can be used to calculate the number of daylight hours.

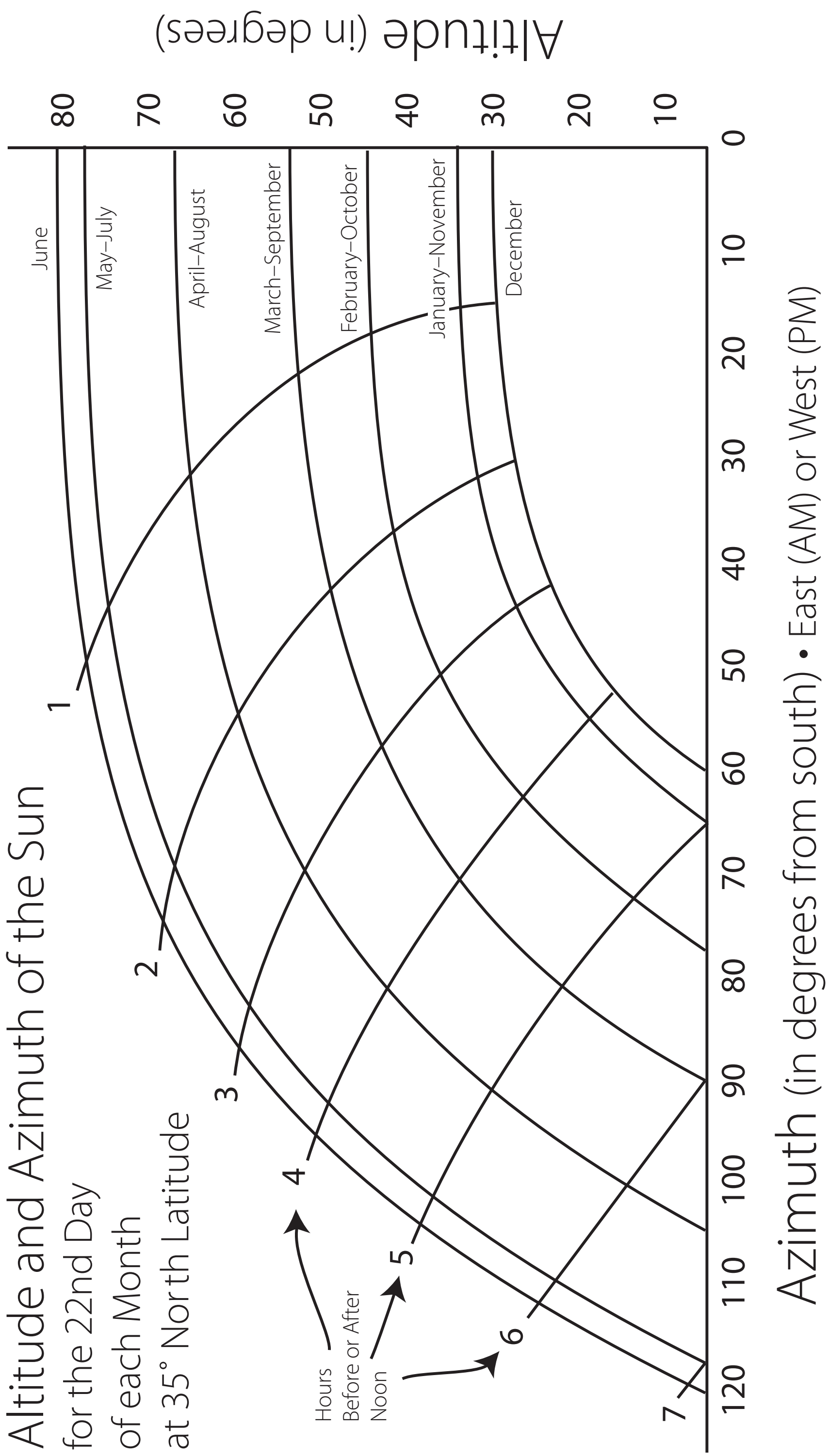
Altitude represents the height of the sun above the horizon, measured in degrees. The horizon is zero degrees. The point straight up at the center of the sky (the zenith) is altitude ninety degrees. Halfway up is forty-five degrees (see *How to Measure Distances and Time Using the Stars*). Azimuth represents the sun's compass direction, also measured in degrees. Due north is zero degrees, due east is ninety degrees, due south is 180 degrees, and due west is 270 degrees.

