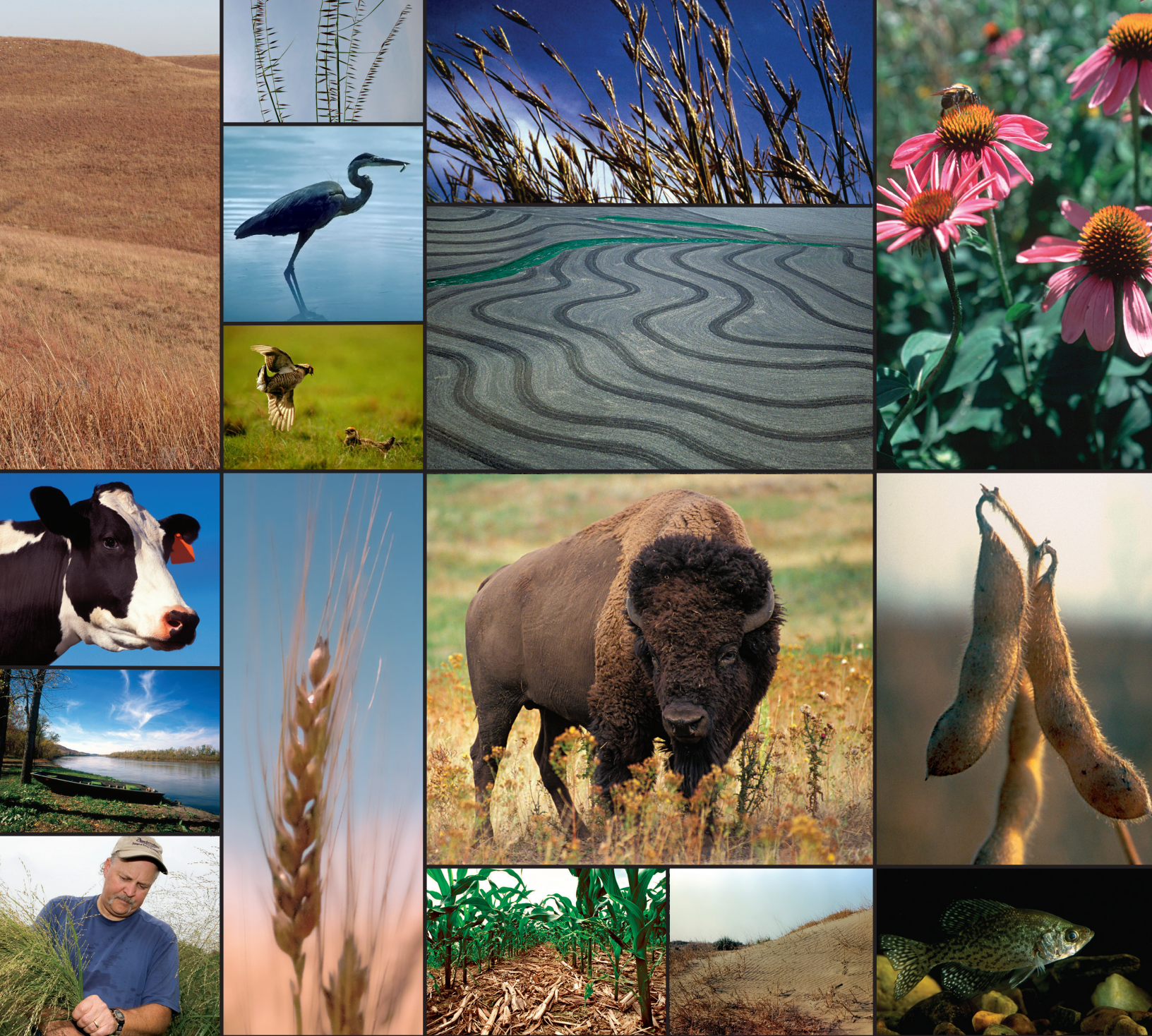




Kansas Foundation for Agriculture in the Classroom

Educator's Guide

Exploring Kansas Natural Resources



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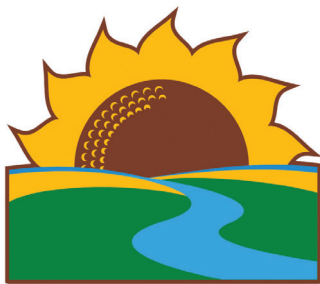
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Kansas Foundation for Agriculture in the Classroom

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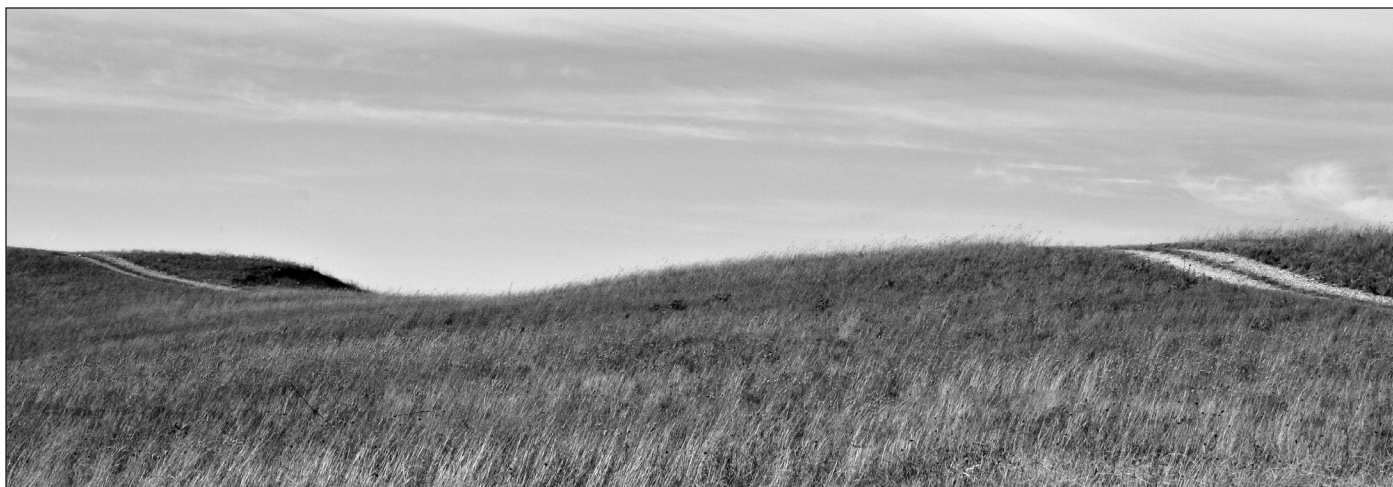
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Exploring Kansas Natural Resources

*"In the end, we will conserve only what we love.
We will love only what we understand.
We will understand only what we are taught."*

Baba Dioum, Senegalese agricultural policy-maker

The Kansas Foundation for Agriculture in the Classroom (KFAC) is proud to present Exploring Kansas Natural Resources – the latest in a series of educator's guides designed to assist educators in incorporating lessons about Kansas and Kansas agriculture into their teaching activities.

The production of this educator's guide has been a journey of discovery about Kansas and what makes this state a unique place to live and work. We challenged our assumptions and struggled to reduce complex definitions and concepts into terms teachers could use with upper elementary students. Many times, our questions led to more questions rather than immediate answers. Many individuals and organizations provided answers, shared information, and assisted in the development of this educator's guide.

The lead partner in this project was USDA Natural Resources Conservation Service – Kansas. In addition to providing financial assistance, agency officials generously shared their time and materials.

Kansas is an incredibly complex and diverse state. From one area of the state to another, there are many differences in water resources, climate, plant and wildlife species, and agricultural crops. One key to the future of our state is understanding those differences and recognizing the complexity of agricultural and natural resource issues.

Agricultural uses – cropland, pasture, and rangeland – account for over 90 percent of the state's land area. To be successful, farmers and ranchers work with, rather than against, the land and other natural resources. They balance the needs of livestock and crops while encouraging desirable habitats for plants and wildlife. Their efforts ensure the health of the biomes and water ecosystems found in Kansas.

Kansans often overlook the beauty and diversity of their own surroundings. The goal of this publication is to provide educators with enough information to develop teaching activities that will challenge the attitudes of young Kansans about their own state and the natural resources found here. The success of this project will be determined by those who use the information in classrooms and other educational settings.

Please enjoy and use this guide,

**Mary Anne Stoskopf, Chair
Natural Resources Working Group
Kansas Foundation for Agriculture in the Classroom**

✧ Dedication ✧

Exploring Kansas Natural Resources was written for Kansas students in hopes that they would acquire and nurture an appreciation for their state. This project would not have been completed but for the vision, efforts, and support of several key people.

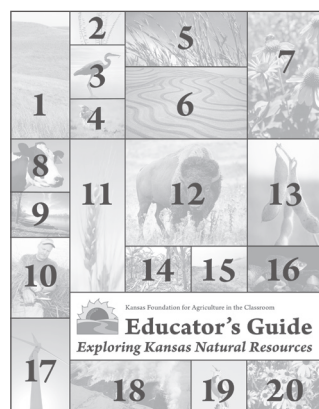
The seeds were planted by Rich Hager who served on the board of directors for the Kansas Foundation for Agriculture in the Classroom from 1985 to 2001. Rich was a state biologist with the Natural Resources Conservation Service for 40 years. He believed in the importance of soil and water conservation not only for this generation, but for the generations to come. Those who knew Rich before his death in 2004 would testify that the world is a better place because he lived and loved the earth.

Once a seed is sown, it takes hard work and vigilance to ensure that a crop can be harvested. Mary Anne Stoskopf, an agricultural producer from Hoisington and KFAC board member since 2000, led the KFAC Education Committee's working group members through the production of *Exploring Kansas Natural Resources*. When the project seemed monumental, she showed enthusiasm and provided an example of how one volunteer can affect others' attitudes and actions so a group's goals can be accomplished. Without her commitment to excellence, her leadership, and her fortitude, you would not be holding this educators' guide.

The Natural Resources Conservation Service has supported *Exploring Kansas Natural Resources* from its early, idea stages to its publication. Retired state conservationist Harold Klaege was instrumental in seeing that this guide makes it to the hands of educators throughout Kansas. He embodies the NRCS motto of working to ensure that this nation's citizens enjoy the benefits of productive soils, clean air and water, and open spaces.

We dedicate this educators' guide to the dreams of these three people, as well as to the countless others who respect and work to sustain the natural resources of Kansas.

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Exploring Kansas Natural Resources

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How to Use This Educator's Guide

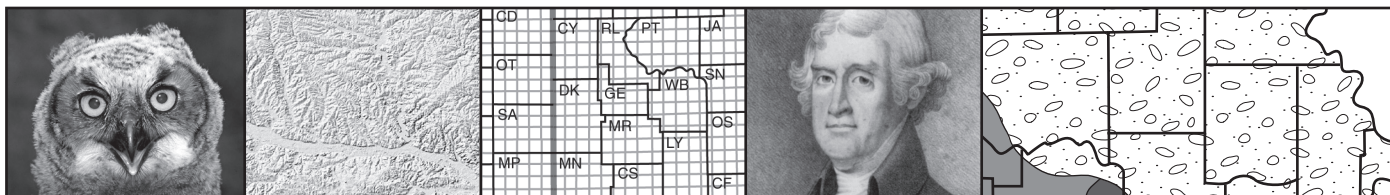
This guide covers the major biomes and water ecosystems found in Kansas. The units tie concepts to specific Kansas examples, such as the plants found in each of the prairie regions of Kansas and the locations and descriptions of the major rivers in the state. Using this information, educators can encourage exploration of nearby natural resources, investigations of other regions of the state, and foster an appreciation of the diversity of Kansas' natural resources.

Showcases at the end of each unit feature specific natural resources or areas in Kansas. These in-depth looks at individual Kansas resources illustrate the concepts in each unit, while encouraging educators to find something similar that might be available for classroom study or student investigations.

Each of the units also includes two profiles of Kansans working in a career field related to the biome or ecosystem featured in that unit. In addition, the final unit in the guide is devoted to career exploration in agriculture and natural resources. Designed to encourage educators and students to start investigating career opportunities available in Kansas, the careers unit includes a table of higher education opportunities offered by Kansas institutions.

Quotations introduce the materials in each unit. Each unit also includes a list of recommended resources (books and websites). The final section of the educator's guide—the appendix—includes a glossary, conversion tables for measurements, and an index.

This educator's guide targets the Kansas Curricular Standards for fifth grade and upper elementary students.



Unit 1) Kansas Overview

A biome is a major regional community of distinctive plants and animals produced and maintained by fairly uniform climatic and environmental conditions. Conditions have led to certain plant life thriving there; consequently, a biome usually derives its name from the dominant plant life. The plant environment creates a culture for certain animals to live, creating interdependence.

The major biomes of the world are tundra, coniferous forest, temperate deciduous forest, the great plains or temperate grasslands, the desert, tropical forest, rain forest, deciduous-tropical forests, grasslands or savanna, chaparral, and equatorial.

BIOMES IN KANSAS

The major biomes in Kansas include the prairie grasslands, forests, and croplands. Water ecosystems in Kansas include streams, rivers, ponds, lakes, wetlands, and their watersheds, as well as aquifers.

INTRODUCTION

KANSAS GEOGRAPHY

- HISTORY
- GEOGRAPHICAL REGIONS

ESTABLISHING KANSAS

- SURVEYING PUBLIC LANDS
- CREATING A NEW STATE: KANSAS
- THE FIRST KANSANS

KANSAS ENVIRONMENTAL FACTORS

- CLIMATE
- WILDLIFE
- LIVESTOCK
- VEGETATION

KANSAS CULTURE

- POPULATION
- ECONOMY
- HISTORICAL AND CULTURAL RESOURCES

STRIKING A BALANCE

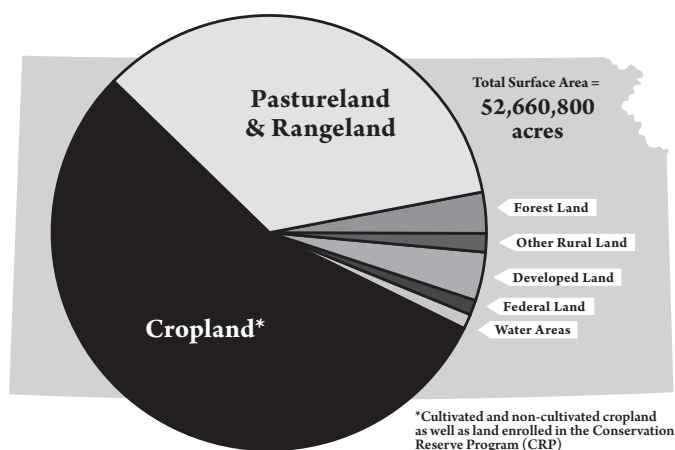
REFERENCES

TEACHER'S RESOURCES

"As to scenery... while I know the standard claim is that Yosemite, Niagara Falls, the Upper Yellowstone, and the like afford the greatest natural shows, I am not so sure but the prairies and plains, while less stunning at first sight, last longer, fill the esthetic sense fuller, precede all the rest, and make North America's characteristic landscape."

Walt Whitman, American poet and author

SURFACE AREA OF KANSAS – LAND AND WATER



Source: 2003 Natural Resources Inventory, USDA Natural Resources Conservation Service

KEY WORDS

Biome – a major regional community of distinctive plants and animals produced and maintained by fairly uniform climatic and environmental conditions; the name usually is derived from the dominant plant life; the largest geographical natural living system.

Ecosystem – a system formed by the interaction of all the living organisms and the physical and chemical factors in the environment in which the organisms live; ecosystems may be large or small.

Environment – the total of all the external conditions and factors, both living and non-living, that affect the existence of an organism.

Habitat – an area that has the minimum required arrangement of food, water, shelter, and space for a particular species.

KANSAS

The state of Kansas may never be a tourist's typical dream destination or a place with dramatic, knock-you-over-the-head type of scenery. But, while Kansas students often study the tropical rainforests of South America or the oceans' depths, there are vibrant and complex ecosystems just outside their classroom windows, waiting to be examined and appreciated firsthand. Without education, it seems impossible that one Kansas wheat field can yield its vast amount of grain. To fully appreciate why this takes place, students must recognize that this can only be achieved because the farmer works *with* the land instead of *against* it.

Kansas has a history and a future unlike any other state. Through closer examination, students in Kansas should have pride and peace in knowing that this richly exciting ecosystem—their richly exciting ecosystem—is the heart of America in more ways than one.

KANSAS FACTS

- The Kansas Territory opened for settlement on May 30, 1854.
- Kansas became the 34th state in the Union on January 29, 1861.
- Today, there are 105 counties and 627 incorporated cities in the state of Kansas.
- According to the most recent census (April 1, 2000), the population of Kansas is 2,688,418 people.
- The east-west span of Kansas is great enough that the sun rises and sets on the western border 30 minutes later than on the eastern side of the state.

KANSAS GEOGRAPHY

"The distinction between past, present, and future is only a stubbornly persistent illusion."

Albert Einstein, physicist

HISTORY

Kansas is continually changing, mostly shifting so slowly that changes are imperceptible. Every time it rains or the wind blows, the process of erosion is moving soil and rocks. Dramatic, noticeable changes happen, too, like earthquakes and floods. Over millions of years, the landscape of Kansas has been altered many times. Its 82,276 square miles of area has seen many changes.

The earth is approximately four and a half billion years old. The features of Kansas indicate that the state has been at different times an ocean, a frozen sheet of ice, and a desert. Every alteration has had an effect on the climate, the terrain, the soil, and the inhabitants of the area at the time it occurred, as well as an effect on what can thrive there today.

The landscape in Kansas hasn't changed much in the past 4,000 to 5,000 years, with the exception of the changes brought about by humans who have moved in. Although American Indians affected the environment, they were hunters and gatherers, mostly living in harmony with nature. When settlers came, farmers plowed the soil, and roads were built and buildings were erected.

How BIG IS KANSAS?

Statistics about the actual size of the state of Kansas vary according to the different sources.

The size of Kansas is set at 82,276 square miles in this educator's guide, based on information provided by the Kansas Geological Survey.

In this guide, statistics based on two additional sources are used to illustrate land use and crop production:

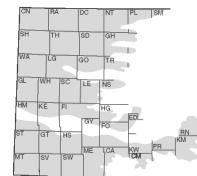
- The Natural Resources Inventory, conducted by the U.S. Department of Agriculture's Natural Resources Conservation Service, reports land use in Kansas based on 52,660,800 acres (82,282 square miles).
- Crop production statistics, provided by the Kansas Agricultural Statistics Service office of the U.S. Department of Agriculture's National Agricultural Statistics Service, are reported based on the U.S. Bureau of Census statistic for the land area of Kansas, which is 52,361,520 acres (81,815 square miles).

GEOGRAPHICAL REGIONS

The state has been divided into regions based on rock type and age, landscape, and landforms. Some regions may appear alike, but their soils were formed at different times. Differences are also found within a single region.

High Plains

The High Plains of Kansas, the western one-third of the state, is an open area of flatlands and gently rolling hills. It was mostly covered by shortgrass prairie, but now much of the region is cropland. There is a permeable, porous, sponge-like bed of rock underneath the High Plains known as the Ogallala Formation. When it rains in the High Plains, the water seeps into the ground and is stored in the rock. Since there is little rain in the region, wells bring water to the surface for humans, livestock, and crop irrigation.



Source: KGS

Arkansas River Lowlands

The Arkansas River cuts through western and central Kansas. The river often flooded and created a flat floodplain for several miles on either side. The Arkansas River starts in the Rocky Mountains, so it has deposited mountain sand and other sediment over the years, creating and re-carving sand dunes in the area.

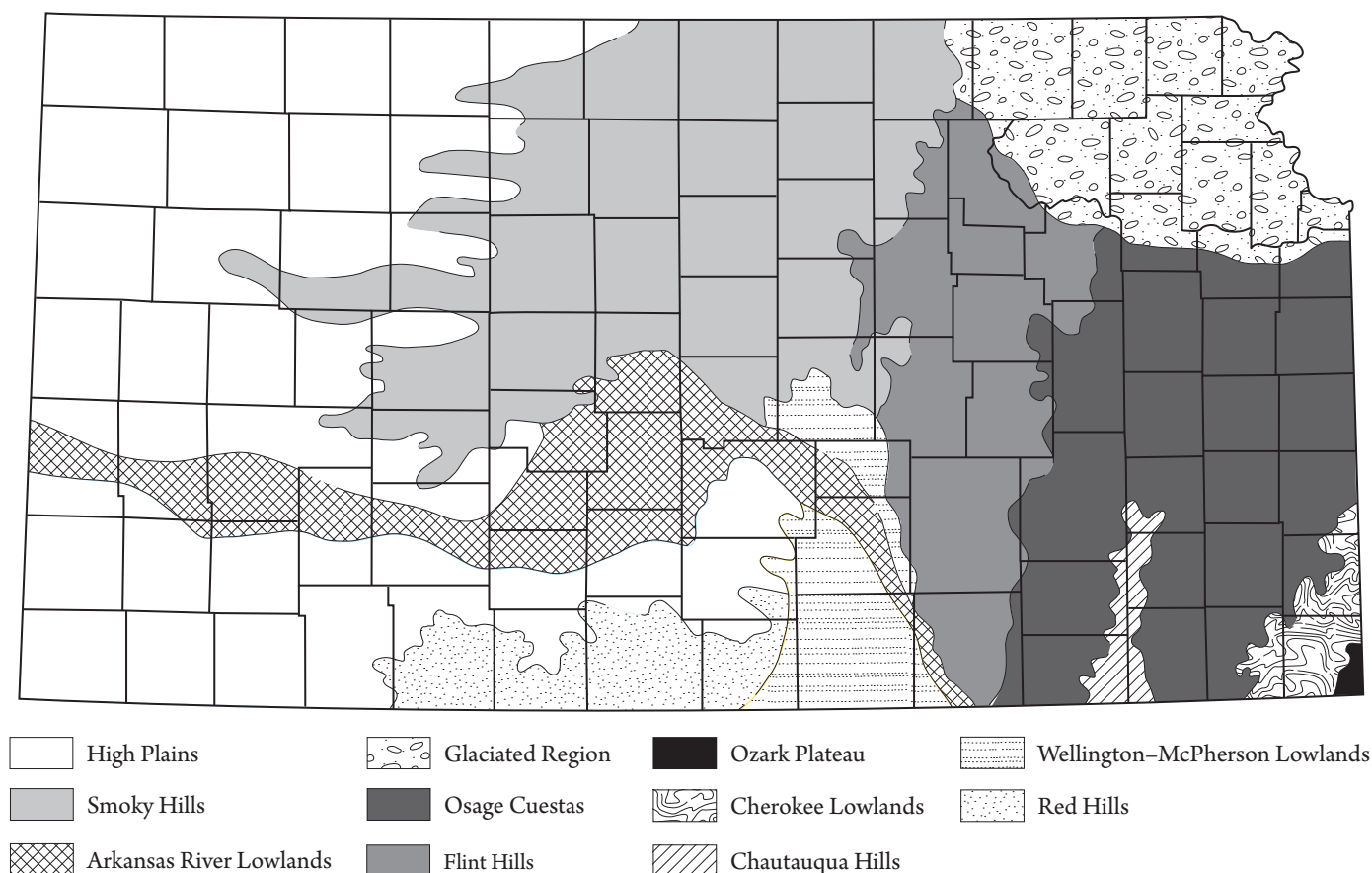


Source: KGS

KANSAS GEOGRAPHY FACTS

- The shape of the state of Kansas is rectangular—208 miles (north to south) by 411 miles (east to west).
- The geodetic center of North America is located in Osborne County. This spot is used as the central reference point for all maps produced by the government.
- The geographic center of the 48 conterminous states is located near Lebanon in Smith County.
- According to the Kansas Geological Survey, the geographic center of Kansas is located less than two miles southeast of Bushton in northwestern Rice County.

GEOGRAPHICAL REGIONS OF KANSAS



Source: Kansas Geological Survey

Red Hills

The Red Hills in south-central Kansas are unique to the state. The soil and the shale in the region contain iron oxide, or rust, so they lend a red hue to the region. The hills have flat tops like mesas and buttes found in the desert southwest.



Source: KGS

Wellington-McPherson Lowlands

Oceans present during the Permian Era, more than 250 million years ago, receded and left behind thick layers of salt. It was buried by sediment and remained hidden in these lowlands until the 1880s when an oil driller located the large salt bed. Today, salt mining is a major industry in Reno, Rice, and Ellsworth counties. The salt is used in industry, to melt ice from roads in the winter, or for table salt.



Source: KGS

Smoky Hills

In north-central Kansas, the Smoky Hills have rocks which were formed from sediment deposited on the sea floor. The eastern Smoky Hills are capped with sandstone. The hills in the middle of the Smoky Hills region are topped with limestone. Because wood was scarce, settlers quarried limestone to use as fence posts and for erecting buildings, lending this area of the Smoky Hills its nickname, "Post Rock Country." Fossils of seashells and sharks' teeth from the Cretaceous Period, more than 65 million years ago, can be found in the area. When the seas dried up in the

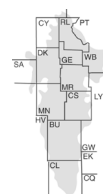


Source: KGS

western Smoky Hills, thick layers of sediment were left behind and formed chalk. In some areas, tall steep-sided chalk formations, such as Castle Rock and Monument Rock in Gove County, were left after erosion. Chalk bluffs can be found along the Smoky Hill River in Logan, Trego, and Gove counties.

Flint Hills

The Flint Hills region, running north and south through east-central Kansas, is one of the few large areas of native prairie grassland left in the United States. The Flint Hills have rolling grasslands and are named for the flint, or chert, that is embedded in the limestone in the hills. The ground was too rocky to plow so many settlers kept heading west, leaving the area for grazing cattle. Millions of cattle are sent to the Flint Hills for summer grazing.



Source: KGS

FLINT HILLS FACTS

Around the Manhattan exit on I-70, the hilltops are flat and about the same elevation. At one time, those hilltops were the floor of an ocean. Over time, erosion created the valleys and stream channels seen today.

The hills between Wamego and Manhattan are the remnants of an ancient mountain range.

Source: Phil Balch, The Watershed Institute

Kansas Overview

Glaciated Region

Several glaciers, huge masses of ice, covered much of the northern United States hundreds of thousands of years ago. The glaciers grew and melted as the climate changed. Most didn't reach Kansas, but at least two dipped down into the northeast corner. When the glaciers retreated, they left behind rocks and soil from other areas. Fertile loess soil, finely ground silt, was left as sediment and makes rich soil for farming in this area.



Source: KGS

Chautauqua Hills

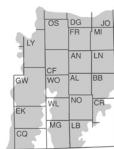
The Chautauqua Hills are known for their thick layers of sandstone and dense vegetation of oak and timber. During the Pennsylvanian and Permian periods, 230 to 310 million years ago, rivers and streams flowed into the seas in this area. Sand and sediment collected at the mouths of the rivers and became shale. Eventually, erosion exposed some outcrops of sandstone and shale.



Source: KGS

Osage Cuestas

The Osage Cuestas region in southeast Kansas is named for the landforms called "cuestas," the Spanish word for cliffs. A cuesta (pronounced kwesta) has a steep slope on one side, called an escarpment, and a gentler slope on the other sides. Cuestas were formed by uplift, or changes in the Earth, when the seas receded and grew during the Pennsylvanian and Permian periods. There is variety in the region; not all the hills in the region are cuestas. This region also has rolling hills and flatlands.



Source: KGS

Cherokee Lowlands

In the late 1800s and early 1900s, the Cherokee Lowlands in the southeastern part of Kansas were home to coal mining and cement, glass, brick, and tile plants which used the natural resources of coal, zinc, clay, and limestone. Some industry still exists there today, but the peak is over. Some of the mined land was reclaimed – companies smoothed the ditches over and planted trees and grass when they finished strip mining. It is used for farming and grazing today.



Source: KGS

Ozark Plateau

In the farthest southeastern tip of Kansas lies the Ozark Plateau. The Ozarks of Missouri, Arkansas, Oklahoma, and Kansas are a hilly and densely forested area. The limestone and flint found in the region are the oldest surface rocks in the state. They were formed during the Mississippian Period, 350 million years ago. Piles of crushed rock, called chat, are left over from the lead and zinc once mined there.



Source: KGS

KANSAS

The names of the state of Kansas and the Kansas River were taken from the name of the Kansa Indians. **Kansa** (pronounced KAN-sah) means "people of the south wind."

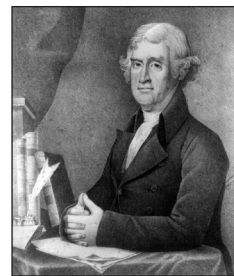
The Kansas River is also referred to as the Kaw River.

ESTABLISHING KANSAS

"Kansas is a kind of open window through which one can look and really see America."

Life magazine, February 14, 1944

Thomas Jefferson was one of the most powerful influences on the history—and layout—of the state of Kansas. Jefferson, a delegate to the Continental Congress from Virginia, made many contributions to the laws of the new central government, including the procedure for creating new states and the process for surveying land.



Thomas Jefferson

Source: Library of Congress

After the Revolutionary War, the Continental Congress needed income to pay war debts and organize the new country. In 1783, the British ceded all land holdings, including the territory west of the Appalachian Mountains to the Mississippi River, to the Americans. The sale of this land helped pay national debts and finance the new federal government.

Prior to the adoption of Jefferson's plans, each state had its own methods of measuring land, often using geographical identifiers such as rivers or streams to establish property boundaries. Disputes over land ownership, and even state borders, were common since the methods used by the states were not consistent.

SURVEYING PUBLIC LANDS

In the plans adopted by the Continental Congress, the borders of new states were to be defined by parallels of latitude and meridians of longitude, except where rivers or lakes shaped the borders. All land would be surveyed before it could be purchased from the federal government, eliminating many disputes over ownership and enabling a person to buy a piece of property without actually having seen or set foot on the land. The land would be divided into simple squares, aligned with each other so that no land was left vacant.

In 1785, Congress passed an ordinance setting out the division of land in new territories into townships of six miles square, with the 36-square-mile townships divided into one-square-mile lots. Four of the square-mile lots, described as "sections," in each township were to be reserved for the government for the maintenance of public schools. (In 1796, the requirement was reduced to one "school" section per township.)

To measure the land, surveyors used chains containing two perches (rods) of 16 ½ feet each, each divided into 25 equal lengths (links) that were 7.92 inches in length. This measuring device was based on "Gunter's chain" developed by Edmund Gunter in England in the 1500s. Gunter's chain was exactly 22 yards in length (8 perches or rods), divided into 100 links each 7.92 inches in length. One mile (5,280 feet) equaled eighty lengths of Gunter's chain. Other instruments and devices were used to establish the lines of latitude and longitude, which were adjusted at regular intervals due to the curvature of the Earth.

The length of the surveyor's chain was the first U.S. unit of measurement written into law in the United States. Each surveyor's chain contained two perches (rods) of 16 ½ feet each, each divided into 25 equal lengths (links) that were 7.92 inches in length.

CREATING A NEW STATE: KANSAS

The borders of the state of Kansas were established by applying the same principles adopted by Congress in 1785. In 1830, the creation of the state of Missouri determined the eastern border of what later became the state of Kansas, although the creation of additional counties in northwestern Missouri in 1837 set the new boundary as the mid-channel of the Missouri River in that region. In 1854, the north-south borders of the Territory of Kansas were set at 40° North and 37° South (latitude). The western border was not set until 1859.

The land was surveyed and divided into townships (six miles square) and sections (one-square-mile lots containing 640 acres). The Kansas–Nebraska border and the 6th principal meridian (108 miles west of the Missouri River) served as the baselines (controls) for the public surveys in Kansas. The legal description of all land in Kansas is derived from those two baselines. All townships in Kansas are numbered according to their placement south of the northern baseline, from 1 South (first tier of townships south of

the Kansas–Nebraska border) to 35 South (the southern tier of townships that lie alongside the Kansas–Oklahoma border). The east–west designation for each township, known as the “range line,” begins at the 6th principal meridian. Range lines extend to 43 West in the far southwestern corner of the state and 25 East in the far southeastern corner of the state. The thirty-six sections in each township are numbered—beginning with Township 1 South in the northeast corner of the township and ending with Township 36 South in the southeast corner. The numbers travel west and then return east before turning back west again, correlating with how a man would plow back and forth across a field at the time. North–south guidelines (meridians) were located 48 miles apart. East–west “parallels” located 30 miles apart (in Kansas) adjusted for surveying inaccuracies. North–south adjustments for the curvature of the Earth were made at the parallels, which often created abrupt jogs in roads laid out on section lines. The legal description of land is recorded as section, township, range, (i.e. 640 acres in 17–22 S–19 W or the northwest 160 acres of 4–1 S–13 E).

KANSAS BORDER – MISSOURI RIVER CHANNEL



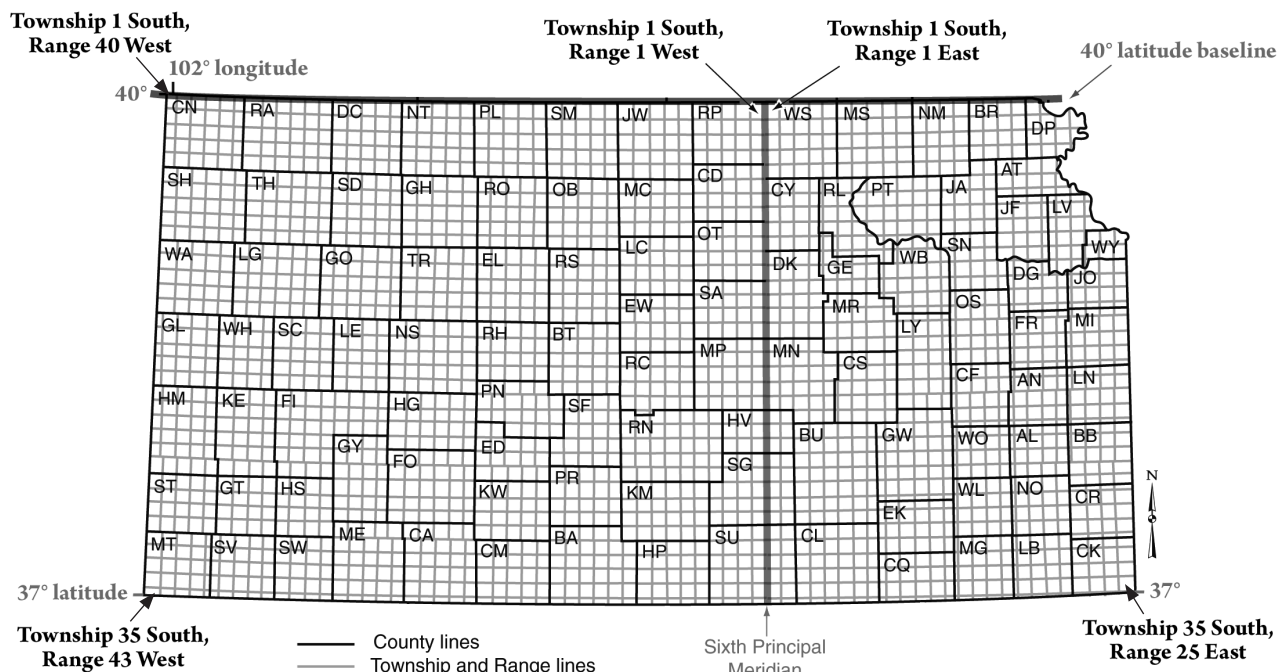
Source: U.S. Geological Survey, EROS Data Center

SECTION NUMBERS IN A TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Credit: BJ Wooding, Cartographer, Barton County Appraiser's Office

KANSAS COUNTIES AND TOWNSHIPS



Source: Kansas Geological Survey

THE KANSAS BORDERS

The eastern border of the state of Kansas was determined when Missouri became a state. Later, changes moved the northeastern border of the state of Kansas to the mid-channel of the Missouri River. Under the Kansas–Nebraska Act of 1854, the north and south boundaries of the Territory of Kansas were set at 40° latitude (north) and 37° (south). Those east, north, and south boundaries became the state's borders when Kansas became a state in 1861.

Under the Kansas–Nebraska Act, the continental divide in the Rocky Mountains (west of Denver, Colorado, today) was set as the western boundary of the Territory of Kansas. As steps were taken to form a state, the settlers struggled with setting the western border of Kansas. At the Wyandotte Constitutional Convention in 1859, the delegates (none of whom lived farther west than Manhattan or Council Grove) decided to exclude the Rocky Mountains, and the miners in the gold fields there, from the new state. The delegates considered several options, including the 26th meridian (roughly following the eastern border of New Mexico north to Sterling, Colorado), the 23rd meridian (approximately a line from Hill City to Dodge City), and the 25th meridian. The delegates compromised by setting the state's western border at the 25th meridian (today's Kansas–Colorado state line).

From 1850 to 1912, lines of longitude in the United States were measured from the Naval Observatory in Washington, D.C. Later, the Prime Meridian (zero) was set at the Greenwich Observatory in London, England. This means that the western border of the state of Kansas, originally set at the 25th meridian, is now about 2.8 miles west of the 102nd meridian—rounded to 102.05 degrees west longitude.

Once Kansas gained statehood, the state legislature determined when counties had reached sufficient population to be named and county governments could be organized. While county borders followed section lines, they did not always follow township lines. In many cases, counties were organized—only to be abandoned later. In those cases, the land was absorbed into other counties.

The grid of states and townships that Jefferson promoted made it possible for individual land ownership, which gave individuals independence and encouraged their interest in creating law-abiding communities. At the time, the opportunity to own land made the United States unique in a world in which all land was either owned by a central government or members of the aristocracy.

THE FIRST KANSANS

Jefferson's procedures also led to the continual removal of American Indian tribes from areas as new territories and states were organized. There were always people seeking additional land and pushing into unorganized areas. The resulting conflicts over land usually led to treaties that removed the American Indians and relocated them, generally to land further west. During his term as President, Jefferson signed 32 treaties that transferred American Indian titles to the federal government.

President Jefferson also led efforts to acquire additional land for the United States. In 1803, needing money to finance a war in Europe, Napoleon Bonaparte sold the United States a large area of land that France had purchased from Spain earlier. Known as the Louisiana Purchase, this area west of the Mississippi River included the Great Plains.

SOUTHWEST KANSAS HISTORY

After 1763, the international border between the Spanish and English territories in America was the Mississippi River. In 1800, the Spanish returned the province of Louisiana (and New Orleans) to the French. In 1803, the French sold this territory to the United States but the boundaries of the "Louisiana Purchase" were not clearly defined. The United States claimed the western drainage basin of the Missouri River as the boundary until an 1818 treaty with Spain through which the United States acquired Florida. In the 1818 treaty, about 7,500 square miles in the southwestern corner of what later became the state of Kansas (south of the Arkansas River to the 100th meridian) was officially returned to Spain.

However, in 1810, Mexico had declared independence from Spain and claimed ownership of that same area. Then, in 1836, the Republic of Texas (a province of Mexico) achieved independence as a nation. In 1845, the United States annexed the Republic of Texas as the state of Texas, leading to the Mexican-American War. A portion of the territory claimed by the Republic of Texas was ceded to the U.S. government in return for the assumption of debts when Texas became a state. That territory included land that is now part of the states of Colorado, Oklahoma, New Mexico, Wyoming, and the southwestern corner of the state of Kansas.

The prairie grasslands of the Great Plains were so different from the forested areas of the eastern United States that early explorers thought the soils were poor because there were so few trees. Following his 1806 expedition thru the southwestern region of the Louisiana Purchase, Lt. Zebulon Pike described the Great Plains as the Great American Desert, a label used by mapmakers and published in textbooks. It took nearly 50 years for government officials to realize the potential of the plains. In the meantime, as it became necessary to accommodate the expansion of the country's population, the American Indians were moved to areas not likely to be desired by settlers— including the region identified as the Great American Desert.

In the 1700s, explorers and traders in what is now the state of Kansas recorded meeting the Padoucas. "Padouca" is the Siouan name of the Comanche. In the late 1700s and through the 1800s, the Kiowa and Comanche dominated the southwest area of Kansas until agreeing to relinquish all claims in Colorado, Kansas, and New Mexico and relocate to reservations in southwestern Oklahoma and Texas in October of 1865.

THE LOUISIANA PURCHASE



Source: U.S. Geological Survey, nationalatlas.gov

THE GREAT PLAINS



Source: Commission for Environmental Cooperation

In the late 1700s, the three main American Indian tribes or nations in what is now the state of Kansas were the Kansa, Osage, and Pawnee. The Kansa claimed the area from what is now Nebraska to the Arkansas River. The Osage claimed a large portion of what is now Missouri, with hunting grounds extending into southeastern Kansas. The Pawnee claimed the whole region of the Platte River, from the Rocky Mountains down across Kansas and Nebraska, as well as the watersheds of the forks of the Kansas River. The Northern Pawnee were located along the Platte River and had villages along the banks of the Republican River. The Southern Pawnee lived along the Arkansas River.

In 1825, the Kansa and Osage nations agreed to treaties restricting their territories. The federal government set aside the remainder of the Osage and Kansa lands for the reservations of tribes removed from other areas, mainly those from north of the Ohio River. (Those living south of the Ohio River were generally assigned lands in the area that became Oklahoma.) In 1833, the Pawnee ceded all land south of the Platte River.

The Cheyenne and Arapaho included most of western Kansas in their traditional hunting grounds. In 1851, a treaty granted them a large portion of the country that became southeastern Colorado and western Kansas. Beginning in 1858, mining discoveries in the mountains of Colorado drove the Cheyenne and Arapaho out of the mountains to the valleys and plains of the Arkansas and Republican rivers. In 1861, all their lands, except one tract, were ceded to the United States government. Under the terms of an October 1865 treaty, the Cheyenne and Arapaho were removed from their reservation in southeastern Colorado to ones in Kansas and the Indian Territory (Oklahoma). In a separate treaty at the same time, the Apache were detached from the Kiowa and Comanche and attached to the Cheyenne and Arapaho. When the tribes were moved to reservations in the Indian Territory (Oklahoma) in 1867, they retained hunting privileges as far north as the Arkansas River in Kansas.

Most tribes moved to Kansas in the 1830s, following the implementation of the Indian Removal Act of 1830. Most of the moves were completed before 1846. The Missouri Shawnee were the first to move to the territory and the Wyandot tribe was one of

THE PEOPLE OF QUIVIRA

In the early 1530s, Spanish authorities in Mexico associated the name "Quivira" with a province in the interior of the continent reported to include seven wealthy cities made of gold. In 1541, Francisco Vázquez de Coronado mounted an expedition to find the province. Instead, Coronado found an agricultural society along the Arkansas River in what is now central Kansas (mainly Rice and Reno counties). The people were given the name "Quivira."

A French trader identified the same people as the "Wichita" in 1719. The region occupied by the Wichita ranged from the middle Arkansas River (east of Great Bend) to the Brazos River in Texas. The Wichita were forced westward and southward by the Osage and Chickasaw. By the 1850s, they were living around the Wichita Mountains in southwestern Oklahoma. In 1859, the Wichita were relocated to a reservation.

During the Civil War, the Wichita fled to Kansas where they lived near the present-day site of Wichita from 1863 to 1867. They returned to their homes on the reservation after the war was over.

the last to relocate in Kansas. Others assigned to lands in Kansas included the Delaware, Kaskaskia and Peoria, Piankeshaw and Wea, Sauk (Sac) and Fox of Mississippi, Iowa, Kickapoo, Cherokee, New York Indians (composed of representatives of the Seneca, Onondaga, Cayuga, Tuscarora, Oneida, St. Regis, Stockbridge, Munsee, and Brothertown residing in the state of New York), Ottawa, Chippewa, Pottawatomie (Potawatomi), Miami, Quapaw, and Sauk (Sac) and Fox of Missouri.

However, the pressure to open Indian lands to adventurous settlers led to new treaties that resulted in the relocation of the tribes to the Indian Territory (Oklahoma). This allowed the federal government to sell the land previously held by the tribes. Even the Kansa and Osage tribes were forced to move in the 1870s. After 1871, all laws affecting American Indians required Congressional action and treaties were no longer made with Indian nations.

The legacy of the tribes is commemorated in the names of cities, counties, rivers and streams, and other landmarks in Kansas. The Ottawa tribe donated 20,000 acres for a university to ensure the education of their children to the Baptists, who had established missions on their land in Franklin County. This was the foundation of Ottawa University in Ottawa, which still provides a tuition-free undergraduate education to descendants of the Kansas Ottawa.

Today, there are three federally recognized American Indian reservations in the state of Kansas: the Iowa Reservation at White Cloud, the Kickapoo Reservation west of Horton in Brown County, and the Prairie Band Potawatomi Reservation south of Holton in Jackson County. The Sac and Fox Tribe of Missouri holds tribal lands in northeastern Brown County, Kansas.

MISSIONS AND MISSION SCHOOLS

As the former territories of the Kansa and Osage nations were set aside for various American Indian tribes or bands being moved from lands farther east, over 30 missions and mission schools were established by various churches in Kansas. None were located farther west than Council Grove.

In St. Paul, the infirmary of the Osage Mission—St. Ann's Academy Infirmary and Guest House—is now a bed and breakfast.

HASKELL INDIAN NATIONS UNIVERSITY

Lawrence, Kansas, is home to Haskell Indian Nations University, a national center for American Indian education, research, and cultural preservation. This unique college enrolls over 1,000 students each semester who represent federally recognized tribes from across the United States. American Indian and Alaska Native culture is integrated into the curriculum.

Early in its history, the school promoted assimilation into the American mainstream but that is no longer the case. In 1884, the first elementary students enrolled in the school, known then as the United States Indian Industrial Training School. Ten years later, the school expanded beyond the elementary grades. By 1927, the high school was accredited by the state of Kansas but the school soon began to evolve into a post-high school vocational technical school. The last high school class graduated in 1965.

In 1970, the school became Haskell Indian Junior College. In 1993, it became Haskell Indian Nations University. Currently, the college offers two-year and four-year degree programs in elementary school education, American Indian studies, business administration, and environmental science.

Source: Haskell Indian Nations University

NATIVE AMERICAN HERITAGE MUSEUM

The Native American Heritage Museum is a state historic site near Highland, Kansas. Originally established as a Presbyterian Mission in 1845, known as the Iowa, Sac, and Fox Mission, the school emphasized industrial and domestic arts as well as farming. Those three tribes signed a treaty in 1837 giving up their land in Missouri in exchange for land in what is now northeastern Kansas and south-eastern Nebraska.

From the 1830s–1860s, wagon trains bound for Oregon and the California gold fields passed the mission, which was on the St. Joseph branch of the Oregon–California Trail. The tribes built a log bridge across Wolf Creek, near the mission, and charged a toll for wagons and traffic using the bridge. However, the emigrant traffic killed many members of the tribes when they were exposed to diseases such as cholera and smallpox.

With the passage of the Kansas–Nebraska Act of 1854, the government negotiated a new treaty with the tribes that reduced their lands and placed the mission too far away from the reservations for the children to attend the school. The mission closed in 1863 but operated as the Indian Orphanage Institute from 1863 to 1866. In 1941, the mission building became the property of the state of Kansas. Today, the Kansas State Historical Society administers the property as a museum, showcasing the arts and history of the emigrant tribes of American Indians in northeastern Kansas.

Source: Kansas State Historical Society

KANSAS ELEVATION EXTREMES

The lowest point in Kansas, 679 feet above sea level, is located in the Verdigris River channel in Montgomery County.

The highest point in Kansas, 4,039 feet above sea level, is at the top of Mount Sunflower in Wallace County.

KANSAS ENVIRONMENTAL FACTORS

“(This land is) the best I have ever seen for producing all the products of Spain.”

Francisco Vasquez de Coronado, Spanish explorer
(In 1541 while exploring the territory which later became Kansas)

Coronado was searching for Quivira, the legendary province with seven cities of gold, when he came across the region and made this pronouncement. Instead of precious metal, he found a surprising bounty of vegetation, wildlife, and possibilities for agricultural production. Kansas is certainly not Spain, but the Kansas climate is a key factor to the abundance and variety of plant growth and animals in the state. Four distinct seasons of weather provide excellent growing conditions for a large variety of crops and native plant life.

CLIMATE

Weather is the state of the atmosphere for a given site at a given time. This includes air temperature, air movement, evaporation rate, cloud formation, and precipitation. Climate is the average weather conditions of a given point during a given set of dates.

Kansas contains three climate types, according to the Koppen climate classification: humid continental, semiarid steppe, and humid subtropical.

The eastern two-thirds of the state have a humid continental climate with cold winters and hot summers, with most of the precipitation falling in the summer and spring.

The western one-third of the state has a semiarid steppe climate. Summers are hot, and often very hot. Winters are cold in the northwest and cool to mild in the southwest. The region is semiarid, receiving on average only 16 inches or less of precipitation per year. In the winter, chinook winds—dry warm winds that blow down the eastern slopes of the Rocky Mountains—can warm western Kansas all the way into the 60s, 70s, and even 80s.

The far south-central and southeastern reaches of the state have a humid subtropical climate, with long, hot summers and short, mild winters and much more precipitation than the rest of the state.

Precipitation ranges from 44 inches a year in the southeastern corner of the state, to less than 16 inches a year in the southwest. The average temperature is 55 degrees Fahrenheit, and the growing season varies from 154 days in the northwest to 200 days in the southeast.

Kansas ranks as the ninth or tenth sunniest state in the country, depending on the source. No state east of Kansas, including Florida, is sunnier on average. Western Kansas has as many sunny days in a year as parts of California and Texas.

Snowfall ranges from around five inches in the fringes of the south to 35 inches in the far northwest.

Frost-free days range from more than 200 in the south to 130 in the northwest.

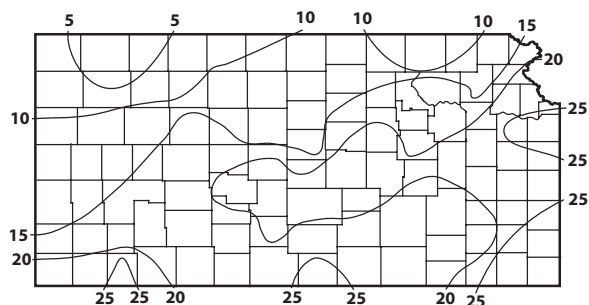
Weather— the state of the atmosphere for a specific site at a specific point in time, including air temperature, air movement, evaporation rate, cloud formation, and precipitation.

Climate— the average weather conditions of a specific site during a particular set of dates.

THE GROWING SEASON IN KANSAS

The normal frost-free period shortens from 200 days at the southeast corner of the state to only 154 days in extreme northwestern Kansas. The shortening of the growing season is due to the rise in altitude from 679 feet above sea level in the southeastern corner of the state to 4,039 feet above sea level at the highest point in western Kansas. From the southern to northern border of the state, the change in distance from the equator (latitude) also affects the length of the growing season. On average, the growing season shortens about one day for each additional eight miles north of the southern border of the state of Kansas.

AVERAGE FIRST 32° F FREEZE IN OCTOBER



Source: K-State Research and Extension

WILDLIFE

Scientists are fascinated by the biodiversity, or variety of differing organisms in a given area, of wildlife in Kansas. Kansas is home to 798 species of vertebrates (mammals, birds, reptiles, amphibians, and fish). In addition, there are approximately 24,000 species of invertebrates (insects, mussels, and crustaceans) in Kansas.

Terrestrial (land-dwelling) animals include the bison, which provided food, shelter, and clothing for American Indians. Bison still forage the prairie in domesticated herds in Kansas. Deer and antelope run wild in the state and prairie dogs scamper in and out of their underground homes. Beaver, bobcat, raccoon, opossum, skunk, muskrat, mink, badger, fox, and coyote are other Kansas mammals.

There are 144 species of fish in the Kansas streams, rivers, ponds, and lakes.



Great Horned Owl

Credit: Roger Hill, USDA NRCS



White-tailed Deer

Credit: Scott Bauer, USDA ARS

The Kansas biomes are home to 468 species of birds, including wild turkeys, chickadees, hawks, owls, prairie chickens, and meadowlarks.

In Kansas, there are 53 species of reptiles and 30 species of amphibians, including rattlesnakes, ringneck snakes, horned lizards, and salamanders.

LIVESTOCK

Many domesticated animals can be found in Kansas. Ruminants, animals with a four-compartment stomach, are able to digest plants and grasses that humans cannot. These animals convert grasses into meat and milk, which are high-quality, complete proteins for human consumption. With 20 million acres of grass, Kansas is ideal for grazing animals. In one year, over six million cattle graze throughout the state. Some move to feedyards in western Kansas; these provide the base for the state's multibillion-dollar beef industry. Dairy, sheep, goat, swine, and poultry farms can be found throughout the state and contribute to a thriving livestock industry.



Beef Calves

Credit: Wayne Stoskopf

VEGETATION

The types of vegetation or plants in the state are unique and varied. As they have adapted, native species have grown in response to the changes in precipitation and soil throughout the state. From east to west, the occurrence of native tallgrass, mixed-grass, and shortgrass prairies can be charted almost exactly with the rain and snowfall changes. The richness and type of soil the vegetation grows on contributes greatly to what can grow there.