The graph shows the sun's altitude and azimuth throughout the day for the twenty-second of each month. Other days can be inferred easily from the chart. The sun's daily path is symmetrical in the morning and afternoon, so only half of the graph is shown.

At noon, the sun is due south (during daylight savings time, this occurs at 1:00; the sun does not care about saving daylight!). From the chart, the sun at noon would be zero degrees from south, or at azimuth 180. For morning hours, subtract the azimuth reading from 180; for afternoon hours add the reading to 180.

For example, on December 22, two hours before noon, the sun is at altitude twenty-six degrees, and is thirty degrees east of south or azimuth 150 (180 - 30). At 2:00, the sun would be thirty degrees west of south, azimuth 210 degrees (180 + 30).

On March and September 22, the sun rises six hours before noon, and sets six hours after noon, so both of those days are exactly twelve hours long (those happen to be the vernal and autumnal equinoxes, the first day of spring and fall, respectively). On June 22, the summer solstice, the sun rises a bit over seven hours before noon, so that day is nearly fourteen and one-half hours long, the longest day of the year.


Altitude and Azimuth of the Sun
for the 22nd Day
of each Month
at 35° North Latitude
Altitude (in degrees)
Azimuth (in degrees from south) • East (AM) or West (PM)
June
May–July
April–August
March–September
February–October
January–November
December
Hours Before or After Noon
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90
100
110
120

Astronomy Clubs, Planetariums, and Observatories

For those interested in further information on astronomical phenomena, the best sources are local astronomy clubs and planetariums. Astronomy clubs allow you to meet people who share a common interest. Clubs also provide opportunities to view astronomical objects through a telescope. Should buying a telescope be in your plans, clubs provide opportunities to “test drive” different telescopes before you buy one.

It’s hard to beat the ability of a planetarium for teaching about the night sky. These domed theaters simulate the night sky beautifully, providing better views of the heavens than our light-polluted cities. Most offer a regular schedule of public performances as well as school field trips with programs geared around public school curriculum. Some planetariums also include educational exhibits.

Oklahoma has few observatories, and most of those are privately owned. While membership in an astronomy club often provides access to a telescope, public-use observatories usually have larger instruments in a permanent, stable installation. They often have equipment for viewing celestial objects in a way astronomy clubs cannot offer. Since universities or planetariums operate most public observatories, professional astronomers who offer greater insight or detailed explanations to questions often run the programs. Those listed below offer public viewing, but call ahead. The schedule may be limited or offered by reservation only.

Telescopes dealers not only maintain a selection of astronomical telescopes and binoculars, they often provide free handouts on various aspects of astronomy. If a telescope is in your future, it’s worth sending for catalogues.

Astronomy Clubs

Arbuckle Astronomy Society
Star Rte., Box D-2
Lone Grove, OK 73443

Astronomy Club of Tulsa
PO Box 470611
Tulsa, OK 74147

Cimarron Star Gazers
PO Box 278
Boise City, OK 73933

Northwest Oklahoma Astronomy Club
1719 Pawnee
Enid, OK 73703

Oklahoma City Astronomy Club
PO Box 21221
Oklahoma City, OK 73156

Odyssey Astronomy Club
5606-B S.E. 15th St.
Midwest City, OK 73110

Planetariums

Kirkpatrick Planetarium
2100 NE 52 St
Oklahoma City, OK 73111
405/602–3761

Oklahoma Baptist University
Shawnee, OK 74801
405/878–2028

Tulsa Air and Space Museum
7130 E Apache St, Tulsa, OK 74115
918/834–9900

Observatories

University of Oklahoma
Physics and Astronomy Dept.
400 W Brooks, Norman, OK 73019
405–325–3961

RMMC Observatory
PO Box 470611, Tulsa, OK 74147
918–636–6682

Light Pollution

Today, people who live in or near large cities have lost the beauty of the night sky. From within or near even small cities and towns, many stars are washed out by the increasing use of outdoor lighting at night. The graceful arch of the Milky Way across the night sky is visible only well away from urban lighting.

While there is a great need for nighttime lighting, there are adverse effects created by the many sources of outdoor light. Glare, light trespass, and light clutter contribute to inferior nighttime environment, reducing visibility and safety. Light, and the energy used to create it, are wasted if put where it is not needed, such as beaming upward into the night sky. It is simply wasted light, energy, and money.

Light that shines directly into a driver's eyes from a streetlight does not aid the driver in seeing at night. This glare actually deteriorates the driver's ability to see, and could lead to an accident. A security light that sprays bright light over a large area may make it impossible to see into the dark shadows, and may help create the very problem it was meant to solve. Good lighting, properly directed, provides safety, security, and reduces cost and energy waste.

Astronomers suffer most severely from poorly designed and improperly aimed lighting. We have all seen billboards illuminated at night from upward-pointing lights. This lighting arrangement makes the beams of light visible for miles to drivers, calling attention to the billboard's message. While this may be a smart advertising ploy, it is terrible for astronomers trying to glean information from faint cosmic objects.

Many cities around major professional observatories have implemented outdoor lighting bans or strict lighting controls to aid astronomers. There are ways you can help in the fight against light pollution.

1. Use only as much light as you need, and put it where you want it. Excess light creates glare and dark shadows, both of which reduce safety and security. Use fixtures with recessed sockets, the type in which the lamp is not directly visible. This reduces glare and prevents stray light from getting up into the night sky.

2. Use the right kind of light. Incandescent light bulbs are not very cost effective. Vapor lights are generally cheaper. But not all vapor lights are equally good for astronomy. Mercury vapor lights shine with a bright blue-white light. High-pressure sodium vapor lights give off a yellowish glow. Both are commonly used in streetlights and home security lights.

Low-pressure sodium vapor lights are the best alternative for astronomy. They glow a deep yellow-orange color. That color makes objects look a bit odd, but this type of light has several advantages. They cost half as much as high-pressure sodium vapor lights and a third as much as mercury vapor lights to operate. Over the course of a year that savings could amount to millions of dollars for a typical city.

Since low-pressure sodium vapor lights emit a single color of light, it is very simple for astronomers to filter that light out. If all outdoor lighting consisted of low vapor sodium lights, astronomers would have no loss of ability to observe the heavens.

For more information about light pollution and proper lighting, write the International Dark-Sky Association, 3545 N. Stewart, Tucson AZ 85716.

How To Find Directions

Directions are easily found at night, if the sky is clear and if you know the constellations. Look at the four seasonal star charts on the following pages. On all four charts the constellation URSA MINOR is in the north. We commonly call Ursa Minor the Little Dipper. The star that marks the end of the Little Dipper's handle is Polaris, the North Star. That star is almost directly over Earth's north pole. As our planet rotates, causing the stars to appear to rise, move and set Polaris stays in the same spot, over Earth's north pole. Because of that special location, Polaris is the one star visible from the northern hemisphere that does not appear to move at all. It always marks the direction North.

In the daytime, we cannot use Polaris to determine North. But we can use the one star visible in the daytime, our sun. Our sun is always due south at solar noon. At that time, all shadows point due north. The problem is that solar noon does not occur when your clock says 12:00. Your location within your time zone affects exactly what the clock reads at solar noon. Because Earth orbits the sun in an ellipse, not a circle, the time from one solar noon to the next is not always exactly twenty-four hours.

To locate North, find a convenient pole (fence pole, flag pole, etc) or push a straight stick upright in the ground. When clock time reaches 11:15 a.m., start measuring the length of the pole or stick's shadow. The shadow gets shorter for the first few measurements, but eventually the shadow begins to lengthen. The shortest shadow occurs exactly at solar noon, and points due north.

To make such an activity more fun, try using people instead of sticks or poles. Go outside in the morning. While one student stands on a sidewalk or blacktop, have another trace out the location of the first student's feet. This is necessary so that the student can stand in the same place later. Trace out the standing student's shadow on the ground.