Kansas has over 300 different soil types. According to the Kansas Agricultural Statistics Service, cropland accounts for 56 percent of the land use (over 29 million acres) while range and pasture lands account for 37 percent (over 19 million acres). Kansas' soils directly impact the economic well-being of its people. Soils help rank Kansas at or near the top of the 50 states annually in wheat production, grain sorghum production, sorghum silage production, and red meat production.

Harney silt loam was designated the official state soil in 1990. It possesses the ideal qualities of a prairie soil, including the best combination of physical and chemical characteristics for producing food and fiber. Harney silt loam covers almost four million acres in 26 west-central Kansas counties.

One acre is approximately the same size as a high school football field (without the end zones).

STATE SPECIES, PLANTS, AND SOIL

State animal– American bison

State reptile– ornate box turtle

State amphibian– barred tiger salamander

State bird– Western meadowlark

State insect– honeybee

State flower– sunflower

State tree– cottonwood

State soil– Harney silt loam

Kansas Overview

Over two million acres in Kansas are considered woodlands or forests by the Kansas Forest Service—over four percent of the land area in the state. There are over 78,000 windbreaks in Kansas, and more than 70 active sawmills.

The cottonwood tree has been designated the state tree. It is a soft wood, and can grow over 100 feet tall and 12 feet in circumference. Its presence can stabilize soil erosion and filter pollution. Other trees found in the state include hackberry, ash, black walnut, and bur oak. The presence of Eastern red cedar is increasing, mostly from lack of fire.



Cottonwood Leaves

Credit: Mary Anne Stoskopf

KANSAS CULTURE

"We've been through a valley. We now stand atop a hill, looking toward the horizon and all the promise it has to offer. To shrink from those challenges would go against everything it means to be a Kansan. We wouldn't be here... if the pioneers who settled our state had looked out upon the wide, open prairie and turned back saying the challenge was just too difficult. Instead, with conviction in their hearts and hope for the future, they moved forward."

Kathleen Sebelius, 44th governor of the state of Kansas

POPULATION

Kansas has a population of over 2.7 million, according to the Kansas Secretary of State's office. One-half of the counties in Kansas are experiencing decreasing populations. The U.S. Census Bureau reports that the 22 counties that are growing in population are experiencing many changes. Since 2000, over 71 percent of the population growth in Kansas has occurred among the state's Hispanic population. Asian populations are also increasing across the state.

Early Kansas settlers represented many countries and cultures. Many Kansans and Kansas communities celebrate that heritage, which includes that of the people who came directly to Kansas from other countries as well as the people who moved to Kansas from other states. Many Kansas citizens are descendants of early settlers from Western Europe, including many of German or British ancestry.

ECONOMY

In 2006, according to the U.S. Department of Commerce, the gross domestic product of the state of Kansas was over \$94.6 billion and the state's per capita personal income was \$34,743, 96% of the national average. In April 2007, the state's unemployment rate was 4.0% according to the Kansas Department of Labor. Agriculture is the number one industry in the state, employing nearly one in five people. In fact, the U.S. Department of Commerce reports that the agricultural industry accounts for a larger share of employment in the Plains states than in any other region of the United States.

Kansas is the nation's second largest producer of beef cattle, and it leads the nation in the production of several crops, including wheat and grain sorghum. Other major agricultural products include corn, soybeans, hay, sunflowers, cotton, and hogs. The

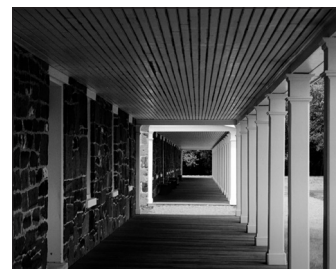
state's industrial and manufacturing outputs include transportation equipment, commercial and private aircraft, food processing, publishing, chemical products, machinery, pharmaceuticals, and mineral resources. Kansas ranks first among the states in helium production, fifth in the production of natural gas and eighth in petroleum production. Other leading mineral resources include cement, salt, coal, building stone, sand and gravel, and clay and shale products according to the state's website. In 2006, the top exports from the state of Kansas were food products and transportation equipment, with total exports from the state of \$8.6 billion. In 2006, exports from the state of Kansas went to 192 foreign destinations. According to the U.S. Department of Commerce, the top markets for Kansas exports in 2006 were Canada, Mexico, the United Kingdom, Germany, Japan, China, Australia, Singapore, Hong Kong, and Brazil.

In 2004, the Kansas Legislature established the Kansas Bioscience Authority in an effort to make bioscience a major part of the Kansas economy. The mission of the Kansas Bioscience Authority is to make Kansas a national leader in bioscience. In October of 2006, Kansas State University dedicated the Bioscience Research Institute, a food security research facility, built on the KSU campus in Manhattan. The K-State Olathe Innovation Campus, a KSU food safety and security center, is planned in Olathe, Kansas, where research will focus on animal health, forensics science, and bioenergy.

HISTORICAL AND CULTURAL RESOURCES

Cultural resources are evidence of past human activity. In Kansas, these may include pioneer homes, buildings, roads, or wagon ruts like the Santa Fe Trail ruts near Council Grove. They may be structures with unique architecture like the state Capitol in Topeka. These are nonrenewable resources and yield unique information about past societies and environments. They can help provide perspectives and answers for modern day social and conservation practices. The history of the state, its distinctive communities, and the people of Kansas surrounds everyone living here today.

The Kansas State Historic Preservation Office can provide information about cultural resources in each area in the state.



Fort Larned National Historic Site

Credit: Wayne Stoskopf

STRIKING A BALANCE

"The throwing out of balance of the resources of nature throws out of balance also the lives of men."

Franklin D. Roosevelt, 32nd President of the United States

People, wildlife, and all life forms exist together on one earth in a balancing act. People have developed a complex culture. Using technology and strength, humans can dominate much of the environment. But with great power comes a responsibility—people must ensure that they continue to respect their environment and do not diminish the diversity of the planet. Kansans must act as stewards of the natural environment, balancing human interests with those of nature.

THREATENED AND ENDANGERED SPECIES

Congress passed the Endangered Species Act in 1973. The U.S. Fish and Wildlife Service in the Department of the Interior and the National Marine Fisheries Service in the Department of Commerce administer the federal law. The U.S. Fish and Wildlife Service has primary responsibility for terrestrial (land) and freshwater organisms, while the responsibilities of the National Marine Fisheries Service are mainly marine (ocean) species, such as salmon and whales.

In 1975, the Kansas Legislature passed the Kansas Nongame and Endangered Species Conservation Act. This state law places the responsibility for identifying and undertaking appropriate conservation measures for state and federally listed species on the Kansas Department of Wildlife and Parks. Statewide and countywide lists of protected species are available on the Kansas Department of Wildlife and Parks' website: www.kdwp.state.ks.us.

One of the great stories of conservation comes from the Dust Bowl of the 1930s. The "dirty thirties," like an earthquake or tsunami, shocked the nation's citizens into realizing that they lived in a fragile world. In 1935, the U.S. Congress passed Public Law 46 which is the basis for all conservation programs today. The Soil Conservation Service was established. Trained scientists began working with agricultural producers to teach them about the relationships between their actions and the subsequent effects on the earth.

To recognize and preserve some of the cultural and natural resources of the country, the government has created several programs, including the National Register of Historic Places and the National Historical and Preservation Act. In addition, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service administer the federal Endangered Species Act.

In 1975, the Kansas Legislature passed the Kansas Nongame and Endangered Species Act which allowed the Kansas Department of Wildlife and Parks to establish an official list of threatened and endangered species in the state.

Much of the clash of nature and people has come because of human population increases around the world. Kansas is a state with a low population and can share its products with those in need—the people of Kansas can feed themselves and others as well. This can benefit Kansans economically and the consumers as well. All Kansans should respect and recognize their responsibilities. A partnership between the land and its caretakers must exist to ensure that generations of people, plant life, and animals will continue to thrive on the planet Earth. ■

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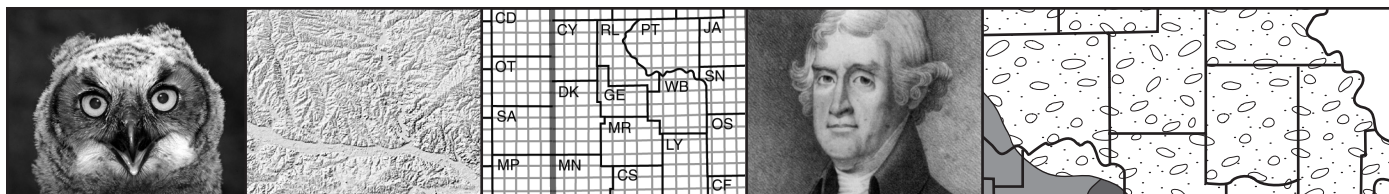
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NOTES:





Unit 2) Prairies

Grasslands are found on every continent except Antarctica. Covering nearly one-half of the earth's land surface, these regions produce approximately 70 percent of the food consumed by the world's population, including crops such as wheat, rice, corn, and sorghum that originated from domesticated grasses.

Nearly 26 percent of the land in the United States is in grassland pasture and rangeland according to a May 2006 U.S. Department of Agriculture report on land uses. Grassland, rangeland, forestland, and cropland account for nearly 75 percent of the uses of the land in the United States.

In Kansas, cropland (cultivated from former grassland) is the leading use of land, followed by pasture and rangeland, which includes both native grasslands and grass stands that have been reestablished on land that was once cultivated. These uses represent over 90 percent of the state's land area.

"Grass is the forgiveness of nature—her constant benediction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass-grown like rural lanes, and are obliterated. Forests decay, harvests perish, flowers vanish, but grass is immortal."

John James Ingalls, U.S. Senator from Kansas

According to studies by geologists, the earth is around four and a half billion years old. The features of present-day Kansas indicate that the state has undergone many changes during its evolution. Kansas has at different times been an ocean, a frozen sheet of ice, and a desert. Every alteration has had an effect on the climate, the terrain, the soil, and the inhabitants of the area at the time it occurred, as well as an effect on what can thrive in Kansas today.

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- CIMARRON NATIONAL GRASSLAND

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REFERENCES

TEACHER'S RESOURCES

Prairies



Greenwood County

Credit: John Charlton, KGS

One part of Kansas that looks now much like it has for the last ten thousand years is the prairie. During the Cenozoic Era (sometime in the last 63 million years), after glaciers smoothed the land into plains and the water run-off created rivers and streams, the deep-rooted grass utilized the exposed soil and set down roots. As it matured and ripened, the prairie grass gradually expanded its territory, mostly by the wind which carried seeds further to new soils. In a new spot, the grass usually adjusted its needs as best possible to the environment, including soil type and the amount of water present. This created a constant if always changing appearance.

By the time the first humans roamed the central part of North America, the grasslands were solidly established. The North American prairie was called an inland sea, both for the resemblance its grasses made to ocean waves as the stalks swayed in the wind, and because it reached farther than the eye could see.



Flint Hills

Credit: Megan Blythe

THE GREAT PLAINS

The Great Plains is a major ecological region found in the central part of the continent of North America, occupying nearly 1.4 million square miles. This area extends from the Canadian provinces of Alberta, Saskatchewan and Manitoba south into northeastern Mexico and from western Indiana to the foothills of the Rocky Mountains. Approximately 34 million people live in the Great Plains, including 32 million in the U.S. portion of the region.

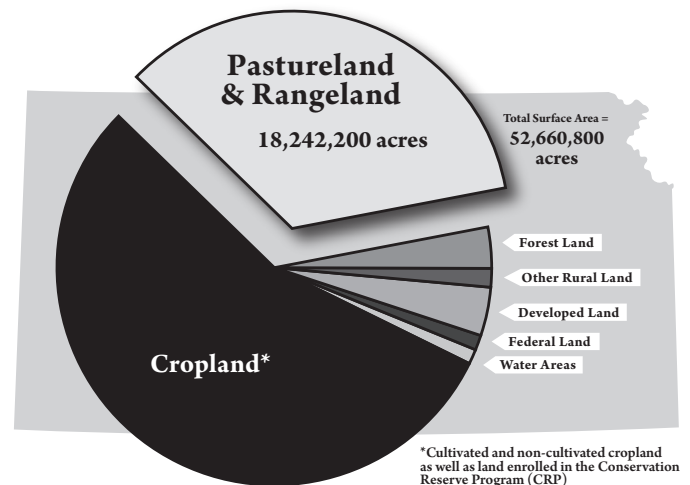


Across the Great Plains, rainfall decreases from east to west—defining different types of native prairies. While there are grassland and forest combinations along the eastern edges of the Great Plains, few native trees occur across other areas of the region. The Great Plains is one of the largest farming and ranching regions of the world and agriculture is the most important economic activity of the Great Plains.

The entire state of Kansas falls within the Great Plains ecological region. However, in Kansas, many people refer to the western two-thirds of the state as the "Great Plains."

Source: EPA

SURFACE AREA OF KANSAS – PRAIRIES (PASTURELAND & RANGELAND)



Source: 2003 Natural Resources Inventory, USDA NRCS

NAMES OF THE PRAIRIE

French explorers and fur traders in the 1700s have been credited with first calling the middle section of America "la prairie," the French word for meadow. The prairie goes by many names.

Rangeland— Land on which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs. It includes desert, tundra, and forested rangeland. Rangeland is most suitable for grazing. There are limiting factors prohibiting cropland agriculture such as rocks, trees, or mountains. Surprising to some, rangeland biomes require human and fossil energy to manage and maintain the grassland for many uses. Without proper management, the prairie moves toward a woody vegetation type. Approximately 47 percent of the earth's terrain is rangeland.

Grassland— Grassland is a generic term referring to an area covered with vegetation types dominated by grasses. It can include tame pasture, rangeland, and other types.

Pasture— A unit of grassland which has a fenced perimeter. A modern term that needed definition only after humans began to contain livestock. Often, biologists consider pasture to be made of one or only a few types of grass versus an area containing a wide variety of plant life like the native grass prairie.



Rangeland

Credit: Doug Wilson, USDA ARS

Tame Pasture— land intentionally planted for grazing, usually seeded to perennial grasses or legumes, such as clover or timothy.

KANSAS PRAIRIES

*"We say of the oak, 'How grand of girth!'
Of the willow we say, 'How slender!'
And yet to the soft grass clothing the earth
How slight is the praise we render."*

Edgar Fawcett, American-English novelist and poet

TYPES OF KANSAS PRAIRIES

The Kansas grassland biome is divided into tallgrass, mixed-grass, and shortgrass prairies. Areas of sand prairie and sandsage prairie grasslands are found in both the mixed-grass and shortgrass prairie regions of Kansas.

Tallgrass prairie—

Before settlement, the tallgrass prairie occupied a north-south strip which encompassed the eastern third of Kansas. The tallgrass prairie exists today since much of the land is not tillable due to terrain, (slope, rock layers, soil depth, etc.). The grasses can grow in excess of six feet tall during moist years if they reside in deep soils. The annual precipitation in this region exceeds 30 inches. The original tallgrass prairie spanned almost 250 million acres. Today, about four percent remains with the largest areas being the Flint Hills of Kansas and the Osage Hills of Oklahoma.



Tallgrass Prairie

Credit: Erwin W. Cole, USDA



Mixed-grass Prairie at Kanopolis State Park

Credit: Wayne Stoskopf

Shortgrass prairie— The shortgrass prairie lies mainly in the western portion of the middle United States, east of the Rocky Mountains. The grasses here are usually less than two feet tall. The westernmost areas receive, at maximum, 15 inches of precipitation per year.

Mixed-grass prairie—

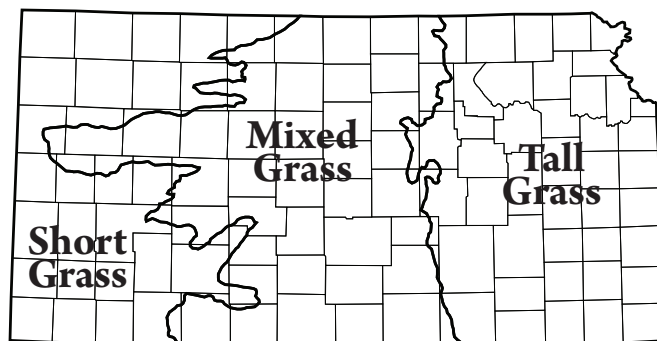
The mixed-grass or midgrass prairie runs through the middle portion of the state. The grasses here often grow to be two and three feet tall. Typically, this region receives 15 to 25 inches of precipitation per year. The primary factors which create mixed-grass prairie in Kansas are precipitation and soil depth.



Shortgrass Prairie in Cheyenne County

Credit: NRCS, St. Francis, KS

KANSAS PRAIRIE REGIONS



Credit: Travis W. Taggart, Kansas Herpetofaunal Atlas, Sternberg Museum of Natural History

SAND AND SANDSAGE PRAIRIES IN KANSAS

Typical sand dunes in Kansas are 20-40 feet high, although they can exceed 80 feet in height. Smaller sand dunes give the landscape a gently rolling appearance while large sand dunes rise as mounds or small hills. Sand dunes are characteristic of two grassland types in Kansas: the sand prairie and the sandsage prairie.

In Kansas, areas of sand prairie are found in the Arkansas River Lowlands, the Red Hills, the Smoky Hills, and the Wellington-McPherson Lowlands. The largest area of sand prairie in Kansas is the Great Bend Sand Prairie, which lies south of the bend in the Arkansas River and covers 1,100 square miles in Barton, Stafford, Edwards, Kiowa, Pratt, Reno, and Rice counties. According to the Kansas Geological Survey, sometime in the last 1,000 years, northwesterly winds probably blew sand out of the Arkansas River and deposited it on nearby lands to form the Great Bend Sand Prairie.

The primary plant species found in the sand prairie is sand bluestem. Other species found in these areas include prairie sand reed, prairie sunflower, beebalm, fourpoint evening primrose, switchgrass, sand-hill plum, and little bluestem.

Tracts of sand prairie in Kansas include Sand Hills State Park in Reno County and Pratt Sandhills Wildlife Area in Pratt County, both owned and managed by the Kansas Department of Wildlife and Parks. Bethel College owns and manages the Sand Prairie Natural History Preserve in Harvey County. Interstate 70 crosses a small area of privately-owned sand prairie in Dickinson County.

Sandsage prairie is found in southwestern Kansas, mostly west of US Highway 183 and south of the Arkansas and Cimarron rivers. Small areas of sandsage prairie are also found in the Red Hills. The conspicuous plant species of the sandsage prairie is sand sagebrush, an aromatic shrub with many gray-green branches that grows up to four feet tall. The lesser prairie chicken is a sandsage prairie resident.

Areas of sandsage prairie in Kansas include the Cimarron National Grassland in Morton County and the Sandsage Bison Refuge and Wildlife Area in Finney County, which is home to the state's oldest publicly owned bison herd. Privately-owned areas of sandsage prairie can be seen along Kansas Highway 25 in southern Hamilton County and Kansas Highway 27 in southern Kearny County.



Kearny County Sand Prairie

Credit: John Charlton, KGS

BURNING THE PRAIRIE

One practice unique to the tallgrass prairie is the prescribed burning of the native prairie in spring. Periodic fires have played a role in the history of the prairie grasslands. Lightning strikes were probably the first sources of fire on the prairie. What might have seemed devastating at first proved to have great benefits. Within weeks of a fire, a green carpet of fresh grass would surface from the blackened hills. The American Indians saw the effects of the burning and set their own fires to attract the roaming bison to the rich grass closer to the Indians' home territories, making for easier hunting that summer. After settlement of the prairies occurred, more fires were from accidental human causes, and could be devastating, but their positive effects on the grassland were the same.

Fire removes standing dead vegetation and light mulch, allowing sunlight to warm the soil and encourage rapid plant growth. Without recurring fires, the accumulation of old growth and mulch insulates the soil. As a result, plant growth is slower and woody plants are encouraged.

It has been hypothesized that fire occurred two to three times within any five-year period in the evolution of the tallgrass prairie. Many ranchers don't burn every year, but mimic this "natural" schedule for optimal grass management. In addition to encouraging desirable grasses, the fire fights back emergent brush and undesirable plant species. Scientists and ranchers agree that a pasture which has been burned at the proper time can increase the total plant productivity by stimulating the growth of warm-season grasses. The grasses' growing points are protected below ground, while shrubs and trees have their growing tissues at the tips of their branches in direct contact with the searing heat of fire. The blackened ground absorbs more sunlight, allowing the soil to warm much more quickly in the spring. Fire can also create a more even distribution of grass, erasing the effects of heavy grazing from the previous summer.

Fire is used today in the tallgrass region on native grasslands to improve the integrity and diversity of the prairie. The burning is done with safety and proper environmental conditions observed. Ranchers and volunteers, often the owners of the neighboring grass, work together to burn a larger area of grass without having to stop the fire at every pasture fence. If managed and implemented correctly, fire is an important practice for maintaining the prairie, controlling woody plants, increasing forage quality, increasing grazing distribution, and removing excessive old growth.

Burning at the wrong time, or when it is so dry that soils are completely exposed and vulnerable to compaction, can be detrimental to grass production. Even so, the mineralization of the soil is increased by burning organic matter, which increases nutrient availability to the grasses. Surprisingly, there is no total reduction in soil nitrogen, although the burning grass does release nitrogen into the air. Burning on shortgrass and mixed-grass prairies is not as effective as in the tallgrass prairies because they receive less rain than the areas in the eastern part of the state. With fire, ranchers have a tool which can increase the prairie's economic output while helping to keep the grassland biome in balance—an excellent marriage.



Prairie Burning

Credit: Megan Blythe

Because plant life is not static, the eastern and western boundaries of the Kansas prairies blend rather than forming a definite boundary. There is a continual shift of plant communities along the borders of the tall, mixed, and shortgrass prairies, mostly because of changes in precipitation, but also because of the presence of fire and grazing animals. For example, a series of dry years result in an increased dominance of short grasses which are better adapted to a dry climate, moving the region's boundaries to the east. Westward shifts occur after periods of relatively high precipitation, which favor the taller grasses.

RANGE PLANTS

Kansas range plants are classified as:

Grasses— The grass family, *Gramineae*, is a diverse group of plants. It has a wide distribution around the world, and a large number of traditional global food crops fall under the grass family, including corn, wheat, rice, and sorghum. Grasses can be introduced or native to the North American continent.

Forbs— Forbs are herbaceous broadleaf plants often referred to as weeds or wildflowers. There are over 1600 known species of forbs in the prairie. Forbs can grow from seed (annual plants) or from previous year's growth (perennial plants). Some plants classified as forbs are the legume or pea, sunflower, and milkweed families. The forb plants perform many roles in the prairie including erosion control, soil conditioning, fertility, and food for wildlife species.



Prairie Coneflower

Credit: Lynn Betts, USDA NRCS

Woody plants— Woody plants are perennial plants with woody stems. Each year, new growth comes via buds on the old growth. This group includes trees, shrubs, vines, cacti, and yucca. Woody plants can be introduced or native to the North American continent. Some species are considered undesirable. Many woody species in the prairie are the result of the elimination of recurring fires that were their natural control.

The following are the dominant native grasses in Kansas. It has been estimated that there are over 180 species of grass in the state.

TALL GRASSES

Big Bluestem *Andropogon gerardii*— Also known as "turkey foot" because the branching seedhead resembles a turkey's foot, its name comes from the bluish cast of the plant during the growing season. In the fall, it takes on a tan to reddish-brown cast. It prefers

RANGE PLANTS

Forbs— plants whose stems and broad flat leaves die down to the soil level at the end of each growing season.

Grass— family of plants characterized by hollow jointed stems and bladelike leaves.

Woody plants— perennial plants with above-ground stems that resemble wood in appearance, texture, or toughness.

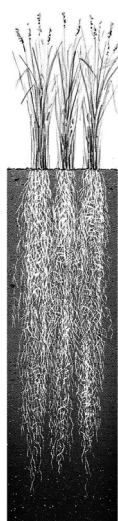
TALL GRASSES



a. Big Bluestem



b. Indiangrass



c. Switchgrass



d. Eastern Gamagrass

Credits: a. USDA NRCS; b. K-State Research and Extension; c. University of Minnesota Extension Service; d. K-State Research and Extension

the relatively moist, deep soils found in eastern and central Kansas. In ideal sites, the seed stalks can exceed six feet in height. Early settlers reported that in some areas big bluestem was as tall as a man sitting on a horse.

Indiangrass *Sorghastrum nutans*– The name comes from the feather-like ligule, or thin outgrowth, at the junction of the leaf and sheath. The seed heads are plume-like and bronze to yellow in color. Indiangrass prefers the relatively moist, deep soils found in eastern and central Kansas. In ideal sites, the seed stalks can exceed six feet in height.

Switchgrass *Panicum virgatum*– Switchgrass is a deep-rooted grass that grows in bunches and can reach up to six feet tall. The rooting depth can exceed 10 feet in deep soils. The seed head is a pyramid shape with many purplish spikelets. It can be identified by a triangular area of hairs where the leaf blade meets the sheath. It prefers soils that are high in calcium or lime versus wet, acidic soils.

Eastern Gamagrass *Tripsacum dactyloides*– This perennial grass is the most productive and palatable of the tallgrass native species. It can grow to eight feet tall with robust stems which are flattened at the purplish base. It grows from stout, scaly rhizomes. The blades can be up to one inch wide with rough and sharp margins. The inflorescence, or flower cluster, has one to three spikes, up to a foot long, with the male spikelets above the female spikelets. The male spikelets are in pairs fitting into the hollows of the seed stem. This grass is closely related to corn. It grows in fertile bottomland, swamps, and along streams. It can grow on fertile uplands under good management.

PRAIRIE PLANT WORDS

Awns– slender, stiff, bristle-like extensions of a plant, like the beards on a head of wheat.

Axil– the space between a leaf and the stem to which it is attached.

Bulb– an underground stem or root, usually surrounded by scale-like leaves and containing stored food for the shoots of the new plant that grows within it.

Floret– small individual flowers that form a larger flowerhead, such as in a sunflower.

Inflorescence– the flowering part of a plant that consists of more than one flower, often several distinct individual flowers.

Ligule– a small flap or row of hairs on the inner or upper side of a leaf where it grows out of the sheath.

Rhizome– an underground stem that is horizontal and produces roots at the joints.

Root– the underground portion of a plant. Draws food and water from the soil and stores plant food.

Rootstock– any underground stem that will take root at the joints.

Sheath– the lower part of a leaf that fits around the stem.

Spike– a long inflorescence attached directly to a stem with the newest flowers at the tip.

Spikelet– a small flower spike, the basic unit of the flower cluster of a grass plant.

Stolon– a long stem or shoot that droops to the ground and may root and form new plants where it touches the soil.

Source: K-State Research and Extension

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MID GRASSES



a. Little Bluestem



b. Western Wheatgrass



c. Sideoats Grama

Credits: a. K-State Research and Extension; b. Robert Mohlenbrock, USDA NRCS PLANTS Database; c. USDA NRCS

MID GRASSES

Little Bluestem *Schizachyrium scoparium*– It is a bunch grass with flattened sheaths, blades and stems purplish to bluish-green, turning leathery brown at maturity. The flower clusters have small fuzzy seeds with twisted awns (slender, stiff, bristle-like extensions of a plant, like the beards on a head of wheat) partially enclosed in the leaf sheaths. It grows on upland and bottomland soils to a height of three feet.

Western Wheatgrass *Pascopyrum smithii* (*Agropyron smithii*)– It grows to three feet from gray, slender creeping rootstock. The stems and leaves are blue-green. The leaves are straight, broad, rough, and strongly veined on the upper surface and roll inward with maturity. The seed head is flat and usually awnless. It is most abundant in moist bottomland areas and prefers clay soils.

Sideoats Grama *Bouteloua curtipendula*– It grows to 3 ½ feet tall with stems growing from strong, scaly rootstock. Hairs grow out of small, bulb-like spots on the leaf blade edges. The inflorescence has many spikelets (20-50) twisting around on one side when ripe, resembling oats. It matures and produces seed in spring and fall. It has good seedling vigor and can withstand long drought periods. It grows on well-drained soils throughout Kansas.

SHORT GRASSES

Blue Grama *Bouteloua gracilis*– It grows in bunches that reach up to two feet tall with erect stems. The inflorescence has two rooster comb-like spikes that curve downward when mature. It grows on hills and plains in shallow to moderately deep soils, primarily in the western half of Kansas.

SHORT GRASSES



a. Blue Grama



b. Buffalograss

Source: K-State Research and Extension

Buffalograss *Buchloe dactyloides*– It is a warm-season sod-forming grass that can produce 12-inch-tall seed stalks. It has creeping stolons which take root at the leafy nodes and forms sod. The leaves have bristly hairs on both sides. The foliage turns reddish brown after frost. The male and female plants grow in separate colonies. Female plants bear seed in bur-like clusters among the leaves. Male plants have a two- or three-spiked, flag-like seed head. Seed is produced throughout the year. It grows on shallow, droughty soils in the western half of Kansas.

FORBS

Showy Partridgepea *Chamaecrista fasciculata*– It is an annual with slender, erect stems. It can grow from one to four feet tall, and branches freely; the branches have short hairs. Each leaf has six to 15 pairs of linear-oblong leaflets. Yellow flowers are clustered in the axils of the leaves. The flat pod (legume) is from one to 2 ½ inches long and contains from four to 20 seeds.



Showy Partridgepea

Credit: Clarence A. Rechenthin, USDA NRCS PLANTS Database

Catclaw Sensitivebrier *Mimosa nuttallii*– A perennial trailing or sprawling plant, one to four feet long, ribbed and armed with hooked prickles. Flowers are up to one inch wide, pink to lavender in color, and grow in clusters. The leaves of this plant have a unique response to being touched: they fold up.



Catclaw Sensitivebrier

Credit: Megan Blythe

Blue Wildindigo *Baptisia australis*– One of the first flowers of spring, it has blue to purple pea flowers grouped on 4- to 20-inch-long stems. The fruit is a pod which is one to two inches long, turns dark-brown to blackish, and tapers into a short beak, containing brown seeds.



Blue Wildindigo

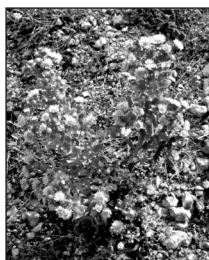
Credit: Megan Blythe



Woolly Verbena *Verbena stricta*— Stems are stout, leafy, and velvety because of a soft coating of whitish hairs. Grows two to four feet tall. Seedheads are stout, dense 6- to 12-inch spikes which sport small, purplish-blue flowers.

Woolly Verbena

Credit: Jennifer Anderson, USDA NRCS PLANTS Database



Curlycup Gumweed

Credit: Megan Blythe

Curlycup Gumweed

Grindelia squarrosa— This is a short-lived perennial. Its tooth-edged leaves are oblong, coarse, thick, and fold around to clasp the stem. The flower head is surrounded by small, pointed leaves which give off a sticky substance.

Ironweed

Vernonia baldwinii— Ironweed is a perennial forb with reddish-purple seed heads with 13 to 34 flowers forming a dense mass of color. Its stems are coarse and thick; the

leaves are large with short stems. It can grow to five feet tall. It is considered an invader in bottomlands and other deep moist sites.

Ironweed

Credit: Clarence A. Rechenthin, USDA NRCS PLANTS Database



COMMON WILDFLOWERS

Butterfly Milkweed

Asclepias tuberosa— Stems are coarse and hairy, and contain a small amount of milky juice. The bright flower heads are composed of many orange-red florets.

Sunflowers— The sunflowers are a group of annual and perennial species native to the prairie. These include the state flower of Kansas, the annual sunflower (*Helianthus annuus*). Among the perennial sunflowers are Maximilian sunflower (*Helianthus maximiliani*), ashy sunflower (*Helianthus mollis*) and compassplant (*Silphium laciniatum*).

Dotted Gayfeather

Liatris punctata— Also called “blazing star,” it is an erect plant growing 30 inches tall. It arises singly or in clusters from the rootstock. The flowers are 3- to 8-disked florets in a purple to rose color. It prefers deep, well-drained soils.

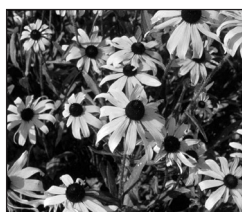
Dotted Gayfeather

Credit: USDA NRCS



Butterfly Milkweed

Credit: Clarence A. Rechenthin, USDA NRCS PLANTS Database



Maximilian Sunflower

Credit: USDA NRCS



PHOTOSYNTHESIS REFERENCE

Grass Makes Its Own Food

USDA Agriculture Information Bulletin 223 revised
Natural Resources Conservation Service, Salina, Kansas, 2003

WOODY SPECIES

Common native trees include bur oak (*Quercus macrocarpa*), black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), and cottonwood (*Populus deltoides*).

Shrubs include American plum (*Prunus americana*), sandhill plum (*Prunus angustifolia*), roughleaf dogwood (*Rhus drummondii*), fragrant sumac (*Rhus aromatica*), and buckbrush (*Symphoricarpos orbiculatas*).

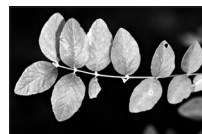
Buckbrush

Credit: Robert H. Mohlenbrock, USDA NRCS PLANTS Database



Bur Oak

Credit: USDA NRCS



THE WEB OF LIFE

The grassland biome purifies the air through photosynthesis. In the process of photosynthesis, the chlorophyll-containing cells in green plants convert sunlight into chemical energy. As the plants do their work, they take in carbon dioxide and release oxygen. One source of carbon dioxide is human-produced fossil fuel emissions. The grass-filled prairies of Kansas are serving as a cleansing filter for the earth's human population as well as a food supply for its livestock and wildlife and, in succession, its people.

All members of the grass family, not only prairie grasses, live and grow on food manufactured mostly in their own green leaves. Rangeland or any grass crop can flourish only if the individual plant can make food for its own growth. The raw materials to make food are present in the soil and the air.



Beef Cow

Credit: Allison Blythe

Water entering the soil forms a film around each soil particle and dissolves some of the minerals present. Tiny root hairs from the plant come in contact with these films of water and absorb the mineral solution. A network of small roots carries this mineral solution to the main roots. The roots transport it to the stems; stems carry it to the leaves.

Plants use phosphorous, nitrogen, potassium, calcium, magnesium, and sulfur to manufacture their food. They use other minerals such as iron, manganese, molybdenum, copper, boron, and zinc in smaller quantities but must have them for good plant growth. All these minerals are contained in the solution carried to the plant.

Minerals from the soil make up about five percent of the solid material found in plants. Carbon, hydrogen, and oxygen from the air and water make up most of the other 95 percent.

Throughout the growing cycle, grass is consumed by grazing animals: bison, throughout history, and domestic cattle as well as others. The nutrients produced in the muscles of these grazers—some of which are so unique they can be found in no other food source—are passed on to meat eaters in a nutrient-dense package. Each link in this process is vital to the health of the grassland and to other consumers in the web.



Bison Herd

Credit: Bob Gress, GPNC

CLIMATE OF THE PRAIRIE

"The stranger [to Kansas], if he listened to the voice of experience, would not start upon his pilgrimage at any season of the year without an overcoat, a fan, a lightning rod, and an umbrella."

John James Ingalls, U.S. Senator from Kansas

The most recognized and accepted identification of climates was introduced in 1900 by Wladimir Koppen, a Russian-German scientist. Koppen divided the world into climatic zones which coincided with patterns of vegetation and soils.

The climate of the grasslands biome of North America is considered Dry Mid-latitude, using the Koppen classification system. Other areas in North America classified Dry Mid-latitude climate include the Great Basin and the Columbia Plateau, the arid tablelands between the Sierra Nevada and Rocky Mountain ranges.

CLIMATIC ZONE OF KANSAS

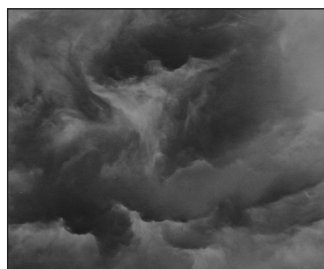
All Dry Mid-latitude climates have a wide range in annual temperature. Summers are warm and winters are cold. Kansas is no exception, as anyone who has spent a year in the state knows! There are huge variations in the temperatures and humidity levels throughout the state during the year. It follows that there are also vastly different ecological communities present in Kansas, including native grasses and prairie plants.

In Dry Mid-latitude climates, there are two main types of air masses: tropical air masses, which move toward the poles; and polar air masses, which move toward the equator. The air masses have a symbiotic, push-pull relationship—either air mass may dominate at one time, but neither has exclusive control. The Dry Mid-latitude climate is created when ocean air masses are blocked by mountain ranges to the west. This allows polar air masses to dominate in winter.

Kansas lies within a zone of interaction between the air masses which affect the climate of the entire North American continent. In summer, warm, moist, unstable tropical air flows north from the Gulf of Mexico and dominates the weather across the state. It is subsequently pushed aside by hot, dry, unstable, continental air masses from the desert southwest. The relative humidity can be high in the eastern part of the state, but the air becomes progressively drier to the west.

RAIN SHADOW EFFECT

The rain shadow effect has had a large influence on the Kansas prairie climate. Rain clouds originate off the Pacific Ocean and are forced to great heights by the three major mountain ranges in the West: the Sierra Nevada range, the Great Basin range, and the Rocky Mountains. The clouds cool and condense at high levels, and send moisture downward in the form of rain or snow. As they travel across the eastern slope of each range, they have less and less water to drop.



Storm Clouds Over Kansas

Credit: Edward A. Almquist

As they move further east, these clouds which have been wrung dry combine with moist air masses from the Gulf of Mexico, creating a new mass of moisture-laden clouds over the eastern Great Plains.

Simply put, the rain shadow effect helps create a higher humidity in the east than the west.

Consequently, the differing precipitation amounts in each region of Kansas contribute to the type of plants that dominate. At the western border, the average precipitation is less than 16 inches per year. On the eastern border in southeast Kansas, the average precipitation is around 44 inches per year. From east to west across Kansas, the amount of precipitation received during the growing season ranges from 65 to 75 percent. During the growing season, about 45 percent of the precipitation falls in the May–June period and about 55 percent falls in the July–September period.

SOILS OF THE PRAIRIE

"... the Latin name for man, homo, derived from humus, the stuff of life in the soil."

Dr. Daniel Hillel, American professor of soil physics

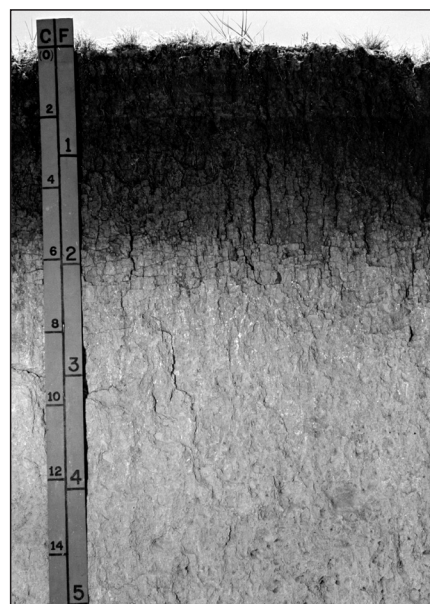
A TEEMING FACTORY OF LIFE

It has been said that humans know less about the earth under their feet than they do about the far side of the moon. Yet every plant and animal on this planet depends on this vast, hidden ecosystem for food and shelter.

The Kansas prairie soil is highly fertile and has been called a teeming factory of life. It is one of the most complete and delicate ecosystems on earth. This contributes to a hugely diverse grass population that exists much the same today as it has for thousands of years.

At the ground level, plants and animals live and grow. A thick cover of growing grass and decaying plant matter insulates the soil. This aids the soil's ability to capture and utilize water in the form of rain, snow, and runoff. The natural mulch maintains a cooler and moister environment which helps the prairie to adapt to drought, a period of low moisture.

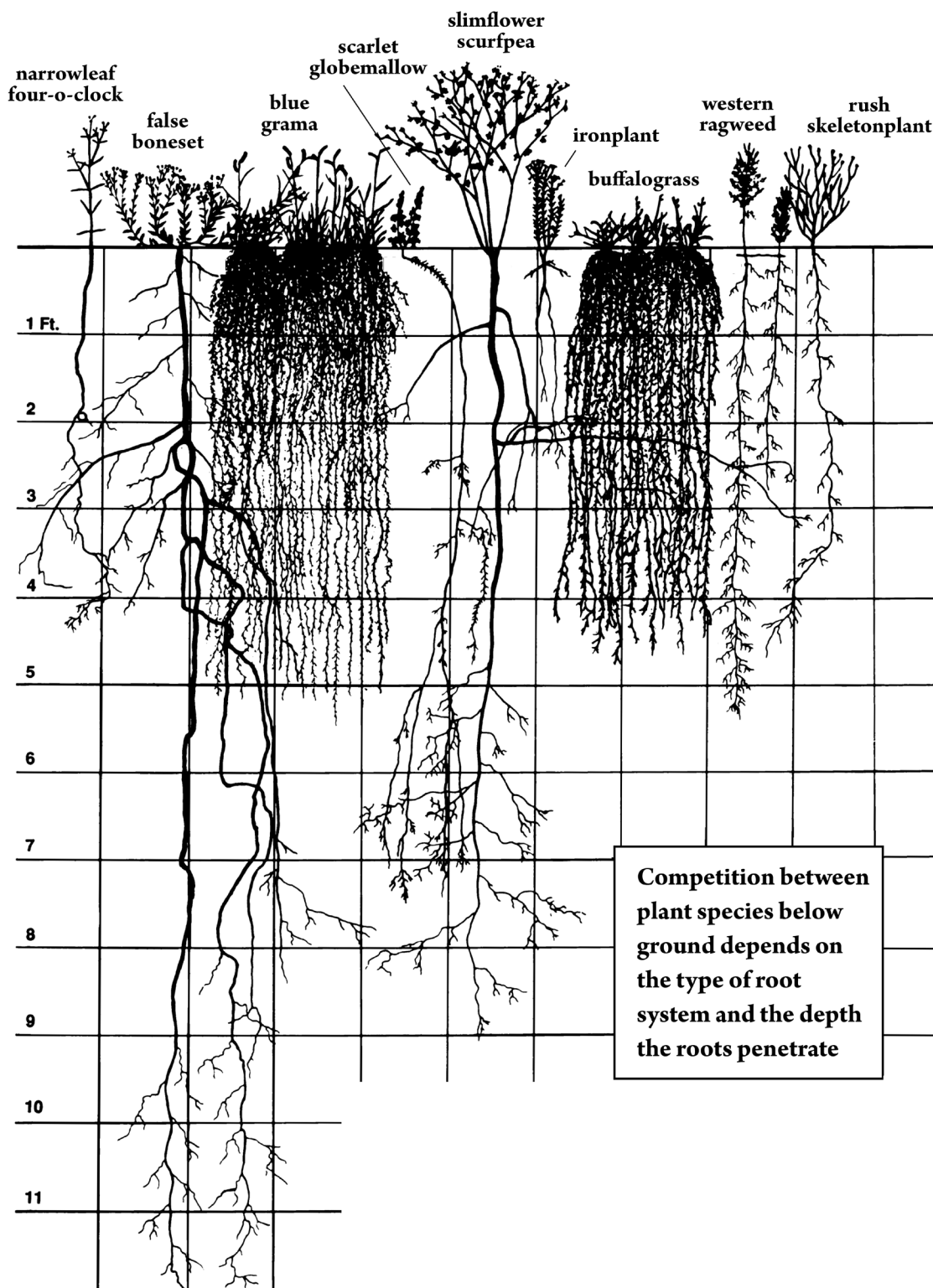
Soil under the prairie is a dense tangle of roots, bulbs, and rhizomes (horizontal stems, above ground or underground, from which aerial stems or leaves can arise). The roots of several species of grass can go deeper than the aerial stems are tall. Some of these roots die and decompose every year, adding large quantities of organic matter to the soil and creating the rich component called "humus." Its dark color permeates through the layers of soil. Roots are able to bring nutrients to the surface for the varied grasses to utilize. Also present in all soils are amoeba, bacteria, mites, nematodes, night crawler worms, and root fungus. All of these contribute to the nutrients which grasses and plants receive from the soil.



**Harney Silt Loam
State Soil of Kansas**

Source: USDA NRCS

COMPARISON OF PRAIRIE PLANT ROOTS



Source: K-State Research and Extension

SOIL WORDS

Humus— the organic component of soil, formed by the decomposition of leaves and other plant material. Its presence increases the ability of soil to retain water.

Mulch— a mass of leaves or composted material that protects or enriches the soil.

LAYERS OF ROCK

Geologists have identified 170 rock layers present in Kansas. Each one can tell a story, including how it was formed and how it was deposited. During parts of the Paleozoic Era, a time period from around 570 million to 245 million years ago, the state of Kansas was covered in water. As soon as any part of the land beneath the water appeared as the oceans receded, the process of erosion tried to wear the rock and soil back down to sea level. The material that eroded, called sediment, was carried by streams and rivers and deposited downstream, compressing into new and different rock layers.

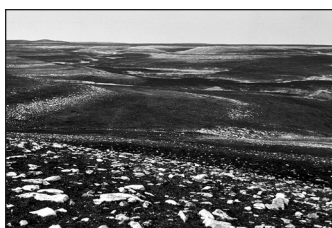
The Cenozoic Era, which began about 63 million years ago, encompasses the most recent time, so scientists know more about it than any other geological time period. Glaciers moved into Kansas from the north during this era. Geologists have found that 70 percent of the original grassland area in North America was formed on soil deposits created by glacial ice. After the glaciers melted, wind and water carried the soil away from some areas and deposited it in other places. As mountains were formed in the western United States, layers of dust were introduced and deposited in Kansas.

TALLGRASS PRAIRIE SOIL

Soils in the tallgrass region are born from layers of shale and limestone. When clay and silt are compacted into a solid rock, it is called shale. Shale erodes quickly into clay when exposed in outcrops. The shale creates slopes in the hillsides, giving the landscape a terraced shape. Some limestone has chert or flint nodules in it, which on freezing and thawing break up into the characteristic flint pieces that give the Flint Hills their name. Chert is stronger than the limestone which surrounds it, so it stays in larger pieces and makes the ground rocky.

As shale and limestone eroded, limestone layers or outcroppings were formed. The limestone layers formed benches that proved too rocky for the settlers to plow. The solution was for livestock to “harvest” the grasses that grew there.

True prairie soils are called mollisols, a type of soil recognized to have high fertility. Many eastern Kansas soils were formed from silt which had been deposited by wind and water. Loess (pronounced “lus”) is windblown silt, carried after the mud hardened and turned to dust. The dust was carried by storms to many areas in the state leaving thicker deposits to the west and thinner deposits in the east. Thick glacial loess deposits occur in northeast Kansas where rocks and gravel were ground down by glaciers and water.



Flint Hills– Chase County

Credit: John Charlton, KGS



Chert– Chase County

Credit: Grace Muilenberg, KGS



Wabaunsee County Outcrop

Credit: Robert Swain, KGS

MIXED-GRASS AND SHORTGRASS PRAIRIE SOILS

The Smoky Hills region of Kansas lies west of the Flint Hills, in the north-central part of the state. Certain rocks present here were on the sea floor during the Cretaceous Period. The hills of the eastern Smoky Hills are capped with sandstone formed by rivers bringing sediment into early Cretaceous seas from the east. The hills in the central Smoky Hills region are topped with limestone formed from shallow deposits, which contain many small fossils. In the western part of the Smoky Hills, thick chalk beds were deposited at the bottom of the deeper parts of the Cretaceous ocean. As some of the layers eroded, the chalk beds were exposed and carved into tall, steep-sided formations by erosion. These remnants of the ancient chalk beds, known for the fossils of swimming reptiles and other dinosaurs, can be seen in Gove, Trego, and Logan counties.

Almost all of the western one-third of the state of Kansas is called the High Plains. The High Plains region is a huge, gently sloping floodplain, the result of millions of years of erosion at work on the Rocky Mountains to the west. The Rocky Mountains were formed during the late Cretaceous and early Tertiary periods. Streams flowing out of the Rocky Mountains carried masses of sand, gravel, silt, and rocks that eventually filled the stream valleys and covered the hills. Beneath the surface, the eroded materials trapped water in underground aquifers, including the Ogallala aquifer, which is one of the main sources of groundwater in western Kansas.

Driving across the state from west to east, most travelers don’t recognize the gradual shift in elevation. The change in sea level is greater than 3,000 feet from the highest point in Wallace County near Colorado to the lowest point in Montgomery County near the southeastern border. The change in elevation is caused by additional layers of sediments present in western Kansas, but not in the east. Most of this sediment originated from the erosion of the Rocky Mountains.

In the shortgrass and mixed-grass regions of Kansas, the subsoil moisture is used each year by the vegetation. The soil remains dry and fertile because there is very little excess water to absorb any nutrients not used by the plants. The soil found in the shortgrass and mixed-grass prairies is sandier than in eastern Kansas.



Sandstone– Marion County

Credit: John Charlton, KGS



Limestone– Russell County

Credit: John Charlton, KGS



Monument Rocks– Gove County

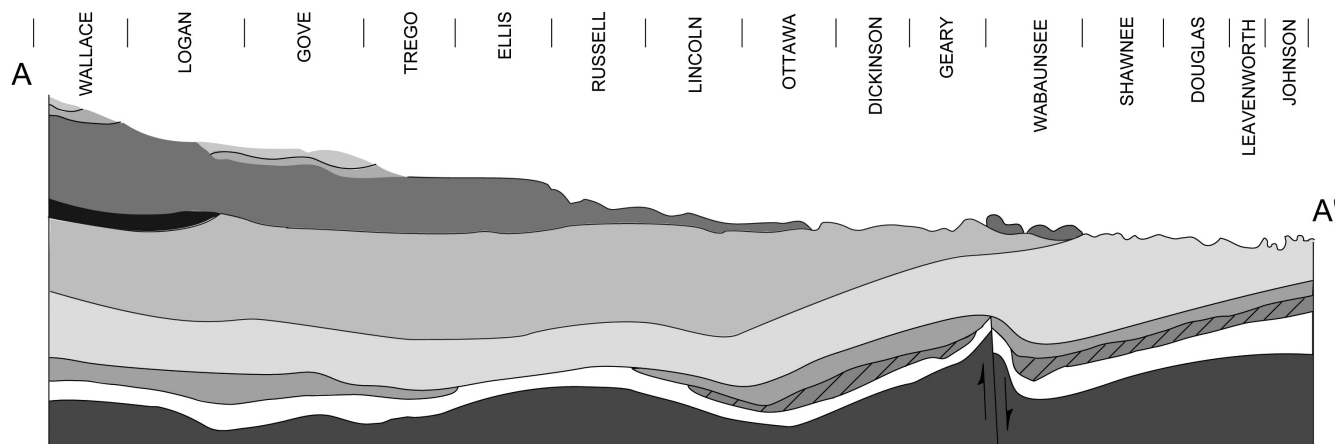
Credit: John Charlton, KGS



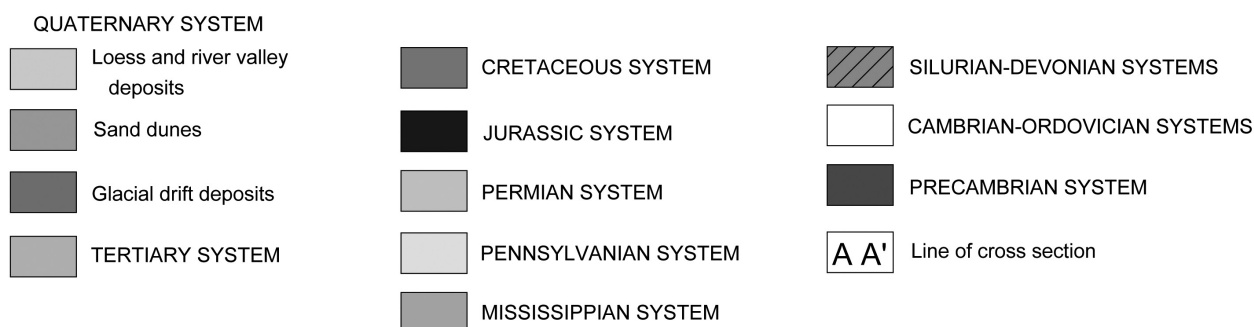
Arikaree Breaks– Cheyenne County

Credit: John Charlton, KGS

GEOLOGICAL CROSS SECTION OF KANSAS (WEST TO EAST ALONG I-70)



Geologic cross section below I-70



Source: Kansas Geological Survey

LEARNING FROM THE PRAIRIE

Farmers have learned from nature and the prairie model: if you regularly rotate which crops are planted, it creates a balanced soil profile. Each crop lends different nutrients to the soil, and most crops benefit from the others' recent presence.

No-till farming and conservation tillage, practices becoming more popular in Kansas and throughout the United States, are a tribute to native grasslands. To reduce erosion from wind and water, farmers reduce the mechanical manipulation of the soil in fields in between the harvest of one crop and the planting of the next. The goal is to preserve the precious topsoil and to create a decomposing crop residue to nourish the new crop.

WILDLIFE ON THE PRAIRIE

"Any glimpse into the life of an animal quickens our own and makes it so much the larger and better in every way."

John Muir, American naturalist

With 20 million acres of grassland in the Kansas prairie, it is not a surprise that grazing animals have been the dominant wildlife. Bison have roamed here, along with mule deer, white-tailed deer, and pronghorn antelope. Smaller mammal species have existed as well, including the coyote, black-tailed prairie dog, jackrabbit, and badger.

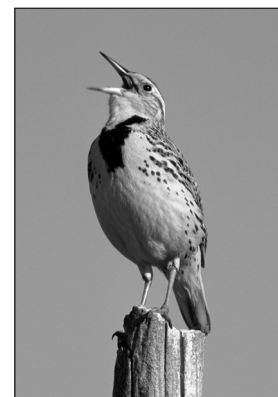
A large variety of birds live on the prairie, including western meadowlark, upland sandpiper, red-tailed hawk, burrowing owl, and prairie chicken. There are snakes and reptiles, including prairie and timber

rattlesnakes and ornate box turtles. Insects are not usually classified as wildlife, but biologists at the Konza Prairie Biological Station near Manhattan have also identified over 50 types of butterflies and over 100 different grasshoppers alone. One species was found and given its common name by a Fort Riley Middle School class participating in their Schoolyard Long Term Ecological Research program.



Pronghorn Antelope

Credit: Jack Dykinga, USDA ARS



Western Meadowlark

Credit: Bob Gress, GPNC

Ornate Box Turtle

Credit: Bob Gress, GPNC

KANSAS STUDENTS NAME GRASSHOPPER

While participating in the Konza Prairie Grasshopper Inventory in September 2001, Mr. Gunderson's eighth grade class from Fort Riley Middle School caught a grasshopper that had no official common name. The students were asked to create a common name for the grasshopper, which has the scientific name *Boopedon gracile*. The students chose "Restored Prairie Calico Grasshopper" because the grasshopper was captured in a field that had recently been planted to native grasses and forbs. The appearance of the grasshopper reminded the students of a calico cat.



American Bison

Credit: Bob Gress, GPNC

BISON FACTS

- Bison weigh from 800 to 2,000 pounds when fully grown and roam in herds.
- When the bison population was at its peak, it was estimated that one herd could number in the tens of thousands and be 12 miles long.
- The average life span of a bison is 15 to 20 years.
- Females, or cows, usually calve at two or three years of age.
- Bison calves weigh from 35 to 65 pounds at birth, and are yellowish-red in color.
- The American bison (scientific name *Bison bison*) was adopted as the Kansas state mammal in 1955.
- Bison actually belong to the same family of animals as domesticated cattle, sheep, and goats and are not related to Asian and African buffaloes, although early explorers called them "buffalo" when they first saw the animals in North America.



American Bison

Credit: Jack Dykinga, USDA ARS

BISON

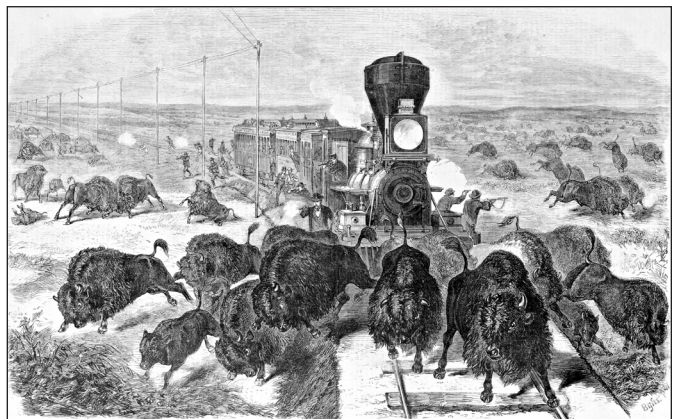
The largest grazing animal of the prairie was the American bison, commonly referred to as buffalo. It has been said that no other indigenous animal has influenced the history of the prairie and Old West so much as the buffalo.

Bison belong to the family *Bovidae*, the same family to which musk ox and domesticated cattle belong. The Latin name is *Bison bison*, specifying that it is not a "true" buffalo like the Asian or African buffalo, which has no hump. About 40,000 years ago, some small Asian buffaloes probably traveled across the Bering Strait into what is now North America. These were the ancestors of the present-day bison.

Prior to the Europeans' arrival on the continent, it is estimated that there were from 30 million to 75 million bison in North America. The first humans in the area probably traveled across the same land bridge as the bison. As the American Indian tribes evolved into hunting and gathering societies, the relationship which bound them to the bison held huge significance. The tribes roamed the entire continent, tracking and hunting the grazing animals. The bison had an effect on how the American Indians lived on the plains: where they lived, the structure of their societies, what tools and weapons they made, the stories they told, and the songs they sang. The demand and subsequent hunt for bison by the white man started in the 1830s. Fur trappers had almost exhausted the supply of beaver for pelts to send to Europe. Noting the large number of bison, the American Fur Company and the Hudson Bay Company switched their orders to bison robes to clothe their European customers.

Encouraged by the Homestead Act of 1862, farmers began to settle the Great Plains. The post-Civil War era brought many more people into the prairies of Kansas, and towns sprang up. As the European settlers moved westward, the population of bison declined in the late 1800s. The settlement of the Great Plains conflicted with the ability of the American Indians to continue their lifestyle. Sitting Bull, a Sioux chief, said of the decrease in the number of bison: "A cold wind blew across the prairie when the last buffalo fell... a death-wind for my people." Initially, bison meat was used locally, but after the railroad system was established, trains allowed for easy shipment of goods. This catered to the taste the people in the East had developed for the bison meat. Additionally, a new tanning process was developed for the hides in the early 1870s, making the preservation of hides easier.

The seemingly endless supply of bison encouraged wastefulness in the hunters. In 1872, two million buffalo were killed just for their



Shooting Buffalo on the Line of the Kansas-Pacific Railroad, 1871

Source: Library of Congress; Credit: Frank Leslie's Illustrated Newspaper

hides, which were selling for around \$3.50 apiece. Based on the number of bones shipped east on the railroad (used to make bone china and fertilizer and in the sugar refining process), approximately 31 million bison were killed between 1868 and 1881. It was estimated that the amount of meat wasted during the period of great slaughter in the 1870s could have fed one million people.

In 1886, the Smithsonian Institute and the New York Zoological Society sent taxidermist William Temple Hornaday to the West to obtain a bison for preservation purposes. As he searched, Hornaday became aghast at the low numbers and he started a national effort to save the bison. In 1905, the American Bison Society was formed with Hornaday as its president. Theodore Roosevelt, who would become the 26th U.S. President but was then a rancher and former New York assemblyman, was selected as an honorary leader. They gathered the remaining few bison onto refuges across the country to regenerate the American herds' total numbers.

Currently there are around 270,000 bison in the United States. The U.S. Department of Agriculture Census for 2002 pinpointed the number of bison in Kansas at 8,767. American bison are raised on private, federal, and state lands.

PRAIRIE CHICKENS

Prairie chickens have thrived in the Kansas prairie biome, but their population diminished when their habitat became settled by humans. In the late twentieth century, efforts were made to protect prairie chickens, and many people now recognize and enjoy their interesting traits. Unlike most birds, greater and lesser prairie chickens are not migratory. They spend the year in the same home area.

The most unique characteristic greater and lesser male prairie chickens share is an intricate courtship ritual called "booming." Areas called "leks"—elevated shortgrass areas, such as hilltops or ridges, often the tallest point for a quarter of a mile—are chosen by the male birds in mid-March. A male will attract a female by stomping and fluffing his feathers while inflating the large orange air sacs on the sides of his neck and giving a muffled cry which sounds like a "boom." The peak of the booming season is usually the first two weeks in April every year, but can run from the end of March to the beginning of May. Reserved sites for viewing the prairie chicken can be found at the Cimarron National Grasslands near Elkhart. More "reserved blinds" are being developed by the Kansas Department of Wildlife and Parks.

Greater Prairie Chickens

The greater prairie chicken, *Tympanuchus cupido*, is a bird which was once very prevalent in the tallgrass biome. It is related to the grouse and has a round, plump body with short legs and neck. The greater prairie chicken weighs two pounds, and it has a wingspan of 28 inches. It forages for seeds, buds, and fruit of native plants and also eats insects.

The greater prairie chicken prefers tallgrass and mixed-grass prairie which has been properly managed by grazing, burning, and fencing of livestock. They utilize many habitats in the tallgrass prairie, using the lightly grazed areas for nesting and the more heavily grazed for their booming.



Greater Prairie Chickens
Credit: USDA NRCS

The original range of the greater prairie chicken stretched from Canada south to Oklahoma and Texas. Now, their year-round populations are focused in parts of Kansas, northeastern Colorado, Nebraska, and North and South Dakota.

Lesser Prairie Chickens

The lesser prairie chicken, *Tympanuchus pallidicinctus*, is a round, stocky ground-dwelling bird that looks—and behaves—much like its cousin the greater prairie chicken. The lesser prairie chicken prefers a more sandy-soiled range with sagebrush and little bluestem grass. Remaining populations are found in pockets in Kansas, Colorado, New Mexico, Oklahoma, and Texas.

The lesser prairie chicken can weigh one and a half pounds and lives from two to five years. Its largest clutch size is 14 eggs. Lesser prairie chickens do not migrate, but prefer a home range less than 1,200 acres in size.

The lesser prairie chicken is considered a candidate species for protection under the Endangered Species Act. Their population declined 78 percent from 1963 to 1980 due to the expansion of cropland agriculture.

The Conservation Reserve Program of the U.S. Department of Agriculture may be an aid in prairie chicken conservation. Farmers and ranchers enroll in the program, agreeing to plant appropriate vegetation, often reseeding native prairie grasses on eligible fields to encourage wildlife habitat and retain topsoil.

SPECIES IN HARMONY

Today, the Kansas prairie is home to both wildlife and livestock. In most situations, it is not a case of opposing interests. A grassland will support both native and domesticated species in harmony if the biome is thriving and healthy. Ranchers regard their stewardship of the soil and grass as a serious responsibility.

Proper management of grasslands can help wildlife most when a diverse grass and forb community is maintained. If herbaceous and woody plants are tall enough, this can provide cover for small mammals and birds. Management aids domestic livestock most when its forages are plentiful and sustained throughout the grazing season.



Mare and Foal
Credit: Tim McCabe, USDA



Greater Prairie Chicken
Credit: USDA NRCS



Lesser Prairie Chickens
Credit: Stephen Ausmus, USDA ARS



Angus Bull

Credit: Julia Stoskopf-Debes

Throughout history, ruminant animals like bison and cattle have grazed and fertilized the prairie, using their four-compartment stomachs to break down the cellulose found in prairie grasses. The stomach of a ruminant digests plant material through microbial digestion. Grass cannot be digested by humans; instead they must eat animal and plant products to absorb the nutrients they need, including the most critical nutrient, protein. Complete proteins like meat and milk contain all the necessary amino acids, the build-

ing blocks for muscles, nerves, and organ tissues.

The 20 million acres of grassland in Kansas support a beef industry that generated over \$6 billion in sales in 2005. According to The Kansas Agricultural Statistics Service, there are over 6.65 million cattle in Kansas, including about 1.5 million cow-calf pairs and 3-4 million yearling cattle. The beef industry generates thousands of jobs in Kansas and plays a leading role in the state's economy, which is recognized by state and national leaders.

GRAZING THE PRAIRIE

Cattle, like humans, have foods that they prefer or would choose over another. They will eat certain grasses first. Often a preference for a certain grass will change as the grass reaches a different stage of growth. This can be good and bad for grass production; the prairies have such a wide variety of grasses that there is usually one kind that is at the prime stage at any particular time during the growing season. However, if a single plant species is dominant, it could lead to overgrazing. Also, when there is a single grass species—a monoculture situation—an insect or plant disease outbreak could devastate the area.

Ruminants can travel great distances as they browse. Some scientists believe that the hooves of ruminants aerate the soil and encourage plant growth without damaging the prairie floor or its deep roots. Additionally, their waste deposits (manure) give nitrogen back to the soil, in a ready-to-utilize form.

The ability of perennial grasses to recover quickly after grazing or mowing makes them especially valuable for forage production and soil conservation. However, if rangeland is overgrazed with too many cattle on too small an area or for too long a period of time, it can appear healthy for a while before it shows the stress. The prairie grass is resilient and can recover a bit by relying on food stored in the roots and crown (the area where new shoots arise and the leaf meets the stem). It cannot overcome repeated loss of green leaves during

the growing season. Repeated removal of green foliage causes a corresponding reduction in the root system. Top growth that is limited cannot feed a large root system. Neither can a stunted root system supply enough raw materials to support a large growth of stems and leaves. For every pound of growth above ground, most grasses produce a pound or more of roots. It has been said that two-thirds of the living prairie is underground.

Decaying grass roots, leaves, and stems, as well as the manure produced by grazing animals, supply organic matter to the soil. This maintains soil fertility and increases the soil's water absorption capacity, reducing erosion. The presence of grass lessens the amount and severity of water flowing off the land, reducing floods and excessive runoff.

If wind erosion occurs, it is largely on land that has little or no plant cover because of extremely dry conditions (drought), improper cultivation, or poor grazing management. Wind-tunnel studies have shown that a good growth of grass breaks the force of the wind before it can reach the ground and move the particles of soil.

IMPACTS ON THE PRAIRIE

"Not everything that can be counted counts, and not everything that counts can be counted."

Albert Einstein, physicist

Several issues are impacting the prairie by changing or limiting its management. They include fragmentation or urban sprawl, alien and invasive species, water quality, air quality, wildlife management, and industrial power. Of these, some range biologists believe that fragmentation and invasive and alien species are the greatest threats.

FRAGMENTATION

Fragmentation, or urban sprawl, is reducing the amount of agricultural land in the United States at a rate of over 1,000 acres per day. Fragmentation results when land is sold in small acreages (1-20 acres), when roads and interstate highways expand rights-of-way, and when new water impoundments are developed. All these factors encourage individuals to move to the country. In addition to reducing the land available for food and fiber production, management options can become limited. For prairies, especially the tallgrass prairie, the continual loss of land under management that can maintain or improve the prairie is an issue. If fragmentation limits the use of prescribed burning as part of the management, the prairie will disappear.



Credit: Daniel F. Merriam, KGS

ALIEN AND INVASIVE SPECIES

Alien and invasive species are relatively new terms used to classify undesirable species. Both pose a threat to the future of the prairies. Alien species are those that are brought into the North American continent either accidentally or deliberately for a specific purpose. Over time, these species become adapted and increase rapidly, replacing existing native or introduced species. Examples of alien species are musk thistle (*Carduus nutans*), sericea lespedeza (*Lespedeza cuneata*), Canada thistle



Musk Thistle

Credit: KDA

KANSAS CATTLE FACT

The 6.65 million cattle in Kansas nearly equals 2 ½ times the state's human population of 2.7 million people.

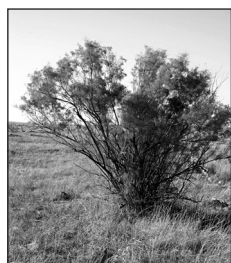
Source: Kansas Livestock Association

**Sericea lespedeza**

Credit: USDA NRCS

**Eastern Red Cedar**

Credit: Megan Blythe

**Tamarisk (Saltcedar)**Credit: Delores Eberle,
USDA NRCS

(*Cirsium arvense*), and Russian knapweed (*Centaurea repens*). In Kansas, these species have been declared noxious by law. Musk thistle was first promoted for ornamental use, while sericea lespedeza was imported for forage, erosion control, and wildlife food. Canada thistle and Russian knapweed were accidentally introduced as contaminants in seed.

Invasive species can be introduced species or native species that have increased in numbers and have replaced desirable grasses. This may occur due to changes in management, weather, or the absence of a natural control. Examples of invasive species are Eastern red cedar (*Juniperus virginiana*), Johnsongrass (*Sorghum halepense*), saltcedar or tamarisk (*Tamarix gallica*), and Causasian bluestem (*Bothriochloa bladhii*). Eastern red cedar is a native tree that invades prairies in the absence of fire. Johnsongrass and Causasian bluestem were introduced as forage species and have increased in many areas. Saltcedar is an introduced species that is found in the Cimarron and Arkansas River drainages.

WATER QUALITY

Water quality has become a major concern affecting prairies. Livestock grazing is considered by some groups to pose a significant risk to water quality. However, research has shown that well-managed prairies have a low level of pollutants in the runoff leaving the land compared to most other land uses. Good management styles benefit both livestock production and wildlife habitat and result in a prairie landscape that can be enjoyed by many.

AIR QUALITY

In 2003, weather conditions reduced the normal burning period of the Flint Hills. It is estimated that the normal burning activities were compressed from six weeks to about one week. Coupled with thermal inversions and heavy cloud cover, the smoke from the burning remained close to the ground. The result was a large plume of smoke that affected cities as far east as Tennessee. Current regulations allow landowners to conduct burning activities in a timely manner. If this flexibility is reduced or severely restricted, management practices of the tallgrass and mixed-grass prairie will be limited.

WILDLIFE MANAGEMENT

Wildlife management is an issue warranting increasing attention; in some instances because there are too few desirable animals, and in some because there are too many. Threatened and Endangered Species petitions have been submitted for the black-tailed prairie dog and swift fox. The lesser prairie chicken is being considered for petitioning. A large deer population has caused more automobile accidents in recent years, and their grazing has caused damage to and loss of crops. Coyotes can harm livestock and even pets in urban areas. Diseases such as rabies are transmitted by wildlife. Prairies provide the major habitat for many of these species. In addition to the humane treat-

ment of wildlife, the primary concerns of landowners are how their own management options will be affected and what adjustments will be made for their loss and inconvenience.

**1886 Ranch**

Source: Library of Congress; Solomon D. Butcher, photographer

WIND ENERGY

*"Madame, bear in mind,
That princes govern all things—save the wind."*

Victor Hugo, French writer and poet

Wind is the result of solar energy. The sun's radiation heats the earth mostly during the day. As air becomes heated, it rises and cold air replaces it. The result is wind.

HISTORY

Since the early 1800s, windmills have been a part of Kansas agriculture—pumping water for livestock and people. Wind power has also been used to generate electricity for individual homes. In 2004, *The Wall Street Journal* identified wind power as one of the top ten growing trends in agriculture across the country.

Wind energy can be used to generate electricity. A wind energy conversion system transforms the kinetic energy of the wind into practical use. The electricity generated by large-scale wind turbines can be collected and mixed with electricity from other power plants and delivered to customers.

GRAY COUNTY WIND FARM FACTS

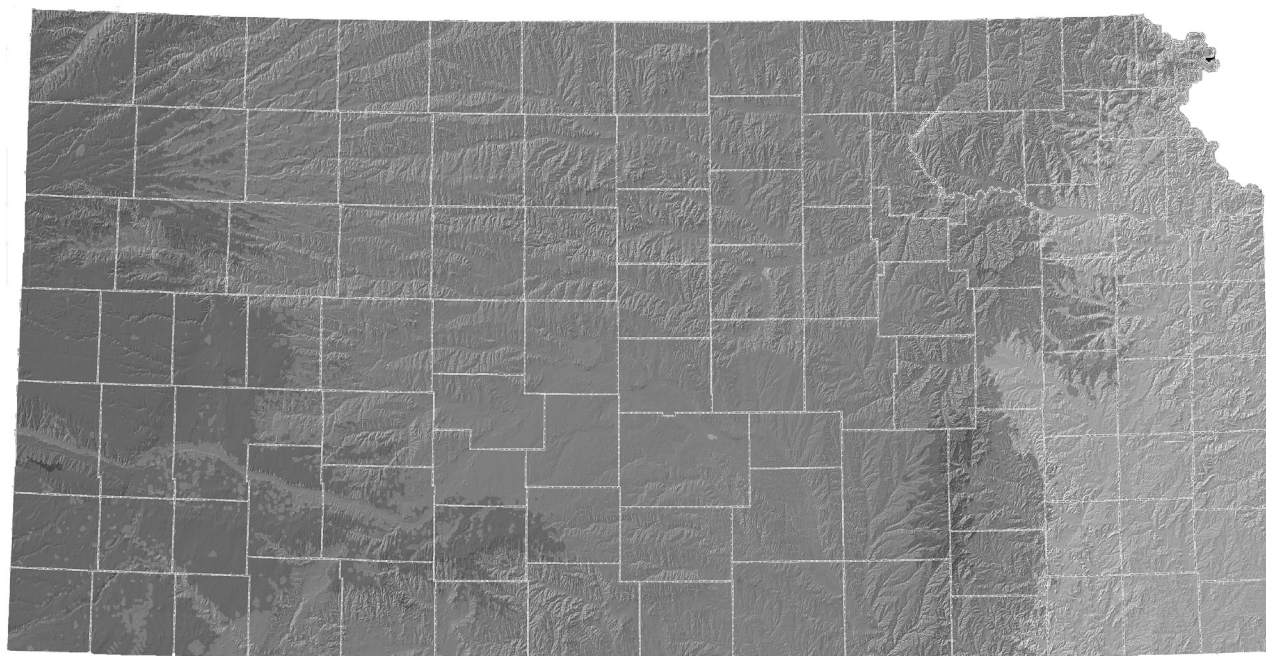
- The turbines at the Gray County Wind Farm are called Vesta 600-kilowatt turbines.
- At 217 feet tall, each tower is taller than the Statue of Liberty.
- Each tower has three blades. Each blade is 77 feet long and weighs 3,300 pounds.
- The average wind speed at the Gray County Wind Farm is 20 miles per hour.

**Gray County Wind Farm**

Credit: Sheila Forrester, USDA NRCS

Source: Aquila

KANSAS WIND RESOURCE MAP



Wind Speed (miles per hour)



Source: Kansas Corporation Commission

WIND ENERGY IN KANSAS

Studies by the U.S. Department of Energy show that Kansas has the country's third-highest wind energy potential, because Kansas winds are mostly strong and constant. The largest wind energy system in the state is Gray County Wind Farm in the southwest, which opened for operation in 2001. According to data from Gray County, the 170 turbines have a generating capacity of 112 megawatts, equal to enough electricity for 33,000 homes. The facility uses six acres of the 12,000 acres it covers for towers and access roads. In addition, farmers can continue to grow their crops around the towers. Landowners earn approximately \$2,000 per tower each year in lease payments.

The negative arguments against wind power include erosion from improper installation and landscaping, bird and bat kill from collision with turbine blades, and upset of wildlife from fragmentation of their habitat. Visual appearance and noise are also complaints. Even within the environmental lobby, there is controversy about wind energy. For example, in 2005 in the Flint Hills, local chapters of the Audubon Society and Nature Conservancy opposed the installation of wind turbines, arguing that they would befoul the landscape and harm wildlife. At the same time, Kansas Sierra Club leaders countered that utilizing wind power could help reduce the United States' dependence on fossil fuels.



Credit: Sheila Forrester, USDA NRCS

THE TIMELESS PRAIRIE

*"If you're not from the prairie,
You've not heard the grass,
You've never heard grass."*¹

David Bouchard, Canadian author

The first explorers who came across Kansas were familiar with the forested regions of Europe and the eastern United States. When they reached the prairie and saw grass instead of trees, they assumed that the soils were inferior. Even as the population of the United States expanded, few people challenged those assumptions and the potential of the prairies remained hidden beneath the waving grasses. Today, the North American prairie is recognized as one of the most productive areas of the world. Increasingly, the world is looking to the Kansas prairies for research and assistance in addressing issues ranging from food security to air quality. Meanwhile, Kansas ranchers and farmers continue to care for the prairie soils and grasses and appreciate the Kansas prairie for its uniqueness. ■

Career Profile:**JAN LYONS****Cattle Rancher, Lyons Ranch**

She is a grandmother of seven, the mother to two, a wife of one, the caretaker to a respected herd of cows, and a leader of the entire beef industry. Jan Lyons raises Angus cattle near Manhattan in the tallgrass region of Kansas. She discovered her love of cattle early, showing steers at the county fair and helping her father on the family farm. "We never had too much extra growing up, so all the kids helped. I found out how much I enjoyed being outside, working with my dad and the cattle rather than being inside."

Lyons and her family settled in northeast Kansas and started Lyons Ranch, a purebred Angus cattle operation. As the ranch grew, so did her involvement in industry organizations, like the Kansas Livestock Association, which represent producers on the county, state, and national levels.

In 2004, Lyons was elected president of the 26,000 member National Cattlemen's Beef Association, the largest and oldest beef industry group. For "vacations" from the ranch, she has lobbied and testified before Congress on behalf of the cattle industry and traveled to meetings across the country to discover and share the concerns of producers from different states. The phone in her kitchen rings constantly—from reporters wanting background and quotes on international trade and health issues to neighbors wanting to buy another Angus bull from her herd. She says it is sometimes a crazy juggling act, but certain things make life come into focus: one of her favorite things to do is to see her cows and their calves grazing contentedly just before sunset.

Lyons says her favorite part of the year is in the spring when the cows are calving. "Seeing the new babies bond with their mothers—it is truly miraculous. It is like Christmas for me when they start having their long-awaited calves."

Lyons says that ranching is a privilege. "We are so fortunate to be entrusted with the care of some of the most unique and powerful grasses anywhere in the world. The native grass is ideal for grazing cattle—cows and calves and yearlings all thrive here in Kansas."

Proper management of the prairie is the key to keeping the native grass biome productive and healthy. "So many of our activities on the ranch such as burning pastures, chopping thistles, developing good water sources, and utilizing rotational grazing, are done to help the native grass," Lyons says. "We must use optimal stocking rates and manage the grass so it is replenished every year and will sustain for many generations to come."

Lyons stresses that ranchers and farmers are intelligent caretakers of the land, not plunderers of its bounty. "We know that our survival depends on our judicious use of the precious resources like grass and water. Being involved in farming or ranching is a great life," she says. "It isn't easy, but the people who are in it have chosen not only a business but a way of life. The people you meet are salt-of-the-earth, good people who work hard and have a deep, strong value system. I feel very lucky to be one of them and to have represented them."



Courtesy: Lyons Ranch

ENDNOTES

1. David Bouchard, *If You're Not from the Prairie* (Orca Book Publishers, 2002), p. 14.

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Grass Makes Its Own Food. Rev. ed. Salina, Kansas: U.S. Department of Agriculture Natural Resources Conservation Service, 2003.

Haddock, Michael John. *Wildflowers and Grasses of Kansas: A Field Guide*. Lawrence, Kansas: University of Kansas Press, 2005. <<http://www.kswildflower.org>>

Ohlenbusch, Paul D., Elizabeth P. Hodges and Susan Pope. *Range Grasses of Kansas*. Rev. ed. Manhattan, Kansas: Kansas State University, 1983. <www.oznet.ksu.edu/library/crps12/c567.pdf>

Pasture and Range Plants. Hays, Kansas: Fort Hays State University, 1989.

Taggart, Travis W. *Kansas Herpetofaunal Atlas: An On-line Reference*. Hays, Kansas: Sternberg Museum of Natural History, Fort Hays State University, 2007. <<http://webcat/fhsu.edu/ksfauna/herps>>

TEACHER RESOURCES**BOOKS:**

* *Teachers & Advanced Readers; AR - Accelerated Reading Level*

American Bison

Berman, Ruth. 1992 (AR - 6.7)

An American Safari: Adventures on the North American Prairie

Brandenburg, Jim. 1995 (AR - 7.5)

America's Prairies

Staub, Frank. 1994 (AR - 7.0)

America's Prairies and Grasslands: Guide to Plants and Animals

Wallace, Marianne. 2001 (AR - 6.2)

Bison

Winner, Cherie. 2001 (AR - 5.5)

Bluestem Horizon: A Story of a Tallgrass Prairie

Lee, Evelyn. 1998 (AR - 4.8)

The Buffalo Train Ride

Webber, Desiree M. 2005 (AR - 6.3)

Butter in the Well

Hubalek, Linda. 1994

Career Profile:**MALETA FORSBERG***Artist, Olive Springs Schoolhouse Gallery*

It has been said by naturalists that the artwork that Maleta Forsberg creates is some of the best and most biologically correct at depicting wildlife. She uses pen and ink, pencil, watercolors, acrylics, and oil paints to create her realistic canvases. Although she likes to work “on-site,” navigating her four-wheel drive pickup truck down the back roads of the state and carrying her supplies through farm fields and native pastures to reach the ideal spot, Forsberg also paints and sketches at her home on a hillside near Lindsborg in a studio designed to capture the north light. From its windows, she has a panoramic view of the valley below. “I watch the deer and the wild turkeys as they pass through. For inspiration, I don’t have to go very far,” she says.

Forsberg grew up in eastern Kansas “in the day when we still put up hay by hand,” she remembers. “I used to go out to my grandfather’s farm and watch the crew work. I loved the colors of the grasses and the prairie hay as it matured.” As a young girl, Forsberg liked to sketch and was always drawing for enjoyment. “I don’t think we had so many distractions as there are for kids these days. And there were always subjects close for me to work with: all sorts of animals, horses, the prairie, people.

My uncle had a pony for me before I was even born,” she laughs.

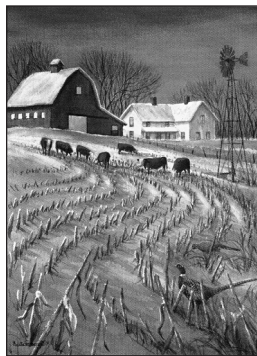
“Nature has always been a huge inspiration to me,” she says. “I love the wildflowers that come out around August, the sunflowers and the gayfeathers. I watch the wheat fields go from green to ripening when they make the waves of grain like a golden ocean.”

Forsberg has a deep appreciation of the land and its inhabitants. “I really love seeing how the changing of the seasons can affect the colors and variety of the area. Sometimes you can see the same thing over and over, but then, all of a sudden, one day, see something completely different in it.” In addition to her own independent works for galleries and shows, people often commission Forsberg to paint their family farmstead to help record their own precious memories and enhance their lives. She tries to work every day and is truly seeing her surroundings with an artistic eye, always thinking about her work if not actually painting.

“I think there are so many things to see around you, wherever you are,” Forsberg says. “People are in such a hurry on their way to get somewhere. If they just buzz through Kansas without really taking a look, they are missing a lot.”



Courtesy: Olive Springs Schoolhouse Gallery



Twilight by Maleta Forsberg

TEACHER'S RESOURCES (CONTINUED)***Cowgirls: Women of the American West***

Jordan, Teresa. 1992

Energy at Work: Wind Energy

Sherman, Josepha. 2004

Food Chains in a Meadow Habitat

Nadeau, Isaac. 2002. (AR - 5.1)

Grasslands

Scheff, Duncan. 2001. (AR - 4.3)

If You Were a Pioneer on the Prairie

Kamma, Anne. 2003 (AR - 5.1)

The Prairie

Ormsby, Alison. 1999 (AR - 7.5)

***PrairieErth* ***

Least Heat-Moon, William. 1991

Prairie Animals

Winner, Cherie. 2004

Temperate Grasslands

Hoare, Ben. 2003 (AR - 7.5)

They Came from the Bronx: How the Buffalo Were Saved from Extinction

Waldman, Neil. 2001 (AR - 5.8)

A Walk in the Prairie

Johnson, Rebecca. 2000 (AR - 4.2)

***We Pointed Them North* ***

Abbott, E.C. 2003

OTHER RESOURCES FOR TEACHERS:**Sod Box Requests:**

Cimarron National Grassland

242 East Highway 56

P.O. Box 300

Elkhart, KS 67950

(620) 697-4621

Prairie Showcase:**KONZA PRAIRIE BIOLOGICAL STATION**

Konza Prairie Biological Station is a native tallgrass prairie preserve owned by The Nature Conservancy and Kansas State University. It is operated as a field research station by the K-State Division of Biology. The station, which is just over 8,600 acres in size, is dedicated to a threefold mission of long-term ecological research, education, and prairie conservation. It is a unique outdoor laboratory, open to scientists and students from throughout the world. It also serves as an environmental education facility and as a "benchmark" for comparisons with areas that have been affected by humans. Konza Prairie is a member of the Organization of Biological Field Stations and the Association of Ecosystem Research Centers, and is a National Science Foundation Long-Term Ecological Research site.



Konza Prairie

Credit: May Hammel

Konza Prairie is located in the Flint Hills region of north-eastern Kansas, approximately six miles south of Kansas State University and the city of Manhattan. There are more than 600 plant species on Konza Prairie and several dozen species of fish, amphibians, reptiles, and mammals. Over 200 species of resident and migratory birds have been recorded on the preserve.

The objective of the Konza Environmental Education Program is to teach students the process of science through hands-on ecological research. Over 900 students visit the Konza Prairie each year through the Schoolyard Long-Term Ecological Research program. Another Konza Prairie project—“Prairies Across Kansas”—allows 5th through 12th grade teachers and students from across Kansas the opportunity to interact with Konza Prairie research efforts while studying native prairie sites near their own schools. This program is designed for Kansas teachers who are not able to bring students to the Konza Prairie.

WEBSITES:**Great Plains Nature Center**

<http://www.gpnc.org>

Kansas Grasses

Clinton E. Owensby, Professor of Range Management,
Kansas State University

<http://spuds.agron.ksu.edu/ksgrasskey/linedraw.htm>

Konza Prairie Biological Station

<http://climate.konza.ksu.edu/konza/>

The Noble Foundation Plant Image Gallery

www.noble.org/webapps/plantimagegallery/

PLANTS Database

USDA Natural Resources Conservation Service

<http://plants.usda.gov>

On the Prairie

The University of Minnesota's Bell Museum of Natural History

www.bellmuseum.org/distancelearning/prairie

USDA Forest Service National Grasslands

www.fs.fed.us/grasslands

NOTES:

Prairie Showcase:**CIMARRON NATIONAL GRASSLAND**

The Cimarron National Grassland is located in the southwest corner of Kansas within Morton and Stevens Counties. Named for the Cimarron River which runs through it, the grassland is one of 20 national grasslands in the United States that are administered by the U.S. Department of Agriculture Forest Service.

Cimarron National Grassland is the largest parcel of public land in Kansas. After severe drought and dust storms devastated areas of the United States in the 1920s and 1930s, President Franklin D. Roosevelt and the United States Congress directed the reclamation and regeneration of marginal land. Following a recommendation by the National Planning Board in 1933, the Resettlement Administration purchased the Cimarron grasslands for around \$4 an acre. Today, Cimarron National Grassland covers 108,175 acres. Most of the grasses are native types that have been seeded to create a typical grassland environment.

The area contains the longest publicly owned stretch of the Santa Fe Trail in the country. Ruts from the Santa Fe Trail commerce route, which was traveled from 1821 to 1880 and ran from Missouri to New Mexico, are still visible. A hiking trail has been created alongside the Santa Fe Trail—far enough from the visible ruts for hikers to be able to view but not disturb the landmarks.

Wildlife on Cimarron National Grassland includes pronghorn antelope, mule deer and white-tailed deer, quail, turkey, lesser prairie chicken, mountain plover, and dove. At last count, 345 bird species and 31 species of amphibians and reptiles live on the grasslands. Species numbers and diversity change over time as a result of weather fluctuations that affect food supplies and breeding habits. Cimarron National Grassland is open for camping, fishing, four-wheeling, hunting, and wildlife viewing. It has been recognized as one of the top 100 places in the United States for bird watching.

The condition of the grasslands is manipulated through the use of livestock grazing and prescribed burning. Each year, from May 1 to October 31, members of the Morton County Grazing Association graze around 5,000 head of cattle there—depending on moisture and grass conditions. (Each member of the association has obtained grazing permits allowing them to use the land.) There are approximately 500 miles of fence and over 250 watering facilities on the grasslands.

According to Nancy Brewer, Rangeland Management Specialist for Cimarron National Grassland, the area contains three main ecosystems: a shortgrass prairie ecosystem, a riparian ecosystem around the Cimarron River, and a sand and sage prairie ecosystem. Each system contains its own vegetative species.

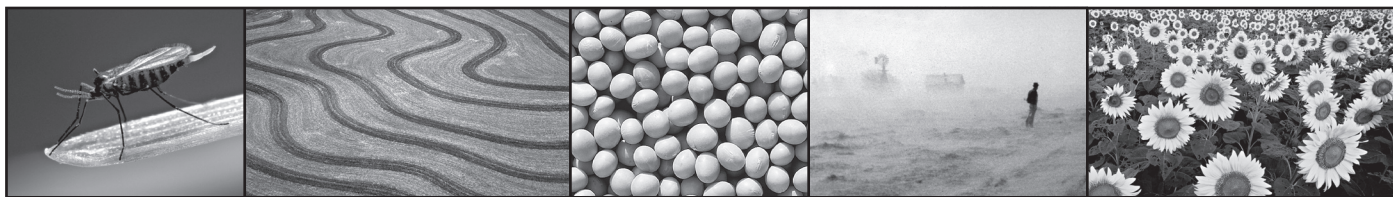
Teachers are invited to request a Sod Box from the Cimarron National Grassland office to share with their students. Each box contains interactive projects that help teach about the prairie ecosystem, including books and grass seeds.



***"Point of Rocks" in
Cimarron National Grassland***

Credit: John Charlton, KGS

NOTES:



Unit 3) Cropland

Kansas has more available cropland, about 30 million acres, than any other state except Texas. All together, the cropland acres in Kansas would cover approximately 46,159 square miles, an area larger than 28 other individual states, including such states as Pennsylvania, Ohio, Virginia, and Tennessee. In Kansas, around 23 million acres of cropland are planted each year. The major Kansas crops include wheat, corn, soybeans, grain sorghum, alfalfa, cotton, and sunflowers. Other field crops include potatoes, pinto beans, oats, barley, and canola.

It was not always this way. In 1806, Lt. Zebulon Pike thought the prairie grasslands were not capable of growing crops. Major Stephen H. Long verified Pike's observations a few years later, considering this part of the country uninhabitable by people dependent on agriculture for their subsistence. This area was labeled the "Great American Desert" and for many years, most people thought it would not be a suitable place to live, let alone someday worthy of the title "Breadbasket of the World."

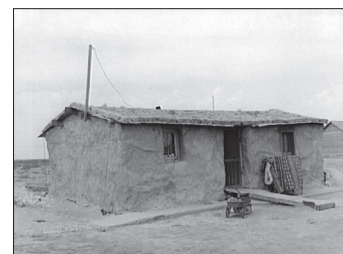
Today, nearly 90 percent of the land in Kansas is devoted to agriculture. This includes cropland (land available for the cultivation of plants or agricultural produce, such as grain, vegetables, or fruit), land used for livestock production (pasture, rangeland, and grassland), and land producing forestry and other related products (forests, orchards, and Christmas tree farms).

"Reasonable people adapt themselves to the world. Unreasonable people attempt to adapt the world to themselves. All progress, therefore, depends on unreasonable people."

George Bernard Shaw, Irish-British playwright

In 1803, Kansas joined the United States as part of the Louisiana Purchase. However, early pioneers generally settled along the eastern border of the state until the Homestead Act of 1862 opened the Kansas Territory for land ownership. During the next few decades, Kansas experienced a population explosion such as in the twenty years from 1870 to 1890 when the population of Kansas nearly quadrupled, from 364,000 to over 1.4 million. People claimed land for farms and ranches. Other new arrivals built towns and railroads.

Railroads and town development companies even paid people to go to eastern states and foreign countries to recruit people to come to Kansas. Wealthy families in the eastern states and European countries invested in land in Kansas, expecting large profits on those investments.



Sod House, Sheridan County, 1939

Source: Library of Congress;
Russell Lee, photographer

INTRODUCTION

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CAREER PROFILES

- MARK TADDIKEN, AGRICULTURAL PRODUCER AND STATE SENATOR
- JIM KRUEGER, ASSISTANT STATE CONSERVATIONIST, NRCS

SHOWCASES

- HARNEY SILT LOAM, STATE SOIL
- KSU AGRICULTURAL RESEARCH CENTER-HAYS

ENDNOTES

REFERENCES

TEACHER'S RESOURCES

Cropland



**Log Barn,
Cherokee County, 1936**

Source: Library of Congress;
Arthur Rothstein, photographer

Pioneering homesteaders, however, found that it was incredibly hard work to create new farms, homes, and communities in the vast grasslands of Kansas. The hard work, natural disasters, and other factors convinced many to abandon their efforts. Others persevered and laid the foundation for Kansas as we know it in the twenty-first century.

Land that can produce a crop for harvest is called cropland. Today, over 56 percent of the land in Kansas is

considered cropland according to the Kansas Agricultural Statistics Service. Only a portion of that cropland is used for crops in any given year. Some of the cropland is left idle (unplanted). Cover crops and soil improvement crops, planted to prevent erosion or to add organic matter or nitrogen to the soil, are also planted on "idle" cropland. More than 10 percent of the cropland in Kansas, over three million acres, has been enrolled in the Conservation Reserve Program (CRP) for ten or more years. Cropland enrolled in the CRP is usually planted to grasses and forbs but some of the marginal cropland has been planted to trees.

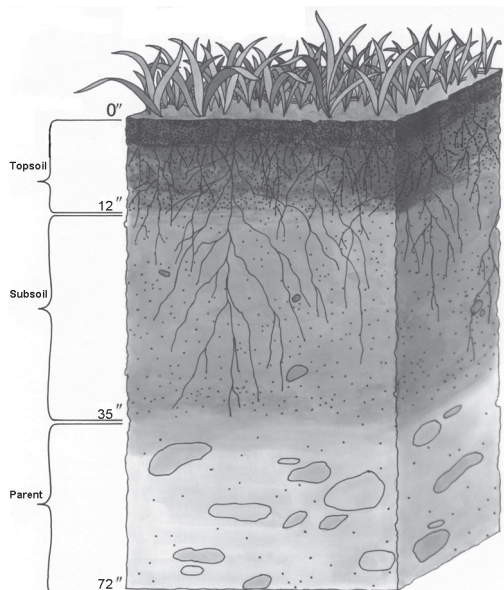
SOILS

"Out of a long list of nature's gifts to man, none is perhaps so utterly essential to human life as soil."

Hugh Bennett, first chief, Soil Conservation Service

The rich, productive soil of Kansas is the state's most valuable natural resource. Soil is the naturally occurring mixture of minerals, organic matter, water, and air that forms on the surface of the earth. Some soils were formed by the breaking down and weathering of rock. Others were formed from materials transported and deposited by water, wind or glaciers. It takes 100 to 600 years or more to form an inch of topsoil, the most productive soil layer.

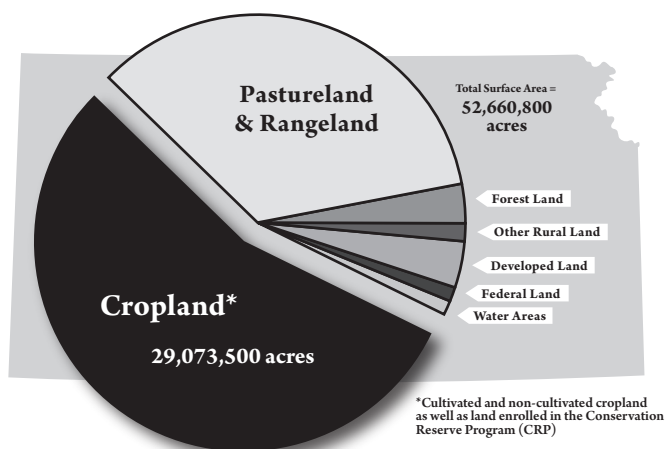
A soil is usually made up of four layers, called horizons. The layer at the earth's surface is the topsoil. Going down, the other three



Soil Profile

Source: USDA NRCS

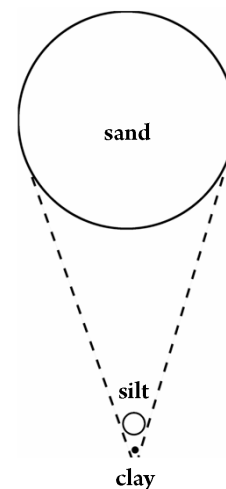
SURFACE AREA OF KANSAS – CROPLAND



Source: 2003 Natural Resources Inventory, USDA NRCS

layers are the subsoil, parent material, and bedrock. The thickness and qualities of each layer will vary depending on location. The mineral particles that make up the soil are clay, silt, and sand. The largest and most abundant of the three sizes of particles are sand particles. Silt particles feel like powder. Clay particles are so small that they can only be seen through electron microscopes. Soil textures are determined by the percentages of sand, silt, and clay in the soil mixture. Clay soils are fine and sticky while silty soils are smooth but crumble when wet. Sandy soils are gritty and abrasive whether wet or dry. Loam soils contain equal amounts of sand, silt, and clay. Color is an indicator of soil properties and is used to identify different soil layers. Generally, the color of a soil becomes darker as the amount of organic matter in the soil increases. Organic matter is plant and animal material in various stages of decomposition.

Particle Size



Unlike sand particles, individual silt and clay particles cannot be seen unless they are magnified.

Source: KFAC

The National Cooperative Soil Survey program has been mapping the soils of the United States for over 100 years. They have established a system of identification that divides all the soils in the United States into 12 soil orders. Each of the soil orders is then subdivided several times, resulting in about 18,000 different soil types. Every soil type has distinct properties. The soil type never changes but the health (productivity) of the soil can be influenced by the way the soil is managed.

KANSAS SOILS

Over 300 different soil types have been identified and mapped in the state of Kansas. The dominant soil order of the Kansas croplands is the mollisols. Mollisols are naturally fertile and can hold large amounts of water. They have a very distinct dark color and are

SOIL SURVEYS

Every county in Kansas has a soil survey, compiled by the U.S. Department of Agriculture Natural Resources Conservation Service in cooperation with the Kansas Agricultural Experiment Station. Originally published as a book of maps, the information is now available online (<http://websoilsurvey.nrcs.usda.gov>). The online database includes location-specific soils data, including information on soil suitability for various uses.

Originally, the soil surveys were published to provide information in planning land uses, including predictions of soil limitations and the impacts of selected land uses on the environment.

enriched with organic matter. These soils are capable of producing abundant agricultural crops.

The soils of Kansas evolved under the great prairie grasslands. Kansas has more acres of prairie soils than any other state and Kansas soils are internationally recognized.

Every state has an official state soil. In 1990, Harney silt loam was adopted as the Kansas State Soil. Harney silt loam possesses all the desirable qualities of an ideal prairie soil. It is the most widespread soil type in Kansas, covering almost four million acres in 26 counties.

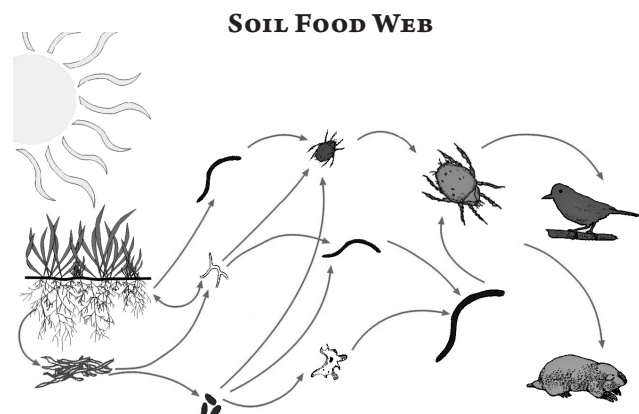
SOIL FOOD WEB

When we think of what lives in the soil, one of the first things we typically think of is the plants that grow in the soil. During photosynthesis, plants use water, the sun's energy, and carbon dioxide from the atmosphere to make the food necessary for the plants to grow and develop. Organisms living in the soil feed on carbon stored in the soil by plant roots and other decaying organic

materials. The soil food web builds as some organisms specialize in decomposing materials and predators at higher and higher levels in the food chain feed on the incredible diversity of organisms present in the soil. According to the National Soil Survey Center of the USDA Natural Resources Conservation Service, a single spade full of rich soil can contain more species of organisms than can be found above ground in the entire Amazon rain forest! Each time an organism is consumed or something decomposes, nutrients are converted into a different form and become available to plants and other organisms. All plants depend on the soil food web for nutrients. Increasing the organic matter of the soil also increases the ability of the soil to produce crops.

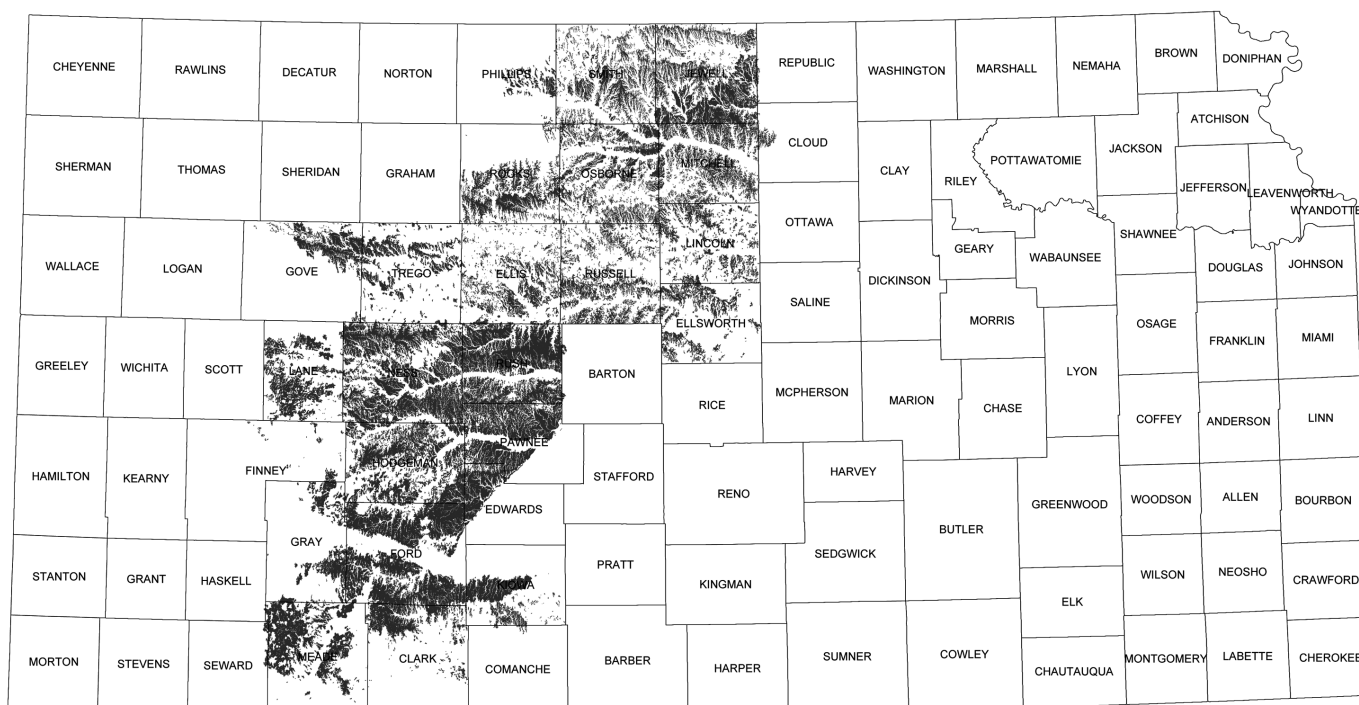
The soil food web is critical to the four major soil functions:

- Providing a physical, chemical, and biological environment for the exchange of water, nutrients, energy, and air needed to support the growth of plants and animals.



Source: USDA NRCS

HARNEY SILT LOAM IN KANSAS



Source: USDA NRCS

Cropland

- Protecting the quality of water, air, and other resources by filtering, buffering, degrading and detoxifying potential pollutants.
- Regulating the distribution and storage of water and other nutrients and compounds dissolved in the water.
- Storing, controlling the release of, and cycling plant nutrients and other elements.

PLANT NUTRIENTS

Since 1940, crop production has increased dramatically after remaining fairly constant during the decades following the Civil War. Today, most crops have the potential to produce three to five times the average yield per acre of 1940. Scientific research and technological advances in genetics, seed production, fertilizers, equipment, pesticides, and herbicides have helped farmers achieve these results. Farmers also manage soil nutrients, adding nutrients to the soil to meet the needs of specific crops while minimizing the loss of unused soil nutrients through erosion and evaporation. There are at least 16 nutrients essential for a plant to complete its life cycle. These include nutrients obtained from water and air, such as hydrogen, oxygen, and carbon, as well as nutrients obtained from the soil. Nitrogen, phosphorus, and potassium (in that order) are the three nutrients most critical for plant growth and development.