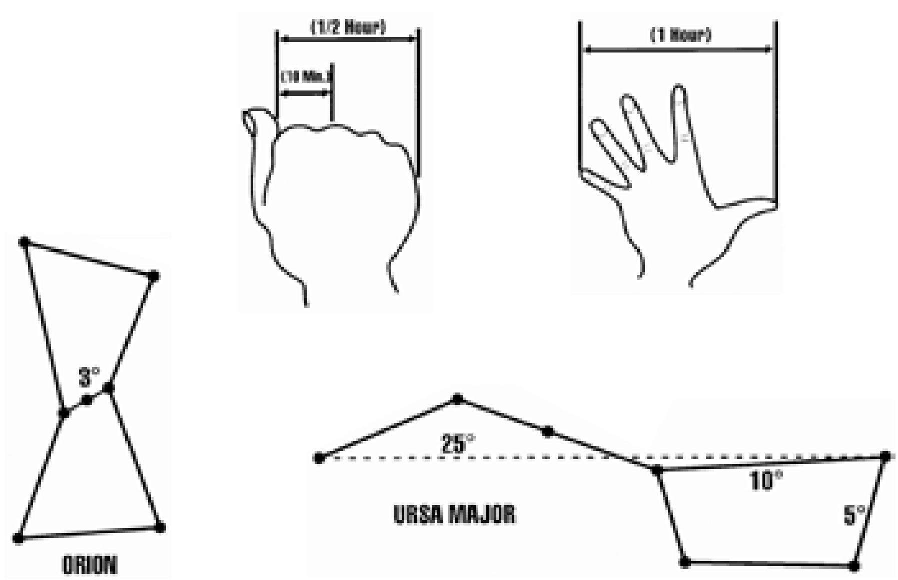
Come back to the same spot in the afternoon. Have the student place his feet in the exact same spot, as marked by the traced footprints. Once again trace the student's shadow. You now have a record of the different locations of the sun in the sky!

For young children, the concept of Earth's rotation is extremely difficult. After all, we do not feel any motion, although in Oklahoma we are moving at 850 miles per hour as Earth rotates. And we can easily see that the sun "moves" across the sky during the day and the Moon "moves" at night.

How to Measure Distances and Time Using the Stars

Distances in the sky are measured in degrees, just as the altitude and azimuth of the sun. Estimates of such distances can be made with your hand. Make a fist and stretch your arm out full length. The span across your knuckles from the first finger to the pinky equals ten degrees. Ten degrees is about equal to the span across the top of the Big Dipper's bowl. Stretch your fingers out wide and your hand spans about eighteen degrees, roughly two-thirds the width of the Big Dipper, or the distance diagonally across Orion *(see star maps)*. The space between your knuckles is about three degrees, the length of Orion's belt. These measures can be used to estimate position in the sky. At 10:00 a.m. December 22 the sun is twenty-six degrees above the horizon, or about 2.5 "fists" *(see Determining the Sun's Position)*. The highest the sun gets in Oklahoma is eighty degrees, or eight "fists" high.

The diagram indicates some distances using a few familiar constellations. Hand measurements let you quickly judge height or separation of objects in the sky. These hand measurements can be used to estimate the passage of time, too. Earth rotates once every day. In that twenty-four-hour period, Earth rotates through 360 degrees, or fifteen degrees per hour. By the time a star has moved the width of your outstretched hand, just over an hour has passed. Your closed fist measures about half an hour, and movement across your first two knuckles equals ten minutes. To measure the passage of time, note the location of some star, planet or the Moon near a tree, housetop, utility pole or other convenient marker, or find one near the eastern horizon. Periodically gauge its movement with your hand. Cowboys in the past measured time this same way when herding cattle at night.



Meteorites

Often while working in a field or yard, people stumble across an odd rock that just doesn't look or feel like other rocks in the area. These are often mistaken for a meteorite. Actual meteorite finds are quite rare, except in those areas near a known asteroid impact like the Barringer Crater near Flagstaff, Arizona.

Two common mistakes lead to most incorrect identifications of a terrestrial rock being a meteorite. Most people are not familiar with the variety of rocks that may be found in the area. Much of western Oklahoma is covered with red sandstone. Any other type of rock, especially dark-colored ones, may be mistaken for a meteorite by someone unaware that other types of rock might also exist in the area.

Often, rocks appear on the surface of a field where few if any other rocks are found, perhaps even in a small depression. Rocks buried underground can work their way up to the surface. You see a similar effect by opening a can of mixed nuts. The small peanuts are all at the bottom and the larger Brazil nuts and pecans lie on top. As the can of nuts is handled, the smaller peanuts fall through spaces between larger nuts, and the larger ones "float" to the top, even though they are much heavier than the smaller nuts. Large, dense rocks may work to the surface the same way.