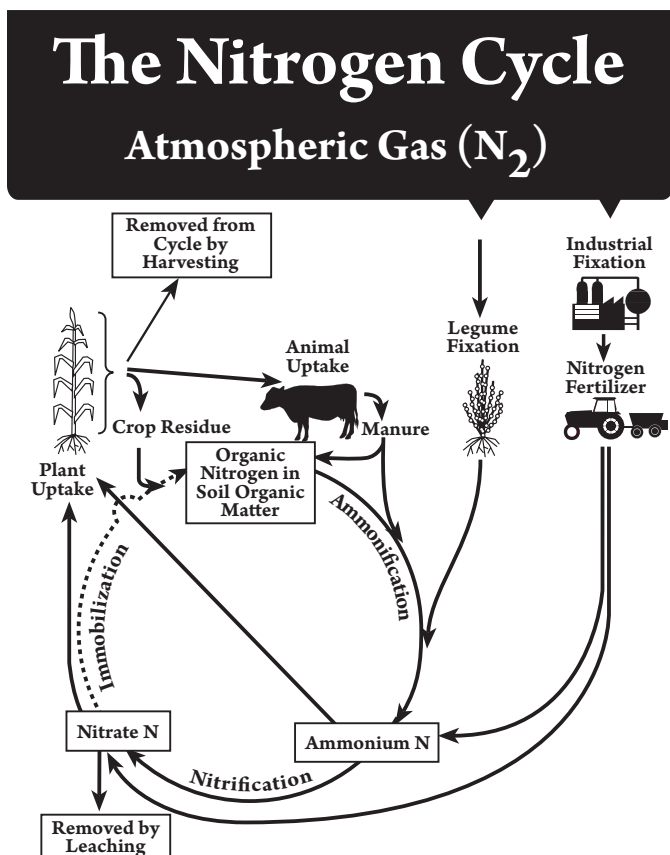
Plants use **nitrogen** to make proteins, used by plants to grow, develop, and produce seeds. Although 80 percent of the air that we breathe is nitrogen, plants cannot use the same form of nitrogen that we breathe. Some plants, called legumes, can collect nitrogen from the atmosphere and convert it into a form of nitrogen plants can use. Legumes also store excess useable nitrogen in the soil for future crops. Organic matter in the soil, through the soil food web,

creates and stores nitrogen in the soil. Commercial fertilizers and livestock manure are additional sources of nitrogen that can be used to increase plant production. Inadequate nitrogen is a common factor limiting a crop's ability to grow and produce. Nitrogen is the most expensive nutrient for the farmer to provide.

Phosphorus, also referred to as phosphate, helps plants use the sun's energy for photosynthesis, grow healthy roots and fight disease. All plants require more phosphorus during periods of rapid growth and phosphorus is essential for seed production. Phosphorus is taken up from the soil by the root system of the plant. However, if the phosphorus found naturally in the soil is in a form that the plant cannot use, phosphorus (in a form that the plant can use) must be added to the soil. Phosphorus is found in deposits of phosphate rock that are mined to manufacture phosphate fertilizers.

All plants require **potassium**, but annual crops and crops high in carbohydrates, such as potatoes, require high amounts of potassium, commonly referred to as potash. In addition to helping plants resist disease and tolerate drought and extreme temperatures, potassium assists different plants in different ways. In some plants, it strengthens the stalks. It increases the oil content of oilseeds. Potassium enhances the size and color of some fruits and vegetables.

Potassium is the seventh-most abundant element in the Earth's crust but only 2 percent is available to plants, generally in a form that is water soluble—able to move with the water in the soil and be taken up through the root system of plants. Potash is mined from underground deposits formed when ancient seas and oceans evaporated. Some potash is produced from the Great Salt Lake in Utah but most of the potash used in the United States is imported from Canada.



Source: K-State Research and Extension

SOIL TESTS

Soil tests are used to determine when it is necessary to add nutrients to the soil to sustain or increase crop production. Soil samples are collected and sent to laboratories for chemical analysis. Farmers use the results to manage crop production. Soil tests generally include testing for nitrogen, phosphorus, potassium, soil pH, and organic matter.

Soil pH is a measure of soil acidity or alkalinity, a measurement of the way the electrical charges on the surface of soil particles interact with chemical combinations in the soil mixture. Soil pH affects the rate at which plants absorb water, directly affecting the growth and development of plants. A neutral soil pH is 7.0 but most crops will grow well at soil pH levels of 6.0 to 7.5. When necessary, amendments are added to the soil, generally by spreading the material over the surface of the soil and then incorporating it into the soil mixture using tillage.

SOIL pH

Acidic	< 7.0
Neutral	7.0
Alkaline	> 7.0
Alkali	> 8.5 with high levels of sodium

Soil acidity is a natural soil process that develops over time as soil nutrients, mainly calcium, magnesium, and sulfur, are removed through high humidity and rainfall, plant growth, and soil uses. Acidic soils, those with a pH of less than 7.0, may be treated with finely ground limestone (lime). The active agent in limestone, calcium carbonate, creates a chemical reaction on the surface of the soil particles and neutralizes the acidity (pH) of the soil. The calcium then becomes part of the soil's nutrients that can be utilized by plants. Most limestone also contains magnesium carbonate, replenishing the soil's supply of magnesium for plants through a similar process. Adding lime to the soil increases the ability of many compounds in the soil to be absorbed in a form that plants can easily use as well as increases the activity of microorganisms in the soil. Soils with a pH of above 7.0



**Horse-Drawn
Lime Spreader, 1936**

Source: Library of Congress;
Arthur Rothstein, photographer



Lime Application, 2007

Credit: Trent Winter

are alkaline. Many soils in the western half of Kansas have a pH in the 7.5 to 8.5 range. Most crops will grow well on those soils unless the high pH is caused by excessive sodium. Alkali soils, those with a pH above 7.5 associated with high levels of sodium, may become toxic to all but salt-tolerant plants. Water and air movement may be restricted in high alkali soils and tillage does not help those problems. Although gypsum and sulfur may be used to lower soil pH levels using methods similar to those used to add lime to soils at the other end of the soil pH scale, it is not always practical or cost-effective.

Cost is just one factor that must be considered before taking any action to address soil pH levels. Many of the crop protection products that farmers use are also pH sensitive, requiring applicators to know the pH levels of the water used to mix the products for application procedures, soil pH levels, crop nutrient requirements, and other requirements specific to each location and crop.

WATER

"Rained a little last night. Enough to lay the dust. Corn nearly all dried up. For the life of me I don't see how the farmers will winter. No oats, no corn, no fruit, no grass, no nothing..."

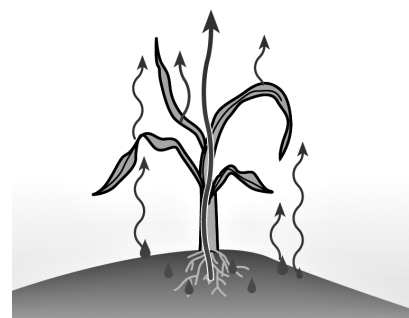
Diary of a Kansas farmer, July of 1887¹

Just as water is an absolute necessity to sustain human life, it is also essential to growing plants. In fact, some plants contain more water than solid matter, such as the alfalfa plant that is almost 80 percent water.

TRANSPIRATION

Through a chain reaction-type process called transpiration, water is pulled from the soil into the roots of a plant, up through the cells of the plant, and eventually out into the atmosphere through tiny openings in the plant's leaves. During the process, the water carries essential nutrients to the cells of the plant, so any interruption of the flow of water interrupts the plant's growth and development and the production of dry matter, such as flowers, seeds (grain), leaves,

EVAPOTRANSPIRATION



- **Evapotranspiration is the combination of evaporation and transpiration**
- **Evaporation is water movement from wet soil and leaf surfaces**
- **Transpiration is water movement through the plant**

Source: K-State Research and Extension

or stalks. Heat, sunlight, humidity, and wind affect the rate of transpiration, which is generally highest during the middle of the day and lowest at night. Transpiration continues only as long as there is an adequate supply of moisture in the soil. Once the water runs out, the plant begins to wilt. Even if the plant does not die, it may be damaged to the point where it can no longer produce a seed or forage crop. As much as 98 percent of the water absorbed by the roots of a plant may be released into the atmosphere through transpiration. In a Kansas cornfield, one acre of corn plants might transpire an amount of water during the May–September growing season that would cover the same area of land with water 11 inches deep.²

The production of a crop is determined by the timing and amounts of water provided to the plants during critical growth and development stages. Since plants absorb water through the root system, the water must be available in the root zone—either soaking down to that level from the soil surface or being pulled up from below through the soil layers. The soil acts as a reservoir—gathering, storing, and holding water until it is needed by plants. The soil type determines the ability of the soil to store water and release it as needed by plants. Since it is difficult to differentiate between water

WATER REQUIREMENTS FOR CROPS

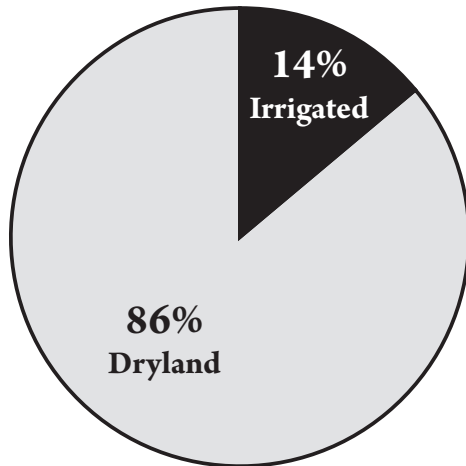
Crop	Water Requirement
Canola	Low
Oats	Low
Grain sorghum	Intermediate
Sunflowers	Intermediate
Wheat	Intermediate
Corn	High
Cotton	High
Soybeans	High

Source: K-State Research and Extension

Cropland

lost to evaporation and water released to the atmosphere through the process of transpiration, the term "evapotranspiration" is often used to describe the combination of water processes.

KANSAS CROPLAND: DRYLAND VS. IRRIGATED

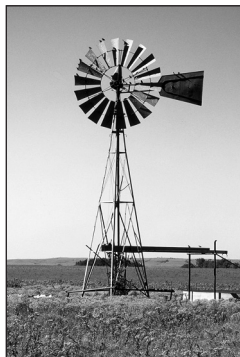


Source: Kansas Agricultural Statistics Service

IRRIGATION

The amount of precipitation, water that falls in the form of snow or rain, varies greatly across the state of Kansas. Cropland is classified as irrigated or dryland (non-irrigated), depending on whether the precipitation falling on the land is supplemented with other sources of water or not. Irrigated cropland produces over 40 percent of the world's food supply.³ According to the Kansas Agricultural Statistics Service, around 14 percent of the cropland that is harvested each year in Kansas is irrigated. That irrigated cropland produces over 20 percent of the total value of the crops harvested in Kansas each year. Precipitation determines the need for irrigation water, which increases or decreases depending on the amount of rainfall during the crop's growing season and whether the rainfall occurs at the critical stages of growth and development. In Kansas, corn is the leading irrigated crop. A higher percentage of alfalfa acres in the state are irrigated than soybeans, even though the number of irrigated soybean acres in Kansas is higher than the number of irrigated alfalfa acres. All but two counties in Kansas (Elk and Woodson) have some irrigated land. Finney, Haskell, and Gray counties have the largest number of irrigated cropland acres in the state.⁴

Irrigating land to grow food and to grow feed for livestock is an agricultural practice that stretches back at least 5,000 years. Some of the earliest methods included diverting water from streams or rivers through ditches and irrigation channels and creating storage reservoirs to hold water by blocking the natural flow of water. Over time, irrigation methods were modified as agricultural practices changed and concerns about water quality or quantity were addressed. In Kansas, early settlers first tried to farm using the same methods they had



Chase County Windmill
Credit: John Charlton, KGS

used in eastern states or other countries, including irrigating crops using water from streams and rivers when necessary. In many areas of Kansas, those water sources were unavailable or unreliable so the pioneers relied on groundwater. They dug wells and by the late 1800s, many Kansans were relying on the wind to provide the power to pump water from the wells. In 1895, there were over 1,200 irrigators in the western half of the state—96 percent of those used wind power (windmills).⁵ Kansas established a state board of irrigation in 1895 to research, demonstrate, and promote irrigation in 20 counties in western Kansas. The first experimental pumping station was built at Goodland in Sherman County and irrigation plants were built in at least three other counties—Gray, Stanton, and Hamilton.⁶ Two years later, the irrigation stations and assets were sold when the state legislature reorganized irrigation efforts in western Kansas. The federal government also assisted in the development of the Garden City Irrigation project in Finney County while private irrigation companies formed and built irrigation canals in many areas of Kansas. Some succeeded but many early irrigation companies failed.

In the very first sentence of the 1955 Yearbook of Agriculture, Ezra Taft Benson, the U.S. Secretary of Agriculture, said "I have little need to remind you that water has become one of our major national concerns."⁷ In the 1940s and 1950s, new technologies developed that allowed water to be withdrawn in much larger quantities from the aquifers underlying central and western Kansas. Those cost-effective technologies drove an expansion in irrigated cropland in Kansas and surrounding states that in turn led to an expansion of the livestock industry in Kansas, particularly the livestock feeding, processing, and related industries in southwest Kansas. Irrigation equipment and methods have continued to be refined to conserve water, just as crop varieties have been developed to require less water even while increasing yields.

Kansas farmers continue to seek ways to use irrigation water more efficiently and reduce the demand on water resources. Today, the most common irrigation method in Kansas is the center pivot sprinkler with drop nozzles. According to the Kansas Department of Agriculture's Division of Water Resources, this system is used on over 1.9 million acres in Kansas, almost 62 percent of the irrigated land in Kansas. Center pivot systems fitted with low-pressure dropped nozzles can increase water-use efficiency by 85–95 percent according to the Groundwater Foundation. Newer sprinkler heads are adjustable and can be raised or lowered for each crop.

Water for irrigation is managed and regulated through a system of water rights (permits to use a set amount of water from a specific source for a specific purpose) administered by the Division of Water Resources of the Kansas Department of Agriculture. Today,



Flood Irrigation near Syracuse, 1939

Source: Library of Congress;
Russell Lee, photographer



Drilling for Water near Garden City, 1939

Source: Library of Congress;
Russell Lee, photographer



Center Pivot Irrigation with Drop Nozzles

Credit: Cindy Baldwin

new water rights for irrigation in Kansas are rarely issued and the state has developed new programs intended to promote water conservation and slow down declines in aquifer water levels. There are no simple answers or quick fixes to water issues. Plant roots will not grow when the soil is too dry. Simply shutting off irrigation wells and switching to dryland farming would have economic consequences far beyond the farms and families directly affected. Agriculture continues to take additional measures to use water more efficiently even as the potential impacts of cutting back irrigation on local, regional, state, and national industries and economies are being researched and considered.

KANSAS CROPS

"The greatest service which can be rendered any country is to add a useful plant to its culture."

Thomas Jefferson, 3rd President of the United States

Less than 20 percent of the land in the United States is used to grow crops, but in Kansas, over one-half of the land in the state is planted to crops each year. Kansas farmers produce a variety of crops, including wheat, corn, soybeans, grain sorghum, alfalfa, cotton, sunflowers, potatoes, pinto beans, oats, barley, canola, and fruit and vegetable crops.

KANSAS CROP SUMMARY

Kansas is known as the "Wheat State" because it consistently ranks at or near the top among the 50 states in the United States in the production of wheat, wheat flour milled, and wheat flour milling capacity. In addition, Kansas is the number one producer in the United States of wheat gluten, the natural protein derived from wheat and wheat flour. Kansas farmers produce one-fifth of all the wheat grown in the United States, according to the Kansas Wheat Commission.

Even though Kansas is called the "Wheat State," more bushels of corn



Wheat

Credit: Kansas Wheat Commission

2006 CROP PRODUCTION: HOW KANSAS RANKED AMONG THE 50 STATES

1st	wheat	291,200,000 bushels
1st	grain sorghum	145,000,000 bushels
2nd	sorghum for silage	600,000 tons
3rd	sunflowers	168,060,000 pounds
4th	all hay	6,550,000 tons
5th	summer potatoes	1,824,000 hundredweight*
7th	alfalfa hay	3,610,000 tons
8th	corn for grain	345,000,000 bushels
8th	pinto beans	210,000 hundredweight*
11th	corn for silage	3,600,000 tons
11th	soybeans	98,560,000 bushels
16th	cotton	140,000 bales**
* one hundredweight = 100 pounds ** based on 480 pounds per bale		

Source: Kansas Agricultural Statistics Service

than wheat are produced in the state according to the Kansas Agricultural Statistics Service. Kansas is among the top ten corn-producing states in the United States, producing nearly 4 percent of the corn produced for grain in the United States. Corn silage is also a major product in Kansas, with an average 2.5 million tons of silage harvested each year and used as livestock feed, mainly by the beef industry.

Each year, Kansas produces nearly 50 percent of the U.S. grain sorghum crop. Grain sorghum is also referred to as milo. The United States is the largest producer of grain sorghum in the world but in terms of acreage or dollar value, grain sorghum is not the largest or the most valuable crop produced in either the United States or the state of Kansas.

Until recently, the United States was the world's largest exporter of soybeans. Today, the U.S. is still the largest producer of soybeans in the world and this country accounts for almost 40 percent of the world's soybean production. In the United States, soybeans rank second (behind corn) in the number of acres planted and the value of the crop produced. Soybean acreage is fluctuating in Kansas, a reflection of national trends. In 2004, soybean production in Kansas jumped 95 percent from the year before. Although Kansas only produces 3 to 4 percent



Corn

Credit: Lynn Betts, USDA NRCS



Grain Sorghum

Credit: High Plains Journal

Cropland

of the soybeans produced in the United States, the state still ranks in the top ten states in soybean production according to the Kansas Agricultural Statistics Service.

Long before Kansas adopted the native wild sunflower as the state flower in 1903, Kansas was known as the "Sunflower State." Each year, around 150,000 acres in the state are planted to sunflowers. Kansas ranks third in both sunflower acreage and production among the states that produce sunflowers in the United States.

In Kansas, more farms grow alfalfa than corn. Kansas produces about five percent of the alfalfa produced in the United States and ranks eighth among the states in both alfalfa acreage and production. Unlike many Kansas crops, alfalfa is a perennial plant and stands of alfalfa are maintained for years, rather than months. Alfalfa is the most important forage crop grown in the United States.

Other field crops grown in Kansas include cotton, potatoes, pinto beans, oats, barley, and canola. Early Kansas farmers experimented with producing cotton but from 1943 until 1982, Kansas did not even keep official state production records on cotton. Today, cotton is making a comeback in Kansas and the annual cotton crop contributes millions of dollars to the state's economy. Kansas potato production is valued at over \$10 million annually while the state's average pinto bean production is valued at almost \$5 million. Oats and barley are grown for the cereal and food industry or for livestock feed. Canola is an oilseed.



Soybeans

Credit: Minnesota Soybean



Sunflowers

Credit: Bruce Fritz, USDA ARS



Alfalfa Bales

Credit: High Plains Journal



Cotton Plant

Credit: Scott Bauer, USDA ARS

AGRICULTURAL BIOTECHNOLOGY

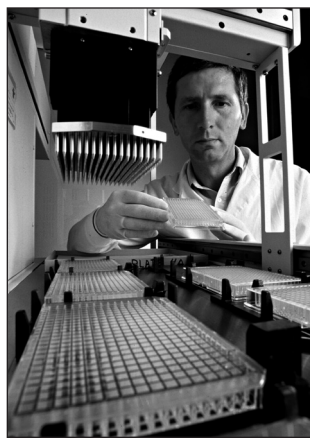
Just like the early Kansas pioneers, today's farmers and ranchers continue to research and experiment with a variety of crops that might meet industrial needs or provide new consumer products. Scientific research, including the selection of specific genes to improve plant qualities, is critical to maintaining the supply of food needed to feed the world's population and protect natural resources at the same time. Traditional plant breeding methods involved the transfer of thousands of genes at a time and it took several years to isolate the genes responsible for specific traits. Modern technol-



Sorghum Breeding

Credit: KSU Ag Research Center-Hays

ogy allows plant breeders to make precise genetic changes and address disease, insect, or environmental challenges more rapidly. In the United States, agricultural biotechnology, the technology used by plant breeders to add beneficial traits to plants, is regulated by three agencies: the U.S. Department of Agriculture's Animal



Gene Mapping

Credit: Scott Bauer, USDA ARS



Biotechnology Research

Credit: Keith Weller, USDA ARS

and Plant Health Inspection Service (APHIS), the Environmental Protection Agency, and the Food and Drug Administration's Center for Food Safety and Nutrition. Foods and plants produced using biotechnology are among the most tested food and agricultural products in history. Today, from 60 to 70 percent of the processed foods available in U.S. grocery stores contain at least one ingredient derived from agricultural biotechnology.⁸

KANSAS CROPLAND HISTORY

"What is the secret to success?"

"Two words: 'Right Decisions.'"

"How do you make the right decisions?"

"One word: 'Experience.'"

"And how do you get experience?"

"Two words: 'Wrong decisions.'"

Tim Nichols and Craig Wiseman, songwriters,

Live Like You Were Dying⁹

Most Kansas farmers and ranchers would agree that experience really is the secret to success. The early pioneers certainly experimented with a wide variety of crops and farming methods until they experienced success. Even then, they sought new information and employed new farming methods in search of continued success. Unfortunately, some of the experimentation also resulted in unanticipated negative consequences. Those experiences led to more research and experimentation and ultimately resulted in changes in agricultural methods and even societal values.

EARLY KANSAS AGRICULTURE

American Indians grew the first agricultural crops in the area that is now the state of Kansas. Early Spanish explorers observed the Quivira Indians cultivating the soil and the Kansa Indians served corn and other vegetables to other early explorers. In 1827, the federal government appointed Daniel Morgan Boone, son of the famous Kentucky hunter and trapper, to instruct the Kansa Indians at the Shawnee Methodist Mission in the "arts of agriculture."¹⁰ Farms were common on the lands reserved for the American Indians by the time Congress passed legislation creating the Kansas Territory in 1854. However, prior to the end of the Civil War, settlers in the Kansas Territory usually raised barely enough food for their own consumption and some years did not even manage to do that.

HUMAN MIGRATION

Emigrant – a person who moved (migrated) away from one region of a country to another region of the same country (as used historically).

Immigrant – a person who moves (migrates) into a different country.

KANSAS AGRICULTURE 1870s TO 1930s

After the Civil War ended, emigrants rushed into Kansas. Many were unemployed war veterans who came to try their luck in the new state. In the 1870s, the population of the state grew faster than the state's ability to feed its people. The state rallied in the 1880s under another wave of immigrants who tried new farming methods and crops. The land resources seemed endless and even more land was placed under cultivation as confidence grew in the new state, new crops, and new agricultural practices. The most fertile productive land was claimed first, but as settlers continued to pour into the state, marginal land—land that was not well suited for planting and growing crops—was pulled into production.

Since most of the early settlers came into Kansas from the eastern states, they were able to adapt familiar farming methods and crops to the climate and soils in eastern Kansas. As the settlers moved westward out into the prairie grasslands, they soon learned that things needed to be done differently. Some of the early settlers came from forested areas in eastern states where grasses like clover, bluegrass, and timothy were cultivated for grazing. They did not think that the native prairie grasses would support continued livestock grazing. Until the late 1880s, many people did not realize that the native bluestem, gama, and buffalo grasses needed to be preserved.

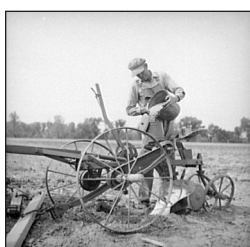
Many of the settlers arrived with horses or mules. The Kansas climate encouraged the development of horse-drawn machinery that could take advantage of soil moisture while it was available and harvest crops rapidly in between the periodic storms. In the 1870s, newer horse-drawn machinery allowed the farmer/operator to ride, rather than walk. One reason that growing wheat became more popular in Kansas than raising corn was because machines could be used to harvest and thresh wheat while corn still had to be harvested by hand.

Farmers and manufacturers continually worked to improve the machinery needed for agriculture in Kansas and other Plains states but there was no real consensus on the best way to farm the former grasslands. Beginning in the early 1860s, many people advocated deep plowing and scorned the farmers who barely scratched the surface of the soil when preparing the seedbed and planting crops. Some people even promoted



Cutting Corn, Sheridan County, 1939

Source: Library of Congress; Russell Lee, photographer



"Riding" Corn Planter, Jefferson County, 1936

Source: Library of Congress; Arthur Rothstein, photographer

EARLY KANSAS POPULATION GROWTH

1855	8,601
1860	107,206
1870	364,399
1880	996,096
1890	1,428,108
1900	1,470,495
1910	1,690,949
1920	1,769,257
1930	1,880,999

Sources: U.S. Census Bureau and Kansas State Historical Society

the theory that plowing opened the soil up so it could absorb and hold water and that plowing more land in Kansas would cause it to rain more often in the state!

Despite prolonged periods of dry weather, severe economic distress, and extreme weather events (blizzards, tornadoes, windstorms, and dust storms), many families did manage to adapt to the Kansas environment. They continued to be optimistic about their opportunities to be more successful. They were supported by the efforts of the U.S. Congress and the state legislature. In 1862, Congress authorized and provided monetary support for an agricultural college in each state, which resulted in the selection of Manhattan, Kansas, as the site for the Kansas State Agricultural College (KSAC), now Kansas State University. In 1887, Congress authorized and provided for an agricultural experiment station in each state. In Kansas, the Experiment Station became a branch of KSAC. The Experiment Station's responsibilities included the testing of seeds, the introduction of new crops, plant breeding, soil analysis, studying crop rotation, and distributing research results. In 1900, the state of Kansas acquired the Fort Hays military reservation, part of which became a branch of the KSAC Agricultural Experiment Station and is now known as the Kansas State University Agricultural Research Center–Hays.



Horse-Drawn Plow

Source: USDA NRCS

CHANGING KANSAS AGRICULTURE

1862 – Congress authorizes an agricultural college in each state.

1863 – Kansas Legislature establishes Kansas State Agricultural College (KSAC) in Manhattan, later renamed Kansas State University.

1867 – Congress authorizes an agricultural experiment station in each state; Kansas Agricultural Experiment Station becomes branch of KSAC.

1900 – State of Kansas acquires Fort Hays military reservation; establishment of Hays branch of Kansas Agricultural Experiment Station, later renamed Kansas State University Agricultural Research Center–Hays.



Plow pulled by Steam Traction Engine, Belpre, 1910

Source: Library of Congress; Wm. O. Durstine, photographer

Beginning in the early 1900s, new developments in farm machinery allowed farmers to cultivate and harvest larger areas of land more quickly. During World War I, an increased demand for food in Europe pulled thousands of grassland acres into crop production. Much of the new cropland was planted to wheat, which intensified an existing problem caused by the Hessian fly. This insect lays its eggs in the stalks of the growing wheat plant, which is damaged when the eggs hatch and the larvae begin feeding on the plant material. In order to combat the Hessian fly problem, Kansas farmers were instructed to work the ground as soon as the wheat crop was harvested, plow deep to bury the wheat stubble, and keep tilling the soil until all the volunteer wheat had sprouted and been destroyed. Today, Kansas farmers deal with the Hessian fly problem by destroying volunteer wheat shortly after harvest, planting after the egg-laying period has ended in the fall, and choosing varieties with genetic resistance to the problem. However, starting in the early 1900s, Kansas farmers acted according to the recommendations available at that time which told them to plow deep and work the fields often if they or their neighbors were planning to plant wheat.



Hessian Fly

Credit: Scott Bauer, USDA ARS

In the mid-1920s, smaller lightweight tractors became more affordable. By 1930, most farmers were using tractors, rather than horses, to produce crops. Land that had grown feed for the horses and mules became available for crop production and the tractors made it possible to farm more acres, increasing the size of many farms.



Planting with both Horses and Tractor, 1940

Source: John Vachon, USDA

THE DUST BOWL

For thousands of years, whenever people used up or damaged the natural resources in the area where they were living, they simply moved to a new location. In the United States, pioneers moved further inland as the population of the country grew. People rode across the prairie grasslands on their way west—or east—but few people understood the potential of the prairie states and many believed "The Great American Desert" was an accurate description for the area. Once homesteaders staked their claims in the Plains states, there were very few opportunities left to claim "new" land or natural resources in the United States.



Dust Storm

Source: USDA NRCS

There were warning signs that bringing the prairie grasslands under cultivation would have long-term consequences. A series of intermittent dry years in the late 1800s, prairie fires, and overgrazing contributed to dust storms that blocked railroad tracks with drifts of dust, killed livestock, and filled homes and buildings with tons of topsoil. When the rains and snows returned, the farmers planted and harvested crops, and turned even more grassland into cropland. Additional grassland was converted into cropland during World War I. When prices dropped after the war ended, many landowners chose to leave some cropland unplanted, abandoning it until prices rose again. The dry years came before that happened.

In the 1930s, a widespread severe drought affected the entire country. In 1934, over 80 percent of the United States experienced extremely dry conditions. The driest region included the southwest area of Kansas, southeastern Colorado and the panhandles of Texas and Oklahoma. The eight years from 1933 to 1940 are known as the drought years of the period called the "Dust Bowl." However, the dust storms started as early as 1932 in the Plains states. By 1934, an estimated 100 million acres of farmland had lost all or most of its topsoil due to wind erosion. During the Dust Bowl, red-colored soil from Oklahoma was blown as far north as Canada and as far east as the Atlantic Ocean.



Soil Drifts around Barn, Liberal, March 1936

Source: Library of Congress; Arthur Rubenstein, photographer

DUST BOWL FACTS

The eight years from 1933 to 1940 have been designated as the Dust Bowl period, even though dust storms in the Plains states started in 1932.

April 14, 1935 is known as "Black Sunday"—one of the worst dust storms in the history of the United States occurred on that day.

On April 27, 1935, the passage of national soil conservation legislation coincided with a dust storm that blew into Washington, D.C., while Congress was in session.

During the Dust Bowl period, the driest region in the United States included southwestern Kansas.



Dust Storm

Source: USDA NRCS

One storm in May of 1934 that started in Montana and Wyoming carried soil 300 miles out into the Atlantic Ocean. By some estimates, that single storm carried up to 350 million tons of soil. In March of 1935, the regional high school basketball tournaments at Garden City and Hays were cut short by a dust

storm. The dust got so bad that—even with the lights on—players could not see from one end of the basketball court to the other.¹² One of the worst dust storms occurred on Sunday, April 14, 1935, which became known as "Black Sunday." The next day, a reporter used the term "Dust Bowl" to describe the driest area of the continent. Over time, the term also became associated with the time period and the dust storms.

Even before "Black Sunday," government leaders were considering soil conservation issues. They understood that the country needed to protect its soil resources and assist farmers in implementing agricultural practices that prevented further soil erosion. Hugh H. Bennett led those efforts.

SOIL CONSERVATION SERVICE

Hugh Bennett joined the Bureau of Soils in the U.S. Department of Agriculture in 1903 as a technician whose main work was to classify and map the soils across the country. He understood the soil and its permanence but also recognized its fragility. Bennett wrote articles and spoke regularly about the "national menace" of soil erosion. On April 27, 1935, Bennett testified before Congress about the importance of creating a new national soil conservation program that would teach good management of the country's soil. Coincidentally, at the same time, a major dust storm was brewing. The dust storm blew into Washington, D.C., blackened the skies and helped Bennett persuade Congress to take proactive measures. That day,



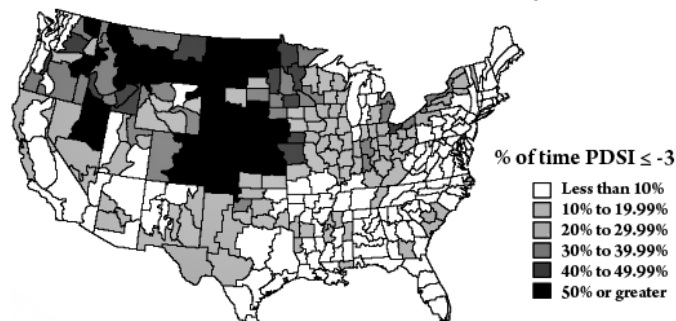
Hugh H. Bennett

Source: USDA NRCS

PALMER DROUGHT SEVERITY INDEX

1934–1939

Percent of Time in Severe and Extreme Drought



Source: National Drought Mitigation Center

Congress passed Public Law 46 – the Soil Conservation Act of 1935 and the basis for all national soil and water conservation programs today. That law established the Soil Conservation Service in the U.S. Department of Agriculture. Hugh Bennett was appointed the first chief of the Soil Conservation Service, reorganized as the Natural Resources Conservation Service in 1994.

Despite the ongoing drought, which coincided with and contributed to the Great Depression, the Soil Conservation Service immediately began efforts to highlight conservation activities beneficial to the land and soil. Those early efforts were not successful, in part because the information was too technical and confusing. A lack of local leadership and coordination as well as the lack of financial resources also threatened the successful adoption of soil conservation practices.

SOIL AND WATER CONSERVATION TIMELINE

1930s – severe drought affects the United States.

1935 – Congress passes the Soil Conservation Act of 1935, the basis of all national soil and water conservation programs.

1935 – Soil Conservation Service (SCS) established in the U.S. Department of Agriculture.

1937 – Kansas legislature passes the Kansas Conservation Districts Law. Kansas law establishes the State Soil Conservation Committee, later renamed the State Conservation Commission.

1938 – first county conservation district formed in Kansas (Labette County).

1944 – Kansas Association of Conservation Districts (KACD) organized.

1954 – last of 105 county conservation districts established in Kansas (Shawnee County).

1994 – SCS reorganized as the Natural Resources Conservation Service (NRCS).

STEWARDSHIP WEEK

Since 1955, the National Association of Conservation Districts has sponsored the national Stewardship Week program. Stewardship Week focuses on the power of individuals to protect natural resources through education, personal actions, and responsible use.

SOIL CONSERVATION DISTRICTS

In February 1937, President Franklin D. Roosevelt sent a letter to each state governor urging the states to pass legislation establishing state soil conservation programs similar to a model Conservation District Law developed by Congress. In March 1937, Kansas passed the Kansas Conservation Districts Law, becoming the second state to authorize the creation of conservation districts. The law also established a State Soil Conservation Committee, later re-named the State Conservation Commission, to promote soil and water conservation. Today, the State Conservation Commission provides leadership and guidance to local conservation districts, administers financial assistance programs, and coordinates conservation activities across the state with many other organizations.

In June 1938, the Labette County Conservation District became the first authorized conservation district in the state of Kansas. There are conservation districts in each of the 105 counties in the state, including Shawnee County, which (in 1954) was the last county to form a conservation district. Local agricultural producers and landowners serve on the conservation district boards, which provide nonpolitical leadership, encourage local participation in conservation activities, and coordinate the efforts of local, state, and national agencies to conserve, maintain, and improve soil and other natural resources on private lands.

The 105 county conservation districts belong to the Kansas Association of Conservation Districts (KACD). The KACD is a nonprofit, nongovernmental, voluntary organization that serves as a voice for the conservation districts on state policy, legislation, and communication.

Kansas farmers continue to benefit from the partnerships formed during the 1930s when the future of agriculture in Kansas and other Plains states looked very bleak. Scientific research and experimentation carried on at Kansas State University and the Agricultural Research Centers across Kansas address specific crop and livestock needs and distribute research results through educational programs offered by K-State Research and Extension offices located in each county. Several local, state, and national agencies provide technical knowledge and financial assistance, including the Natural

KANSAS BANKERS AWARDS

Since 1945, the Kansas Bankers Association has sponsored Soil Conservation Awards to recognize farmers and ranchers who have completed high-quality soil conservation work. In each county, a local committee selects the award recipients each year. The committee considers the quality and maintenance of completed conservation work, along with the use of the land, the completeness of the conservation plan, and special conservation practices addressing energy, forestry, grassland, pollution control, or wildlife habitat conservation. The Kansas Bankers Association also sponsors Windbreak, Wildlife, and other awards. Each local conservation district office maintains a list of all award winners.

Resource Conservation Service, the State Conservation Commission, and the U.S. Department of Agriculture. Those resources are often coordinated through the conservation districts, which continue to provide local leadership in soil and water conservation.

SOIL AND WATER CONSERVATION

"The finest workers in stone are not copper or steel tools, but the gentle touches of air and water working at their leisure with a liberal allowance of time."

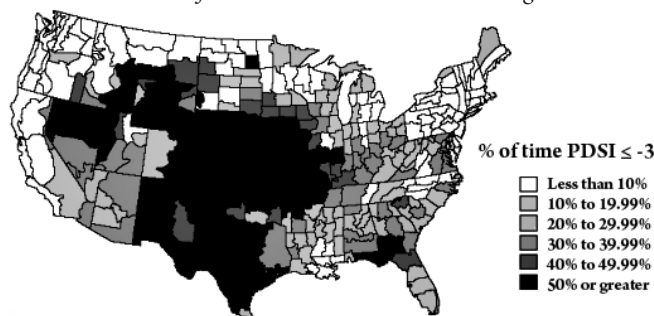
Henry David Thoreau, writer, philosopher, and naturalist

Since the 1930s, there have been other periods of severe and widespread drought but the United States has not experienced another catastrophic Dust Bowl. At the same time, U.S. farmers and ranchers have produced enough food to keep up with an expanding population in the United States while supplying agricultural exports and food aid for the increased worldwide population. Agricultural producers manage natural resources while maintaining the productivity of the land by using the appropriate soil and water conservation practices.

Crop production may involve any combination of cropping practices and tillage operations. Tillage includes mechanical manipulation of the soil, modification of soil conditions (adding nutrients, water, or lime), management of crop residues and weeds, incorporation of chemicals for crop production, or any combination of those actions. Common cropping practices in Kansas include crop rotation, growing a planned sequence of crops versus continuously growing only one crop on the same area of land, and summer fallow, leaving the land idle during at least one growing season to accumulate moisture in the soil for the next year's crop.

PALMER DROUGHT SEVERITY INDEX 1954–1956

Percent of Time in Severe and Extreme Drought



Source: National Drought Mitigation Center

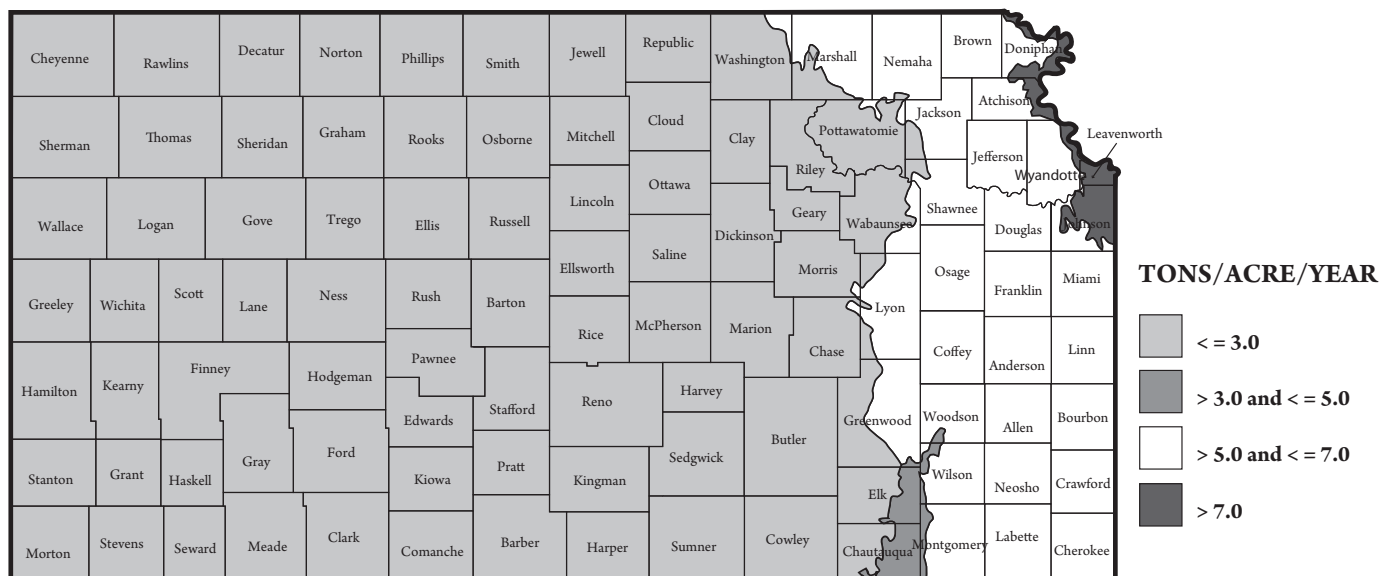
SOIL EROSION

Kansas farmers balance crop production with soil and water conservation activities to minimize the loss of water and valuable topsoil. When wind or water moves topsoil, the soil carries away nutrients needed by crops. As demonstrated by the dust storms of the 1930s, wind erosion can be a problem in Kansas, especially when it is very dry in the late winter and early spring. In western Kansas,

Wind speeds as low as 13 miles per hour can cause soil particles to begin moving if the soil is highly erodible.

Source: K-State Research and Extension

KANSAS CROPLAND SOIL LOSS – WATER EROSION



Source: K-State Research and Extension

CONSERVATION WORDS

Conservation tillage— any tillage sequence or tillage and planting combination that leaves at least 30 percent of the soil surface covered by the residue of the previous year's crops.

Erosion— transportation of soil due to wind or water movement.

Runoff— water that is not absorbed by soil.

Sediment— particles resulting from rocks, soil, or organic matter moved by water or wind and deposited in a different location.

Splash erosion— erosion resulting from the impact of raindrops hitting the soil.

Tillage— preparation of land for crop production.

patterns. The goal is to limit the water's ability to flow along the top of the soil—keeping the soil in place and the water on the land where it fell.

Many of the same conservation practices also reduce wind erosion. Wind speeds as low as 13 miles per hour can cause soil particles to start blowing if the soil is highly erodible (i.e. the soil surface is dry, smooth, loose, finely granulated, and unprotected by residue). In areas where soils are vulnerable to wind erosion, additional conservation measures are taken. These might include planting crops at an angle to the prevailing winds or alternating wide strips of growing crops with strips of stubble from previous crops.

TILLAGE

At one time, most tillage methods consisted of breaking up the soil, pulverizing any large clods or clumps of plant material, and smoothing out the soil, thus reducing soil particle size and creating a smooth, finely ground seedbed. Today, Kansas farmers use a wide range of tillage methods, generally choosing the minimum

necessary to meet crop production requirements for yield production goals. They decide which tillage methods to use based on a number of factors, including but not limited to, the crops that are being grown, the existing soil and climatic conditions, and economic factors such as fuel costs. Most tillage methods create rough surfaces, increase subsoil water storage capacity, and leave part or all of the residue from previous crops on or near the surface of the soil. In addition to more conventional tillage operations, Kansas farmers may practice conservation tillage, no-till farming, strip tillage, and summer fallow (ecofallow).

Conservation tillage is any tillage sequence or tillage and planting combination that leaves at least 30 percent of the soil surface covered by the residue of the previous year's crops. Research on conservation tillage began in the 1930s in the United States. Since the mid-1960s, conservation tillage practices have become more common in Kansas.

No mechanical manipulation of the soil takes place on cropland that is no-tilled. **No-till farming** is a continuous process requiring special planting equipment since no tillage takes place between the harvest of one crop and the planting of the next. During the planting process, less than 10 percent of the soil surface and existing crop residue are disturbed. The planting equipment prepares



Conservation Tillage

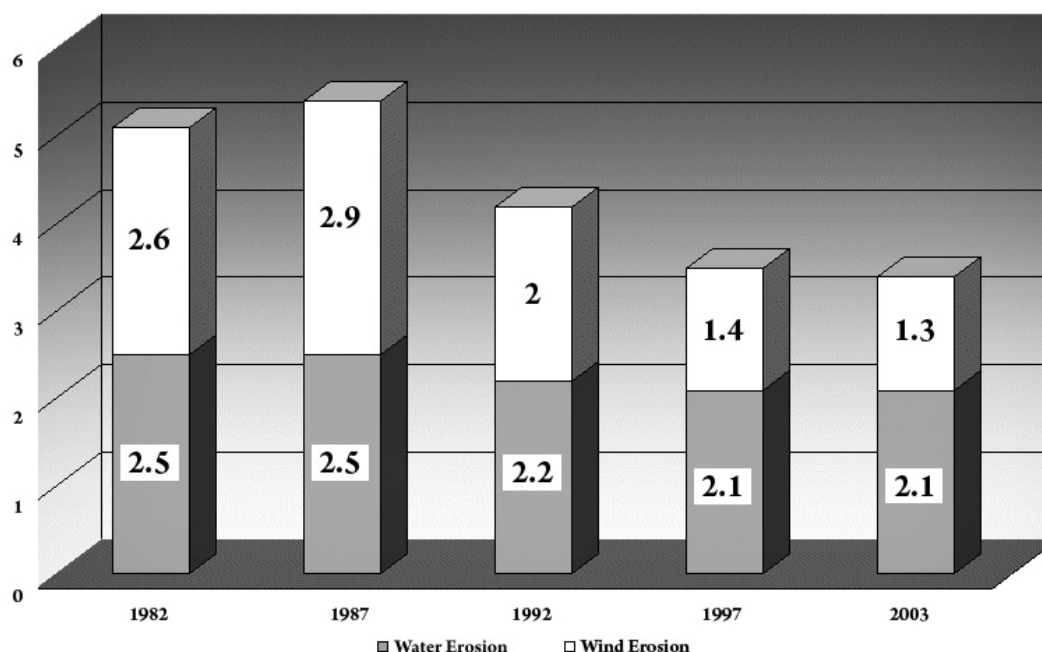
Source: USDA NRCS



No-till Farming

Source: USDA NRCS

EROSION ON KANSAS CROPLAND BY YEAR (TONS/ACRE/YEAR)



Source: USDA NRCS

a seedbed, deposits the seed, and leaves the surface of the soil and the crop residue virtually undisturbed. The residue helps retain any natural precipitation or water applied to the land by irrigation and minimizes soil and nutrient losses. No-till management practices also reduce soil water losses due to evaporation and can reduce soil erosion from crop fields significantly.

Strip till, also called zone tillage or strip till planting, is a method of tilling and planting in narrow rows (strips). The soil and residue is left undisturbed in between the six- to eight-inch-wide rows. Special equipment is required for strip till farming. Depending on the type of equipment purchased, the seedbed will be prepared at the same time that the seed is being planted or two separate trips through the field for tilling and planting will be required. Precise farming methods, such as global positioning systems (GPS) and autosteer guidance systems, may be used to more accurately place fertilizer and seed in the same narrow strips of soil crop after crop.

Historically, **summer fallow** was the main dryland cropping system in western Kansas. In the traditional cropping pattern, after two wheat crops, a field would be idled (left fallow or unplanted) for 14 to 15 months to build moisture in the soil profile for future crops. As necessary, weed growth would be controlled with shallow cultivation, which in turn allowed some soil moisture to evaporate. As Kansas farmers began rotating wheat with other crops, the fallow periods became shorter—limited to the growing seasons of the different crops rather than the entire cropping year for a single crop such as wheat. The development of herbicides allowed farmers to control weed growth during the fallow periods without losing moisture during the process of cultivation. Today, **ecofallow** is another term used to describe the system of rotating crops with fallow periods. Examples of current ecofallow rotations might include: wheat – grain sorghum – fallow, wheat – wheat – grain sorghum – fallow, or wheat – corn – fallow.

MANAGING LAND AND NATURAL RESOURCES

Kansas farmers apply a variety of conservation practices such as farming on the contour, strip cropping, building terraces and grassed waterways, and planting buffer or filter strips to minimize soil and water erosion of Kansas cropland. New technologies assist Kansas farmers with the placement of nutrients and the efficient use of water resources.

Contour farming can reduce erosion dramatically. When a field is farmed on the contour, all the tillage and planting operations go around or back and forth across the slope of the land. The furrows wrap gently around the slope and each acts as a small dam, preventing water from running wildly down the slope. Instead, the water goes down the slope a little at a time in much the same way that a car would wind down a very steep mountain, rather than driving straight down from top to bottom. Farming on the contour can reduce soil and water losses by as much as 50 percent.¹¹



Contour Farming

Credit: Jeff Vanuga, USDA NRCS

Strip cropping may be combined with contour farming, alternating strips of planted crops throughout the field to limit soil and water losses even more. For instance, a strip of small grains (wheat, oats, or rye) or a strip of legumes (alfalfa or clover) might be planted among strips of spring-planted row crops which are typically the most erosion-prone because the small seedlings cannot stop much water and soil movement during early spring rains. Strip



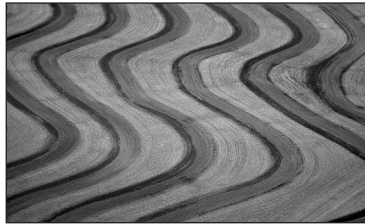
Strip Cropping Corn

Credit: Gene Alexander, USDA

Cropland

cropping is also used to prevent wind erosion. Strips (several rows wide) are planted perpendicular to the prevailing wind direction so that the wind blows across the rows of plants, rather than down the furrows. Wide strips of stubble, standing crop residue from a previous crop, are alternated with the strips of growing crops to catch any soil particles that might start moving with the wind.

A **terrace** is a raised, generally horizontal ridge of earth embankments constructed across a slope, following the contour of the land. A shallow channel on the uphill side of the terrace is designed to capture water and slow it down, while the terrace redirects the water



Kansas Terraces

Credit: Jeff Vanuga, USDA NRCS

into slower moving channels such as grassed waterways or outlets. Terraces are designed to be capable of controlling the water runoff from a 10-year storm event (the heaviest rainfall to be expected once in 10 years). There are many types and sizes of terraces but in Kansas, most terraces are farmed at the same time and in the same way as the rest of the field. Through the Conservation Reserve Program, some terraces have been permanently planted to grass while crops are still grown on the land between the terraces. The many miles of terraces on Kansas cropland create an artwork on the land.

Grassed waterways are natural or constructed channels used to carry water from natural precipitation through or from cropland. Water flows into these broad shallow channels, which are planted to grass. The grass provides cover for the soil and the soil stays intact when there is water runoff.



Waterways

Credit: Tim McCabe, USDA

The grass also serves as a net and catches any particles in the flowing water. Water moves along the grassed waterway until it reaches a holding area, such as a pond, or leaves the field.

Buffer strips, filter strips, and field borders are other strips of vegetation that slow water down and trap sediments. **Field borders** are strips of perennial grasses or legumes along and around the edge of a cropland field.



Buffer Strip

Credit: Jeff Vanuga, USDA NRCS

Buffer strips or filter strips are strips of permanent vegetation (grasses, trees, and shrubs) planted along bodies of water including streams, rivers, ponds, and lakes. Water slows down as it passes through the vegetation and sediments are trapped there. Any nutrients attached to the soil particles are also trapped and deposited where the plants or trees can use them.

Precision agriculture, or precision farming, incorporates several technologies using computers and/or satellites. These technological tools may include global positioning systems (GPS), geographi-

PRECISION AGRICULTURE TOOLS

Autosteer— automatic guidance system that operates agricultural machinery using GPS for accuracy and GIS information to vary operations at specific sites; requires human operator monitoring while following a sequence of computerized instructions that allow "hands free" steering.

Geographical information system (GIS)— computerized system of collecting, analyzing, and displaying information specific to geographical references.

Global positioning system (GPS)— navigational tool based on satellites orbiting the Earth and transmitting signals allowing GPS receivers to determine the receiver's location, speed, and direction.

cal information systems (GIS), automatic guidance systems (autosteering), yield monitors, and remote sensors. Information about soil and crop conditions is collected and analyzed so that inputs (seeds, nutrients, water, and chemicals) can be varied according to the needs of the

crop at site-specific locations, rather than applied at the same rate across the larger field. Computerized yield monitors on harvesting machines help farmers pinpoint locations where there might be problems affecting crop production. Automatic guidance systems can steer and operate agricultural machinery more accurately and efficiently than human operators. Autosteering reduces any overlap or "skips" as the machinery passes through the field. It also allows operators to return to the same locations time after time, especially important in strip till planting where the seed is placed into the same narrow strip of soil each growing season. Irrigators use remote sensors to monitor crop conditions and apply irrigation water more efficiently. As the new technologies become more affordable and practical for different types of farm situations, precision agriculture will become more commonplace in Kansas agriculture.



GPS Automatic Guidance System

Credit: Trimble Navigation

ANIMAL FEED AND WILDLIFE HABITAT

"I know of no pursuit in which more real and important services can be rendered to any country than by improving its agriculture, its breed of useful animals, and other branches of a husbandman's cares."

George Washington, First President of the United States

Animals were very important to early Kansas settlers. Horses and mules provided transportation and power. Domestic and wild animals provided food and materials for clothing, furnishings, and other household needs. Farms and ranches raised crops to provide feed for the livestock, as well as food for the people living and working there. While people dreamed of being self-sufficient, in reality, most families traded surplus agricultural products with other families or merchants to get everything they needed or wanted.

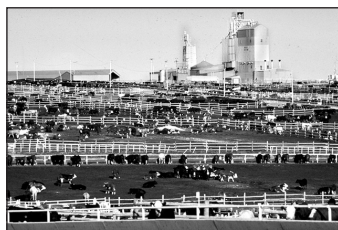
With each new development in farm machinery, individual farmers could do more fieldwork in less time and the size of farms grew. At the same time, transportation, manufacturing, and other industries provided easier access to many items for those people who had surplus agricultural products to sell. Eventually, tractors and automobiles replaced horses and mules on most Kansas farms. Until after World War II, though, most of those farms still produced a mixture of both crop and livestock products. Today, many farms and ranches in Kansas specialize in either crop or livestock production. Many others are still diversified - involved in both segments of agricultural production.

KANSAS BEEF INDUSTRY

The beef industry in Kansas is an example of an agricultural industry that includes both producers who specialize in beef production and those who combine crop and livestock production. Producers who specialize in crop production also play a vital role in supplying the grains and feed for the leading agricultural industry in the state of Kansas.

Beef is big business in Kansas. In fact, Texas is the only state with more cattle than Kansas. However, Kansas ranks first among the states in the number of cattle commercially processed each year. Nearly 25 percent of all the cattle fed for meat production in the United States are fed in Kansas.

The beef industry played an important role in the development of the state, from early cattle ranches and famous cowtowns to the big stockyards in Kansas City and Wichita. However, until the late 1960s and early 1970s, Iowa was the top cattle-feeding state. New developments in irrigation technologies led to increased crop production in central and western Kansas where the drier climate is more favorable for cattle feeding. Processing facilities moved closer to the feedyards and brought new jobs and industries to the state.



Beef Feedlot

Credit: Tim McCabe, USDA

In Kansas, the beef industry utilizes cropland in many ways. Each use is customized to the area of the state, field conditions, and each individual farm's operations and plans. After a crop is harvested, cattle may be allowed to graze on the crop residue, such as stalks and leaves of grain sorghum or corn. In some areas of the state, winter wheat grows fast enough to allow some grazing early in the fall without hurting yields significantly the next summer. Manure from feedyards, used as a source of nitrogen fertilizer on croplands, also increases the organic matter in the soil.

Using crops such as grain sorghum, corn, and wheat, the production of ethanol generates coproducts such as distillers grains, used as a high-quality feed ingredient in the beef feeding and dairy industries. As more ethanol plants go into production in Kansas, distillers grains will play a larger role in the state's livestock industry.

OTHER KANSAS LIVESTOCK

Other livestock such as dairy cattle, swine, sheep, horses, poultry, and bison also benefit from the resources provided by Kansas cropland. Even though none of these livestock industries is near the size of the Kansas beef industry, all make a positive impact on the Kansas economy.

The value of the milk produced by the **Kansas dairy industry** is over \$300 million each year. There are only 900 dairy operations in Kansas—"operation" meaning any place having one or more milk cows on hand at any one time. However, all together, there are 110,000 dairy cattle in Kansas, barely over 1 percent of the U.S. total. Back in the 1930s, there were almost 900,000 dairy cattle in Kansas, but the numbers began dropping after World War II as better refrigeration and packaging became available. Today, there are 20 dairies in Kansas with more than 500 dairy cattle each. Together, those 20 dairies produce over 270 million gallons of milk each year. High-quality alfalfa is one of the most important feeds for dairy cattle, which require very specific nutrients from feed mixtures to achieve their genetic potential for milk production. Alfalfa is also a natural source of calcium, which is an important nutrient for milk production.



Dairy Cow

Credit: Peggy Greb, USDA ARS

According to the Kansas Pork Association, Kansas pork producers spend about \$145 million each year for feed grains, primarily grain sorghum but including corn and soybean products. The **Kansas swine industry** includes 1,400 farms with 1.8 million hogs and pigs that eat over 30 million bushels of grain each year. In 2006, Kansas farmers marketed live animals valued at over \$370 million and produced nearly 900 million pounds of pork. Even though the number of hogs in Kansas was twice as high in the 1890s as it is today, the swine industry is a significant part of the Kansas economy.¹³



Pig

Credit: Scott Bauer, USDA ARS

In Kansas, the number of farms with sheep and swine are about the same. Sheep numbers peaked in Kansas in 1943 at 1.61 million, but started dropping dramatically in the 1960s and, at 77,000 head in 2007, are the lowest they have been since the 1860s. Today, the principal product of the **Kansas sheep industry** is lamb, meat from an animal that is less than one year old.

The **Kansas livestock industry** includes many other animal species. Some species, such as horses and mules, have been in the state for a long time. Although the Agricultural Statistics Service does not track the number of horses in Kansas, the American Horse Council has reported that there are 9.2 million horses in the United States, and the equine industry has an annual economic impact of \$39 billion. Other species, like bison, vanished from the Kansas prairies in the 1870s. Brought back from the edge of extinction, today small herds of domestic bison roam Kansas grasslands and contribute to the agricultural economy. Poultry, including those producing specific products such as eggs, provide local markets for crops, generate agriculture-related jobs, and contribute to the local and state economies. The number of meat goats in Kansas is rising rapidly in response to the increasing demand for those meat



Chicken

Credit: USDA

Cropland

products. Kansas croplands provide high-quality feed ingredients designed to meet the specific nutritional needs of the wide variety of livestock species in the state.



Source: USDA NRCS

KANSAS WILDLIFE

The agricultural lands of Kansas support an abundant and diverse wildlife population. Kansas wildlife species also take advantage of the high-quality feeds produced on Kansas cropland. Deer are plentiful in the state now but after they were driven out of the state while it was being settled, deer were rarely seen in Kansas. In the 1950s, deer started drifting back into the state and today, deer populations are high enough that deer-vehicle collisions are a major problem in Kansas. Deer in Kansas feed mainly on agricultural crops, such as corn, alfalfa, grain sorghum, wheat, and soybeans. Historically, wild turkeys were part of the prairie biome and were hunted by the American Indians and early Kansas settlers. Loss of habitat and lenient hunting laws led to the disappearance of the turkey in Kansas until a strong reintroduction effort was launched in the late 1960s and

early 1970s. Other species, such as the ring-necked pheasant, are not native to the state but thrived in the state after being released here by state wildlife officials. There are 467 species of birds found in Kansas. This includes birds like the ducks and geese that migrate through the state in the spring and fall as well as birds that are year-round residents of the state. The soil and water conservation practices of today's Kansas farmers benefit wildlife in addition to feeding domestic livestock.

EARTHWORMS

Although technically an invertebrate rather than an "animal," earthworms are very important to Kansas farmers and ranchers. Earthworms improve the soil as they tunnel through it, mixing the soil, shredding plant residue, and burying the residue in the soil. Earthworms swallow soil, tiny bits of plants, and microorganisms as they work their way up and down through the soil layers. As earthworms digest soil and excrete waste (worm castings), nutrients are deposited in the lining of tunnels created by the burrowing activity. Worm castings also contain microorganisms that help convert nutrients into forms that can be used by plants. The tunneling activity creates openings for water and air to move through the soil, particularly necessary when tillage is not used to break up the surface of the soil as in no-till farming. The tunnels also create spaces where the roots of a plant can grow. As a plant's root system pulls water through the tunnels left by the earthworms, the plant also receives nutrients, including those deposited in the worm castings. The presence of earthworms is usually a good indicator of a healthy soil system.

CROP-BASED FUELS

Ethanol— fuel produced from grains and plants high in starches; mixed with unleaded gasoline before it is sold to consumers.

Biodiesel— fuel produced from vegetable oils, animal fats, or recycled cooking oils; mixed with petroleum diesel fuel before it is sold to consumers.

CROP-BASED FUELS

"I said, ah ha, this is a light at the end of the tunnel, a way we can grow our way out of some of the problems we are in."

Willie Nelson, entertainer and songwriter

According to the federal government, renewable energy accounts for around 6 percent of the energy currently consumed in the United States. Fuels produced from crops and agriculture-related products can replace traditional energy sources, such as petroleum and coal, and reduce the United States' dependency on foreign imports. Groups such as the 25 x '25 coalition promote increased use of renewable fuels in the United States. The goal of the 25 x '25 coalition is to find ways to produce 25 percent of the nation's energy from renewable resources by 2025. Those renewable resources will include agricultural products, including Kansas crops.

Kansas crops are already being used to produce ethanol and biodiesel, fuels that are efficient and have positive health and environmental benefits. The biofuels industry is rapidly expanding, both in the United States and around the world. Crop-based fuels such as ethanol and soy biodiesel are considered biofuels. However, biofuels can be produced from many different biomass products and are not limited to crop-based components.

25 x '25 GOAL

The goal of the national 25 x '25 coalition is "By 2025, America's farms, forests, and ranches will provide 25 percent of the total energy consumed in the United States, while continuing to produce safe, abundant, and affordable food, feed, and fiber."



ETHANOL

Ethanol (ethyl alcohol) is produced from grain high in starches, such as corn and grain sorghum. In Kansas, historically, more grain sorghum was used in ethanol plants than corn although that was not the case nationwide. Corn and grain sorghum are interchangeable in the ethanol making process. Most of the new ethanol production facilities use the "dry milling" method to produce ethanol, which grinds the grain into flour before beginning a fermentation process. During the fermentation process, only the starch (carbohydrate) component of the grain is converted into alcohol. The dry milling process produces three products: alcohol (ethanol), distillers grains and carbon dioxide. Distillers grains are fed to livestock and the carbon dioxide is used in food processing and bottling as well as the petroleum industry.

Before it is sold to consumers, ethanol is blended with gasoline. The first ethanol-blended gasoline in the United States was available in the 1970s and was called “gasohol.” Today, ethanol is blended into nearly 50 percent of the fuel supply in the U.S. Every major automaker in the world has approved the use of E10, a blend of 10 percent ethanol and 90 percent unleaded gasoline. Any vehicle requiring unleaded gasoline can operate on E10. Flexible Fuel Vehicles can operate on unleaded gasoline blended with ethanol percentages from zero to 85 percent. A computer in the fuel system of a Flexible Fuel Vehicle automatically adjusts for the level of ethanol in the fuel mix. Currently, a blend of 85 percent ethanol and 15 percent unleaded gasoline is being marketed as E85.

**Ethanol Lab**

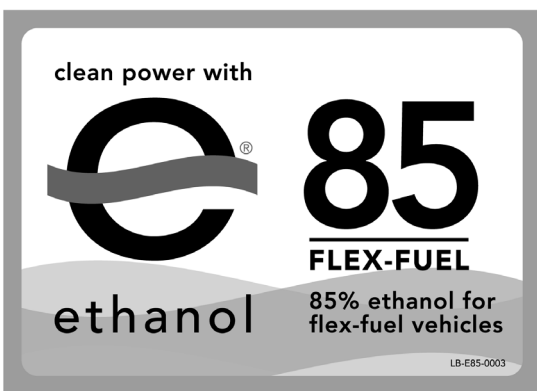
Source: ICM, Inc.

**Ethanol Race Car**

Credit: Ethanol Promotion and Information Council

In the future, perennial grasses such as switch-grass or forage crops such as sorghum may provide the cellulosic biomass necessary for ethanol production. Ethanol produced from plant materials, or cellulosic biomass, is chemically identical to that produced from grains such as corn or grain sorghum. However, the carbohydrates found in plant materials (cellulose) are more complex than those found in grains (starch), requiring different processes to break the carbohydrates down into simple sugars that can be fermented into ethanol. Cellulosic biomass includes crops grown specifically for fuel production as well as plant wastes such as wheat straw, sawdust, or paper pulp.

Ethanol benefits the environment because it is made from renewable resources and it reduces exhaust emissions. Ethanol production provides additional markets for Kansas crops and valuable coproducts for agricultural and industrial needs. Research continues to increase the efficiency of the ethanol-making process and explore new opportunities for producing ethanol from other plant-based materials.

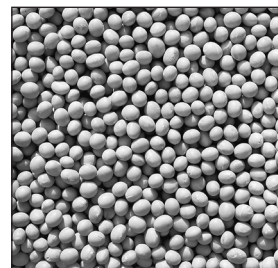


BIODIESEL

In 2004, President George W. Bush signed the first national legislation containing tax incentives for biodiesel production and use. According to the Department of Energy, biodiesel, a renewable fuel for diesel engines that is derived from natural oils like soy oil, has become America's fastest growing alternative fuel. One bushel of soybeans yields 1.5 gallons of biodiesel, according to the American Soybean Association.

To produce biodiesel, soybeans or other oilseeds are processed into vegetable oil. Then, through a chemical process called “transesterification,” the vegetable oil is separated into two products—methyl esters (biodiesel) and glycerin, which is used in soap, lotion, and other products. Biodiesel can be made from vegetable oils, animal fats, or recycled cooking oil. It is a clean-burning fuel that works in any diesel engine or fuel system. It does not contain petroleum but it can be blended with standard diesel fuel. Biodiesel blends, such as B2 (2 percent soybean oil and 98 percent petroleum diesel) and B20 (20 percent soybean oil and 80 percent petroleum diesel) are available in Kansas.

Both production and use of biodiesel is expanding in the United States. The U.S. Navy, the largest user of diesel fuel in the world, uses biodiesel at several naval facilities. The U.S. Coast Guard and the U.S. Postal Service also use biodiesel. City buses, school buses, government vehicles, trucks, and other vehicles run on biodiesel. Many farmers also use biodiesel and soy-based lubricants to produce the next crop of soybeans, completing a cycle of renewable energy.

**Soybeans**

Credit: Lynn Betts, USDA NRCS

**Soy Biodiesel Tour Bus**

Credit: Keith Weller, USDA ARS

SEEDS OF SUCCESS

“Look not mournfully into the past. It comes not back again. Wisely improve the present. It is thine. Go forth to meet the shadowy future, without fear.”

Henry Wadsworth Longfellow, American poet

Early explorers did not understand the prairie biome they encountered in the area that became the state of Kansas. They did not understand that the soils supporting the prairie grasslands were some of the most fertile and productive soils in the world. Hardy pioneers and generations of innovative farmers and ranchers built Kansas into a leading agricultural state. Scientists, researchers, industry, and government leaders continue to seek ways to assist farmers and ranchers in maintaining the productivity of the state's cropland.

Today, Kansas farmers grow a variety of crops. These crops are used to create food, feed, fiber, fuel, and industrial and consumer products for people in Kansas, across the United States, and around the world. The productivity of the prairie's soils is no longer in question. ■

Career Profile:**JIM KRUEGER****Assistant State Conservationist, Natural Resources Conservation Service**

Jim Krueger is a man who smiles a lot. His life has focused around the natural resources of the state. Over the years, he has helped agricultural producers and the public learn about the environment and how to conserve, improve, and sustain the land and its resources.

Krueger grew up on a farm in Washington County. When he finished high school, he attended Kansas State University majoring in animal sciences with a minor in agronomy. For 15 years after he graduated, he worked in production agriculture, farming in Washington County. Around 1990, he was encouraged by his wife Peggy to apply for a job with what was then the Soil Conservation Service and is known today as the Natural Resources Conservation Service (NRCS). It appealed to him because of the opportunity to affect the land in a larger sense than just the acres he was farming.

"The vision statement of NRCS is helping people help the land," Krueger says. "The main focus is to assist landowners as they address everything that affects their land, including all aspects of the environment—soil, water, air, plants, and animals. That had some appeal to me."

In regards to farmland, Krueger says that what affects the land most is soil erosion, caused by either wind or water, although improved farming techniques have helped decrease all erosion. "Today, specialists focus as much on the soil health and vigor, in addition to erosion," Krueger says. "We are looking for the presence of organic material and microorganisms and microbiotic activity within the soil. No-till and reduced-till practices will help enhance all of these."

Although Krueger has worked with NRCS for 20 years, his job description has changed. The one constant has been the necessity to be able to interact with people, including agricultural producers, landowners, and the public.

In the early 1990s, Krueger worked as a district conservationist based out of Abilene. His personality strengths, including the ability to communicate to farmers the importance of utilizing conservation techniques, served him well. In one year, he supervised the building of more than 1.2 million feet of terraces. In addition, Krueger developed a relationship with local media, sharing progressive ideas with the community through news articles and radio programs.

"I was working with producers on a daily basis, helping them solve their problems," he says. In addition to farmers involved in crop production, Krueger was ready to talk to any kind of livestock producer; he has helped cattle ranchers and hog producers incorporate good waste management practices, and has helped greyhound farmers install pollution controls in their kennels.

When Krueger became a state resource conservationist in 2003, his main job was to work with state specialists to utilize the new technologies available to implement NRCS programs. He also worked with partner groups who helped disseminate information, including universities, technical advisory groups, and other state, local, and federal agencies.

Today, as the assistant state conservationist for operations, Krueger is farther from the agricultural producers, but his work might affect them more. "I work to ensure that each field office has the resources they need to get all the best and newest information out to the producers," he says. "Those offices are my customers." Jim is also responsible for operations and administrative management, technical assistance provided to land users through programs for which the NRCS has responsibility, and preparation and maintenance of required records and reports. He serves as a member of the Kansas management team, supervises staff, guides and coordinates the workload analysis and workforce planning process in the state, assists in developing budget estimates, and provides leadership in the Government Performance Review Act in Kansas.

Krueger says that the main thing that has remained constant during his tenure with NRCS is the agency's commitment to the land and landowner. "If you can work with people and listen to their concerns and their problems, if you have some common sense, you'll do well," he says. "That is what everyone needs."



Credit: USDA NRCS

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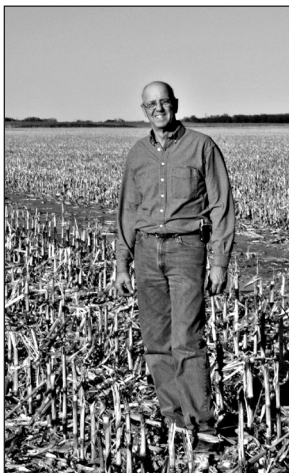
Career Profile:**MARK TADDIKEN****Agricultural Producer and State Senator**

Mark Taddiken, a farmer from Clifton, was first elected to the Kansas Senate in 2000. As a state senator, Taddiken's job is to look out for the best interests of Kansas; when he is farming, his job is to care for the land and his family. Taddiken spends 90 days out of the year representing eight rural counties in Kansas. He deals with a wide variety of issues during each legislative session, just as he enjoys a variety of agricultural activities and challenges while farming.

When the state legislature is not in session, Taddiken loves running the farm. "This is where my heart is. I love being outdoors and working with the land to provide food for others," Taddiken says. His family farms the same land that his great-grandfather did when he settled near Clifton 130 years ago. Taddiken believes that his background as a farmer helps him do his job better as a state legislator. Since Taddiken represents rural counties, his agricultural background helps him understand the challenges faced by many of the people who live in his district. "Agriculture is the number one industry in Kansas and many issues that come before the senate have ties to agriculture. Many of the natural resource and agricultural issues affect each other." Renewable energy topics, such as ethanol, biodiesel, and wind energy, are among recent legislative topics. Taddiken, other legislators, and their staffs research and discuss issues before deciding which legislation or actions to pursue.

Taddiken believes that being a farmer has helped him understand statewide concerns such as balancing the state's budget. "A farmer realizes that if there is money, one cannot just go and spend it; one needs to think about the future," Taddiken says. Agriculture has changed drastically since Taddiken started farming. There is more information to sort through and new technologies are available. "To run a farm these days, a farmer must be educated—whether that be formal education, on-the-job training, or just keeping current on changes in the industry." Taddiken thinks that keeping updated on agricultural industry topics helps him be a better representative of the people in his district.

Taddiken is not afraid to ask questions that will help him understand other viewpoints. A well-rounded perspective enables him to empathize with his constituents. "My job as a senator is to make Kansas a better place to live," Taddiken says.



Credit: Trent Winter

Cropland Showcase:**HARNEY SILT LOAM**

Kansas became the seventh state in the United States to adopt an official soil when Harney silt loam was adopted as the Kansas State Soil on April 12, 1990.

Kansas has more acres of prairie soils than any other state and over 300 different soil types. Due to the state's unique soil legacy and the completion of the state's most comprehensive soil inventory by the USDA Natural Resources Conservation Service, it was proposed that a typical prairie soil be selected to serve as the state soil. It took five years and a strong grassroots effort before legislation was passed naming Harney silt loam as the Kansas State Soil. This soil serves as a standard against which other soils in the state can be compared.

Harney silt loam possesses the ideal qualities of a prairie soil and it is the most extensive soil in the state, covering almost four million acres in 26 west-central Kansas counties. A variety of crops, irrigated and dryland, are produced on Harney silt loam.

Harney silt loam is a very deep well-drained soil formed by wind-blown silt called "loess." This soil typically has a dark grayish-brown topsoil layer about 12 inches deep. Below this lies the subsoil layer that is about 23 inches thick and is a mixture of silt and clay. The upper part of the subsoil layer is grayish-brown in color while the lower part is brown. The parent (lowest) layer of the soil is 35 to 70 inches deep, yellowish-brown in color, and contains a few chalky sediments.



Credit: USDA NRCS

Cropland Showcase:**KSU AGRICULTURAL RESEARCH CENTER-HAYS**

Famous names, including those of General George Armstrong Custer and Buffalo Bill (William F. Cody), add color to the history of the KSU Agricultural Research Center in Hays—once part of the Fort Hays military reservation. Deactivated in 1889, Fort Hays was transferred to the state of Kansas in 1900. A resolution signed by President McKinley set aside 4,160 acres for a state institution of learning at Hays, 3,263 acres for an agricultural experiment station and 177 acres for a state park.

Established in 1901, the Fort Hays Branch Experiment Station began conducting research appropriate to western Kansas where rainfall is more limited. Early research focused on improving wheat and grain sorghum varieties and included irrigation and soil conservation studies, tree nurseries, and livestock research. In the 1940s, scientists at the Station expanded the range management research—focusing on grazing intensities, improved grass varieties, range reseeding, grass fertilization and weed control. Rangeland research conducted by scientists at the Hays Station resulted in new management practices specifically for native shortgrass prairies and pastures.

Scientists at Hays were among the first to test and demonstrate the advantages of crossbreeding cattle. The entomology and beef cattle research programs at Hays cooperatively developed insecticide-impregnated ear tags for fly control. Researchers at Hays pioneered conservation tillage practices using chemical weed control and today, reduced tillage practices are common throughout the Midwest.

In 1994, legislation changed the name to KSU Agricultural Research Center-Hays (ARCH). The Center, which owns 7,345 acres and leases another 465 acres, includes over 2,400 acres of cropland and 5,120 acres of rangeland.

Current research programs focus on beef cattle production, crop production, pests (weeds, insects, and diseases) associated with most of the major crops grown in Kansas, the genetic improvement of specific crops, and rangeland management. Using new technologies, scientists at the KSU Agricultural Research Center-Hays are engaged in cooperative research projects with scientists around the world. Those research projects—rather than colorful names from the history books—continue to bring international recognition to KSU Agricultural Research Center-Hays.



Credit: KSU Agricultural Research Center-Hays

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TEACHER RESOURCES

BOOKS:

* Teachers & Advanced Readers; AR - Accelerated Reading Level

The Amazing Dirt Book

Bourgeois, Paulette. 1990

Angels in the Dust

Raven, Margot Theis. 1996 (AR - 4.2)

Century Farm: One Hundred Years on a Family Farm

Peterson, Cris. 1999 (AR - 4.4)

Children of the Dust Bowl

Stanley, Jerry. 1993 (AR - 6.8)

Compost Critters

Lavies, Bianca. 1993 (AR - 6.9)

Dig In! Hands-On Soil Investigations*

Available thru National Science Teachers Association

www.nsta.org/store

Earthworms

Holmes, Kevin. 2000 (AR - 3.3)

A Handful of Dirt

Bial, Raymond. 2001 (AR - 7.0)

Next Year Country: Dust to Dust in Western Kansas, 1890-1940*

Miner, Craig. 2006

Oddhopper Opera: A Bug's Garden of Verses

Cyrus, Kurt. 2007 (AR - 2.7)

Out of the Dust

Hesse, Karen. 2006 (AR - 5.3)

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Out of the Dust: Scholastic Literature Guide*

Beech, Linda Ward. 2000

Rock Cycles

Harman, Rebecca. 2005 (AR - 6.2)

Rooted in Dust: Surviving Drought and Depression in Southwestern Kansas*

Riney-Kehrberg, Pamela. 1997

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Moss, Marissa. 2003 (AR - 4.8)

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This Land is Your Land

Guthrie, Woody. 1998 (AR - 4.7)

Wiggling Worms at Work

Pfeffer, Wendy. 2003 (AR 3.8)

WEBSITES:

The Adventures of Herman: The autobiography of Squirmin'

Herman the worm

University of Illinois Extension

<http://www.urbanext.uiuc.edu/worms/index.html>

(Also in Spanish)

Kansas Association of Conservation Districts

<http://www.kacdnet.org/>

KSU Agricultural Research Center-Hays

<http://www.wkarc.org/Arch/arch.asp>

International Plant Nutrition Institute

www.ipni.net

Soil Biology Primer

USDA NRCS

http://soils.usda.gov/sqi/concepts/soil_biology/biology.html

State Soils

USDA NRCS

http://soils.usda.gov/gallery/state_soils/

Stewardship Week educational materials

National Association of Conservation Districts

<http://www.nacdnet.org/stewardship>

25 x '25 Alliance

www.25x25.org

Web Soil Survey

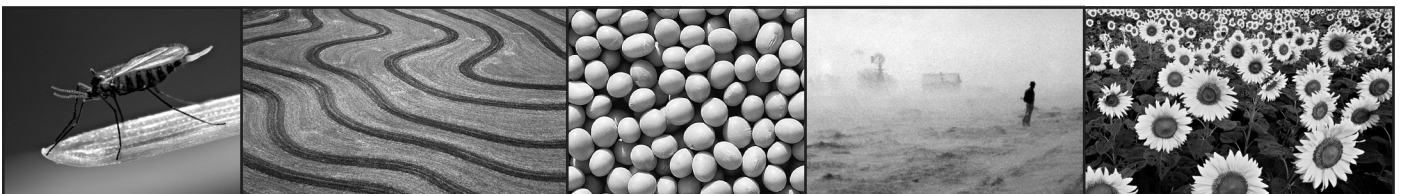
USDA NRCS

<http://websoilsurvey.nrcs.usda.gov>

Wessels Living History Farm

<http://www.livinghistoryfarm.org>

NOTES:





Unit 4) Kansas Crops

The state of Kansas is often called the "Wheat State" or the "Sunflower State." Year after year, the state of Kansas leads the nation in the production of wheat and grain sorghum and ranks among the top ten states in the production of sunflowers, alfalfa, corn, and soybeans. Kansas farmers also plant and harvest a variety of other crops to meet the need for food, feed, fuel, fiber, and other consumer and industrial products.

INTRODUCTION

WHEAT

- WHEAT USES
- WHEAT HISTORY

CORN

- CORN USES
- CORN HISTORY

GRAIN SORGHUM

- GRAIN SORGHUM USES
- GRAIN SORGHUM HISTORY

SOYBEANS

- SOYBEAN USES
- SOYBEAN HISTORY

SUNFLOWERS

- SUNFLOWER USES
- SUNFLOWER HISTORY

ALFALFA

- ALFALFA USES
- ALFALFA HISTORY

COTTON

- COTTON USES
- COTTON HISTORY

OTHER KANSAS CROPS

FOOD, FEED, FIBER, FUEL, AND THE FUTURE

CAREER PROFILES

- CINDY FALK, NUTRITION EDUCATOR, KANSAS WHEAT COMMISSION
- MARY KNAPP, STATE CLIMATOLOGIST

SHOWCASES

- WHEAT GENOMICS LABORATORY, KSU
- ETHANOL

ENDNOTES

REFERENCES

TEACHER'S RESOURCES

"When tillage begins, other acts follow. The farmers, therefore, are the founders of human civilization."

Daniel Webster, American statesman and orator

When Kansas became a state, most of the people in the United States were farmers. According to the U.S. Department of Agriculture, the food and fiber produced by the average farmworker at that time supported fewer than five people. Farming methods, which had not changed significantly for several decades, were passed down from one generation to the next. The Homestead Act of 1862 promoted the idea that anyone could become a farmer but people soon realized that once they went beyond the eastern edge of Kansas, survival depended on changing those traditional farming methods.



Credit: Louise Ehmke

Out of necessity, Kansas adopted an attitude of innovation and experimentation. Since 1863, faculty at the Kansas State Agricultural College (KSAC) and the KSAC Agricultural Experiment Station have assisted Kansas farmers in meeting crop production challenges. Both entities, now known as Kansas State University and the Kansas State University Agricultural Experiment Station and Cooperative Extension Service (K-State Research and Extension), continue those efforts today. Research conducted at research centers and experiment fields across the state provide test results for a variety of crops.

By 1961, 100 years after Kansas became a state, each American farmer was supplying enough food and fiber to meet the needs of 26 people. Today, one farmer in the United States feeds around 144 people. Without Kansas crops, that statistic would be much different. In 2007, Kansas crops were planted on 22.6 million acres, an area larger than 11 other individual states.

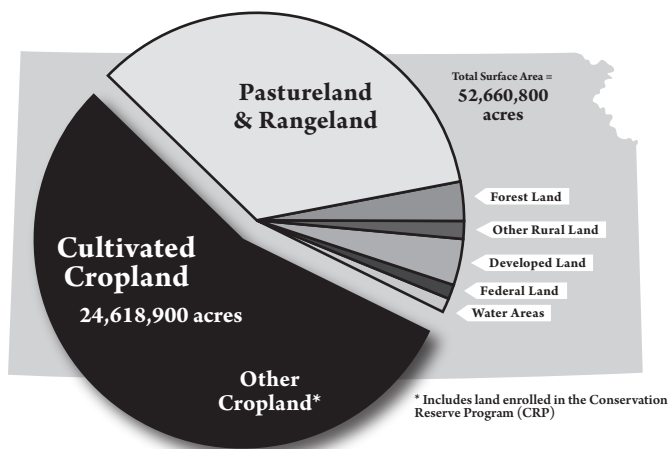
FEEDING PEOPLE

One farm worker produced enough food and fiber to meet the needs of this many people in the United States and around the world:

1861	< 5 people
1961	26 people
2007	144 people

Source: USDA

SURFACE AREA OF KANSAS – CULTIVATED CROPLAND



Source: 2003 Natural Resources Inventory, USDA NRCS

Crops are cultivated plants planted on cropland. Crops can be categorized according to use, by plant families, as annuals or perennials, or in other ways. Generally, fruits, vegetables, flowers, and ornamental plants are considered horticultural crops and included in the both the state and national agricultural crop statistics. Several terms refer to a wide range of agricultural crops that are produced for human food or livestock feed, or processed and resold in a variety of consumer or industrial products. These terms include grains, oilseeds, and forages. Grains are divided into "coarse grains" (corn and grain sorghum) and "small grains" (wheat, oats, barley, triticale, rye, and rice). The term "cereal grains" is used to describe crops from the grass family of plants which produce seeds (grain) used as food by people and livestock. Cereal grains include wheat, rice, corn, grain sorghum, rye, oats, barley, millet, and triticale. Oilseeds include soybeans, sunflowers, canola, cotton, and flax. Forages include those crops harvested for livestock feed, such as alfalfa, forage sorghum, or brome. The term "row crop" originally described crops planted in a specific way, including soybeans, corn, grain sorghum, sunflowers, and cotton. Cotton and flax would also be considered "fiber crops."

Kansas crops serve many purposes. Kansas farmers plan planting sequences and harvesting options according to individual situations, field conditions, potential demand for products, and anticipated economic returns on investments of inputs, time, and capital, as well as other variables. Individual fields may not be planted to the same crop year after year and the acreage statewide may shift between the major crops from year to year, but the overall number of acres planted to crops in Kansas remains reasonably constant. The attitude of innovation and experimentation that allowed Kansans to survive many early challenges is still present in Kansas agriculture today. Kansas crop producers continue to look for new opportunities to produce a variety of crops for food, feed, fiber, fuel and other products.

KANSAS CROPS

Check out the Kansas Agricultural Statistic Service's web site for the most recent reports on Kansas crop production or for historical data.
http://www.nass.usda.gov/Statistics_by_State/Kansas/index.asp

CROP CATEGORIES

Agricultural crops— crops produced for human food, livestock feed, or consumer and industrial products.

Fiber crops— crops produced for the fiber; for example, cotton and flax.

Forages— crops harvested for livestock feed; for example, alfalfa, forage sorghum, and brome.

Grains— crops that produce a small hard seed.

Horticultural crops— fruits, vegetables, flowers, and ornamental plants; considered agricultural crops.

Row crops— originally used to describe crops planted in a specific way; includes soybeans, corn, grain sorghum, sunflowers, and cotton.

Source: Jim Shroyer, Crop Production Specialist, K-State Research and Extension

WHEAT

(*Triticum aestivum ssp. vulgare*)

"No race can prosper till it learns that there is as much dignity in tilling a field as in writing a poem."

Booker T. Washington, educator and author

Flour milling is one of the oldest industries in Kansas. Early pioneers heading west on trails through Kansas had their grain ground into flour in eastern Kansas as early as the 1850s. Many of the early mills were dual-purpose—serving as sawmills during the daytime and grinding grain into flour during the night. At the same time, people were planting more and more wheat in Kansas. By 1878, people were predicting that Kansas would become the "greatest and best wheat growing state in the Union." ¹ Those predictions came true. Almost every year, Kansas does produce more wheat than any other state. Kansas also mills more wheat flour and produces more wheat gluten than any other state.

Today the volume of wheat produced in Kansas is amazing. According to the Kansas Wheat Commission, a single Kansas wheat harvest could fill a train that would stretch from the western edge of the state to the Atlantic Ocean. Kansas farmers produce 20 percent of all the wheat grown in the United States. One bushel of wheat is equal to 60 pounds of wheat. A normal Kansas wheat



Wheat

Credit: Kansas Wheat Commission

GRAINS AND OILSEEDS

Cereal grains– wheat, rice, corn, grain sorghum, rye, oats, barley, millet, and triticale.

Coarse grains– corn and grain sorghum.

Feed grains– grain fed to livestock; often interchanged with coarse grains.

Oilseeds– soybeans, sunflowers, canola, cotton, and flax.

Small grains– wheat, oats, barley, triticale, rye, and rice.

Source: Jim Shroyer, Crop Production Specialist, K-State Research and Extension

WHAT IS AN ACRE?

Acre– a unit of measurement for land.

One acre equals 43,560 square feet (approximately the same size as a high school football field, not including the end zones).

One square mile equals 640 square acres.

ONE BUSHEL

Corn	56 pounds
Grain Sorghum	56 pounds
Soybeans	60 pounds
Sunflowers	27 pounds
Wheat	60 pounds

harvest of several hundred million bushels adds more than a billion dollars to the state's economy, according to the Kansas Agricultural Statistics Service.

Nearly all of the wheat grown in Kansas is winter wheat—planted and sprouting in the fall, going dormant in the winter, growing again in the spring, and ready for harvest in early summer. Winter wheat is ideally suited for the Kansas climate. Precipitation during winter and spring combines with summer sunshine and warmer temperatures to ripen the wheat in June and July, making it one of the most picturesque crops in the world.

Wheat contains gluten, the basic structure in forming the dough system for breads, rolls, and other baked goods. Other grains have gluten but not as much as wheat. There are three classes of wheat produced in Kansas: hard red winter wheat, hard white wheat, and soft red winter wheat. Hard red



Wheat Bread

Credit: Wheat Foods Council

winter wheat accounts for almost 40 percent of the wheat grown in the United States and 94 percent of the wheat grown in Kansas. This wheat has good milling and baking characteristics and makes high-quality yeast breads and rolls. At this time, about 5 percent of the wheat produced in Kansas is hard white wheat, which is primarily used for tortillas, hard rolls, noodles, and yeast breads. Hard white wheat production is being driven by the interest from foreign buyers of Kansas wheat, who typically purchase nearly one-half of the state's annual wheat production. Soft red winter wheat makes up only 1 percent of the wheat produced in Kansas. It is grown in the eastern part of the state and used to make cakes, crackers, flat breads, and pastries.

TIMELINE FOR PLANTING AND HARVESTING KANSAS CROPS

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
					wheat harvested			wheat planted			
				grain sorghum (milo) planted				grain sorghum (milo) harvested			
				sunflowers planted			sunflowers harvested				
		corn planted					corn harvested				
				soybeans planted				soybeans harvested			

Source: KFAC, Exploring Kansas Crops Educator's Guide

KANSAS WHEAT FACTS

- The grain produced in a single Kansas wheat harvest could fill a train that would stretch from the western border of the state eastward to the shore of the Atlantic Ocean.
- One acre of wheat will produce enough grain in one year's harvest to supply bread to feed a family of four for 10 years.

Source: Kansas Wheat Commission

WHEAT USES

According to the Kansas Wheat Commission, nearly 50 percent of the U.S. wheat crop is exported each year for food use. Another 36 percent of the wheat produced in the United States is consumed in food uses within the United States. Ten percent of the U.S. wheat crop is fed to U.S. livestock and 4 percent is used as seed.

Wheat is the primary grain used in U.S. grain foods—approximately three-fourths of all U.S. grain food products are made from wheat flour. More foods are made with wheat than any other cereal grain. One acre of wheat (the size of a high school football field without the end zones) will supply enough bread to feed a family of four for 10 years, according to the Kansas Wheat Commission.



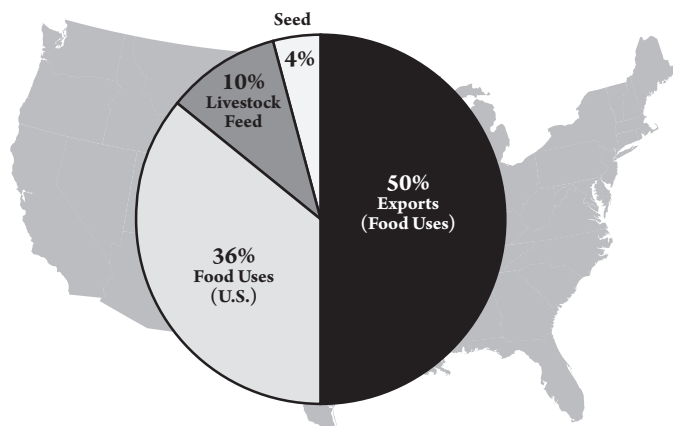
Wheat Foods

Credit: Wheat Foods Council

Overseas food aid is another important use of Kansas wheat. The abundant wheat crop in Kansas enables the United States to provide shipments of wheat to people in other countries to relieve their suffering due to crop failures, war, drought, floods, hurricanes, and other disasters.

Nonfood and industrial applications represent a growing market for U.S. wheat producers. The unique elastic qualities of wheat gluten, which make wheat ideal for making breads, rolls, and other food products, also make wheat useful in the production of consumer and industrial products such as adhesives, packaging materials, paper, and construction materials. Wheat can also be used to produce ethanol and cosmetic or pharmaceutical products.

U.S. WHEAT USES



Source: Kansas Wheat Commission



Kansas Wheat

Credit: Kansas Wheat Commission

WHEAT HISTORY

Wheat is a member of the grass family of plants that produce a dry one-seeded fruit commonly called a kernel. Wheat originated in the "cradle of civilization" in an area now included in Iraq, Syria, Iran, and Turkey, nearly 10,000 years ago. Wheat's earliest ancestors were wild einkorn, or "one-seed," and emmer. Archeologists have found seed kernels of both plants in excavated villages in Egypt and southwestern Asia's "Fertile Crescent," the area between the upper reaches of the Tigris and Euphrates rivers. There is evidence that during the time of the Swiss Lake Dwellers in early Europe (around 5,000 B.C.), people ground and mixed wheat with water, before baking it to make unleavened (flat) cakes of bread. The first evidence of leavened bread, which rises or expands due to the addition of yeast, appears in Egyptian hieroglyphs from over 5,000 years ago. The Chinese recorded growing wheat in 2700 B.C.²

During his second voyage to the New World, Christopher Columbus introduced wheat into the West Indies. The first wheat crop was grown there in 1494. During 1510 to 1520, Spaniards took wheat to Mexico to grow for bread making. From there, wheat spread into the area that is now the southwestern United States. Later in that same century, other explorers took grains of wheat to the East Coast, where settlers at several places along the East Coast grew wheat as a crop in the early 1600s.

The first record of wheat growing in Kansas is that of a crop of wheat produced at the Shawnee Methodist Mission (Johnson County) in 1839. Production in the state grew steadily and reached one million acres in 1876. Yields were usually in the range of 10 to

MESOPOTAMIA—CRADLE OF CIVILIZATION

Mesopotamia ("land between two rivers") refers to the basins of the Tigris and Euphrates rivers and the geographical area watered by these two rivers. Today, this region includes Iraq, eastern Syria, southeastern Turkey, and southwestern Iran.

Mesopotamia is called the "Cradle of Civilization" because the first literate societies developed in this region. The people of Mesopotamia adopted food production innovations, such as irrigation and using plows to soften the soil before planting. They also adopted other early technologies, including metalworking (copper, bronze, gold, and iron), glassmaking, textile weaving, and water storage and control using dams and aqueducts. Mathematical systems that originated in this region are the source of today's 60-minute hour, 24-hour day, 360-degree circle, and weeks of seven days each. Mesopotamian astronomers also worked on a 12-month calendar based on the cycles of the moon.

THE FERTILE CRESCENT

The Fertile Crescent was an area of land suitable for growing crops that stretched from the southeastern coast of the Mediterranean Sea around the Syrian Desert north of the Arabian Peninsula to the Persian Gulf.

The rich soil and half-moon shape of the area led to the name "Fertile Crescent." The climate encouraged the domestication of plants and animals, a key step in the development of human civilization. This agricultural revolution made it possible to increase food supplies and allowed nomads and cave dwellers to become farmers and herders. Cattle, goats, sheep, and swine—four of the most important species of domesticated animals—originated in the Fertile Crescent. The direct ancestors of eight plants—emmer wheat, einkorn, barley, flax, chickpea, pea, lentil, and bitter vetch—also originated in the Fertile Crescent.

The Fertile Crescent included two geographical areas: Mesopotamia on the east and the Mediterranean on the west.

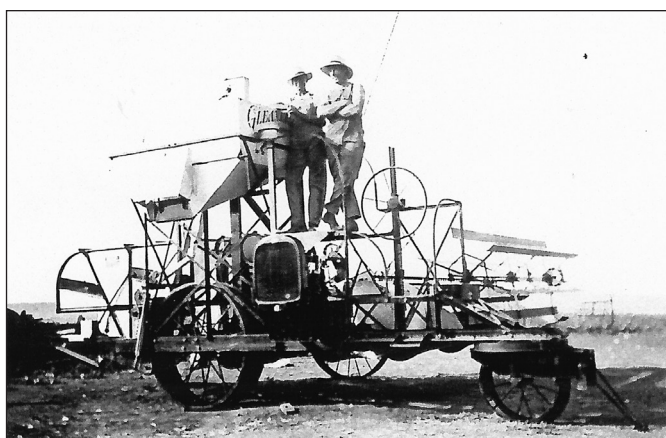
20 bushels per acre. In 1866, the state recorded the first one million bushel wheat harvest. Settlers coming to Kansas brought small quantities of seed with them, varieties that they had grown in the eastern United States and Europe. However, those wheat varieties usually came from areas with mild climates and grew poorly in the Kansas environment.

The situation changed slowly but steadily after the introduction of Turkey Red hard red winter wheat to south-central Kansas by German Mennonites from the Ukraine. The first crop of Turkey Red wheat was planted in Marion County in 1873 and harvested in 1874. The one-year increase in wheat production in Kansas from 1877 to 1878 (668,819 acres) was unparalleled in the history of the United States.³ The success of the Turkey Red wheat variety was so pronounced that in 1888, the Topeka Daily Capital reported that "All parts of Kansas grow good corn but in wheat Kansas can beat the world."⁴ By 1919, when the first wheat variety survey was taken, over 82 percent of the wheat acreage in Kansas and nearly 30 percent of the wheat acreage in the United States was planted to Turkey Red wheat. It remained the most popular wheat variety in Kansas until 1939 and was the most popular wheat variety in the United States until 1944.⁵

KANSAS WHEAT TIMELINE

1839 — first record of wheat grown in Kansas.
1863 — 10,000 acres of wheat grown in Kansas.
1866 — first one million bushel wheat crop.
1869 — over 100,000 acres harvested.
1873 — first crop of Turkey Red variety planted in Kansas (harvested in 1874).
1874 — Kansas State University began wheat research.
1876 — one million acres harvested.
1891 — first crop of over 50 million bushels.
1915 — first 100 million bushel crop.
1930 — first crop over 200 million bushels.
1937 — wheat planted on 17,110,000 acres in Kansas (current state record).
1947 — 14,855,000 acres of wheat harvested in Kansas (current state record).
1952 — first 300 million bushel crop.
1973 — first crop valued at over \$1 billion.
1979 — first 400 million bushel crop.
1980 — Kansas wheat crop valued at \$1,587,600,000 (current state record).
1997 — 501,400,000 bushels of wheat produced in Kansas (current state record).

Source: Kansas Agricultural Statistics Service



New Combine, 1936

Courtesy: Stoskopf Farms



Modern Combine

Credit: Kansas Wheat Commission

Kansas Crops

Modern varieties of winter wheat in Kansas contain, on average, about 50 percent of Turkey Red hard red winter wheat in their pedigrees according to the Kansas Wheat Commission. However, present-day varieties are very different from the older wheat varieties. The newer varieties produce more grain, grow shorter stalks, mature earlier, are resistant to specific pests and diseases, and produce better quality grain for bread and other products.

In the 1980s, hard white winter wheat was introduced in Kansas. Researchers at the Kansas State University Agricultural Research Center at Hays led the efforts to develop varieties that would produce well under typical Kansas growing conditions. Domestic and foreign buyers are driving the demand for increased production of hard white winter wheat in Kansas.

PLANT VARIETIES

A variety is a plant with specific genetic characteristics that make it different from other plants of the same species. The best variety is usually one that makes full use of available rainfall, soil fertility, and the growing season. Farmers also select varieties based on insect and pest resistance, soil conditions, climatic conditions (such as wind, low rainfall, or a shortened growing season), and anticipated uses.

CORN

(*Zea mays*)

"Corn is the sign and seal of a good American agricultural country ... Kansas has corn and so has luck." ⁶

John Alexander Martin, Kansas governor, 1885–1889

In the United States, corn is the largest crop, both in the number of acres planted and the cash value of the crop produced. The United States produces over 40 percent of the world's corn crop, according to the U.S. Grains Council. Even though Kansas is called the "Wheat State," more bushels of corn than wheat are produced in the state despite the fact that fewer acres are planted to corn than wheat (3–3.7 million acres vs. 9.5–10 million acres). However, the growth of the ethanol industry may cause shifts in crop plantings. In a typical year, the Kansas corn crop yields an average of 135–150 bushels per acre. One bushel is equal to 56 pounds of corn. According to the Kansas Agricultural Statistics Service, Kansas farmers grew a record 465.8 million bushels of corn in 2005.

The predominant type of corn grown in Kansas is yellow dent corn. Kansas is among the top ten corn-producing states in the United States, producing nearly 4 percent of the corn produced for grain in the United States.

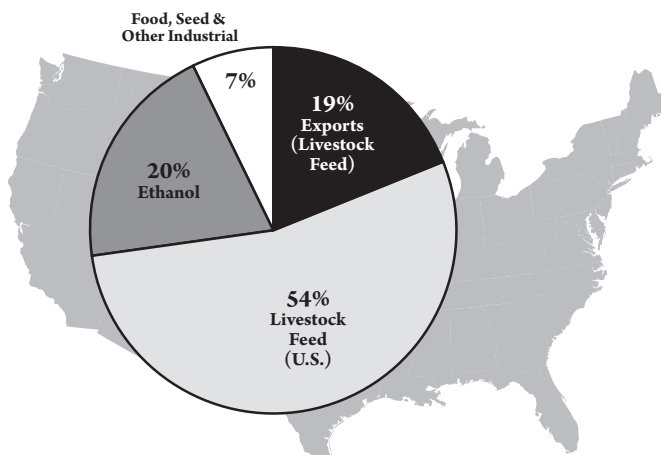
Corn silage is also a major product in Kansas, with an average 2.5 million tons of silage harvested each year and used as livestock feed, mainly by the beef industry.



Corn

Credit: Larry Rana, USDA

U.S. CORN USES



Source: U.S. Grains Council

CORN USES

Nearly 75 percent of the corn produced in the United States is fed to livestock. Around 19 percent of the U.S. corn crop is exported for use as a feed grain and livestock in the U.S. consume about 54 percent of the annual corn crop. Food, industrial, and seed uses consume approximately 27 percent of the U.S. corn crop, according to the U.S. Grains Council.

One of the largest industrial uses of corn is the production of ethanol, which consumed more than 20 percent of the corn produced in the United States in 2006. In Kansas, historically more ethanol was made with grain sorghum than with corn but the two grains are interchangeable in the ethanol making process. In 2007, ethanol production plants in Kansas used over 76 million bushels of grain sorghum and corn. According to the National Corn Growers



East Kansas Agri Energy Ethanol Plant, Garnett

Credit: Kansas Corn Growers Association

SILAGE

To produce silage, corn or sorghum plants are harvested while the plants are immature (still growing). During the harvesting process, whole plants are chopped into small pieces, then transported to a storage area where they are packed tightly so that the plant material will ensile (ferment). The result is a sweet-tasting, easily digestible livestock feed.

Corn is the largest crop produced in the United States, in both number of acres planted and the cash value.



Corn Kernels

Credit: Tim McCabe, USDA NRCS

Association, one acre of corn can produce enough ethanol to run a car for 72,000 miles on E10 (a blend of 10 percent ethanol and 90 percent unleaded gasoline). In Kansas, there are several fueling sites offering fuel for vehicles using E85 (a blend of 85 percent ethanol and 15 percent unleaded gasoline).

Thousands of food items contain corn or are made using some component of the corn kernel. Nearly four times as much corn is turned into corn sweeteners, used in everything from soft drinks and pasta sauces to hot dogs and yogurt, as is used to produce cereal and other food products. Corn-based plastics and textiles, used in the packaging of food and other products, are made from cornstarch, which is also used in pharmaceutical and pet products. Products using corn or corn components are so common that most people do not realize that everything from toothpaste to windshield washer fluid may contain corn.



Cornstarch Products

Credit: Scott Bauer, USDA ARS

CORN HISTORY

Corn is native to the American continents. Corn was developed from a wild grass in central Mexico over 7,000 years ago. Until American Indians shared their corn with the explorer Christopher Columbus, corn was not grown outside of North, Central and South America. When he returned to Spain, Columbus took some corn with him and the crop quickly spread throughout Europe and the rest of the world.

The American Indians called corn "maize." It was their main food. Some tribes considered corn one of the three "sisters," along with beans and squash. Many American Indian ceremonies and traditions, including festivals at planting and harvest times, emphasize the importance of corn. Surplus corn was stored for use during the winter.

In 1621, the Pilgrims at Plymouth Rock would have starved if American Indians had not taught them how to grow corn. The Pilgrims and early settlers learned many ways to use corn, such as stuffing mattresses with cornhusks, burning corncobs for fuel, making toys from cornhusks, and feeding corn to livestock. Corn was so valuable that early settlers traded corn with the American Indians for food and furs.

ETHANOL FACT

One acre of corn can produce enough ethanol in one year's harvest to run a car for 72,000 miles on E10 fuel.

Source: National Corn Growers Association

KANSAS CORN TIMELINE

1866— 217,000 acres harvested; produced 6.1 million bushels of corn.

1872— one million acres harvested.

1876— two million acres harvested.

1879— three million acres harvested; first 100 million bushel crop.

1881— four million acres harvested.

1883— five million acres harvested.

1888— first 200 million bushel crop.

1902— 214 million bushel crop; 7,140,000 acres harvested.

1917— 9,156,000 acres of corn harvested in Kansas (current state record).

1934— 5,174,000 acres planted; 172,000 acres harvested.

1991— first crop over 200 million bushels since 1902; 1,650,000 acres harvested.

1994— first 300 million bushel crop.

1996— first Kansas corn crop valued at over \$1 billion.

1998— first 400 million bushel crop.

2005— 465,750,000 bushels of corn produced in Kansas (current state record).

Source: Kansas Agricultural Statistics Service

In Kansas, corn was the principal crop grown by early pioneers. As early as the 1850s, Kansas farmers were producing large quantities of corn but found it difficult to transport the grain to the markets, which were located closer to the populated areas. Some people fed the corn to livestock and marketed the livestock or meat. Many resorted to burning excess corn for fuel, only to find themselves without food, livestock feed, or seed for planting the next year's crop following the great grasshopper disaster of 1874.

The record for the number of acres of corn harvested for grain in Kansas was set in 1917—almost 9.2 million acres. That means that in 1917, almost 6 percent of the land in the state had been planted to corn that was actually harvested for grain (not pastured for grazing, cut for livestock feed, or lost to drought, disease, insects, or other disasters). In 1933, 7.7 million acres of corn were planted in Kansas.