Meteorites come in one of three types. **Iron meteorites** consist almost entirely of iron and nickel, and are thought to originate in the cores of large asteroids. Early in the life of our solar system, these large asteroids *differentiated,* that is iron, nickel, iridium, platinum and other metals sunk to the center, just as in Earth, while the object remained in a liquefied state. The asteroids cooled and solidified with a metallic core and a rocky surface. Later, massive collisions with each other broke them apart, freeing the pure metallic parts, the source of iron meteorites. The outer, rocky material provides the source for **stony meteorites**, while the interface between the two regions is the source for **stony-iron meteorites**. All meteorites contain at least small amounts of nickel and iron, just as these metals can be found at the surface of Earth.

Most meteorites possess properties that distinguish them from terrestrial rocks. Meteorites tend to be far denser than ordinary rock; typically two to three times their density. All meteorites share at least some affinity for a magnet, and most are highly attracted to one. Meteorites *never* have a spongy or porous structure on the surface or in the interior.

As a meteorite flies through the atmosphere at tremendous speeds, it creates great friction with the air molecules around it. The heat generated by the friction heats the air to incandescence, the glowing trail behind a meteor in the night sky. The surface of the meteorite gets quite hot too, but the meteorite came from space where its temperature may have been below -200^0 F. for millions or billions of years. The flight of a few seconds through our atmosphere cannot warm the interior, and within a minute or two, the meteorite is freezing to the touch.

The heat of passage through the air creates a black "fusion crust" on the meteorite, although it will weather to a rusty brown color within a few months or years. The surface of the meteorite is often slightly melted by the heat of atmospheric entry, leaving small indentations resembling thumbprints, or flow lines where melted material flowed over the meteorite. The interiors of most meteorites shine like metallic silver. Meteorites are almost never round or rough, but have irregular shapes and a smooth surface.

In many locations around Oklahoma, iron smelting occurred in the past. It may have been a railroad foundry works, an old army base or blacksmith shop. Bits of old iron slag exist in many of these places, and are often mistaken for a meteorite. They generally will have little or no attraction for a magnet, but will show metallic luster on the inside.

If You Suspect You Have Found A Meteorite

Smithsonian Astrophysical Observatory suggests that you ask the following:

Is the object **solid**, not porous? Yes or No

Is the object of **irregular** shape? Yes or No

Is the object very **heavy** for its size? Yes or No

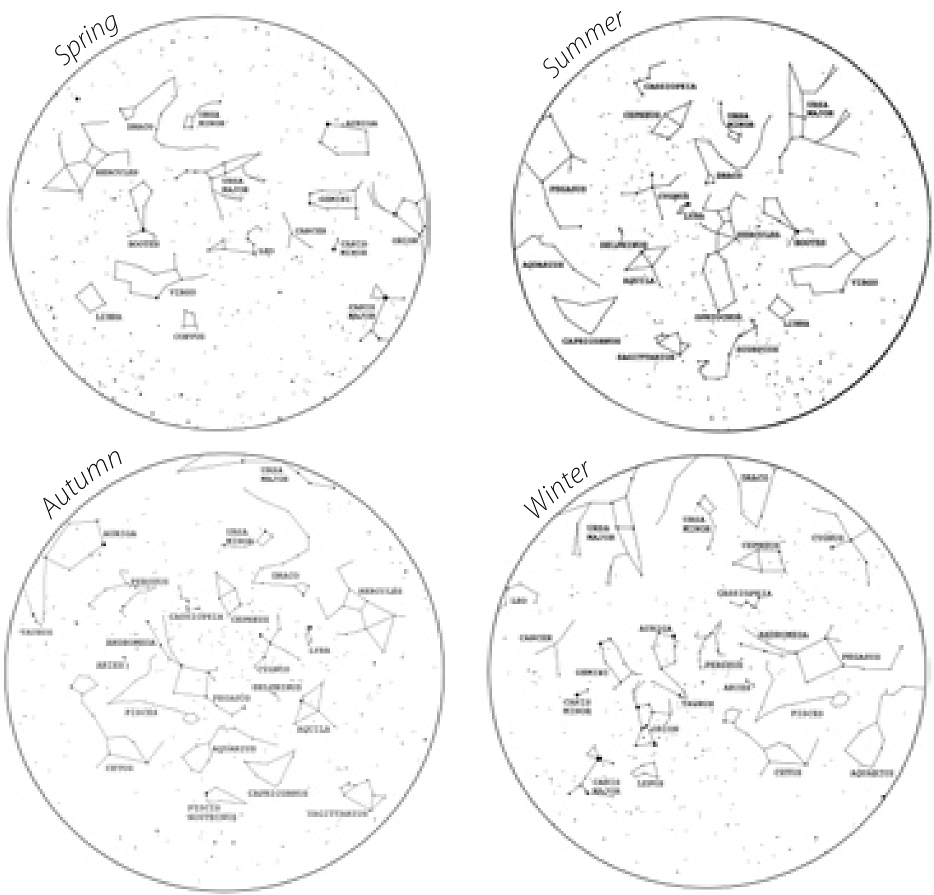
Is the object **black** or **brown** on the outside? Yes or No