Kansas Crops

Dramatic changes in precipitation resulted in the setting of a Kansas record the next year. In 1934, only 172,000 acres of corn were harvested for grain in Kansas.

Between 1930 and 1945, there were huge changes in corn production in the United States. There were changes in how corn was harvested as corn went from being picked by hand to being harvested by machinery. There were also major changes in the selection of seed corn. Before the 1930s, seed corn was selected from the tallest or most productive stalks of corn with the expectation that the seeds would grow plants that would produce similar or improved results. However, since pollen that blew in with the wind contained parentage of plants with a wide variety of genetic traits, yields were never consistent and often less than expected.

In 1930, Roswell Garst formed a partnership with Henry Wallace, a plant geneticist who provided seed for Garst to grow a small crop of hybrid seed corn in Iowa. Garst then sold the seed corn to other farmers and by 1945, almost all of the corn grown in the United States was from hybrid seed. The production of hybrid seed requires careful control of the parent seed lines used in the genetics of the hybrid. New seed is purchased each year, chosen for the specific needs of the field in which it is to be planted and the weather and other natural conditions of that specific growing season.

Hybrid seed corn helped the United States respond to worldwide food needs during World War II. By 1969, less than 40 years after the introduction of hybrid seed corn, corn production in the United States had doubled even though only half the number of the acres planted to corn in 1930 were planted to corn in 1969.⁷ In Kansas, the changes were even more dramatic. Kansas corn growers went from producing 67 million bushels on 7.1 million acres in 1930 to producing 95 million bushels of corn on 1.5 million acres in 1969.

Today, corn is the most widely distributed crop in the world. Corn can grow at altitudes as high as 12,000 feet in the South American Andes Mountains and as low as sea level. It can grow in tropical climates that receive up to 400 inches of rainfall a year or in areas that receive only 12 inches of rain annually. Corn is grown on every continent except Antarctica.



Irrigated Corn near Syracuse, 1939

Credit: Library of Congress;
Russell Lee, photographer

GRAIN SORGHUM

(*Sorghum vulgare*)

"If Kansas were limited to the growing of one crop, sorghum would best meet its requirements for feed and grain."

Sorghums for Kansas, Agricultural Experiment Station Bulletin
304, 1942

The United States is the largest producer of grain sorghum in the world and Kansas leads the nation in grain sorghum production each year, producing nearly 50 percent of the U.S. grain sorghum crop. Grain sorghum, sometimes called "milo," is one of the most important dryland crops in the area from stretching from Texas to South Dakota. It can be grown under a variety of climatic conditions and has a unique ability to "wait" for precipitation. In other words, as it begins to get dry, a sorghum plant starts shutting down growth and seed production. Once it rains, the plant jump-starts its growth and seed production cycle. This characteristic is important in areas where rainfall is low or erratic and limits the production of other spring crops.



Grain Sorghum Head

Credit: High Plains Journal



Grain Sorghum Plants

Credit: High Plains Journal

HYBRID SEED

Hybrid seed is produced by controlling pollination and allowing only specific genes to be transferred to seed-producing plants. The result is a plant with specific characteristics, which is unable to produce seed for future plants with the same exact characteristics. Therefore, each planting requires the purchase of new seed.

Hybrid seed produces a crop that grows and matures at a uniform rate. Researchers have developed hybrids that are resistant to pests and diseases, use nutrients more efficiently, and produce more grain or plant material.

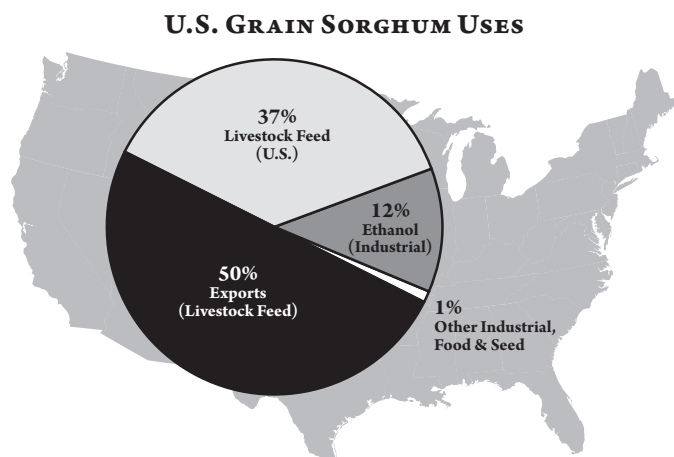
Grain sorghum is one of the later-planted spring crops, generally planted in late May or early June in Kansas. This allows the soil to store water from spring rains prior to planting so that it is available to the sorghum plant's extensive fibrous root system as the plant grows and temperatures rise during the summer. When things work right, the hottest weather of the season is already history before the sorghum plant hits the critical seed-producing stage.

Harvesting grain sorghum in Kansas often presents challenges. Grain sorghum is a perennial plant and the plant remains green and alive after producing seed (grain) until it is killed by freezing temperatures, tillage, or herbicides. In Kansas, the harvest occurs between September and the end of November. The grain is often slow to dry and harvest delays increase the risk of damage due to wind, snow, birds, and other wildlife. Harvesting grain sorghum before the grain dries down to an acceptable level is usually not an option because wet grain sorghum cannot be stored for very long before the grain begins to spoil or starts sprouting. However, planting grain sorghum earlier in the spring does not guarantee an earlier harvest due to the plant's ability to shut down and wait on moisture during the growing season.

In terms of acreage or value, grain sorghum is not the largest or most valuable crop produced in either the United States or the state of Kansas. Less than 500 million bushels of grain sorghum are produced each year in the United States. One bushel of grain sorghum is equal to 56 pounds of grain sorghum although, unlike most other grains and oilseeds, grain sorghum is usually sold by the "hundred-weight" (100 pounds) rather than by the bushel. In Kansas, the number of acres planted to grain sorghum increased to 2.8 million acres in 2007 according to the Kansas Agricultural Statistics Service. The Kansas grain sorghum crop is usually valued around 300 million dollars. In addition, nearly 2.5 million tons of sorghum silage are harvested each year in Kansas and used as livestock feed, mainly by the beef industry.

GRAIN SORGHUM USES

The real value of the grain sorghum crop is in its uses. The primary use (87 percent) of the U.S. grain sorghum crop is as a feed grain for livestock. Consumption is split between exports (50 percent) and U.S. livestock (37 percent), according to the U.S. Grains Council. Over 80 percent of the grain sorghum produced in Kansas is fed to livestock. The production of ethanol, which already consumes around 12 percent of the U.S. sorghum crop each year, represents an expanding market for grain sorghum. In Kansas,



Source: U.S. Grains Council

more ethanol was made with grain sorghum than corn. The ethanol market is growing. Only 1 percent of the grain sorghum produced in the United States is used as seed or in food and other industrial uses.

Although grain sorghum is primarily a feed grain in the United States, that is not the case in many other countries. Worldwide, people and livestock consume nearly equal amounts of sorghum. Sorghum is the leading cereal grain in Africa, and is grown in over 60 countries around the world.⁸

Food sorghums (for human consumption) are specific varieties of grain sorghum that produce a white berry that makes a white flour. The yellow and red grain sorghums commonly grown in Kansas, as well as some varieties of cream-colored grain sorghums, do not qualify as food-grade sorghums. Grain sorghum does not contain gluten so sorghum food products can play an important role in the diets of people who cannot eat foods containing gluten.



Grain Sorghum Products

Credit: Stephen Ausmus, USDA ARS

Not all sorghums are grain sorghums. For example, grassy sorghums, such as sudan, are grown for feed and hay, and sweet sorghums are grown to make sorghum syrup. In the late 1800s and early 1900s, broomcorn, a type of sorghum grown for the branches and fibers of the seed clusters, was a very important crop in Kansas. Buyers paid \$80 to \$100 a ton for Kansas broomcorn, which was shipped all over the world. Some years, Kansas produced over twice as much broomcorn as any other state in the United States. Liberal, Kansas, was considered the biggest broomcorn market in the United States at one time.



Broom Corn

Source: Library of Congress;
Russell Lee, photographer

GRAIN SORGHUM HISTORY

Sorghum is a grassy plant that is native to Africa. Areas of India and Assyria were also among the first to grow sorghum as a cereal crop. During the thirteenth century, grain sorghum reached China.

The first sorghum seeds brought into the United States may have arrived during the late 1700s on ships. Some historians believe that Benjamin Franklin introduced the first sorghum crop to the United States. Sorghum production was not widespread in the United States until the 1850s, when sorghum seeds were imported from France and South Africa. The U.S. government became interested in sweet sorghum as an alternative source of sweetener. The U.S. Department of Agriculture conducted experiments on the feasibility of producing sorghum sugar. The work also included improvement of the sorghum varieties. The U.S. Patent Office and members of Congress distributed seed to farmers. There were sorghum sugar plants in several Kansas towns and Kansas was the only state producing sorghum sugar in 1891.⁹ Even so, at the beginning of the 1900s, the government supported a new crop in western Kansas, sugar beets, that had a higher sugar content than sorghum. A sugar

Kansas Crops

beet factory was built in Garden City in 1906, signaling that the production of sorghum sugar could not compete successfully with the sugar cane or sugar beet industries. By the 1950s, most of the sweet sorghum grown in the United States was grown for forage (livestock feed).

One of the earliest recognized sorghum varieties, known as Black Amber by Kansas settlers, is said to have originated in China. Early settlers brought this sweet sorghum variety to Kansas around 1880 to grow for the production of sorghum molasses. During a drought, they discovered that the sorghum was also a good forage sorghum for livestock and for the next 30 years, that variety was the leading forage sorghum grown in the state.¹⁰ During this period, the livestock industry in the state went through the transition from grazing on the open range in large herds to smaller herds grazing in fenced pastures and fields. The Black Amber sorghum variety made it easier for farmers to grow the feed necessary for their livestock.

There is some question as to when the earliest grain sorghums became established in the United States. Different varieties carried names not ordinarily associated with grain sorghum today, including African millet, Egyptian corn, milo maize, durra, kafir corn, rice corn, and Jerusalem corn. "Rice corn" came to Kansas from California, where it became established in 1874 after having been imported from Egypt. For at least ten years, rice corn was the only grain sorghum grown in Kansas. There are varying reports about how another variety known as "Jerusalem corn" arrived in Kansas. One report is that a missionary in Palestine sent two seeds of Jerusalem corn to a farmer in Finney County. Another report is that a settler from Kentucky brought the first Jerusalem corn seed with him to Finney County. This variety may have reached America during colonial times or may have been grown in Georgia as early as 1838. In 1876, two other varieties of grain sorghum were brought into the United States from South Africa; both reached Kansas by 1889.¹¹

In 1872, there were just over 4,000 acres of sorghum growing in Kansas, almost all of which was grown for syrup or sugar. Sorghum production exploded in Kansas in the next 40 years as sorghum production switched first to forage sorghums and then to grain sorghums. In just one year, 1896, the acreage planted to grain sorghum more than doubled. The Agricultural Experiment Station at Manhattan conducted early sorghum research in Kansas but once the state acquired the old Fort Hays military reservation in 1900, the Agricultural Experiment Station at Hays, now known as the Kansas State University Agricultural Research Center – Hays, took the lead in conducting sorghum research in Kansas. Careful selection and testing for desired characteristics improved yields. In 1904, the Hays Experiment Station released 4,500 pounds of sorghum seed to Kansas farmers.

The first grain sorghum variety developed at the Hays Experiment Station was Pink kafir. According to the Kansas Agricultural Experiment Station, the U.S. Department of Agriculture imported Pink kafir seed from South Africa in 1905. Seed was sent to the William Rockefeller Ranch at Russell, Kansas, but soon became contaminated. The Hays Experiment Station obtained some of the



Sorghum, Shawnee County, 1938

Source: Library of Congress;
John Vachon, photographer

contaminated seed in 1907 and, from 1907-1910, purified the variety through testing and selection. In 1909, seed was sold to growers and the variety was widely distributed.¹² Pink kafir was considered one of the most valuable grain sorghum varieties for many years. By 1910, production of all types of sorghum in Kansas was valued at almost \$14 million and over 1.2 million acres were planted to sorghum.

Beginning about 1920, changes in harvesting equipment brought about changes in the height of the grain sorghum varieties planted in Kansas. Shorter "dwarf" varieties were developed that could be harvested by combines (rather than being cut, bundled into "shocks," and threshed or fed later). In 1935, seed had to be shipped in from Texas when the drought the year before caused a shortage of grain sorghum seed in Kansas. The Kansas grain sorghum crop was a total failure in 1936.

For many years, producers chose from a handful of standard grain sorghum varieties. Since the late 1950s, researchers have offered grain sorghum producers hundreds of hybrid grain sorghums. Hybridization, which requires the purchase of new seed each year, has resulted in yield improvements as well as quality improvements, such as disease resistance, pest resistance, and standability (stalk strength). Grain sorghum is grown under a wide range of climatic conditions across the state and the average length of the growing season varies greatly from one side of the state to another.

Any changes in the number of acres planted to grain sorghum in Kansas are reflections of national trends, caused in part by the potential for higher economic returns from planting and harvesting other crops. Grain sorghum continues to be an important crop in Kansas, providing a valuable product to the Kansas livestock and ethanol industries. Kansas continues to be a leading producer of grain sorghum in the United States.



Kafir Corn, Sheridan County, 1939

Source: Library of Congress;
Russell Lee, photographer



Sorghum Shocks, Shawnee County, 1938

Source: Library of Congress;
John Vachon, photographer



Feed Wagon, early 1920s

Courtesy: Stoskopf Farms

KANSAS GRAIN SORGHUM TIMELINE

1904– first release of grain sorghum seed from Hays Agricultural Experiment Station.

1910– over 1.2 million acres planted; valued at almost \$14 million (all sorghum types).

1932– over two million acres planted; over one million acres harvested.

1933– over three million acres planted; only 112,000 acres harvested.

1940– 4.6 million acres planted; first crop to produce over 20 million bushels.

1944– first time over two million acres harvested; produced nearly 50 million bushels.

1957– nearly 8.2 million acres planted (current state record); over 6 million acres harvested (current state record); first crop to produce over 100 million bushels.

1971– first crop over 200 million bushels.

1972– first crop valued at over \$300 million.

1973– first crop valued at over \$400 million.

1979– first crop valued at over \$500 million.

1986– first crop over 300 million bushels.

1996– 354,200,000 bushels produced (current state record); crop valued at over \$800 million (current state record).

Source: Kansas Agricultural Statistics Service

SOYBEANS

(Glycine max)

"... wouldn't it be wonderful if someday, the President sat down and looked at the crop report and said, man, we've got a lot of soybeans; it means we're less dependent on foreign sources of energy."

George W. Bush, 43rd President of the United States

The soybean plant grows in a bushy shape, rather than with straight stalks like wheat, corn, and grain sorghum. The soybean plant is a legume, which means that the growing soybean plant produces and deposits nitrogen into the soil through its root systems. The next crop uses the stored nitrogen when it begins growing in the same field, reducing the amount of added fertilizer required by the new crop. Soybeans are planted in late spring



Soybeans

Source: Minnesota Soybean

and produce 60-80 pods over the summer. Each pod holds three seeds (soybeans). Each soybean is slightly larger than a pea. It takes 2,500 to 3,400 soybeans to weigh one pound. One bushel of soybeans is equal to 60 pounds of soybeans.

Until recently, the United States was the world's largest exporter of soybeans. Currently, although the world-wide consumption of soybeans is rising, the U.S. accounts for less than 40 percent of the world's soybean production, according to the American Soybean Association. In the United States, soybeans rank second (behind corn) in the number of acres planted and the value of the crop produced. At the present time, soybeans account for 90 percent of the oilseeds produced in the United States.

The number of acres planted to soybeans in Kansas is fluctuating. In 2004, soybean production jumped 95 percent from the year before to a record 111.1 million bushels according to the Kansas Agricultural Statistics Service. In 2006, Kansas farmers planted over three million acres of soybeans but soybean acreage in Kansas dropped by over 20 percent in 2007. New herbicide resistant varieties of soybeans that allow for better weed control and produce higher yields, along with a rising demand for corn, are some of the factors driving the changes in soybean production in Kansas.



Soybean Plants

Source: USDA



Soybeans Ready for Harvest

Credit: Scott Bauer, USDA ARS



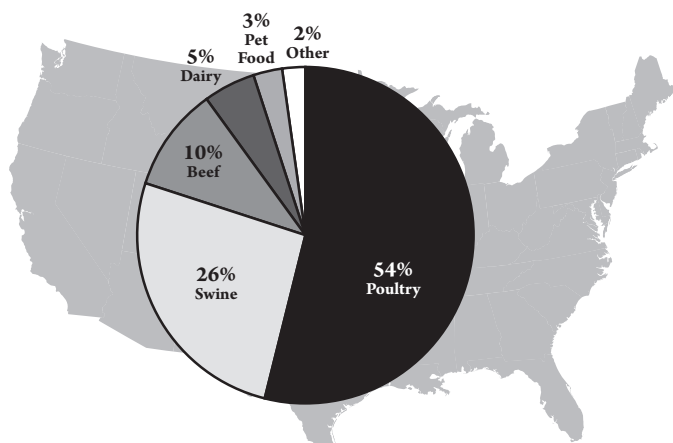
Pod with Soybeans

Credit: Scott Bauer, USDA ARS

SOYBEAN USES

Nearly all the soybeans produced in the United States are "crushed," which is the process of separating and extracting the oil. The extraction process creates soybean meal, an easily digested, high protein product. For every bushel (60 pounds) of soybeans that is crushed, 80 percent (48 pounds) becomes soybean meal. Worldwide, soybean meal is the largest source of protein feed. Over 90 percent of the soybean meal consumed in the United States is fed to livestock. According to the American Soybean Association, 54 percent of the soybean meal produced in the U.S. is fed to poultry. Another 26 percent is fed to swine. Swine cannot digest raw soybeans but can eat soybean meal because the soybeans have been

U.S. SOYBEAN USE BY LIVESTOCK



Source: American Soybean Association

SOY OIL

Soy oil (soybean oil) is the most widely used vegetable oil in the world.

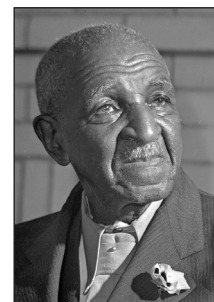
Source: American Soybean Association

SOYBEAN HISTORY

A Chinese emperor made the first record of soybeans around 5,000 years ago in books describing plant life. Chinese records suggest that soybeans were sown yearly during ceremonies by Chinese emperors. These were such significant events that poets wrote about the importance of the crop to Chinese civilization. Soybeans were important to the rest of Asia as well.

In 1765, the first soybeans in the United States were planted on a farm in Georgia. A seaman brought the seed to the United States from China, by way of England. The crop was harvested for hay and what remained was tilled into the soil for use as a fertilizer for future crops. While in England in 1770, Benjamin Franklin sent soybean seeds to a leading botanist in Pennsylvania. In the 1800s, sailors loading ships leaving China used soybeans as an inexpensive ballast. When the ships arrived in the United States, the soybeans were dumped so that the ships could be loaded with cargo. U.S. farmers began growing the soybeans and even raised one variety to use as soy sauce.

During the Civil War, soldiers and others who could not get "real" coffee often substituted soybeans for coffee beans. In the late 1800s, soybeans became popular as a forage crop for cattle. Then, in the early 1900s, George Washington Carver began studying soybeans and discovered the potential for soybeans to be more than just a forage crop. Carver researched potential soy protein and oil products, including a variety of food and industrial products - even a biodiesel fuel product.



George Washington Carver

Source: Library of Congress; Arthur Rothstein, photographer

cooked during the oil extraction process. Soybean meal is also used in baking ingredients and as a meat substitute in foods for human consumption.

The most widely used vegetable oil in the world is soybean oil (soy oil). Between 18 to 19 percent of the weight of the whole soybean is oil. Nearly all of the soy oil produced in the United States is used in salad and cooking oil, bakery shortening, frying fat, and margarine. Industrial applications for soy oil, which consume 12 percent of the soy oil produced in the United States, are expanding and expected to consume even more soy oil in the future. Soy oil is used in plastics, printing inks, lubricants, solvents, crayons, textiles, and biodiesel.

While whole soybeans represent nearly 80 percent of the soybean products exported by the United States, only a small portion of the U.S. soybean crop is not crushed. Whole soybeans are used for seed, dairy feed, snack foods, and processed into traditional soyfoods, such as tofu and soy flour.



Soybean Products

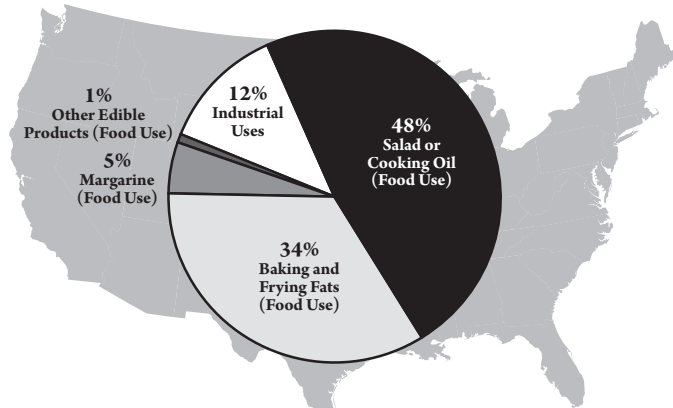
Credit: Scott Bauer, USDA ARS



Soy Crayons

Source: Minnesota Soybean

U.S. SOY OIL USES



Source: American Soybean Association

Soybeans became popular in the southern states where Carver's research was promoted and farmers were looking for alternatives to cotton. In 1890, the Kansas State Agricultural College Experiment Station in Manhattan offered free soybean seed to farmers to introduce the crop into Kansas.¹³ However, the Kansas Department of Agriculture did not begin tracking soybean production in the state until 1924. That year, farmers in Kansas planted 11,000 acres but harvested only 2,000 acres of soybeans, producing just 22,000 bushels, according to the records of the Kansas Agricultural Statistics Service. From late 1929 to 1931, William J. Morse, a scientist with the U.S. Department of Agriculture, spent two years in Japan, Korea, and China collecting over 4,000 soybean varieties. Researchers used those seeds to lay the foundation for the United States to become the world's leader in soybean production.

By 1940, the United States was a net exporter of soybeans and soybean products. Soybean production began expanding again in the mid-1940s when herbicides and pesticides became available for use by farmers. During World War II, food processors turned to soy oil when imports of edible fats and oils were disrupted. Soybean

KANSAS SOYBEAN TIMELINE

1890 – Kansas State University offered free soybean seed to farmers.
1924 – 11,000 acres planted but only 2,000 acres harvested, producing 22,000 bushels.
1931 – first crop over 100,000 bushels.
1941 – first crop over 500,000 bushels.
1942 – 2.4 million bushels produced; 290,000 acres planted but only 212,000 acres harvested.
1950 – 7.1 million bushels produced.
1961 – 703,000 acres planted; produced 15.1 million bushels.
1966 – first 20 million bushel crop.
1973 – 1.2 million acres harvested.
1987 – 2.1 million acres harvested.
2004 – 111,110,000 bushels produced (current state record).
2006 – 3.2 million acres planted (current state record); 3.1 million acres harvested (current state record); crop valued at \$601.2 million (current state record).

Source: Kansas Agricultural Statistics Service

meal triggered an expansion in livestock and poultry production in the United States in the early 1950s when it became available as a low-cost, high-protein feed ingredient. In the late 1950s and 1960s, an inexpensive source of nitrogen fertilizer, anhydrous ammonia, led to higher crop yields and soybean acreage increased in many states, including Kansas.

In 1973, Kansas farmers planted—and harvested—over one million acres of soybeans for the first time. Even though soybean acreage slipped across the United States in the 1980s, Kansas reached a milestone in 1987 when Kansas farmers planted over two million acres. During the 1990s, production across the United States continued to soar and the U.S. was the world's largest producer and exporter of soybeans. Stiff competition from South America, especially Brazil and Argentina, cut the United States' share of the world's soybean exports from 95 percent in the 1990s to below 50 percent today.

Inside the United States, the demand for soy oil is being supported by the interest in renewable fuels, such as biodiesel. About 85 percent of the biodiesel produced in the U.S. is produced from soy oil.

BIODIESEL

One bushel of soybeans (60 pounds) yields 1.5 gallons of biodiesel.

Source: American Soybean Association

SUNFLOWERS*(Helianthus annuus)**"What is a weed? A plant whose virtues have not yet been discovered."*

Ralph Waldo Emerson, American author, poet, and philosopher

Although Kansas is known as the "Sunflower State," the state flower is actually the wild sunflower that is native to North America. The sunflowers that are planted by Kansas farmers today are generations removed from the seeds that were taken to Europe, started a sunflower industry in Russia, came back to North America with Russian immigrants, started a commercial breeding program in Canada, and were imported back into the United States.

**Sunflower Heads**

Credit: Bruce Fritz, USDA ARS

Russia continues to be the world's largest producer of cultivated sunflowers. Other significant producers are Argentina, the European Union, China, India, Turkey, and South Africa. In the United States, 1.9 million acres were planted to sunflowers in 2007. Kansas ranks third in both sunflower acreage and production behind North Dakota and South Dakota. North Dakota alone accounts for over 50 percent of the planted acres and 25 percent of the nation's production of sunflowers. According to the Kansas Agricultural Statistics Service, around 150,000 acres are planted to sunflowers in Kansas each year, producing over 450,000 pounds of sunflowers valued at over \$46 million.

One unusual characteristic of sunflowers is that the plants follow the sun as it moves across the sky from east to west each day (returning to the east each morning), an action called heliotropism. This continues until the growth stages where the closed buds open up, the "flowers" appear, and pollination takes place. Then the stems stiffen and the sunflower heads always face east. The sunflower heads become heavy as the seeds fill and the heads may turn so that they face the ground.

Sunflowers are drought-tolerant and heat-tolerant. Cultivated sunflowers are grown from hybrid seed that is purchased each year. Each seed grows a single stalk with one sunflower head, unlike the native sunflower plants that produce multiple heads. Each

**Field of Sunflowers**

Credit: Bruce Fritz, USDA ARS

FOLLOWING THE SUN

Heliotropism— the action of plants, such as sunflowers, following the sun from east to west during the day and returning to the east each morning.

sunflower plant has an extensive root system, with a long taproot that can reach deep into the soil to find water. Researchers have measured sunflower roots that were growing nearly 9 feet below the surface of the soil. Because there are so many wild sunflowers growing in Kansas, the chances are increased that insects that find sanctuary in native sunflowers will attack cultivated sunflowers at susceptible stages of development. However, some insects are beneficial and the use of insecticides is always carefully managed according to the amount of insect activity, the pest species present, and the stages of plant growth. After the sunflower seeds have formed, bird damage is another concern producers must face. In some areas of Kansas, resident or migrating birds make it impractical to grow sunflowers.

There are two types of sunflowers produced in Kansas: oilseed and non-oil (confection). Each type requires specific crop production management techniques, separate storage, and different processing facilities. Oilseed sunflowers produce seeds that are shiny, black and smaller than the seeds of non-oil sunflowers, which produce black-colored seeds with white stripes that are approximately five-eighths of an inch long. Nearly 80 percent of the sunflowers produced in the United States are oilseeds.

The sunflower industry is an important agricultural industry in Kansas even though Kansas does not lead the nation in sunflower production statistics. Kansas is home to several sunflower processing and birdseed packaging plants, including a sunflower oil production plant near Goodland and two confection sunflower processing plants at Colby and Goodland.



Cultivated Sunflowers

Credit: Edward McCain, USDA ARS



Wild Sunflowers

Credit: Douglas S. Helmke, KRW



Opening Sunflower

Source: National Sunflower Assn.



Drying Sunflowers

Source: National Sunflower Assn.

SUNFLOWER SEEDS

Oilseed sunflowers— small, shiny black seeds; produce oil for baking, frying, and food products.

Non-oil (confection) sunflowers— black-colored seeds with white stripes, approximately 5/8 inch long; produce seeds for baking, eating, birdseed, and pet food.

Seed Comparison:

(left) Non-oil seeds
(right) Oilseeds

Source: National Sunflower Association



SUNFLOWER USES

The oil content of an intact oilseed sunflower seed is over 42 percent. There are three different kinds of oilseed sunflowers; each produces an oil with distinctive qualities. According to the National Sunflower Association, 70 percent of the oilseed sunflowers planted in the United States are NuSun® varieties. NuSun® oil is an excellent frying oil and is used commercially by major snack food manufacturers and other segments of the food industry. High oleic sunflower oil is a commercial oil used in baking, frying, and in food products such as non-dairy creamers, cereal, crackers, and dried fruit. In many countries, the traditional sunflower oil, linoleic sunflower oil, is the preferred oil for cooking. In the United States, it is also used in margarine and salad oils.

Sunflower meal is produced in the process of "crushing" sunflower seeds to extract sunflower oil. Nearly all of the sunflower meal produced in the United States is used as an ingredient in livestock feed. Oilseed sunflowers can also be fed to dairy cattle or packaged for birdseed.

Non-oil (confection) sunflowers produce seeds for baking or for sunflower seeds, an American original! Confection sunflower seeds are sorted according to size. The largest seeds are sold intact. The hulls (shells) are usually removed from medium-sized seeds, which are sold as sunflower kernels and used in food products ranging from snacks to breads. The smallest seeds are sold for birdseed and pet food.



Sunflower Oil and Chips

Source: National Sunflower Assn.



Sunflower Kernel

Source: National Sunflower Assn.



Sunflower Seeds

Source: National Sunflower Assn.

SUNFLOWER HISTORY

The sunflower plant is native to Central America, where the sunflower held a place of honor in the Aztec culture. The Aztec temples in what is now Mexico included pure gold symbols of sunflowers. From Central America, the domestication of sunflowers spread north and east. Native Americans grew and used sunflowers in many ways. Food uses included flour, seeds, and oil. Purple sunflower dyes were used for body painting and for painting and dyeing fabrics and other materials. Sunflower stalks were used as building materials and parts of the sunflower plant had medicinal uses.

In the 1500s, Spanish explorers carried sunflower seeds back to Europe where the sunflower became an ornamental garden plant. Although some experimentation with oil extraction took place in the 1700s in England, the sunflower was not recognized as a food plant until it reached Russia, sometime before 1800. Sunflower oil was being commercially manufactured in Russia by 1830. It jumped in popularity when sunflower oil was left off the list of foods prohibited from being consumed during Lent by the Russian Orthodox Church. Selective breeding programs developed single-headed, large-seeded plants and varieties with high oil content.

When the Lewis and Clark expedition passed through the Great Plains in 1805, the explorers noted how the American Indians made use of the sunflower plants. Early travelers and settlers used dried sunflower stalks for fuel and sunflower seeds for poultry feed. About the same time that Russian sunflower seed was finding its way back into the United States, probably being carried into states like Kansas by Russian immigrants, Kansas was attracting attention as the "Sunflower State." As early as 1880, newspaper editors and other prominent citizens proposed that the wild sunflower be adopted as the state flower.¹⁴ In 1903, the sunflower was named the official state flower.

Argentina started producing sunflowers in the 1870s and became the world's second largest producer of sunflower oil after



Seeds in Sunflower Head

Source: National Sunflower Assn.

THE STATE FLOWER OF KANSAS

An act of the Kansas legislature, approved by Governor Bailey on March 12, 1903, named the sunflower as the official state flower.

73-1801. State flower and floral emblem. WHEREAS, Kansas has a native wild flower common throughout her borders, hardy and conspicuous, of definite, unvarying and striking shape, easily sketched, moulded, and carved, having armorial capacities, ideally adapted for artistic reproduction, with its strong, distinct disk and its golden circle of clear glowing rays -- a flower that a child can draw on a slate, a woman can work in silk, or a man can carve on stone or fashion in clay; and

WHEREAS, This flower has to all Kansans a historic symbolism which speaks of frontier days, winding trails, pathless prairies, and is full of the life and glory of the past, the pride of the present, and richly emblematic of the majesty of a golden future, and is a flower which has given Kansas the world-wide name, "the sunflower state": therefore,

Be it enacted by the Legislature of the State of Kansas: That the helianthus or wild native sunflower is hereby made, designated and declared to be the state flower and floral emblem of the state of Kansas.



State Flower

Credit: Kendra Goering

Source: Kansas Statutes

the Spanish Civil War of the 1930s created a shortage of olive oil imports in Argentina. The sunflower industry in North America took longer to develop than that of Russia or Argentina. In the United States, the first commercial use of sunflowers was as silage feed for poultry. In 1930, Canada started the first official government sunflower breeding program. From Canada, sunflower production spread down into Minnesota and North Dakota.

In the late 1970s, Russia could not export enough sunflower oil to meet the demand in Europe and producers in the United States

KANSAS SUNFLOWER TIMELINE

1903– native wild sunflower named state flower.

1988– 200,000 acres planted; produced over 240 million pounds of sunflower seeds.

1994– first 300 million pound crop.

1995– 300,000 acres planted.

1999– first 400 million pound crop.

2001– 335,000 acres planted (current state record); 323,000 acres harvested (current state record).

2005– 452,100,000 pound crop (current state record); crop valued at \$46.5 million (current state record).

Source: Kansas Agricultural Statistics Service

Kansas Crops

expanded sunflower acreage to over 5 million acres. According to the National Sunflower Association, the first NuSun® oilseed sunflower varieties were developed in the mid-1990s in anticipation of health concerns that the food industry would be asked to address. In Kansas, the number of acres planted to sunflowers jumped in 1994 and has remained fairly constant ever since. Today, Western Europe depends on its own production to meet its demand for sunflower oil.



Sunflowers

Credit: Bruce Fritz, USDA ARS

Sunflowers have always been popular. Famous artists like Picasso and van Gogh and modern-day designers have used sunflowers as the subject for art, fabric, and objects of every kind imaginable. Poets, songwriters, authors, and movie producers have all immortalized the state flower of Kansas. No longer just a wildflower, the sunflower is also one of the leading agricultural crops in Kansas.

ALFALFA

(*Medicago sativa*)

"On every stem, on every leaf... and at the root of everything that grew, was a professional specialist in the shape of a grub, caterpillar, aphid, or other expert, whose business it was to devour that particular part."

Oliver Wendell Holmes, American poet and writer

Known as "lucerne" in most countries around the world, alfalfa is a perennial plant that grows two to three feet tall and produces lush green foliage with leaves that have a high protein content. As a legume, the alfalfa plant has the ability to take nitrogen from the atmosphere and transform it into the form of nitrogen that the plant needs for growth and development. Excess nitrogen produced by the alfalfa plant is stored in the soil for the next growing season or future crops. The roots of an alfalfa plant can penetrate as deep as 25 feet below the soil's surface.



Alfalfa Plant

Credit: Mary Anne Stoskopf

When planting alfalfa in Kansas, the goal is to establish a field of healthy growing plants before extreme weather conditions hit—either the heat in late spring or a hard freeze in the fall. The production for several years depends on planting and maintaining a good "stand" of healthy plants. Planting alfalfa is an expensive operation usually requiring extensive seedbed preparation. Adequate soil moisture for seed germination and timely rains during early growth stages often mean the difference between success and failure. A thin stand, one in which the alfalfa plants are farther apart, allows weeds to grow between the alfalfa plants and reduces the quality of the hay that can be produced. Weeds also attract and harbor insects that attack the alfalfa plants and reduce the quantity of hay produced.

When planting, the choice of alfalfa variety is a critical management decision because it determines hay production qualities and quantities for several

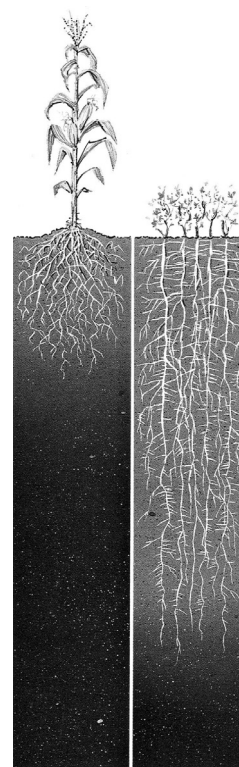
Alfalfa Re-growth

Credit: Mary Anne Stoskopf



Depth of Corn Roots (left) vs. Alfalfa Roots (right)

Source: University of Minnesota Extension Service



years. Soil types, disease and pest resistance, availability of water or drought tolerance, and the anticipated livestock market determine variety choices.

Alfalfa is a labor-intensive crop.

When provided with adequate water, alfalfa plants re-grow each time they are harvested during the growing season and stop growing only after the first hard freeze in the fall. Under optimal growing conditions, alfalfa reaches the stage for harvesting approximately 28 days after the previous time the stems and leaves were cut from growing plants. During the growing season, each harvest of the alfalfa plants is considered one "cutting." A swather (machine) cuts the alfalfa plants about 2 inches above the ground and gathers the cut alfalfa into windrows, long narrow piles that run the length of the field.

An alfalfa plant is about 80 percent water so the cut plant material must dry down before it can be baled—collected and compacted into manageable units for transportation and feeding. The leaves—which have the highest nutritive value, taste better, and are easier for livestock to digest—dry faster than the stems. By the time the stems are dry, the leaves are so dry they would all fall off if the alfalfa was baled right then. To help the cut alfalfa dry uniformly, a rake may be used to roll and fluff the windrows, bringing the bottom layer to the top. Timing is critical as the producer waits for humidity levels to be just right to produce high-quality bales of alfalfa. If the alfalfa is baled at high moisture levels, it will produce mold inside the bales and livestock will not eat the hay. If the alfalfa is too dry when it is raked or baled, it will not have as high a nutritive value because the leaves will not stay attached to the stems and it may need to be mixed with higher-quality hay before livestock will eat it.

Swathing and baling is the most common harvesting practice for alfalfa in Kansas. However, alfalfa is also harvested as haylage—cut as a green crop by a forage cutter that deposits the cut alfalfa into a truck. The truck delivers the alfalfa directly to a dairy, feedlot, alfalfa pellet mill, or other feed processing facility.



Swather— front view

Credit: Mary Anne Stoskopf



Swather— rear view

Credit: Mary Anne Stoskopf



Baling

Credit: Dean Stoskopf



Raked Windrows

Credit: Dean Stoskopf

Unlike many other Kansas crops, alfalfa is a perennial plant and fields of alfalfa are maintained for years, rather than months. A well-maintained field of alfalfa may produce good quality hay for five to seven years in Kansas. Alfalfa fields provide habitat and food for many species, but alfalfa plants are particularly vulnerable to insect pests that can strip the leaves off the plants or even kill the plants. When it becomes necessary, an insecticide targeted for the specific insect species threatening the crop will be used on the alfalfa plants. Since alfalfa is pollinated by insects, insecticides are chosen very carefully and used only when necessary. When harvested as hay or silage, alfalfa is cut before seed production starts. If a seed crop is being produced, pollination is critical and beneficial insects, usually bees, may even be placed in the alfalfa field to ensure that pollination takes place.



Alfalfa Flower

Credit: Keith Weller, USDA ARS

According to the National Agricultural Statistics Service, around 21.5 million acres of alfalfa were harvested in the United States in 2007. Domestic animals, many on the same farms where the alfalfa is produced, consume about 90 percent of the U.S. alfalfa crop each year. In Kansas, more farms grow alfalfa than corn. Kansas produces about 5 percent of the alfalfa produced in the United States, according to the Kansas Agricultural Statistics Service. Among the states, Kansas ranks 8th in both alfalfa acreage (900,000 acres) and production (3.6 million tons in 2006). Alfalfa production is measured in tonnage - the number of tons of plant material removed per acre.

ALFALFA USES

Alfalfa is the most important forage crop grown in the United States. The highest quality hay is high in protein and low in fiber, meaning that it supplies high levels of energy and nutrition without requiring the animal to use as much energy to digest the feed as other feeds and grains might. In addition to protein, alfalfa provides other important nutrients such as calcium and carotene.

Around the world and in the United States, alfalfa is primarily fed to dairy cows. In Kansas, the highest quality alfalfa is usually sold to dairies; however, most of the alfalfa produced in Kansas is fed to beef cattle. Calves in feedyards or cows without calves do not have the high-protein, low-fiber dietary requirements of dairy cattle. In addition to cattle, alfalfa is important in the diets of other



Dairy Cows

Credit: Scott Bauer, USDA ARS

ALFALFA BALE COMPARISON

Small Square Bale:

60-90 pounds, 14 inches by 14 inches x 30-36 inches long

Round Bale:

1500 pounds, 5 feet wide, 5 1/2 feet tall

Large Square Bale:

2000 pounds, 4 feet by 4 feet x 8 feet long



Small Square Bale vs. Round Bale

Credit: Jessica Baetz Caylor



Round Bale vs. Large Square Bales

Credit: Mary Anne Stoskopf

animals, including horses, sheep, and small animals such as rabbits, mice, and gerbils. Many animals eat dehydrated alfalfa made by drying, grinding, and forming the alfalfa into cubes or pellets appropriately sized for the targeted animal species.

Although alfalfa sprouts first appeared on salad bars in the 1970s, alfalfa sprouts (produced from alfalfa seeds) remain a minor use of the U.S. alfalfa crop. On the other hand, alfalfa is the main crop used to produce honey in the United States, accounting for one-third of the honey produced in this country each year.¹⁵



Honey

Credit: Scott Bauer, USDA ARS

ALFALFA HISTORY

Alfalfa is an ancient crop, probably first grown more than 6,000 years ago in the Persian region (Iran, Iraq, and Sudan). From Persia, alfalfa spread to the Greek, Roman, and Chinese empires as it was carried along as feed for military and other horses. The Romans introduced alfalfa in Europe, and during the Middle Ages, alfalfa spread into many areas of Northern Africa and Europe, including Spain. In most countries around the world, the plant was, and still is, called "lucerne." However, when the plant first reached Spain, the Spanish called it by its Arabic name—"alfalfa," meaning "horsepower." Spanish and Portuguese explorers brought alfalfa to Central and South America. In the early 1850s, alfalfa moved

ALFALFA FACT

Alfalfa is the one of the most important crops grown for livestock feed in the United States. Alfalfa is high in protein and other nutrients important in the diets of dairy cattle, beef cattle, and other animals.

KANSAS ALFALFA TIMELINE

1870s– KSAC Agricultural Experiment Station begins field experiments with alfalfa.

1893– State Board of Agriculture's first report of alfalfa as a separate crop states 75,200 acres were harvested in Kansas.

1895– first crop over 100,000 acres.

1898– first crop over 200,000 acres.

1903– first crop over 500,000 acres (566,592 acres).

1912– first crop over one million acres.

1915– tonnage and value first reported by State Board of Agriculture; over 1.3 million acres harvested, produced 4.6 million tons valued at \$28.4 million.

1919– 2.5 million tons produced (largest crop produced until 1957); valued at \$61.8 million.

1921– State Board of Agriculture began tracking alfalfa seed production.

1955– 1,538,000 acres harvested (current state record).

1998– 4.6 million tons produced (current state record).

2006– 3.6 million tons produced; valued at \$397,100,000 (current state record).

Source: Kansas Agricultural Statistics Service

north to California. On the eastern coast of the United States, early colonists, including Thomas Jefferson, experimented with growing alfalfa. German immigrants planted alfalfa in New York in the 1820s from seed they carried into the United States. It was in California, however, that the potential of alfalfa for hay production was first recognized. Alfalfa production spread from the west coast eastward, although alfalfa seed production is still concentrated in the northwestern states.

Like many other crops in Kansas, early settlers brought the first alfalfa seeds into the state. In the early 1870s, the Kansas State Agricultural College's Experiment Station began field experiments with alfalfa. ¹⁶ In the 1880s, alfalfa gained a reputation as a profitable crop in Kansas. However, the State Board of Agriculture did not report "tame grass" statistics, which included alfalfa and other types of hay, until 1891. By 1893, the State Board of Agriculture was reporting alfalfa as an individual crop and alfalfa seed was in high demand. One Kansas farmer reported that the seed from his 1893 alfalfa crop was worth the price of the land it was raised on, and he had had two cuttings



Hay Wagon, 1937

Credit: Library of Congress;
Russell Lee, photographer

of hay that year as well. ¹⁷ In 1894, the State Board of Agriculture completed a study of alfalfa and by 1902, alfalfa was growing in 99 counties in Kansas. Alfalfa acreage in Kansas had expanded from 75,000 acres in 1893 to nearly 500,000 acres in 1902. In 1908, the government bought and furnished Peruvian dryland alfalfa seed for 30 farmers to plant in Grant and Haskell counties. ¹⁸

According to the records of the Kansas Agricultural Statistics Service, in 1919, there were 1.3 million acres of alfalfa planted in Kansas, producing 2.5 million tons of alfalfa hay. In 1923, the number of acres dropped below one million but production continued to rise.

Acreage dipped in the late 1930s, reaching a low of 380,000 acres in 1939 before starting to climb again in the 1940s. In 1947, the state once again had one million acres of alfalfa in production. A record number of acres were in alfalfa production in 1955–1.5 million acres. Kansas growers set the record for the largest alfalfa crop ever produced in Kansas—to date—in 1998 when they produced 4.6 million tons of alfalfa on one million acres.

In 1980, the Kansas Agricultural Experiment Station established an official alfalfa testing program. New varieties are tested for at least three years, providing growers with useful performance comparisons.



Round Bales

Source: High Plains Journal

COTTON

(*Gossypium hirsutum*)

*"Not a breath of air stirred over the free and open prairie;
the clouds were like light piles of cotton;
and where the blue sky was visible, it wore a hazy and languid aspect."*

Francis Parkman, American historian

Even though it is grown as an annual crop in the United States, cotton is a perennial plant that does not die in the fall in its native tropical habitat. The growing season in Kansas is relatively short because warm days and warm nights are required for optimum growth and development. In Kansas, cotton is generally planted during the month of May and early June.

Because it is a perennial plant, cotton produces vegetation (leaves) and fruiting structures (fruiting branches, flower buds, blooms, and bolls) at the same time. Fruiting branches produce the flower buds, referred to as cotton squares, which bloom and may become harvestable cotton bolls. Typically, only 35 to 40 percent of the flowers (blooms) make cotton bolls. The fruit of the cotton plant is the boll, a capsule with four to five sections that contains the seed, linters (fuzz attached to the seed), and lint (long fibers).



Cotton

Credit: Scott Bauer, USDA ARS



top left: Cotton Flower

Credit: USDA NRCS

top right: Open Cotton Boll

Credit: Peggy Greb, USDA ARS



left: Cotton Boll close-up

Credit: USDA NRCS

The U.S. cotton crop is mechanically harvested. In Kansas, cotton producers use stripper machines that pull all the bolls from the cotton plants. The cotton is collected and compressed into large blocks, called modules, covered with tarps, and stored at the edge of the field until the modules can be transported to a cotton gin. Each module will contain about 10 to 11 bales of cotton after ginning. At the cotton gin, the lint is separated from the cottonseed and cleaned. The lint is packed into bales weighing 480 pounds each. Each bale is sampled and valued according to the length of the cotton fiber (measured as "staple"), color (whiteness), fiber strength, micronaire (fineness), uniformity, and the amount of leaves or other things such as dust, grass, or oil that might be found in the cotton. Both quality and quantity determine the value of the harvested lint.



Cotton Harvester

Credit: David Wright, USDA ARS



Cotton Module

Credit: Gary Kramer, USDA NRCS

BALE OF COTTON

Each cotton bale weighs 480 pounds. It takes about 2,350 pounds of cotton to produce a 480-pound bale of cotton lint (long cotton fibers).



Credit: Ken Hammond, USDA

Source: National Cottonseed Products Association

The lint accounts for about one-third of the harvested crop. It takes about 2,350 pounds of cotton to produce a 480-pound bale of lint. Another 740 pounds of seed and 210 pounds of gin trash (stems, leaves, etc.) will be produced from the same 2,350 pounds of cotton. Although cottonseed once had no value, today cottonseed accounts for about 15 percent of the value of the cotton crop. There are three products produced from cottonseed—oil, meal, and hulls.

It is estimated that the U.S. cotton crop stimulates around \$120 billion in business revenue in the United States economy each year. In 2007, over 11 million acres were planted to cotton in the United States, expected to produce over 20 million bales of cotton according to the National Cottonseed Products Association. Texas, Arkansas, and Mississippi lead the states in cotton production. Cotton production in Kansas climbed from just 1,200 acres in 1994 to 115,000 acres in 2006 before dropping back to 55,000 acres in 2007. In 2006, Kansas produced 140,000 bales of cotton, according to the Kansas Agricultural Statistics Service.

COTTON USES

Today, the world uses more cotton than any other fiber, and cotton is the leading value-added crop in the United States. According to the National Cotton Council of America, the main uses of the U.S. cotton crop are apparel (64%), home furnishings (28%), and industrial products (8%). Nearly all Kansas cotton is used to produce denim.

Cottonseed can be fed to dairy cattle as "whole cottonseed." Cottonseed is also run through delinting machines, cleaned, and dehulled to produce cottonseed oil. On average, one ton of cottonseed produces about 320 pounds of oil, 910 pounds of meal, 540 pounds of hulls, and 167 pounds of linters. Of the three products produced from cottonseed—oil, meal, and hulls—cottonseed oil is the most valuable. It is extracted from the seed kernels after the hulls and cotton linters have been removed. Cottonseed oil, which requires



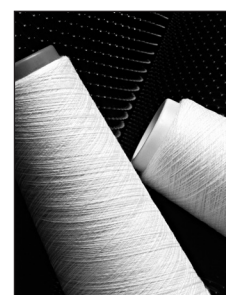
Raw Cotton (left) vs. Ginned Cotton (right)

Credit: USDA ARS



Examining Cotton Gin Waste

Credit: Scott Bauer, USDA ARS



Cotton Yarn

Credit: Scott Bauer, USDA ARS



Denim Jeans

Source: Franklin County CD

ONE BALE OF COTTON CAN MAKE:

215 jeans
249 bed sheets
409 men's sport shirts
690 bath towels
765 men's dress shirts
1,217 men's t-shirts
1,256 pillowcases
3,085 diapers
4,321 mid-calf socks
21,960 women's handkerchiefs
313,600 \$100 bills



Credit: Scott Bauer, USDA ARS

Source: The National Cotton Council

further processing before it is used in food, is used primarily as a salad or cooking oil and it is also used in baking and frying snack and other foods. Crushed cottonseed meal, made by crushing the seed kernels without removing the linters, is a concentrated high-protein livestock feed, often mixed with other feed ingredients. Cottonseed meal is also used as a lawn and garden fertilizer.

Credit: The Cotton Foundation

The cottonseed hull is the tough coating that surrounds the seed kernel and linters. Some of the cotton linters attach themselves to the hull. Cottonseed hulls are fed to livestock as roughage, rather than as a protein supplement. They are also sold as mulch for flowerbeds.

Cottonseed linters, the short fibers removed from the seed, are used in a wider variety of consumer and industrial products than any of the other cottonseed components. Cotton linters are used in cotton swabs, cotton balls, and medical items. Other industrial uses of cotton linters include carpet yarns, vehicle and furniture cushions, mattresses, and high-grade paper, including paper used in printing money.



Cotton Oil



Cottonseed

Credit: Scott Bauer, USDA ARS



Cotton Lint

Credit: Peggy Greb, USDA ARS

COTTON HISTORY

Cotton has been grown and used in the manufacture of fabric and textiles for thousands of years. Evidence exists that cotton was cultivated in both the Western and Eastern hemispheres, apparently during the same time period 5,000 to 7,000 years ago. Cotton textiles have been found in Pakistan, Peru, and Mexico. Early

explorers, including Christopher Columbus and Hernando Cortez, found cotton growing in the West Indies and Mexico.

However, the varieties of cotton grown in Central and South America did not grow well in the southeastern United States. In the early 1600s, colonists began growing small amounts of cotton. Following the American Revolution, cotton was recognized as one of the major crops in the United States. At the time, the British still controlled the textile industry and even went so far as to prohibit anyone familiar with textile machinery from moving to another country. In 1793, Samuel Slater disguised himself as a farmer, came to the United States and, from memory, built the machinery for the first successful cotton yarn mill in this country. Also in 1793, Eli Whitney invented the cotton gin, a simple hand-turned machine that could separate lint from cottonseed. By 1860, the United States was producing almost a billion pounds of cotton each year, nearly two-thirds of the world's supply.¹⁹

When the Civil War disrupted cotton production in the traditional cotton growing states, settlers in Kansas and other western states experimented with raising cotton. Someone in practically every county in Kansas tried growing cotton but by 1878, there were only 508 acres in 22 counties planted to cotton.²⁰ Kansans continued to plant cotton through the years, mostly in southern and southeastern Kansas. In 1887, it was reported that 30 carloads (railcars) of cotton had been produced near Iola.²¹ In 1928, 300 bales of cotton were produced on 1,700 acres in Kansas according to the records of the Kansas Agricultural Statistics Service.

In the 1930s, cotton acreage in Kansas began dropping until 1943 when only 200 acres were planted. According to the Kansas

KANSAS COTTON TIMELINE

1887– 1,639 acres harvested.

1888– over 200,000 acres harvested; produced 653,000 pounds valued at \$51,600.

1892– harvested acres slipped below 700 acres.

1910– only three acres of cotton reported in Kansas.

1913– State Board of Agriculture stopped reporting cotton statistics in annual report.

1928– Kansas Agricultural Statistics Service began reporting cotton statistics; 1,600 acres harvested; 300 bales of cotton produced

1943– cotton acreage slipped to 200 acres; reporting suspended until 1982.

1996– 4,000 acres harvested; produced 4,100 bales of cotton.

1997– 10,000 acres harvested; produced crop valued at \$2.6 million.

2003– 80,000 acres harvested.

2006– 110,000 acres harvested (current state record); 140,000 bales produced (current state record).

Source: Kansas Agricultural Statistics Service

Agricultural Statistics Service, 100 bales of cotton were produced on those 200 acres but official state production records were not kept from 1943 until 1982. In 1982, 500 acres were planted to cotton in Kansas. Just 15 years later, in 1997, production jumped to 10,000 acres and by 2000, 40,000 acres of cotton were growing in Kansas.

One of the factors affecting the profitability of growing cotton is the ability to gin the cotton before the quality of the lint is affected by weather or other conditions. Since 1998, four gins have been built in Kansas at Winfield, Anthony, Cullison, and Moscow. Watch for cotton to continue to gain prominence as a major agricultural crop in Kansas.

OTHER KANSAS CROPS

"I know of nothing so pleasant to the mind, as the discovery of anything which is at once new and valuable—nothing which so lightens and sweetens toil, as the hopeful pursuit of such discovery. And how vast, and how varied a field is agriculture, for such discovery."

Abraham Lincoln, 16th President of the United States

Kansas farmers have always experimented with a variety of agricultural crops. In the 1860s, flax, hops, rye, tobacco, and Indian corn were included in the state's annual agricultural reports. Crops such as hemp, castor beans, sugar beets, cowpeas, and broomcorn were prominent agricultural crops in Kansas at one time or another. Some crops that have always been produced in Kansas, such as potatoes, oats, and barley, have never been as prominent as wheat or corn. Nevertheless, these crops make a significant contribution to the Kansas economy and add to the diversity of agricultural products grown in Kansas. For example, according to the Kansas Agricultural Statistics Service, potato production in Kansas is valued at over \$10 million annually while the state's average pinto bean production is valued at almost \$5 million. Oats, grown for the cereal and food industry or for livestock feed, are planted on 90–100,000 acres in Kansas each year, but many years over one-half of those acres are harvested as hay. Barley is also grown for the cereal and food industry or for livestock feed.



above: **Triticale**

Credit: Louise Ehmke



top right: **Potato Plant**

Credit: Scott Bauer, USDA ARS



bottom right: **Pinto Beans**

Credit: Scott Bauer, USDA ARS

Scientific research and experimentation continues to play a vital role in the development of new crops or new varieties of traditional crops that will be profitable for Kansas farmers to grow. Crops like cotton are making a comeback in Kansas because the modern-day varieties have improved genetic qualities that fit the needs of today's agriculture. New varieties of traditional crops, like hard white winter wheat, allow Kansas farmers to add value to traditional agricultural products and tap into new markets. Today, agricultural biotechnology allows plant breeders to make precise genetic changes and address specific challenges more rapidly than traditional plant breeding methods.

Canola may turn out to be another major crop in Kansas. Canola is a member of the mustard family of plants, with bright yellow flowers. New winter canola varieties have been developed that are planted in the fall, similar to winter wheat, and are harvested just prior to winter wheat in early summer. Canola is an oilseed, producing tiny purple seeds that are crushed for oil. The oil can be marketed as cooking oil or used for making biodiesel.



Canola

Credit: Bob Nichols, USDA

At the present time, 70 percent of the canola oil used in the United States is imported from Canada and Europe, according to K-State Research and Extension faculty. However, one of the challenges facing Kansas canola producers is the lack of canola processing facilities within the state. Perhaps this will change, just as the number of cotton gins in the state has risen with the increase in cotton production in Kansas.

Another crop making headlines in Kansas is rice. In 2006, officials announced plans to open a bioprocessing facility for plant-made pharmaceuticals in Junction City, Kansas. Plans call for the facility to process rice. All of the rice produced in Kansas will be delivered to the facility for processing. One reason the Kansas site was selected is that rice is not a traditional or historical Kansas crop. Rice is not expected to become a major agricultural crop in the state.

Interest in cellulosic-based ethanol may drive other changes in Kansas crop production. Crops under consideration for cellulosic ethanol include perennial grasses, such as switchgrass, and forage sorghums. However, dramatic shifts in Kansas crop acreage probably will not occur until additional research is completed and production facilities are in place. By then, researchers and crop producers may have set their sights on other opportunities.

FOOD, FEED, FIBER, FUEL, AND THE FUTURE

"We are probably far from possessing, as yet, all the [crops] for which nature has fitted our country. To find out these, will require an abundance of unsuccessful experiments. But if, in a multitude of these, we make one or two useful acquisitions, it repays our trouble."

Thomas Jefferson, 3rd President of the United States

All together, Kansas crops represent the largest land use in Kansas. Nearly 50 percent of the land in Kansas, around 23 million acres, is planted to agricultural crops each year. Even though Kansas is known as the "Wheat State" or the "Sunflower State," Kansas is a leading producer of a wide variety of crops. The crops produced in Kansas propel the state's economy, creating jobs in food, feed, fiber, fuel, and related industries. Kansas crops, products from those crops, and products from livestock fed Kansas crops are distributed throughout the United States and exported around the world.

Today, Kansas farmers face many of the same challenges that the early Kansas settlers faced—erratic rainfall and unpredictable climatic conditions, destructive insects, weeds, and crop diseases. Advancements in technology, plant breeding, and scientific knowledge give today's crop producers additional tools to compete against the challenges and protect the future of their families' investments in the croplands of Kansas. ■

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Career Profile:**CINDY FALK****Nutrition Educator, Kansas Wheat Commission**

Cindy Falk is a spokesperson for agriculture. She works with media, consumers, educators, students, and even trade representatives. She combines the goals of Kansas wheat producers with the magic of public relations and the result increases the domestic demand for wheat.

Falk grew up on a diversified farm in Pottawatomie County. At an early age, her mother began teaching her about cooking and baking skills. As a 4-H member, she learned about many things, including public speaking and foods and nutrition. "I began presenting 4-H bread demonstrations in middle school and received awards at the county and state level," Falk says. "Teachers, 4-H leaders and judges instructed me with communication skills, and as I grew up, serving as a volunteer in different organizations helped me develop leadership skills."

She served as a volunteer spokesperson for wheat in 1986, sharing information about the crop by presenting bread demonstrations and nutrition and wheat marketing talks. Three years later, Falk was hired by the Kansas Wheat Commission to expand her duties and increase the size and scope of her public relations work. Her job title is now nutrition educator. Her job title has changed over the years, but her duties have always focused on marketing Kansas wheat.

"I enjoy representing Kansas's wheat producers and promoting an agricultural product in my home state," Falk says. While no day is the same, each day's work includes responding to consumer questions and requests for educational materials.

"Yesterday, after reading e-mails, I presented a program on the benefits of whole grains in the diet to a ladies' organization. Following the program, I participated in a conference call with the national Wheat Foods Council membership committee. And afterward, I assisted other staff members with hosting an Israeli Trade Team that was in Manhattan, Kansas."

At certain times of the year, Falk presents information to students at agricultural events, works in the Kansas Wheat booth at the Kansas State Fair, and also writes articles and recipes. Over the past fifty years, the Kansas Wheat Commission has developed hundreds of recipes using a variety of wheat products. Currently, many are featured on the Kansas Wheat Commission's website and in annual recipe booklets.

When a state or national publication or media requests a specific recipe, Falk is called upon to put her culinary and design skills into action. "The media usually also request a photo of the prepared food. Part of my job is to develop, test, write, and bake the product for the photo," she says. "Next, I arrange or 'stylize' the food, so it appeals to consumers so they will want to prepare the recipe. A professional photographer is often hired to snap the photo while some photos are taken in our test kitchen by staff."

Falk is most proud of the education programs and exhibits that she has helped offer to audiences of all ages. "With help from our dedicated spokespersons and staff, we have educated many people about agriculture, nutrition, and home baking. We can take credit for spreading the word about the importance of wheat foods to a healthy diet and efforts to increase consumption," she says. "The most overwhelming exhibits I have assisted with were at national meetings such as the American Dietetic Association, National 4-H Congress and conferences of FCCLA (Family, Career and Community Leaders of America, Inc.). And, with new technology, our messages and educational materials can be used throughout the world."

Her message is not full of empty promises—Falk believes in what she promotes. "Farmers provide a safe and affordable food supply that all of us can enjoy," she says. "It is very rewarding to know that the product you are marketing is a nutritious food consumed throughout the United States and the world." Falk sees many opportunities ahead for the career-minded. "The work that needs to be done to promote agriculture is almost unlimited."

**Cindy Falk (at left)**

Credit: Kansas Wheat Commission

TEACHER RESOURCES**BOOKS:**

* Teachers & Advanced Readers; AR - Accelerated Reading Level

The Biography of Corn

Nielsen, L. Michelle. 2007 (AR - 7.5)

The Biography of Cotton

Gleason, Carrie. 2005 (AR - 7.3)

The Biography of Wheat

Lackey, Jennifer. 2007 (AR - 6.8)

The Bread Winner

Whitemore, Arvella. 2004 (AR - 4.5)

Cotton T-Shirt

Ridley, Sarah. 2006 (AR - 5.8)

Farmland Innovator: A Story about Cyrus McCormick

Welch, Catherine A. 2007 (AR - 5.2)

Career Profile:

MARY KNAPP

State Climatologist

If a farmer wonders what the probability of drought is in the coming year, he or she might call Mary Knapp for the answer.

Knapp is a climatologist for the state of Kansas. She works from the Weather Data Library at Kansas State University, merging pieces of information to answer questions about weather and how it affects the citizens of Kansas and the agriculture of the state.

"It's like solving a huge puzzle," Knapp says. "I really like my job."

Knapp herself began asking questions about the weather early on. "I was just always interested in that sort of thing—weather and its effect on every aspect of life. In 1966, a major tornado had devastating effects on Topeka and its surrounding areas. It left a lasting impression. During high school in Junction City, I did a science fair project on weather modification by cloud seeding and the legal aspects of altering the climate," she says. "It made a big impact."

Knapp attended Kansas State University majoring in agronomy because of the variety of coursework and the diversity of opportunities available to its students and its graduates and its ability to "take you places."

After graduation, Knapp worked as a Peace Corps volunteer on a rice growing project in the Dominican Republic. To ensure the success of the crop, the growers needed to know about the crop itself, but in addition they needed information about the cultural practices of the area, the issues within the community, and the weather and microclimate of the country.

After her volunteer experience, Knapp returned to Kansas State University to work for the department of entomology and then moved to the newly formed department of communications. She subsequently took the job as state climatologist.

Among her primary responsibilities is the duty of sharing information about the weather with the people across the state. Because weather conditions affect crops in many ways, farmers pay particular attention to the information Knapp and her colleagues provide.

"We try to get the truth out," Knapp says. "Kansas has a variable climate. We try to help people think about weather outlooks, maybe consider crops in areas that traditionally haven't grown them before."

To answer someone's query, Knapp looks for the data, using many sources and computer models. The questions she asks are varied: Can we grow cotton further north? Are we fighting invasive species or are we bringing them in? What do we need to consider when we start problem solving? Are we even asking the right questions?

Other things to consider are the sources of the data and its possible bias. "Does the logic need to be questioned?" Knapp asks.

She says climatologists follow a standard learning model: "It's very important to take the time to investigate, explore, and evaluate. That's the only chance to really get answers."

With technological advances and the extensive use of computers, Knapp's job has changed over the years. There was a "huge language gap" between the scientists in agriculture and the computer specialists when she began her job.

"When I first started, desktop computers weren't available," she says. "I have tried to fill the gap between those who know how to use computers with the science needed to use them for that. We are trying to merge data from water, plants, economics, weather, insects, and lots of other fields to try to answer questions in agriculture."

Knapp cautions that one has to take care not to make drastic conclusions and provide quick solutions to fix what can be regarded as a problem. "I think there are a lot of uncertainties about global warming, and our data is for such a short time, really," Knapp says. "When people tamper with nature, they may end up with larger issues than they even knew they had to begin with...we should be wary of 'fixing' what we don't know a lot about yet. Each one of us can do things to minimize our impact on the environment, while trying to increase our understanding of how it works."

Knapp is undaunted by the challenge of constantly merging information and then offering answers. "People ask tough questions about weather—some of the data we have and some of it isn't to be found yet," Knapp says. "To do this job, I recommend the ability to communicate—a desire to know about things—a curiosity and persistence to always be asking questions."



Credit: Barbara Oplinger

TEACHER'S RESOURCES (CONTINUED)

From Seed to Plant

Gibbons, Gail. 1993 (AR - 3.4)

George Washington Carver What Do You See?

Benge, Janet. 2003 (AR - 5.0)

The Gristmill

Kalman, Bobbie. 1990 (AR - 5.3)

Haystack

Geisert, Arthur. 2003 (AR - 3.4)

The Honey Makers

Gibbons, Gail. 2000 (AR - 4.8)

How It Happens at the Cereal Factory

Rocker, Megan. 2004 (AR - 5.4)

How Plants Survive.

Kudlinski, Kathleen V. 2003 (AR - 4.6)

Kansas Crops Showcase:**WHEAT GENOMICS LABORATORY
AT KANSAS STATE UNIVERSITY****Department of Plant Pathology**

Crop loss can be devastating in an economic sense to a farmer, but it may also trickle down to higher priced groceries at the store and hungry people worldwide.

Scientists at the Wheat Genomics Laboratory at Kansas State University are trying to help wheat breeders avoid problems like crop loss and accentuate the positive characteristics of what is the most consumed cereal grain. By studying the specific gene order, scientists can find answers to the problems that plague a wheat crop, such as diseases, insects, and low yields. In the future, the possibilities an accurate genome map could help produce are varied: for example, a grain that has higher protein content or exhibits more cancer fighting traits for those who eat it, or a wheat that can be grown in the desert, requiring less land and less water.

The Wheat Genomics Laboratory is actually several labs in which researchers work on different projects that reveal certain aspects of wheat's genetic code. A bigger picture results as the findings of each lab are compiled. One of the goals of the research is to share the discoveries to enhance others' knowledge of the structure and function of a plant's genome.

The rooms that make up the Wheat Genomics Laboratory may look like conventional labs, but some contain large, highly specialized equipment including an Q-bot, a \$250,000 robot which is used to automate the picking of bacterial colonies that are used in DNA cloning, and an Applied Biosystems DNA sequencer, used to read the DNA sequence of a clone.

John Fellers, USDA Research Molecular Biologist in the Department of Plant Pathology, says that there are around 100 people working at any one time, most of whom have a background in genetics, biology, plant pathology, and biochemistry. Many are educators and international students. Fellers grew up on a farm and says that has contributed to his excitement about the lab work. "I can see the impact and possibilities that my work has on agriculture."

Fellers' main project deals with wheat leaf rust, a fungi that can spread through a wheat field and be carried across countries and continents if conditions are right. Leaf rust can cause a 20 percent crop loss. The reddish-orange pustules that form on the wheat leaves are filled with spores that spread easily. Leaf rust causes both the infected leaves to die prematurely and all the nutrients to go toward the fungi rather than toward grain production.

An accurate genome sequencing map can help wheat breeders utilize the plant's own resistance to invaders like rust. When an infestation occurs, the plant can sometimes stop the spread by killing the cells around the point of infection.

"It is like a lock and key, where the lock is the resistance gene in the plant and the key is a protein in the pathogen," Fellers says. "If they fit together, you get resistance, but if something doesn't fit or is more or less powerful in the lock or the key, you get infection."

Some wheat varieties are less likely to develop leaf rust, but the resistance lasts only a few years. With a genome sequencing map, the scientists hope to find the exact spot where the resistance takes place and capitalize on it through biotechnology.

"Plants get sick. They get fungal, bacterial, viral, and insect infestations just like people do," Fellers says. "However, they don't have a circulation system, so you can't immunize them against disease, and they can't swat away insects. The plants just have to sit there and take it."



John Fellers in the Wheat Genomics Laboratory

Credit: Julia Stoskopf-Debes

The Life and Times of the Honeybee

Micucci, Charles. 1997 (AR - 5.2)

The Life Cycle of a Sunflower

Tagliaferro, Linda. 2007 (AR - 1.5)

Pancakes, Pancakes!

Carle, Eric. 2005 (AR - 3.2)

Plant Development *

Hopkins, William G. 2006

The Story of George Washington Carver

Moore, Eva. 1990

The Super Soybean

Bial, Raymond. 2007

A Weed Is A Flower: The Life of George Washington Carver

Aliki. 1988 (AR - 4.3)

Kansas Crops Showcase:

ETHANOL

Ethanol (ethyl alcohol) is a grain alcohol produced from crops high in starches or sugars. Most of the ethanol produced in the United States is made using corn. However, ethanol can be produced from any starch-rich material, including grain sorghum, wheat, barley, and potatoes. Sugar cane is used to produce ethanol in Brazil, which leads the world in ethanol production. Historically, more grain sorghum has been used in Kansas ethanol plants than corn. The two grains are interchangeable in the ethanol-making process.

Cellulosic Ethanol

Researchers are developing methods to produce cellulosic ethanol, which would be made from materials high in cellulose, such as wheat straw, corn stover, milo stalks, wood chips, and grasses. In August 2007, Abengoa Bioenergy announced plans to build a cellulosic ethanol plant at Hugoton as well as a grain-based ethanol plant at the same location. The company received funding from the U.S. Department of Energy to develop the cellulosic plant. While technology is developing rapidly, no commercial-sized cellulosic plants were in operation in 2007. Most industry-watchers believe cellulosic ethanol production will become a reality in the near future.

Production Process

Most of the newer ethanol production plants use the "dry milling" method to produce ethanol from grain. A bushel of corn or grain sorghum produces 2.8 gallons of ethanol during an eight-step process that takes several days.

STEP 1. MILLING

The grain is ground into small particles. This exposes the starch, which will be used for the fermentation process. The starch is removed and milled into a fine powder. The remaining material—protein, fiber, vitamins, and minerals—is used for livestock feed.

STEP 2. COOKING

The starch powder is mixed with water and an enzyme that helps break the starch into smaller particles. The resulting mash is cooked to liquefy the starch and reduce bacteria levels, before being heated to 225 degrees to help break the starch down further.

STEP 3. CONVERSION

The mash is removed from the cookers and cooled. Then a second enzyme is added to help convert the liquid starch into a sugar (dextrose) that can be fermented.

STEP 4. FERMENTATION

The mash is mixed with yeast, which changes the sugar to ethanol and carbon dioxide. It takes about 48 hours for the mash to ferment.

STEP 5. DISTILLATION

The fermented mash contains about 10 percent ethanol. To separate the ethanol from the water and any remaining solids, the mixture is heated to a temperature at which ethanol vaporizes. The ethanol vapor is collected. As it

cools, it condenses and becomes a liquid. The solids become distillers grain, a nutritious livestock feed. The carbon dioxide is collected, purified, compressed, and sold for many uses, such as carbonated beverages, dry ice, food processing, and petroleum extraction.

STEP 6. DEHYDRATION

To purify the ethanol and remove any remaining water, the ethanol passes through a dehydration system. After this step, the ethanol is approximately 200 proof.

STEP 7. DENATURING

A small amount of gasoline is added to the ethanol (2 percent to 5 percent) to make it unfit for human consumption—a requirement for all fuel-grade ethanol.

STEP 8. PROCESSING AND DISTRIBUTION OF COPRODUCTS

For every bushel of corn or grain sorghum used in the production of ethanol, one-third becomes ethanol, one-third becomes distillers grains, and one-third becomes carbon dioxide.

History

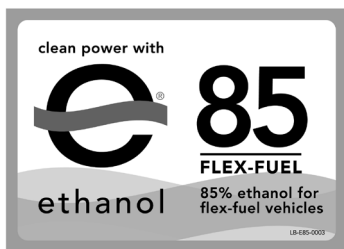
Ethanol has been used in the United States since 1826 when inventor Samuel Morey first used it as a motor fuel. In the 1850s, ethanol was a popular fuel for lighting in homes. Henry Ford's first automobile, designed in the late 1880s, ran on pure ethanol. In 1908, he designed the "Model T" to run on pure ethanol, gasoline, or a blend of the two fuels. However, just as the use of ethanol was gaining momentum in the United States, it was banned during Prohibition. Because it was considered liquor from 1919 until 1933, the only legal way to sell ethanol in the United States was to mix it with petroleum fuel. Ethanol production increased, particularly in the Midwest, but dropped dramatically starting in the mid-1940s due to low prices for petroleum-based fuels. Interest in ethanol production revived in 1973 as the result of an OPEC



Ethanol Fermentation

Credit: ICM, Inc.

(Organization of the Petroleum Exporting Countries) oil embargo. Legislation intended to reduce pollution led to increased acceptance, use, and production of ethanol. In 2005, legislation passed that



required the use of 4 billion gallons of biofuels in the U.S. fuel supply beginning in 2006 and 7.5 billion gallons by 2012. Today, ethanol is blended into nearly 50 percent of the fuel supply in the United States. Any vehicle requiring unleaded gasoline can operate on E10, a blend of 10 percent ethanol and 90 percent unleaded gasoline. Flexible Fuel Vehicles can operate on unleaded gasoline blended with ethanol percentages as high as 85 percent, known as E85 fuel.

Environmentally Friendly

In engines, ethanol burns much cleaner than petroleum-based gasoline. When ethanol is blended and used with gasoline in automobiles, carbon monoxide and hydrocarbon tailpipe emissions are significantly reduced. In 2005, the U.S. Department of Energy estimated that the use of ethanol-blended fuels reduced carbon dioxide emissions equivalent to those produced annually by over 1 million automobiles.

The quantity of water used by an ethanol plant may be a concern and is addressed during the site selection process. Most modern ethanol production plants re-use the water that circulates through boilers and cooling towers during the heating and cooling processes involved in ethanol production. Water that comes into contact with the grain and contains dissolved solids may be concentrated into a syrup and added to distillers grains. Systems that do not discharge any liquid water from the fermentation process into the environment are under development. New technologies continue to improve the utilization of water in the ethanol-making process.

Kansas Impact

By January 2008, the 11 ethanol plants in Kansas were capable of producing over 439 million gallons of ethanol each year. With other plants in various stages of planning and construction across Kansas, ethanol production in the state continues to increase.

The rapid expansion of the ethanol industry is creating a high demand for skilled workers who are educated and trained for a variety of positions including electricians, shipping and receiving operators, microbiologists, chemists, engineers, and marketing professionals. New career opportunities are being created across Kansas and other states in the Midwest, many near rural communities.

TEACHER'S RESOURCES (CONTINUED)

WEBSITES:

The Alfalfa Factory: A Remarkable Perennial Legume Finds Many Uses

USDA Agricultural Research Service

<http://ars.usda.gov/is/AR/archive/jul02/legume0702.htm>

Cotton Counts Educational Resources

National Cotton Council of America

<http://www.cotton.org/pubs/cottoncounts/resources.cfm>

Cottonseed and Its Products

National Cottonseed Products Association.

www.cottonseed.com/publications/cottonseedanditsproducts.asp

Ethanol

National Corn Growers Association

www.ethanolfacts.com

Ethanol Promotion and Information Council

www.drivingethanol.org

The Humble Soybean

American Soybean Association

<http://66.201.71.163/soyindustry/index.htm>

Kansas Agricultural Statistics Service

Annual Statistical Bulletin - Farm Facts

(by state total or individual county)

http://www.nass.usda.gov/Statistics_by_State/Kansas/index.asp

Kansas Corn Commission

Kansas Corn Growers Association

Kansas Grain Sorghum Producers Association

www.ksgrains.com

Kansas Grain Sorghum Commission

www.ksgrains.org

Kansas Soybean Association

Kansas Soybean Commission

www.kansassoybeans.com

Kansas Wheat

www.kswheat.org

National Sunflower Association

www.sunflowerlsa.com

Weather Data Library

K-State Research and Extension

www.oznet.ksu.edu/wdl/

NOTES:





Unit 5) Forests

Kansas is usually described as a prairie state, bringing to mind wide expanses of grassland and fields of grain. Historically, periodic prairie fires kept much of the state treeless, particularly the western half. Today, Kansas has more forestland (woodland) than such states as Nebraska, North Dakota, Nevada, Delaware, and Rhode Island. According to the Kansas Forest Service, acre for acre, the forests in Kansas are some of the best and most productive in the United States.

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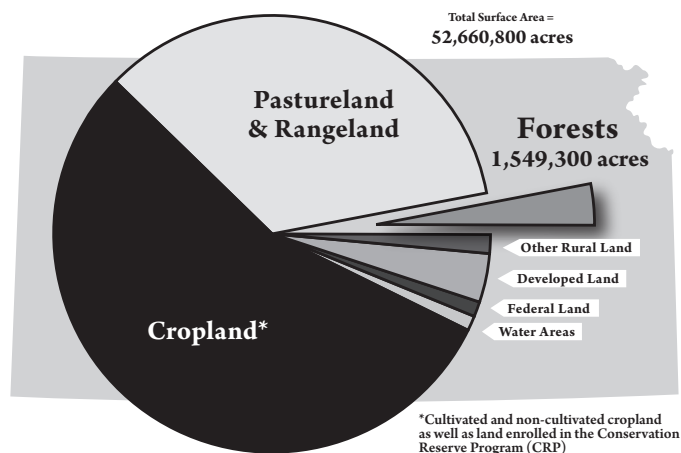
- COTTONWOOD, KANSAS STATE TREE
- THE KANSAS SILK INDUSTRY, 1870-1897

ENDNOTES

REFERENCES

TEACHER'S RESOURCES

SURFACE AREA OF KANSAS – FORESTS



Source: 2003 Natural Resources Inventory, USDA NRCS

"To exist as a nation, to prosper as a state, and to live as a people, we must have trees."

Theodore Roosevelt, 26th President of the United States

In Kansas and other Great Plains states, the central hardwood forests of the United States transition into grassland and cropland. According to the Kansas Forest Service, when European settlers came to what is now the state of Kansas, there were an estimated 4.5 million acres of forestland in the area (8.5 percent of the state's land area). By 1936, when the first recorded statewide inventory of forestland was conducted, less than 30 percent of the estimated original forestland acreage remained.¹ Since then, forestland in Kansas has steadily increased in size. According to the 2005 Kansas Forest Inventory, forestland covers 2.13 million acres in Kansas, over 4 percent of the state's total land area. However, the statewide inventory does not include all the trees in Kansas, only those meeting a specific criteria based on the size of area covered by trees and the density of the trees within that area.

The majority of the forestland in Kansas is found in the eastern one-third of the state, most of which is adjacent to streams and rivers.

TREE TALK

"The creation of a thousand forests is in one acorn."

Ralph Waldo Emerson, American essayist, poet, and philosopher

DEFINITION OF A TREE

It isn't always easy to define what a tree is. Not all trees are tall. The dwarf prairie willow, which is common in the sandy areas of Reno and



Tree Growth

Source: USDA NRCS

Harvey counties and is often found in the sandstone areas of eastern Kansas counties, may only grow to be 18–39 inches tall. Some trees, like the saguaro cactus, have spines rather than leaves or needles.

However, trees do share some characteristics that distinguish them from other plants. For example, a tree has one main woody trunk that supports the structure of the entire tree. A tree stands on its own roots and as the crown (upper branches and leaves) of the tree spreads, the roots extend to keep up with the circumference of the crown. The total root spread of a tree under the ground can actually be far wider than the crown of the same tree. Since tree roots need oxygen as well as water, the majority of a tree's roots will grow just above the level below which the soil is permanently wet. Most trees will drown if their roots are submerged in water for very long so a tree will spread its roots over a large area to capture as much of the rainwater that soaks into the ground as possible. This also allows a tree to collect nutrients and water from a much larger area than most plants.

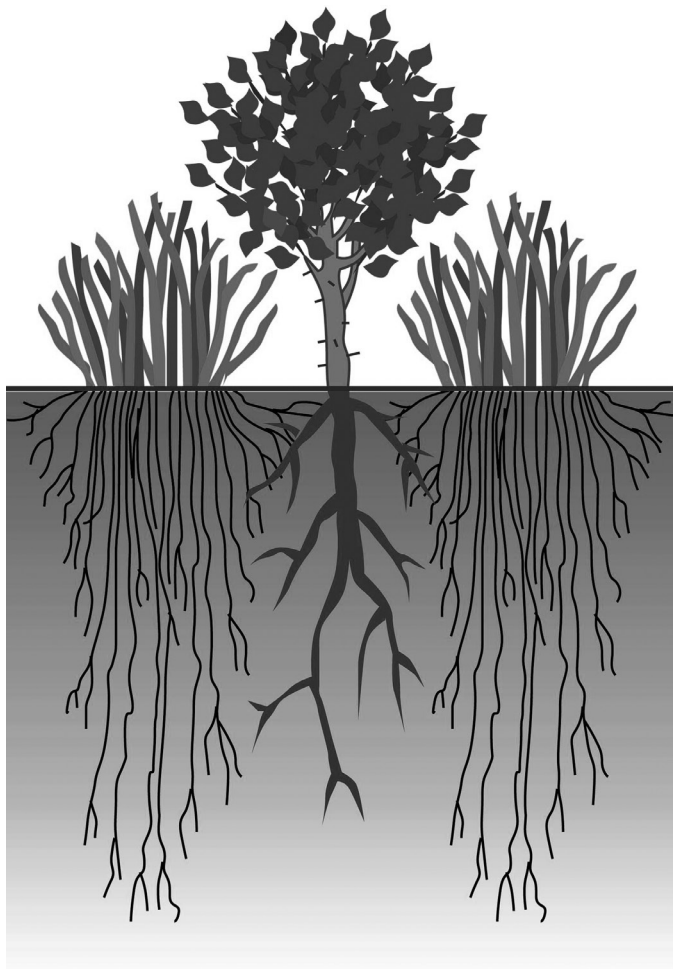
Trees also live longer than most other plants. Trees are a type of perennial but unlike iris or tulips, trees do not die back each year. Many trees do become dormant each winter but the trees remain alive and continue to grow taller and thicker each year. Annual extensions of the twigs become branches and then huge limbs—building the framework of the tree taller and wider if space allows.



Seeds

Source: USDA NRCS

TREE VS. PLANTS COMPARISON

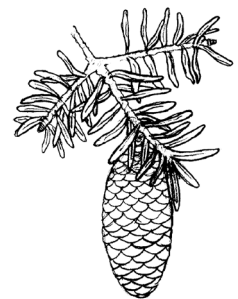


Source: USDA NRCS

CLASSIFICATION OF TREES

Worldwide, there are over 20,000 different species of trees. Over 800 different species grow in North America. Over 125 different species of trees grow in Kansas. The types of flowers and seeds trees produce (if any), how they reproduce, and how they grow are used to categorize trees. Labels, such as coniferous or deciduous, broad-leaved or needle-leaved, and hardwoods or softwoods, identify categories of tree species. The terms “hardwoods” and “softwoods” are especially confusing because these terms refer to broad categories of tree species, rather than specific trees based on the hardness or the weight of the wood produced from those trees.

Coniferous trees are also called conifers. Most conifers have thin, needle-like leaves. Pines, hemlocks, redwoods, spruces, and firs are all types of conifers. Conifers bear (produce) cones. Some of the cones, like juniper berries, don't look like typical “cones.” Conifers include the world's largest trees and hold all the world's age records for trees. Most needle-leaved trees are evergreens. Evergreen trees have leaves year-round rather than being bare in the winter. Evergreen trees do not drop all their needles at once.



Conifer

Source: USDA NRCS

TREE CATEGORIES

Softwoods— conifers and needle-leaved trees.

Needle-leaved— trees with thin, needle-like leaves; includes evergreens and most conifers.

Coniferous (conifers)— trees whose seeds develop inside cones; for example, pine, hemlock, redwood, spruce, and fir; considered softwoods.

Evergreens— trees that have leaves year-round; considered softwoods.

Hardwoods— broad-leaved trees.

Broad-leaved— trees with flat, broad leaves; for example, oak, willow, birch, maple, cottonwood, and palm.

Deciduous— trees that shed all their leaves every year; includes most broad-leaved trees in North America; considered hardwoods.

Instead, these trees produce new leaves each year, dropping only the oldest leaves from a two- to four-year cycle. Needle-leaved or coniferous trees are also called softwoods.

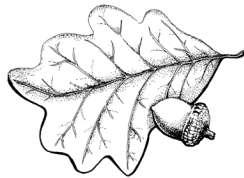
Deciduous trees are trees that lose all their leaves every year. In North America, almost all broad-leaved trees—trees with flat, broad leaves—are deciduous trees. This group includes oaks, willows, birches, maples, cottonwoods, and palms. Broad-leaved trees are also called hardwoods.

Like all plants, trees must be pollinated to produce seed to ensure continued survival of the species. Most forest trees, including conifers, are pollinated by the wind. Trees that need to attract insects to carry their pollen often grow at the edge of the forest. Honeybee hives are often placed in or near orchards to ensure proper pollination of fruit trees.



Evergreen

Source: USDA NRCS



Deciduous (Oak Leaf)

Source: USDA NRCS



Apple Blossom

Source: Wm. E. Carnahan, USDA

Forest— an area with trees.

FORESTS IN KANSAS

"Reading about nature is fine, but if a person walks in the woods and listens carefully, he can learn more than what is in books..."

George Washington Carver, American agricultural chemist and inventor (attended school and lived in Minneapolis, Kansas)

What is a forest? There are over 250 definitions of the word "forest," but the presence of trees determines whether an area is a forest. Basically, a forest is an area with trees. The statewide inventory of Kansas forest resources does not include all trees in Kansas, only those meeting a specific criteria. In Kansas, the inventory of forest resources includes timberlands, windbreaks, riparian forests, tree farms and tree plantations, orchards, and urban and community forests. The inventory does not include trees growing on Christmas tree farms, living snow fences, or trees growing on private property in towns and cities.

TIMBERLANDS

Timberlands are areas capable of producing wood for commercial and industrial uses. The timberlands along the eastern border of Kansas are actually part of the western margin of the large eastern deciduous forest of the United States. In Kansas, most timberland stands are of natural origin and are mainly hardwoods. Planted timberlands are almost always species such as black walnut that are highly valued for the lumber. Each year, Kansas timberlands grow enough wood to build 1,000 homes.²

WINDBREAKS

Windbreaks, also called shelterbelts, are trees planted in single or multiple rows spaced at regular intervals. The number of windbreaks in Kansas dramatically increased after the devastating dust storms of the early 1930s in an effort to minimize wind erosion and further loss of valuable topsoil. When wind speeds exceed 13 miles per hour, fine soil particles move easily. A windbreak reduces the speed of the wind and can reduce the impact of the wind over a horizontal distance from 10-30 times the height of the trees growing in the windbreak.

KANSAS INVENTORY OF FOREST RESOURCES

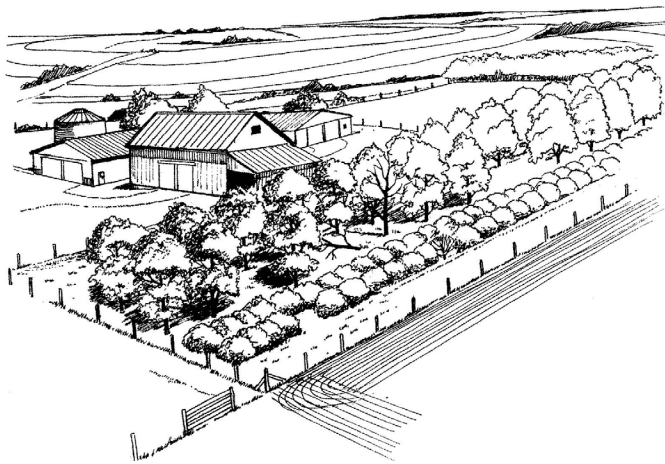
INCLUDED:

- timberlands
- windbreaks
- riparian forests
- tree farms
- tree plantations
- orchards
- nut farms
- urban and community forests

NOT INCLUDED:

- Christmas tree farms
- living snow fences
- trees on private property in towns or cities

Source: Kansas Forest Service



Windbreak

Source: USDA NRCS

This also reduces the drying effect of the wind and slows the loss of soil moisture. According to the Kansas Forest Service, Kansas has more than 78,000 windbreaks that cover 114,000 acres. The combined length of the windbreaks in Kansas is more than 20,000 miles³ and more windbreaks are being planted each year. These windbreaks provide important travel corridors for wildlife, as well as wildlife habitat for many species.

In the winter, windbreaks trap and retain moisture from winter snows, increasing soil moisture. Windbreaks also protect crops, farmsteads, and livestock from chilling winds. By reducing the velocity of winter winds, windbreaks significantly lower stress on livestock and reduce feed energy requirements. The results are better animal health, lower feed costs, and increased profitability for agricultural producers.

RIPARIAN FORESTS

Ribbons of forested habitat follow major streams and rivers throughout the state of Kansas, even those areas that are susceptible to periods of drought. Areas of trees and shrubs that grow naturally along streams and rivers are called riparian shrublands or riparian forests, depending on the type of vegetation growing in the area. Riparian areas that are planted to shrubs or trees and related plants are called riparian forest buffers or riparian forest buffer strips. These streamside forests slow the flow of excess rainfall over the land and are designed to catch soil and excess nutrients before they enter the stream or river and are carried downstream.

Research has proven that trees stabilize streambanks better than other types of vegetation. Tree roots hold the soil in streambanks in place during periods of heavy rainfall or snowmelt, reducing the amount of sediment that enters the water and protecting water quality downstream. Riparian forest buffers



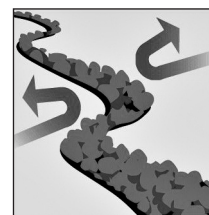
Riparian Forest

Credit: Julia Stoskopf-Debes

planted between cropland and streams can reduce fertilizer, pesticide, and sediment runoff into streams by as much as 90 percent, according to the Kansas Forest Service.

The use of riparian buffers is not limited to agriculture. Nonpoint source pollution, the leading cause of water quality problems, comes from both rural and urban sources. For example, a riparian buffer might be planted between a large parking lot and an adjacent stream. As contaminants such as oil, antifreeze, paper trash, mud, salt, and animal wastes are washed out of the parking lot by rainfall, the trees, shrubs, and other plants in the riparian buffer would collect debris and filter the water before it entered the stream. The quality of the water in the stream would be improved, not only for that community, but also for other communities downstream.

Riparian forest buffers also trap and filter flood debris. The stiff stems of trees and shrubs resist and slow the speed of water coming out over the banks of a stream or river during a flood. Trees reduce flood damage by keeping unwanted debris out of fields and communities. By slowing the flow, trees also help to store floodwater and recharge groundwater supplies.



Riparian Buffer

Source: FISRWG

TREE FARMS

Tree farming in Kansas is rooted in the Homestead Act of 1862 that opened the Kansas Territory for settlement and land ownership. Newspapers and land agents encouraged prospective settlers to bring fruit trees and shrubs with them. Settlers and immigrants planted trees and orchards to recreate the familiar landscapes they had left behind and also to provide food and income. The Timber Culture Act of 1873 provided free land if 40 acres of the homestead claim was planted to trees that were kept in growing condition for 10 years. An amendment to the act in 1878 reduced the requirement to 10 acres. Kansas had more timber claims filed than any other state. In Kansas, land patents from timber claims were issued for over two million acres.⁴ Trees commonly planted on timber claims included cottonwood, mulberry, ash, locust, Osage orange, catalpa, and hackberry. Remnants of the homesteaders' trees can still be found throughout Kansas.

The statewide inventory of Kansas forest resources includes trees found on nut farms and in orchards. According to the U.S. Department of Agriculture, pecans are the only



Honey Locust

Credit: Wayne Stoskopf

TIMBER CLAIMS

Kansas had more timber claims filed than any other state under the provisions of the Homestead Act of 1862 and the Timber Culture Act of 1873.

Source: Kansas Forest Service

AGRICULTURAL CROPS

Fruit, nuts, and Christmas trees are considered agricultural crops, rather than horticultural crops, in Kansas.

Source: Kansas Agricultural Statistics Service

native tree nuts grown for commercial use in the United States. The U.S. is the world's largest pecan producer. According to the Kansas Agricultural Statistics Service, the pecan is the most important commercial nut crop in Kansas. Hazelnuts (filberts), almonds, and English walnuts are also grown in Kansas. The black walnut is a valuable timber tree that is native to Kansas and the nuts are also collected and harvested in Kansas. Most commercial orchards in Kansas are apple orchards or peach orchards.

In Kansas, nuts, fruit, and Christmas trees are all considered agricultural crops. However, the trees growing on Christmas tree farms are not included in the statewide inventory of forest resources.

URBAN AND COMMUNITY FORESTS

Urban and community forests encompass all the trees, shrubs, and associated vegetation in and around population areas, ranging from small towns to large metropolitan areas. This includes trees growing on street right-of-ways, in parks and cemeteries, in recreational areas, and on other public properties. Trees in communities and urban areas reduce the rapid



**State Champion Water Oak,
Pittsburg State University**

Credit: Kansas Forest Service

runoff from rainstorms, improve air quality by providing wind protection and filtering the air, and reduce energy consumption by providing shade and reducing wind speeds. A number of scientific studies have found additional health and social benefits produced by community forests, including a greater sense of community, more social interaction, lower crime rates, reduced mental fatigue and irritability, and reduced stress levels. Currently, the urban and community forests in Kansas occupy approximately 1.5 million acres and continue to expand rapidly.

While not counted as part of the urban and community forests in the statewide inventory, trees on private property provide similar health and social benefits. In addition, according to K-State Research and Extension, homeowners can reduce annual home energy costs by as much as 25 percent with the correct use of trees around a home. Carefully placed trees can provide cooling summer shade, protection from chilling winter winds, and can maximize heating from winter sunlight.

LIVING SNOW FENCES

Living snow fences may look similar to windbreaks but they serve a different purpose. Living snow fences are rows of trees and shrubs planted to keep snow off roads, reducing snow-removal and

related energy costs and making the roads safer for winter driving. Living snow fences may be narrower than windbreaks, containing fewer rows of shorter trees and shrubs. Living snow fences were first planted in the 1900s to protect railroad lines and major highways. According to the Nebraska Forest Service, a living snow fence can capture up to 12 times more snow per foot of height than a slatted or picket fence and can have a service life of up to 75 years. Living snow fences are not included in the statewide inventory of forest resources in Kansas.

NATIONAL FORESTS IN KANSAS

At one time, there was a national forest in Kansas, according to the Kansas State Historical Society. In 1905, President Theodore Roosevelt signed an Executive Order creating the Garden City Forest Reserve, reserving 30,000 acres for the federal government from homesteading claims. In 1906, the government planted the first 80,000 trees on the forest reserve. In 1908, the area was expanded to encompass 302,000 acres in Finney, Kearny, Hamilton, Grant, and Haskell counties. It was renamed as the Kansas National Forest. Although thousands of trees were planted in the artificial forest, very few survived. In 1915, President Woodrow Wilson ordered the experiment stopped and almost all of the land was made available for homesteading.

The National Forest Service does own and manage the Cimarron National Grasslands near Elkhart, which encompasses 108,175 acres. Located in Morton and Stevens counties, this is the largest parcel of public-owned land in Kansas. The third highest point in the state of Kansas is located on the area.

THE KANSAS NATIONAL FOREST

1905— presidential executive order creates "Garden City Forest Reserve."

1908— renamed as the "Kansas National Forest."

1915— national forest abandoned; land made available for homesteading

FOREST ECOSYSTEMS

*"The monarch oak, the patriarch of the trees,
Shoots rising up, and spreads by slow degrees.
Three centuries he grows, and three he stays
Supreme in state; and in three more decays."*

John Dryden, English poet and dramatist

Each area of land where trees are growing is an ecosystem, formed by the interaction of all the living organisms and the physical and chemical factors in the environment in which the organisms live. Forest ecosystems can be described as layers of trees and plants or divided by the functions of the organisms living in the forest.

Water is an important part of any forest ecosystem—not just for the trees and organisms living in the forest but also for people living far beyond the forest's boundaries. The headwaters for nearly all of the major rivers in the United States are found in forests. About two-thirds of the United States' freshwater originates on forested lands. The forests in Kansas are significantly affected by the availability of

Forests

rainfall. In areas of greater rainfall, there are more trees and plants so the trees tend to grow taller as they compete for sunlight, rather than water. In areas of the state where there is less water, there is less competition for sunlight so trees and plants grow lower to the ground and the roots penetrate deeper in the soil in search of water.

Forests also provide valuable wildlife habitat. Some Kansas woodland animals are more abundant today than ever before due to the expansion of woodlands over lands that were originally prairie.

FOREST LAYERS

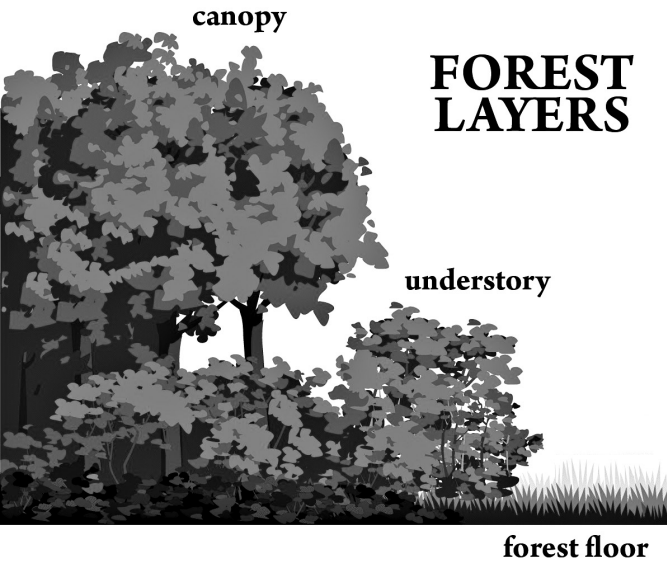
All forests are made up of layers of plants. There are three main layers: the canopy, the understory, and the forest floor. However, the number of layers in an individual forest will depend on several factors, such as the age of the forest and the climate.

The canopy layer is the top layer of the forest, composed of the branches and leaves of the tallest trees. The canopy receives the most sunlight so it is the food-making layer of the forest. During photosynthesis, the tree's chlorophyll—the green pigment in leaves that captures sunlight's energy—works with the water and carbon dioxide absorbed by the tree to produce the sugars that feed the tree, and oxygen is produced and released by the tree's leaves.

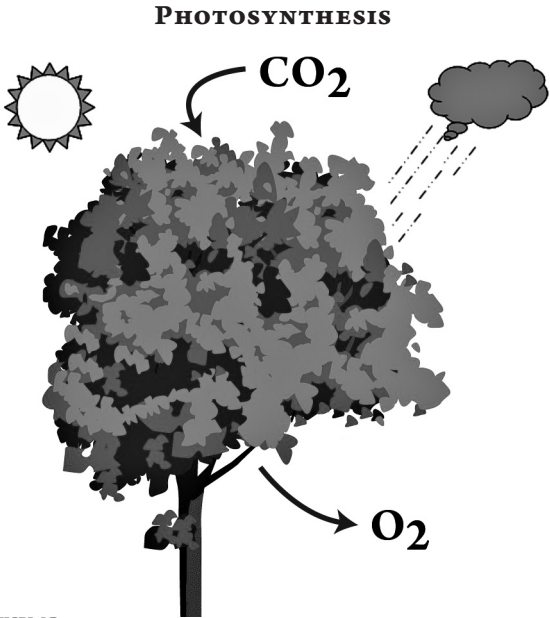
When a tree takes carbon dioxide out of the atmosphere through the process of photosynthesis, carbon is stored in the wood of the tree. This storage of carbon is called carbon sequestration. The carbon is not released back into the atmosphere until the wood decomposes or the wood is burned. According to the Society of American Foresters, one mature tree absorbs approximately 13 pounds of carbon dioxide over one year's time. Through photosynthesis, trees also filter other nutrients and pollutants out of the earth's atmosphere and store those in the wood.

When it rains in a forest, the canopy plays a significant role in reducing soil erosion. Most of the rainfall does not strike the soil directly. Instead, the rain is intercepted by the tree canopy where the leaves absorb the impact of the raindrops.

The term "understory" refers to the layers growing under the canopy trees. A layer of trees makes up the top layer of the understory. This layer may include offspring of the canopy trees that may eventually grow tall enough to become part of the canopy themselves,



Source: FISRWG



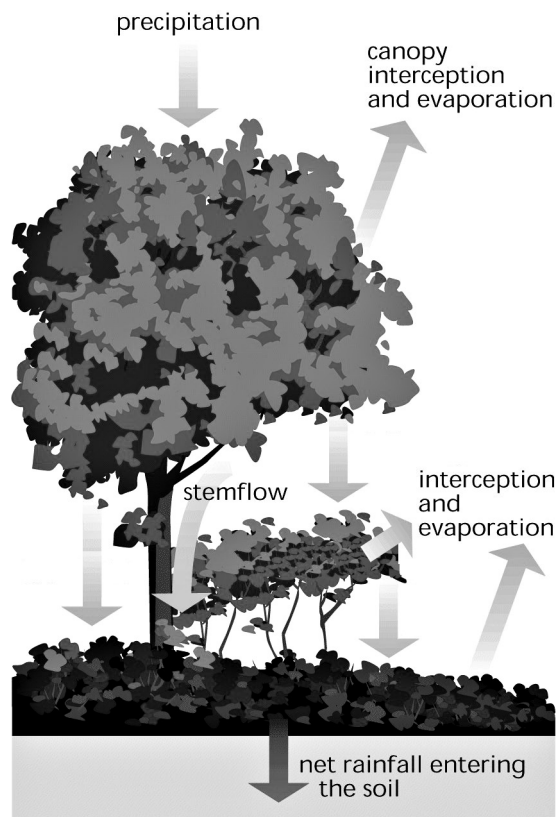
Source: FISRWG

as well as smaller trees of different species that have adapted to growing in the shade of the taller canopy trees. The understory may also include a layer of shrubs—woody plants that have many stems. The next layer down may include grasses, ferns, wildflowers, seedlings, and other smaller plants. When it rains, the layers of vegetation in the understory help absorb the impact of the raindrops and cushion the impact of the water striking the forest floor.

The forest floor is the bottom layer of the forest. Fallen branches and leaves, mosses, and woody debris can be found on the forest floor. An average large, healthy tree that lives for 60 years could grow and shed 3,600 pounds of leaves (2,000 leaves per year).⁵ As they decompose, those leaves are returning nutrients to the soil around the base of the tree each year. The layers of vegetation and the debris covering the forest floor protect the soil from extreme temperatures. The decaying leaves and organic matter on the forest floor cushion falling raindrops. On forested land, the flow of excess water across the surface of the land is slower. The roots of the trees also secure the soil against the forces of wind and flowing water, significantly reducing soil erosion.

By slowing runoff, plant debris on the forest floor allows sediment and sediment-bound nutrients or contaminants to settle on the surface of the forest floor, building layers of soil. Tree roots catch the soil particles and bind them together. Root growth and plant residue improves the soil structure. Some water slowly filters down to the soil layer and seeps into the soil and replenishes the groundwater. Nutrients and contaminants are immobilized in the soil layer,

FOREST LAYERS
<i>Canopy</i> — top layer of tallest trees.
<i>Understory</i> — often more than one layer; smaller trees, shrubs, and plants, such as weeds, wildflowers, ferns and grasses.
<i>Forest floor</i> — bottom layer; fallen leaves, moss, and woody debris.

RAINFALL INTERCEPTION

Source: FISRWG

processed by soil microbes or absorbed by plants and trees as they pull water into their roots.

Water is pulled into a tree's roots, up through the trunk to all the branches and through the smaller branches and twigs to the leaves. At openings along the surfaces of the leaves, transpiration occurs. Water is drawn from the leaves and released back into the atmosphere to fall again as rain or snow, completing the hydrologic cycle.

THE FOREST SYSTEM

Another way to describe a forest is to view it as an ecosystem and classify the organisms in the ecosystem by their functions: producers, consumers, or decomposers.