Does the interior look **shiny** and **metallic**? Yes or No

Is the object **different** from the country rocks? Yes or No

If you answered, "Yes" to all these questions you almost certainly have a meteorite. If you answered "No" to most of the questions, it's probably not. With only one or two "No"s, it may still be a meteorite. Only sensitive chemical tests can answer the question for certain. Your local planetarium or university can usually recommend a testing facility. Inquiries may be made at the University of Oklahoma Department of Geology and Geophysics at 405/325–3253.

Star Charts for Evening Skys of Oklahoma



Life on Mars or Elsewhere in the Universe?

Life first appeared on Earth around 3.8 billion years ago; at least the oldest known fossils date from that time. Earth itself was formed 4.6 billion years ago, along with all the rest of the solar system. But for the first billion years of its existence, Earth was a molten ball of magma. Almost as soon as Earth cooled to a reasonable temperature, the first simple, one-celled life forms came into existence. All other life on Earth evolved from those first living cells. Today, life exists everywhere on Earth where the temperature is below the boiling point of water, and even in some places where water is hotter than that. In every environment on Earth where water exists, life does, too.

Mars formed at the same time Earth did. Today, Mars is a frozen world, where temperatures rarely climb above the freezing point of water. It has one percent as much atmosphere as Earth, and no ozone layer to protect the surface from deadly cosmic rays and UV radiation.

At one time, however, Mars was very Earth-like. Geological evidence suggests that it had a thick atmosphere, rivers, lakes, and oceans. In short, it was a perfect place for life to exist. And it reached those life-supporting conditions before Earth did. Did life form on Mars? No one knows yet, but if Earth is any example, it very likely did.

In the young solar system, numerous asteroids constantly slammed into the various planets. That is what kept Earth and the other planets molten for so long after formation. Remnants of that early bombardment still exist today, asteroids that occasionally slam into our planet. Oklahoma has only one known meteorite impact site, near Ponca City.

Earth's gravity is strong enough that asteroid impacts do not knock debris into space. But Mars is a lot smaller, possessing only one-third the gravity of Earth. Asteroid impacts can and do knock pieces of Mars into space. And some of those have landed on Earth.

In 1996, a team of NASA scientists made a remarkable claim. A meteorite from Mars found in Antarctica contained the fossilized remains of Martian bacteria, or so the scientists claimed. The rock was created by geological processes that generally occur in a wet and warm climate, a perfect place to support life. Some sixteen million years ago, an asteroid slammed into Mars, knocking some of the Red Planet's rocks into space. A piece of one of those Martian rocks, containing the alleged fossils, landed in Antarctica. After years of analysis of the evidence, few scientists believe that the objects found are indeed fossilized bacteria, but the debate is not over yet.

An important question remains: did life form on Mars before doing so on Earth? Many biologists believe that is indeed feasible. And since Mars reached life-supporting conditions before Earth did, it is possible that an asteroid struck Mars 3.8 billion years ago and blasted a piece of rock containing live bacteria into space that eventually crashed to Earth. There is a real possibility that all life on Earth was seeded by life forms that first appeared on Mars.

One might wonder if it is possible that any living entity could survive years in space with no atmosphere, water or protection from cosmic rays and UV radiation. Experiments from our Apollo Moon program indicate that the answer may be yes.

Prior to the first manned landings on the Moon, NASA sent several Surveyor spacecraft that soft-landed on the lunar surface. These were NASA's way of testing lunar landing procedure, making sure we could safely land people there. Apollo 15 landed very near one of the Surveyor spacecraft and NASA directed the astronauts to retrieve the camera on board for a return to Earth. When scientists studied the camera, they found to everyone's surprise, it contained dormant but living bacteria from Earth. The bacteria had survived for three years in conditions almost identical to what a Martian meteorite would face in traveling from Mars to Earth.

Recent studies of that same Martian meteorite from Antarctica, known as ALH 84001, prove that conditions in the rock's interior would have gotten no hotter than 1050’ not hot enough to kill any hitchhiking bacteria. On Earth, biologists have found bacteria living inside rock two miles below Earth's surface. Would Mars be any different? Probably not.

The answer to the question of life on Mars, extant or extinct, probably will not be answered for another twenty years or so, when we land the first humans there. But there is no scientific reason to doubt the possibility. If life did form on Mars, there's a very real possibility that Martian microbes hitching a ride on a meteorite from the Red Planet seeded life on Earth.

Recent spacecraft sent from Earth to study Mars have found water, lots of it, enough to fill all of the Great Lakes several times over. The water currently exists in the form of ice, but the deeper layers may be liquid. We also know that in at least some areas of Mars, sedimentary rocks formed in oceans, like much of the sandstone and limestone rocks in Oklahoma. There is an as yet unanswered question of whether those oceans lasted for a few thousand years or a few million years. If longer times frames are involved, life may have evolved there. On Earth, where water exists, so does life. Was Mars once inhabited, even if only by microbes, or even still inhabited? New missions to Mars will likely answer that question within a few decades.

Mars is not the only extraterrestrial location in our solar system that may harbor life. Jupiter's Moon Europa is, like Mars, a frozen world. Its surface is covered with a sheet of ice. But unlike Mars, Europa enjoys an extra source of heat beyond that coming from the sun. Jupiter, the largest planet with the strongest planetary gravitational field, possesses three other large moons: Io, Ganymede, and Callisto. Europa orbits Jupiter between Io, and Ganymede, the largest moon of our solar system. Europa is squeezed and pulled between the gravity of Jupiter, Io and Ganymede. This flexing heats the moon's core, probably to temperatures high enough that the ice melts into a liquid ocean below the frozen surface.

At the bottom of Earth's oceans, where volcanic activity continually creates new ocean floor, energy from geothermal volcanic vents heats localized areas well above the near freezing temperatures of the typical sea bottom. At these locations, bizarre life forms flourish, life forms found nowhere else on our planet. Many biologists believe that all life on Earth may have come from single-celled microbes that first evolved at these mid-ocean rifts. Similar geological processes likely exist on Europa, and it is entirely within the realm of biological possibility that some form of life exists on the ocean floors of Europa.

Potential homes for extraterrestrial life exist outside of our solar system as well. As of this writing, astronomers have discovered more than 150 planets orbiting other stars, with new discoveries announced regularly. Most of these extra-solar planets are the size of Jupiter or larger, and are not considered likely abodes of life. Smaller, Earth-like planets probably also exist out there, but our technology is not yet sufficiently advanced to detect them. Yet, as we have seen with Europa, moons of large planets may harbor life.

All life needs is temperatures capable of sustaining liquid water. Water is composed of two atoms of hydrogen and one atom of Oxygen. Hydrogen is the most abundant element in the universe while oxygen is the third most common, and their combination, water, is the most common compound in the universe (the second most widespread element, helium, is a noble gas and is not involved in chemical reactions). In at least one case, astronomers detected water vapor in the atmosphere of a large extra-solar planet. If the planet has water, any moons it has will also possess water. Within a few decades, we may find that humans are merely one member of a vast cosmic civilization.

Photograph courtesy—The Oklahoma Redhawks

Oklahoma Redhawks pitcher **Nick Regilio** stretches off the mound in a game during the 2005 season. Barely into the 2005 season Regilio was called up by the Texas Rangers, the Redshawks parent club.