In a forest ecosystem, the producers are the trees and other green plants that make food through the process of photosynthesis. As a tree grows, it collects minerals and nutrients from the soil and

**Producers: Trees**

Source: USDA NRCS

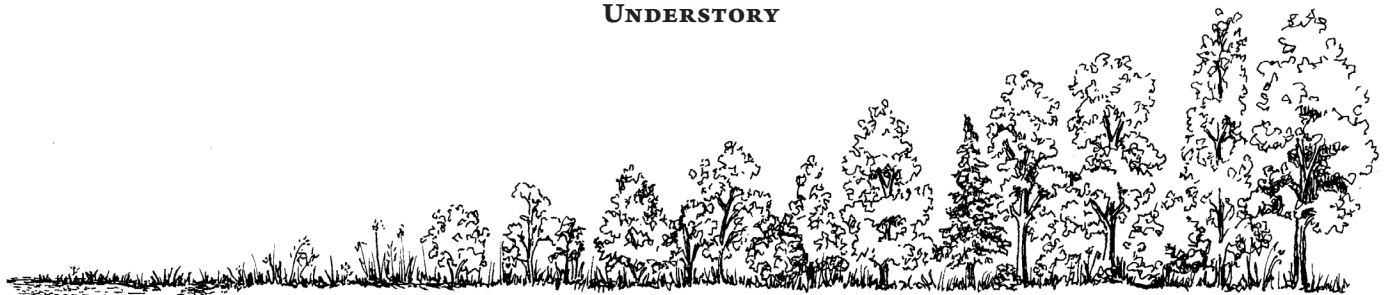
air around it. These nutrients, including carbon, nitrogen, and phosphorus, are used by the tree to make new bark, roots, leaves, branches, twigs, and wood.

In a forest ecosystem, the consumers include living organisms that feed on the trees and green plants directly and those that consume indirectly by eating other organisms that have already fed on the trees or green plants. One example of direct consumption would be a squirrel that eats the pecans from a pecan tree. The coyote or hawk that catches and eats the squirrel would be an indirect consumer in the forest ecosystem, as would a woodpecker that eats the insects that are feeding on a tree. Sometimes, there is a relationship between a producer and a consumer that is necessary to the survival of one or both species. For example, the seeds of the yew tree are coated with toxins. However, fruit-eating bird species such as those in the thrush family feed on yew berries for the fleshy coating of the berries. The poisonous seeds pass through the digestive system of these birds and are "planted" throughout the forest. The yew tree would not continue to reproduce without these birds and their ability to eat the berries and remain unharmed.

**Consumer: Squirrel**

Source: USDA NRCS

The decomposers in a forest ecosystem recycle nutrients and make them available for either producers or consumers to use.

UNDERSTORY**Annual
Grass/Forb****Perennial
Growth/Forb****Shrub****Young Woodland**

Source: USDA NRCS

ORGANISMS IN THE FOREST

Producers— plants that make food through photosynthesis; includes trees and other green plants.

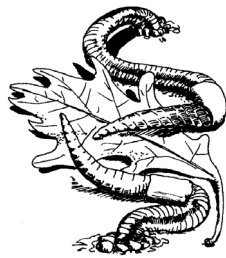
Consumers:

Direct consumers— living organisms that feed on trees and green plants; for example, squirrels, deer, termites, and wood-eating insects.

Indirect consumers— living organisms that feed on direct consumers; for example, the hawk that eats the squirrel, the coyotes that feed on a deer carcass, and the woodpecker that drills into a tree to catch wood-eating insects.

Decomposers— living organisms that recycle nutrients and make them available for producers or consumers; includes fungi, bacteria, insects, and earthworms.

Decomposers such as fungi, bacteria, and earthworms are always at work on the forest floor, breaking down the fallen leaves and woody debris into nutrients that rebuild the soil. When a tree dies, fungi, bacteria, and wood-eating insects such as termites and beetles are usually the first to feed on the dead tree. They soften the wood and the wood-eating insects create tunnels through which water, small animals, and other fungi and bacteria can enter. Some of the insects lay their eggs in the softened wood and the larvae of those insects then feed on the wood when they hatch. As the decomposition slowly progresses, the tree is turned into humus, a rich layer of soil.



Decomposer: Earthworm

Source: USDA NRCS

WILDLIFE HABITAT

Wildlife can be found in all types of Kansas forests, ranging from trees in city parks and farmstead windbreaks to Christmas tree farms and native timberlands. Wildlife species have three essential needs for survival: food, water, and cover. Cover is necessary for nesting, resting or “loafing,” escape, and protection from the elements. Natural or planted forestlands can be excellent wildlife habitat, providing food, cover, and travel corridors. Woodlands produce seeds, berries, leaves, nuts, and fruit, all of which can be food for different wildlife species. Some tree species depend on wildlife to distribute and “plant” seeds. For example, squirrels may hide or lose acorns, which then have a chance to grow into oak trees.



Source: USDA NRCS

Kansas forests provide critical habitat for forest-dependent species, such as the eastern spotted skunk, broadhead skink, and northern spring peeper. Kansas forests also provide important habitat for wild turkeys, deer, and squirrels. A habitat may be a large area or a single tree with the

necessary features. A web-spinning spider’s habitat might be just one branch of a large tree. Other wildlife species such as rabbits, quail, and raptors utilize the woodland edge—the border where two different types of cover come together. Dead trees provide habitat for many species. In addition to the fungi, bacteria, and wood-eating insects that feed on a dead tree as part of the decomposition process, other animals or birds make nests inside decaying trees or seek shelter there. Other species feed on the fungi, insects, or animals already living in the decaying trees. Many birds use snags—standing dead trees—for nesting sites. These birds nest in holes or cavities in the snag.



Source: USDA NRCS

Trees provide shade for streams, rivers, and wetlands. This lowers the water temperature and improves the habitat for fish and other aquatic life. The lower water temperature increases the presence of oxygen while reducing the rate of evaporation and slowing the release of unwanted chemicals from sediment. Overhanging roots provide good fish habitat while fallen leaves and small branches create organic matter, the basic food source for fish and other aquatic life. Large trees and limbs that fall into rivers and streams provide habitat for fish and aquatic organisms. Along streams or by the edges of ponds or lakes, wood ducks nest in tree cavities as high as 60 feet above the water. Once the ducklings tumble out of the nest and down to the water’s surface, they never return to the nest.



Source: USDA NRCS

WORKING FORESTS

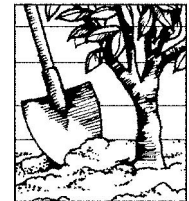
“Plant trees. They give us two of the most crucial elements for our survival: oxygen and books.”

A. Whitney Brown, actor and writer

Trees are a very useful natural resource. Even when a forest is set aside as a wilderness area, the trees feed and shelter wildlife, filter water, and store carbon while releasing oxygen and water into the atmosphere. Forests reduce soil erosion, provide recreation opportunities for people, and provide food and over 5,000 other products.

RENEWABLE RESOURCES

A renewable resource is a naturally occurring resource that can be replenished through natural cycles and management of biological growth and reproduction. Trees are a renewable resource. The forests in the United States are actually expanding, not shrinking! In the United States, 1.5 billion tree seedlings are planted each year and, according to the Society of American Foresters, more trees are grown



Source: USDA NRCS

FOREST FACT

Forests cover about one-third of the United States, about the same amount of land covered by forests 100 years ago.

Source: National Association of State Foresters

through replanting and natural regeneration than are harvested. Since 1930, 64.5 million acres of trees have been planted in the United States—an area equal in size to the states of North Carolina, Virginia, and Maryland combined.⁶ Today, forests cover about one-third of the United States, about the same amount of land covered by trees back in 1907. The 747 million acres of forestland in the United States today is approximately 71 percent as much as there was in 1630.⁷

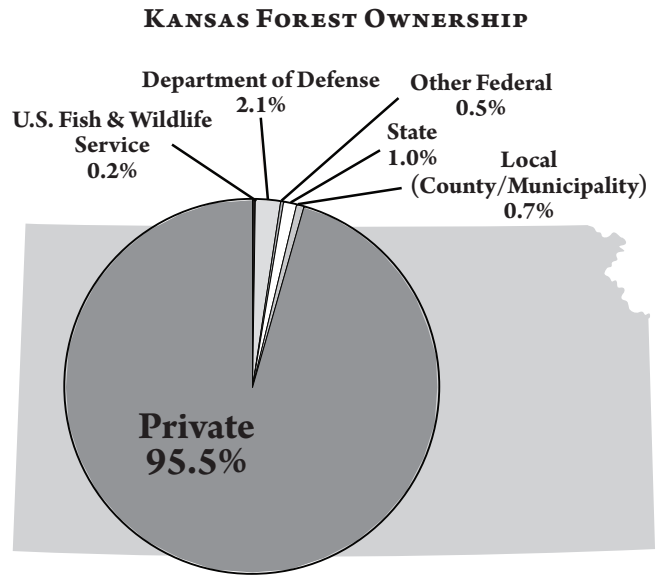
KEY WORDS
Forestry —the science of managing and caring for forests.
Silviculture —the art and science of growing and managing woodlands and forests to achieve desired outcomes.
Agroforestry —the integration of tree and shrub plantings into agricultural systems.

THE SCIENCE OF FORESTRY

In the United States, the importance of the science of forestry was not recognized until the early 1900s. Forestry is the science of managing and caring for forests. The art and science of growing and managing forests and woodlands to achieve desired outcomes is called “silviculture.”

“Agroforestry” is the integration of tree and shrub plantings into agricultural systems to optimize production and conservation benefits. Agroforestry practices include field, farmstead, and livestock windbreaks; riparian forest buffers adjacent to streams, ponds, and wetlands; woodlots and tree farms; wildlife habitat plantings; and living snow fences.

Forests may be managed to meet one, several, or many goals. The key for private landowners and public officials is to determine the goals and strike a balance between uses if there are any conflicts. Forestlands in Kansas present many of the same management challenges as larger forests in other states. However, the Kansas forestry industry is unique because over 95 percent of Kansas forestlands are privately owned and over one-half of those are 50



Source: Kansas Forest Service

KANSAS FORESTS

Over 95% of Kansas forestlands are privately owned.

Source: Kansas Forest Service

acres or less in size, according to the Kansas Forest Service. An inventory of approximately 20 percent of the forestland in Kansas is conducted each year, collecting data from identified plots using satellite imagery, remote sensing technology, and global positioning system (GPS) devices to determine the exact locations of plots not physically visited. The data is examined by researchers from the Kansas Forest Service and other state and federal agencies and used to determine changes in the size and health of Kansas forests.

Since trees require many years to mature, a forest landowner is making a long-term investment in his or her property. Forest management can involve planting, pruning, and thinning trees; removing undesirable trees; timber harvesting; road or trail construction and maintenance; application of chemicals to thwart attacks by insects or disease; and even forest fire management.

Undesirable trees are removed when they hinder the growth of new seedlings or crop trees. Crop trees are the best trees in a stand that will be harvested as logs (timber). These trees are selected because they are tall, straight, free of stem defects, have large crowns, and usually have larger trunk diameters than other trees of the same species. These trees are pruned to increase their log quality. The log produced from a tree trunk that is free of defects when the tree is harvested is worth more than a log with defects in the wood, such as lumps, bumps, or knots. Thinning removes trees that are about the same height as crop trees and is done over time to allow the crop trees to slowly adjust to the added sunlight.



Source: USDA NRCS

Mature trees are sold based on the value of the logs that can be cut from the tree. The value of the logs is based on an estimate of the lumber that will be produced from the tree, calculated using log diameter and length. Kansas has more than 70 active sawmills and timber buyers in the state. Many are small sawmills, either stationary or portable, and provide an excellent market for landowners with only a few trees to sell at a time. According to the Kansas Forest Service, wood and lumber manufacturers in Kansas employ over 3,500 people.



Sawmill

Source: Kansas Forest Service

FOREST FACTS

- More than 5,000 products are made from trees.
- Each year, the average American uses wood and paper equal to a 100-foot-tall tree with an 18-inch diameter.
- Over 50 percent of the paper consumed in the United States is recovered for recycling.

Sources: Society of American Foresters and American Forest & Paper Association

FOREST PRODUCTS

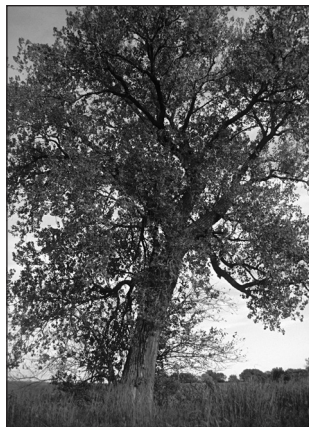
More than 5,000 products come from trees. Paper products include books, computer paper, envelopes, napkins, boxes, newspapers, and magazines. Lumber is used to build homes, shipping pallets, and fences. Other wood products include fine furniture, garden mulch, cork boards, baseball bats, and pencils. Nuts and fruits provide food for people and wildlife. Tree extracts and fibers are used in many health and food products, ranging from toothpaste and deodorant to milkshakes and cinnamon. Tree fibers are also used in carpets and fabrics, such as silk and rayon. Rubber for bicycle tires comes from the rubber tree while cacao beans from the tropical cacao tree are used to make chocolate and cocoa products. Advanced technologies have developed products so that almost 100 percent of a tree can be used when it is harvested today. Also, the need to harvest many older (taller) trees has been reduced by developing engineered wood products that are made by gluing and laminating together wood from small logs from younger trees.

According to the Society of American Foresters, the average American uses wood and paper equal to a 100-foot-tall tree with an 18-inch-diameter trunk each year. Today, most of the trees that are used to make paper are grown specifically for that purpose and harvested as a crop. Paper mills also use recycled paper, as well as wood chips and sawdust, to make new paper. Today, much of the paper used in the United States is recycled paper. Most newspapers contain recycled paper and most cereal cartons are made of 100 percent recycled paperboard, layers of paper or paper pulp that have been pressed together to make them strong. In 2005, a record 51.5 percent of the paper consumed in the U.S. was recovered for recycling—51.3 million tons, an average 346 pounds for each man, woman, and child in the country.⁸ While Kansas forests are not managed for paper production, there are many opportunities to recycle paper and wood products throughout the state.

Trees from Kansas timberlands are harvested as logs, which are processed through sawmills in the state. The sawmills process the logs into lumber, mainly for use in the furniture and pallet industries. Lumber from the Kansas state tree, the cottonwood, is used extensively in the pallet and crate industries. It is lightweight and readily available since the cottonwood is the most

Cottonwood Tree

Credit: Bob Gress, GPNC



abundant tree species in the state. In-state sawmills also market byproducts, such as wood chips, mulch, sawdust, and firewood. Higher-quality “vener logs” harvested in Kansas are shipped to other states or countries to be sliced into very thin sheets of veneer, wood which is overlaid on less expensive wood to provide an expensive-looking product for a more affordable price. Veneers are used in paneling and in the furniture industry.

Black walnut is a valuable timber tree in Kansas. However, it takes a long time before a black walnut tree is ready for timber harvest—as long as 80 years! The wood of the black walnut tree is hard and beautiful when finished. It is highly valued as lumber and veneer and is used for flooring, furniture, musical instruments, gunstocks, plaques, trophy bases, picture frames, and other novelty items. Almost every high school trophy case contains an example of this wood as the Kansas High School Activities Association has used it for all state award trophies in recent years.

Black walnuts are also an important nut crop in Kansas, with over 37 tons of black walnuts collected in an average year. The black walnut is one of the few crops still picked by hand. The shell of the black walnut is a hard, natural abrasive when ground into fine particles. It is used for polishing, to clean jet engines, as filler in dynamite, as a filtration medium, and as an ingredient in cosmetic and dental products.

Pecan trees are grown and harvested for veneer logs in Kansas. Pecans are also an important commercial nut crop. In Kansas, the pecan industry is located in the southeastern and east-central areas of the state. Kansas State University maintains a Pecan Experiment Field east of Chetopa, Kansas, where research is conducted to find pecan varieties most suitable for the growing conditions in Kansas. In 2005, over three million pounds of pecans were harvested in Kansas, according to the Kansas Agricultural Statistics Service.

The first records placing a value on orchard products in Kansas date back to 1860, and Kansas fruits have won many prizes. One of the first awards was the gold medal awarded to the Kansas State Horticultural Society for its display of fruits at the Pomological Congress in Philadelphia in 1869.⁹ Today, most orchards in Kansas are apple orchards. However, the acreage planted to apple trees has been decreasing rapidly in recent years while the acreage planted to peach trees has stayed almost the same. Kansas orchards also produce pears, plums and prunes, cherries, apricots, and nectarines.

Christmas trees are another Kansas forestry product. According to the National Agricultural Statistics Service, there are over 150 Christmas tree farms in the state. Christmas tree farming generates an estimated \$10 million in business annually in the state of Kansas.¹⁰ Before 1959, there were no Christmas tree farms in Kansas. That year,

**Pecans**

Credit: Scott Bauer, USDA ARS

**Pears**

Credit: Keith Weller, USDA ARS

the Delp Christmas Tree Farm, at St. John in Stafford County, became the first Christmas tree farm in the state. Another Christmas tree farm also started that year in Riley County but it no longer produces Christmas trees. Most farms plant seedlings or containerized trees that are 2-4 years old. Those trees will grow in the field another 6-10 years before being harvested. Some trees never grow in a good shape to be harvested for a Christmas tree and will be cut down and sold as wreaths or swags or for use as greenery.

Charcoal is also a forestry product. There is a large charcoal plant in southeastern Kansas that produces briquettes for outdoor cooking. This plant primarily uses byproducts from other sawmills. Charcoal is a fuel product. Today, in developing countries, charcoal is the main fuel people use to cook their food.

KANSAS FOREST SERVICE

"The cultivation of trees is the cultivation of the good, the beautiful, and the ennobling in man, and for one, I wish to see it become universal."

Julius Sterling Morton, Arbor Day founder

The Kansas Forest Service provides technical assistance for citizens and the forest industry and coordinates programs and activities throughout the state. The state office of the Kansas Forest Service is located in Manhattan, Kansas, and there are six district offices throughout the state. Although it is a state agency, the Kansas Forest Service is organized within Kansas State University's College of Agriculture in the Department of Horticulture, Forestry and Recreation Resources.

ARBOR DAY

J. Sterling Morton was a pioneer, journalist, and editor of Nebraska's first newspaper. In 1872, he proposed that the Nebraska State Board of Agriculture establish a tree-planting holiday named Arbor Day. Several other states also observed Arbor Day in the 1870s while schools nationwide began the tradition of participating

in Arbor Day activities in 1882. Following several years of Arbor Day contests, activities, and celebrations, Arbor Day became a legal holiday in Nebraska in 1885. At first, National Arbor Day was observed on the birthday of J. Sterling Morton, April 22nd. Today, the National Arbor Day Foundation designates the last Friday in April as National Arbor Day although some states celebrate Arbor Day at other times more appropriate for tree planting.

The Kansas Legislature has designated the last Friday in April as Arbor Day in Kansas. One program sponsored by the Kansas Forest Service is the Kansas Arbor Day National Poster Contest for fifth grade students.

TREE CITY USA

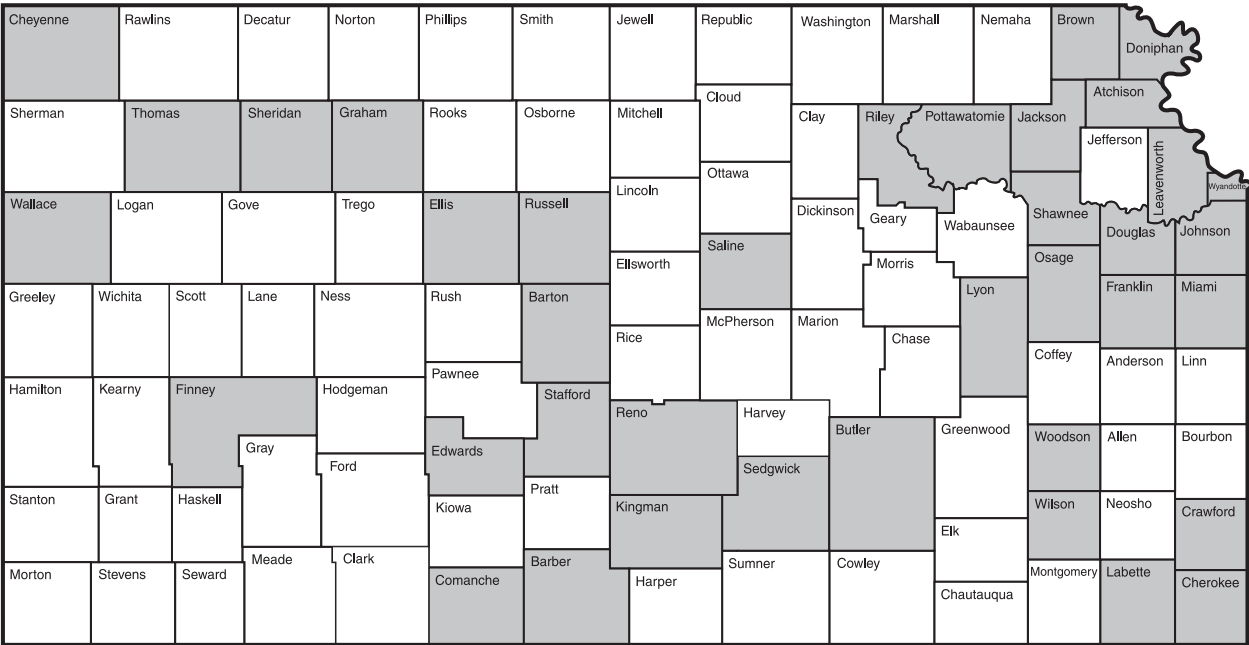
The Kansas Forest Service and the National Arbor Day Foundation sponsor the Kansas Tree City USA Certification and Recognition Program. The Tree City USA award is presented annually to communities that have outstanding tree management programs. In Kansas, 115 communities representing 70 percent of the state's population participate in the Tree City USA program.

KANSAS CHAMPION TREES

The Kansas Forest Service coordinates the Kansas Champion Tree Program. The purpose of this program is to locate and measure the largest trees of the various species found in the state. Currently, the list of champion trees includes 141 champion or co-champion trees located in 38 counties. The Kansas Forest Service's website includes an online database that lists the Kansas champion trees by both tree species and county (www.kansasforests.org).



COUNTIES WITH KANSAS CHAMPION TREES



Source: Kansas Forest Service

TREES IN OUR LIVES

"Someone's sitting in the shade today because someone planted a tree a long time ago."

Warren Buffet, American investor, businessman, and philanthropist

It may seem that the forests in Kansas are not that significant. After all, only 4 percent of the land area in Kansas is forestland while forests cover approximately one-third of the land area of the United States. Even so, Kansas forestlands provide important benefits, including wood, consumer and industrial products, wildlife habitat, erosion control, and improvements in water quality. Trees improve the quality of life in Kansas by providing scenic beauty, recreational opportunities, and protection from extreme weather conditions. Kansas may be a prairie state but Kansas forests are vital to the state's future. ■

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Career Profile:

ERIK WARREN

Artist, Erik's Originals

Erik Warren creates beautiful designs in wood every day. His artist's tool is a scroll saw, a stationary saw with a tiny vertical blade that can cut intricate designs for a wall hanging or create simple children's puzzles. The smell of aromatic cedar usually fills the air in Warren's workshop in Hays. The wood is soft, cuts easily, and does not require additional staining or painting due to the patterns and colors in the wood.

Warren's interest in the scroll saw began when he was in school over 20 years ago. He participated in a special training wood shop. At first, he was cutting boards used by other people in the wood shop. Warren became interested in their work and began using the scroll saw to produce puzzles and decorative crosses. While those are still popular, Warren's advanced skills also allow him to produce larger, more detailed pieces, such as decorative university mascots and custom pieces.

Now in his thirties, Warren's skill with the scroll saw provides an outlet for his energy, as well as a way of providing for his own future. Warren has autism, a developmental disorder that interferes with his ability to communicate with and relate to other people. His parents have worked hard to prove that a person with autism can be a productive member of society. Despite the challenges, Warren graduated from Hays High School and his family has created an environment that allows him to be a productive member of society.

Even though Warren focuses on his work for hours at a time, his work brings him pleasure. "I think his life is in his hands and when they are busy, he has peace of mind," says his father Jim Warren. Erik Warren's ability to express himself with words may be limited but his creations bring joy to many people.



Courtesy: Erik's Originals

Career Profile:**TONY DELP****Owner, Delp Tree Farm**

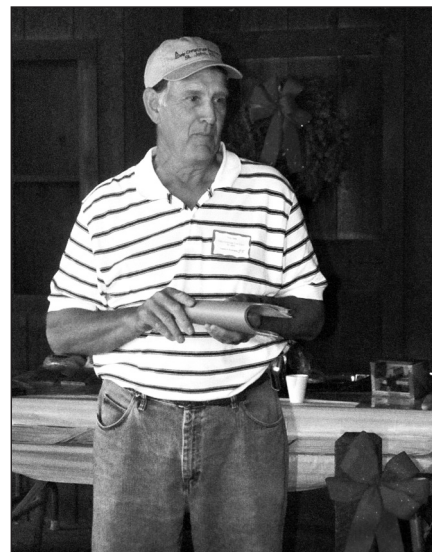
Delp Christmas Tree Farm started in 1959 and was one of the first Christmas tree farms in the state of Kansas. Cecil Delp, Tony Delp's father, got the idea of growing Christmas trees in the sandy soil near St. John while visiting cousins in the state of Michigan. That first year, Cecil Delp planted 17,500 Scotch pine trees. The Christmas tree farm became a 4-H project for Tony and his brother. They hoed the weeds between the trees—by hand—and worked on the farm during the summers.

Tony Delp went to college, graduating with a degree in mechanical engineering and lacking just a few credit hours of earning a master's degree in business administration. He worked in Dallas for seven years before deciding to return to St. John and continue the Christmas tree farm as a family business. With his wife and three sons, the farm expanded to 300,000 trees and shipped Christmas trees all over Kansas and into neighboring states. His sons grew up on the farm and ran the shearing crews, which employed as many as 30 high school students in the summer. Delp really enjoyed getting to know his sons' friends and working with the teenagers.

The Christmas tree business is very competitive and requires a long-term commitment. The Delps plant two- to four-year-old seedlings or transplants that must grow another eight to ten years before they can be harvested. Until 1981, the farm was dryland—completely dependent upon rainfall for water needs. Pipe irrigation provided more consistent water for the trees but the pipes had to be moved by hand. Each year, some trees are damaged or killed by disease or rabbits. Other trees never develop a good shape for a Christmas tree and the branches are used for wreaths and other greenery. Christmas trees are only sold during late November and December while bills must be paid and work must be done all year long to prepare for the Christmas season.

Delp had started a computer business and, in 1991, took advantage of an opportunity to work full-time at a bank in St. John. The number of trees at Delp Tree Farm was scaled back to around 15,000, where it remains today. Each year, 1,500-1,600 Christmas trees are harvested. Ninety percent of the Christmas trees are purchased by customers from the Great Bend, Pratt, and Larned areas. Other trees are shipped to garden centers and other Christmas tree farms in the state. Delp says, "We have the best customers that a business could hope for."

To stay competitive, Delp Tree Farm has chosen to grow different varieties than most of the other Christmas tree farms in the state. Placing the trees under center pivot irrigation has reduced labor costs. Delp Tree Farm continues to be a family affair, with Delp's sons choosing to come home and help at different times. "Operating the tree farm as a family has been a great experience for us," says Delp. The farm has one full-time employee, two part-time employees, and 12 seasonal employees, mostly during the Christmas season.



Courtesy: Delp Tree Farm

TEACHER RESOURCES**BOOKS:**

* *Teachers & Advanced Readers; AR - Accelerated Reading Level*

Apple Trees (AR - 4.2)

Cottonwood Trees (AR - 3.9)

Walnut Trees (AR - 4.0)

Prevost, John F. 1998

The Biography of Silk

Gleason, Carrie. 2006 (AR - 7.3)

Devouring Flames: The Story of Forest Fires

Costain, Meredith. 2006

Food Chains in a Forest Habitat

Nadeau, Isaac. 2001 (AR - 5.0)

Forest Explorer: A Life-Size Field Guide

Bishop, Nic. 2004 (AR - 5.1)

Forests

Nelson, Julie. 2001 (AR - 4.6)

A Fruit is a Suitcase for Seeds

Richards, Jean. 2006 (AR - 3.6)

How Leaves Change

Johnson, Sylvia A. 1986

In a Nutshell

Anthony, Joseph. 1999 (AR - 3.2)

The Life Cycle of a Tree

Kalman, Bobbie and Kathryn Smithyman. 2002 (AR - 5.4)

Life in a Tree

Halfmann, Janet. 2000 (AR - 5.7)

A Log's Life

Pfeffer, Wendy. 2007 (AR - 3.5)

My Favorite Tree: Terrific Trees of North America

Iverson, Diane. 1999

Old Elm Speaks: Tree Poems.

George, Kristine O'Connell. 2007 (AR - 4.6)

One Small Place in a Tree

Brenner, Barbara. 2004 (AR - 3.4)

Forests Showcase:**COTTONWOOD****Kansas State Tree**

The cottonwood was designated as the Kansas state tree in 1937. (The cottonwood is also the state tree of Nebraska and Wyoming.) It is the most abundant tree species in the state. Before Kansas was settled, mature cottonwood trees growing along streams and rivers survived the prairie fires due to their thick protective bark. Cottonwoods were widely planted by settlers in the late 1800s. In the 1930s and 1940s, more cottonwoods were planted as fast-growing tall trees in new windbreaks across Kansas.

Cottonwoods are deciduous trees. The leaves are triangular in shape with a long pointed tip and coarse round teeth on the edges. The flattened stalks that connect the leaves to the stem allow the leaves to flutter at the slightest breeze. Cottonwoods can reach a height of over 100 feet and can have trunk circumferences greater than 12 feet.

The wood of the cottonwood is light in color, easy to work, and lightweight. In the manufacture of furniture, it is used as the core material and other high-grade furniture veneers are overlaid on it. Cottonwood is also used in the construction of pallets, boxes, and crates for transporting merchandise. More cottonwood is harvested and processed than any other tree in Kansas.



Credit: Bob Gress, GPNC

Forests Showcase:**THE KANSAS SILK INDUSTRY: 1870–1897**

At one time, Kansas showed promise of becoming a silk capital of the world. In the 1800s, the French settlement of Silkville in Franklin County was the center of silk production in Kansas. Silk production also took place in the south-central area of the state.

Ernest de Boissiere, a Frenchman, founded Silkville in 1869 for the purpose of manufacturing silk. Early in 1870, de Boissiere planted 40 acres of mulberry trees. He imported silkworms from France and Japan

**House at Silkville**

Credit: Grace Muilenberg, KGS

and brought families from France to Kansas. Those families included experts from the French silk industry. Ten thousand mulberry trees provided the leaves to feed the silkworms so they could spin their cocoons of silken thread. Looms in the silk factory turned out 250-300 finished yards of fabric a day. At the Philadelphia Centennial Exposition of 1876, a sample of the silk was awarded first prize. However, it proved difficult to compete with Italian and Japanese silk production and Silkville had stopped producing silk by 1886.

When Russian Mennonites immigrated to south-central Kansas in the 1870s and 1880s, many brought silk production skills to the region. At one point, more than 40 counties in Kansas reported silk production. In 1887, the State Board of Agriculture organized a special silk commission and authorized the establishment of a silk station in Kansas. The silk station was located at Peabody. It included ten acres of land planted to mulberry trees to grow the food necessary for the station's silkworms. A building was erected and the station bought cocoons, reeled, and sold the silk thread. The primary work of the station was to raise silkworm eggs for free distribution to residents of Kansas who would hatch and raise the silkworms. The silkworms fed on leaves of mulberry trees before forming the cocoons made of silk thread.

Many Kansas families participated in the silk venture, but in 1897, the state legislature ended the state funding and the Kansas silk industry was abandoned.

**Mulberry Leaves**

Credit: Mary Anne Stoskopf

TEACHER'S RESOURCES (CONTINUED)**NOTES:*****Photosynthesis***

Silverstein, Alvin. 2007 (AR - 8.5)

Shelterwood

Shetterly, Susan Hand. 2003 (AR - 3.9)

Silkworms

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Take a Tree Walk

Kirkland, Jane. 2002 (AR - 5.7)

Tree

Burnie, David. 2005 (AR - 7.4)

Trees: Identification, Forests, Historic Species, Wood Types

Meeus, Cathy, ed. 2005

Trees, Leaves, and Bark

Burns, Diane L. 1998 (AR - 3.8)

Wood

Parker, Steve. 2002 (AR - 6.2)

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www.delptreefarm.com

Erik Warren – Erik's Originals

<http://erikoriginals.com>

Forestry for K-12

Society of American Foresters

www.safnet.org/aboutforestry/learn.cfm

Kansas Forest Service

www.kansasforests.org

Tools for Teachers

American Forest & Paper Association

Paper Industry Association Council

www.paperrecycles.org/tools_for_teachers/index.html

Tree Guide

Illinois State Museum

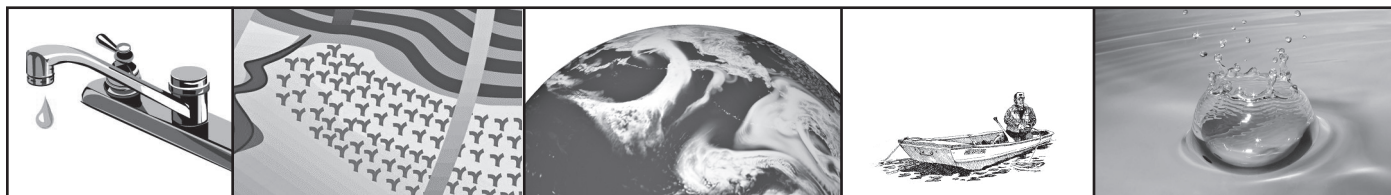
www.museum.state.il.us/muslink/forest/htmls/trees.html

Tree ID Animation

National Arbor Day Foundation

www.arborday.org





Unit 6) Water Overview

All known forms of life depend on water. Although water covers nearly 70 percent of the Earth's surface, less than three percent of the Earth's water is freshwater and much of that is frozen in glaciers and polar ice caps. Freshwater is critical to human survival, which is why it is important to protect the quality of groundwater and surface water resources.



Credit: Roger McLassus,
Wikimedia Commons

As water circulates through the Earth's hydrosphere in a process known as the "water (hydrologic) cycle," the overall volume of the Earth's water changes very little. Specific locations may experience dramatic fluctuations in water availability but overall, the amount of water in the Earth's hydrosphere does not change.

Since water is such an important natural resource, conflicts may arise over its availability or use. Resolving those conflicts will not be quick or easy but it is critical that they are resolved in ways that provide for today's needs, as well as those of future generations.

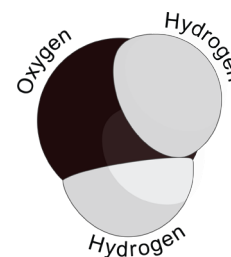
WATER

"If there is magic on this planet, it is contained in water."

Loren Eiseley, American scientist and author

Water is a tasteless, odorless substance that is essential to all known forms of life. In small quantities, it appears colorless to the naked eye. Water covers nearly 70 percent of the earth's surface and is an important natural resource in Kansas.

Water has the chemical formula H_2O , meaning that one molecule of water is composed of two hydrogen atoms



Water Molecule

Source: Wikipedia

INTRODUCTION

THE WATER CYCLE

WATER RESOURCES

- GROUNDWATER
- SURFACE WATER

WATER USES

- AGRICULTURAL USES
- INDUSTRIAL USES
- HOUSEHOLD USES
- RECREATIONAL USES
- WATER RIGHTS

WATER QUALITY

- WATER POLLUTION
- FEDERAL WATER QUALITY LEGISLATION
- KANSAS WATER QUALITY PROGRAMS

WATER CONSERVATION

- WATER CONSERVATION PLANS
- PERSONAL WATER CONSERVATION

WATER FOR FUTURE USES

ENDNOTES

REFERENCES

TEACHER'S RESOURCES

CHEMICAL AND PHYSICAL PROPERTIES

Water

Alternative Names	aqua
	dihydrogen monoxide
	hydroxic acid
	hydrogen hydroxide

Molecular Formula H_2O

Freezing Point 32° F or 0°C

Boiling Point 212° F or 100°C

Density*

liquid – pure water	1.00 g/cc**
liquid – ocean water	1.03 g/cc**
frozen	0.92 g/cc**

*The density of water is affected by temperature and mineral content. Unlike other substances, the density of water increases as the water temperature rises above 32° F – just the opposite of all other substances which achieve maximum density when they change from the liquid to solid phase.

** grams per cubic centimeter

WATER WORDS
Hydro – from the ancient Greek prefix meaning “water.”
Hydrologic cycle – the continuous circulation of water around, over, and through the earth; also known as the water cycle.
Hydrosphere – portion of the earth’s surface that is water; includes atmosphere and underground aquifers.

and one oxygen atom. It can be described ionically as HOH, with a hydrogen ion (H⁺) that is bonded to a hydroxide ion (OH⁻). Water molecules are attracted to each other and attach themselves together because of the negative and positive ionic charges.

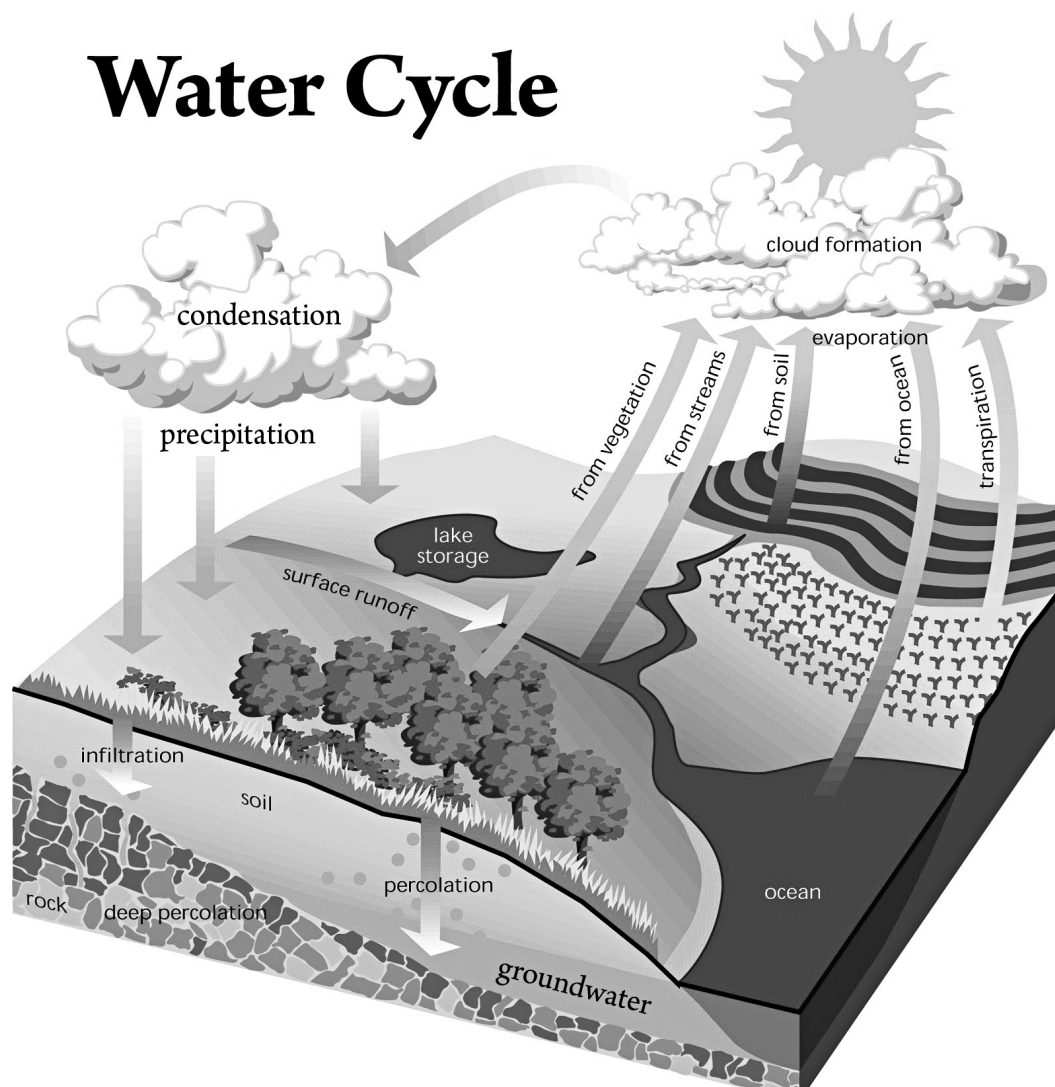
Water is the only pure substance found in nature in all three states of matter—liquid, solid, and gas. One unique property of water is that in its solid form (ice), it floats above its liquid form.

THE WATER CYCLE

*“The world turns softly
Not to spill its lakes and rivers,
The water is held in its arms
And the sky is held in the water.”*

Hilda Conkling, American poet

The movement of water around, over, and through the Earth is called the water cycle. The water cycle – technically known as the hydrologic cycle – is the continuous circulation of water within the Earth’s hydrosphere (all the water found on, under, and over the surface of the planet, including water in the atmosphere). As water moves through the hydrologic cycle, it changes form between liquid, solid, and gas phases. Water moves from one area to another, such as from the oceans to land or rivers, by the physical processes of precipitation, infiltration, runoff, subsurface flow (groundwater), evaporation, and condensation. Precipitation is the falling of water in any form (i.e. rain, hail, or snow) to the Earth’s surface. Infiltration is the process in which water is absorbed into the soil to become groundwater or flows off the surface of the land, in which case



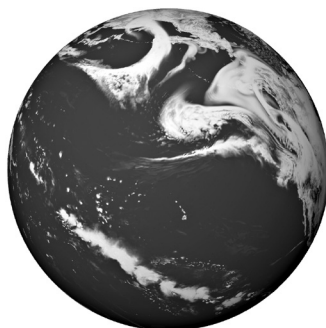
Source: FISRWG

WATER PROCESSES	
Percolation – process that occurs when gravity pulls excess water down through the soil and rock layers.	
Precipitation – any form of water that falls to the earth's surface; for example, hail, rain, and snow.	
Infiltration – process by which water is absorbed into the soil or runs across the land's surface until it reaches a body of water.	
Evaporation – process that occurs when water is heated and turns into water vapor; i.e. changes from liquid to gas state.	
Transpiration – the evaporation of water from plants, mainly through leaves.	
Condensation – the cooling of water vapor.	

it is called runoff. Evaporation or transpiration occurs when water is heated and turns into water vapor or when plants use water and lose water vapor through extremely small surface pores. Condensation takes place when the water vapor cools and forms clouds, which carry the water, moving it to a different location and releasing it in the form of precipitation.

There is no definable start or finish to the water cycle. Water evaporates from the oceans, forms clouds that precipitate back to Earth, and begins to evaporate again. It is a continuous process. Water that evaporates from the ocean and falls over land may evaporate, precipitate, become runoff, and condense multiple times before it returns to the ocean.

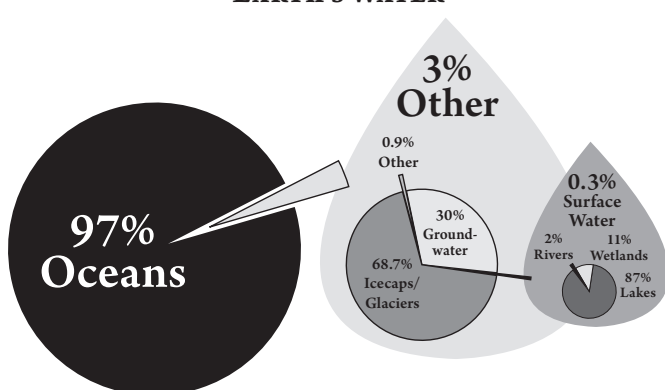
In the context of the water cycle, a reservoir represents the water stored at a specific point within the cycle. The largest reservoir in the water cycle is the collection of oceans, accounting for 97 percent of the Earth's water. The remaining 3 percent of the Earth's water is frozen in ice caps and glaciers,



Planet Earth

Source: NOAA/GFDL

EARTH'S WATER



Source: USGS

stored in underground aquifers (groundwater), stored in lakes or rivers (surface water), or temporarily stored in the Earth's atmosphere (water vapor). The total amount, or volume, of water in the water cycle does not change much, if at all. While the amount of water in specific bodies of water may vary, the distribution of water between the reservoirs in the water cycle remains fairly constant.

The processes of the water cycle vary greatly across Kansas. The western sections of Greeley, Hamilton, Stanton, and Grant counties receive annual precipitation of less than 16 inches and have high rates of evaporation. On the other side of Kansas, the southeastern counties of Crawford, Labette, and Cherokee receive up to 44 inches of precipitation each year.

WATER RESOURCES

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."

Luna Leopold, geomorphologist and hydrologist

Water is essential to all known forms of life. Humans require access to water that does not contain too many impurities, such as high amounts of salt minerals. Virtually all human uses require freshwater. Freshwater is water with less than 0.5 parts per thousand dissolved salts.¹ The Antarctic ice sheet, the largest single mass of ice on the planet, holds nearly 90 percent of the Earth's freshwater.

Water resources are sources of water that are useful or potentially useful to humans. Over 90 percent of the United States' freshwater is stored underground. In Kansas, freshwater is obtained from both groundwater and surface water resources.

GROUNDWATER

Groundwater is water stored underground in a body of rock or other materials called an aquifer. The "water table" is the top elevation of water stored in the aquifer. The water table fluctuates as water enters or is withdrawn from the aquifer. Water that enters an aquifer is called "recharge," usually a natural process. Groundwater recharges occur naturally when surface water infiltrates the soil or other natural barriers to the aquifer. The outflow of water from an aquifer or other body of water is called "discharge." In Kansas, naturally occurring groundwater discharges are springs and seepage to rivers and streams.

WATER RESOURCE DEFINITIONS

Groundwater– water stored underground in an aquifer.

Surface water– water that flows across the surface of the land or is stored in a river, lake, or freshwater wetland.

Recharge– water that enters an aquifer or body of water.

Discharge– water that flows out of an aquifer or body of water.

Water Overview

The depth of the water table varies. The water table may be less than three feet below the surface of the land or more than 300 feet deep. It may even be at the land's surface. When this happens, the ground is often wet and marshy or the water creates a spring, pond, or river.

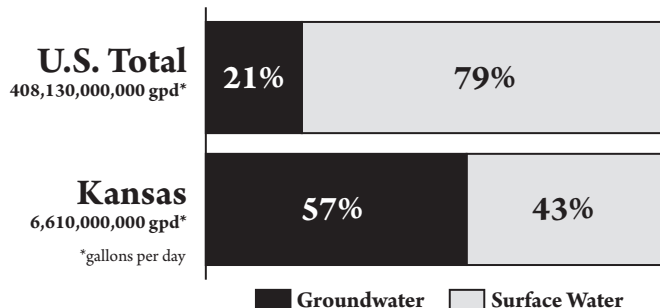
In some areas, including parts of Kansas, groundwater is the only reliable source of large volumes of water. Overall, Kansans rely on groundwater for 85 percent of their water needs. This is a higher percentage than almost any other state in the United States. However, eastern and western Kansas differ dramatically in the reliance on groundwater. In the western two-thirds of the state, where there is usually less precipitation, relatively abundant groundwater resources provide most of the water. Groundwater resources are more limited in the eastern third of the state; however, precipitation and surface water are more abundant there.

SURFACE WATER

Surface water is water that flows across the surface of the land or is stored in a river, lake, or freshwater wetland. The only natural recharge for any surface water system is precipitation within its watershed, the land that drains to that surface water collection and storage area.

However, the total quantity of water in that system depends on many factors, including the storage capacity in lakes, wetlands, and constructed storage areas; the permeability of the soil beneath those storage areas; the physical characteristics of the land's surface in the watershed; the timing of precipitation; and the local climate, which affects the rate of evaporation. All of these factors also affect the amount of surface water lost through the natural processes of the hydrologic cycle, such as evaporation or discharge to the oceans. Through infiltration, surface water becomes groundwater.

U.S. AND KANSAS WATER WITHDRAWALS GROUND VS. SURFACE – 2000



Source: USGS

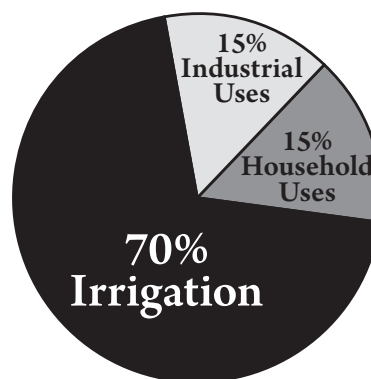
WATER USES

"Water is a common denominator of human activity."

C. E. Busby, geologist and conservationist

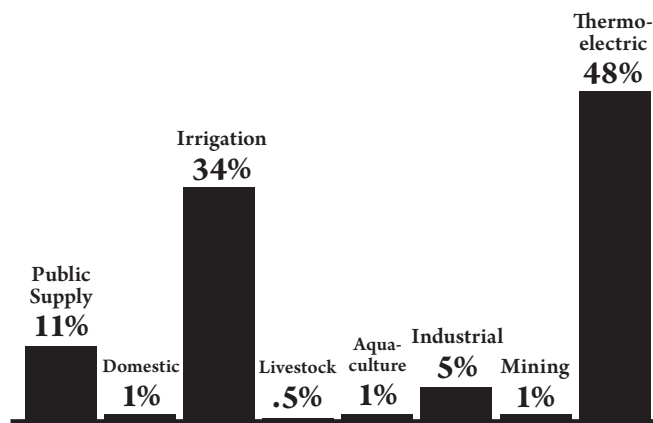
Uses of water can be categorized as consumptive or non-consumptive (sometimes called "renewable"). A use of water is consumptive if that water is not immediately available for another use. Water incorporated into a product, such as an agricultural crop, is considered a consumptive use. Evaporation

ESTIMATED WORLDWIDE WATER USES



Source: Wikipedia

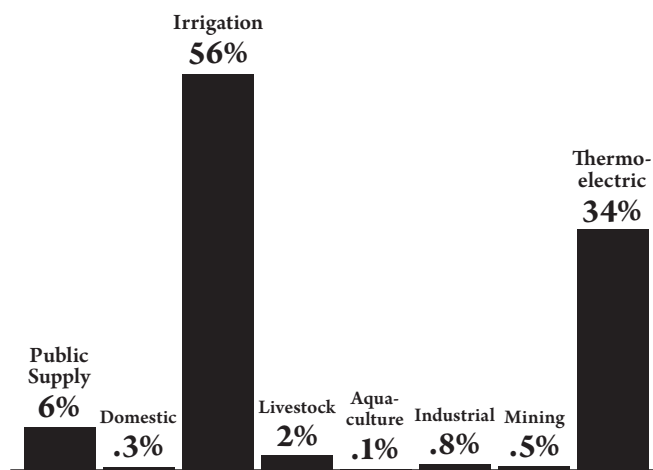
ESTIMATED U.S. WATER USES – 2000*



*Includes the Virgin Islands and Puerto Rico

Source: USGS

ESTIMATED KANSAS WATER USES – 2000



Source: USGS

or the infiltration of surface water (to become groundwater) would also be considered consumptive uses. A source of surface water that can be treated and used again as surface water, such as waste treated in a municipal wastewater treatment system, is generally considered a non-consumptive use of the water.

AGRICULTURAL USES

It is estimated that 70 percent of water use worldwide is for irrigation. According to the U.S. Geological Survey, groundwater provides 37 percent of the water used for agricultural purposes in the United States, mostly for irrigation. In Kansas, irrigation makes it possible to produce the agricultural products that supply the world with food and fiber. As global populations grow and the demand for food increases, Kansas farmers are working to produce more food with less water.

INDUSTRIAL USES

An estimated 15 percent of water use worldwide is for industrial purposes. Major industrial users include power plants, which use water for cooling or as a power source; ore and oil refineries, which use water in chemical processes; and manufacturing plants, which use water as a solvent.

Today, according to the U.S. Geological Survey, hydroelectric plants produce around 10 percent of the energy produced in the United States. The only hydroelectric facility in Kansas is on the Kansas River in Lawrence. In Kansas, Coffey County Lake and La Cygne Reservoir are managed to support electrical generation plants. Both reservoirs also provide recreational opportunities.

HOUSEHOLD USES

Household purposes, including drinking water, bathing, cooking, sanitation, and gardening, use an estimated 15 percent of the water used worldwide. According to the U.S. Environmental Protection Agency, the average American uses 100 gallons of water each day but nearly 75 percent of the water that goes to homes in the United States goes down the drain.² Most of that water is treated and returned to surface water systems, except for water used in gardens and other landscaping activities.

Water fit for human consumption is called drinking water or “potable” water. In the United States, groundwater sources supply an estimated 51 percent of the drinking water for the U.S. population and account for an estimated 99 percent of the rural population’s drinking water, according to the U.S. Geological Survey.³

RECREATIONAL USES

Kansans value water for recreational purposes, including swimming, fishing, camping, bird watching, hunting, boating, sailing, and other water sports.

Worldwide, recreational use is a small but growing percentage of total water use. Most of the lakes and reservoirs in Kansas provide water for recreational uses.

Recreational usage is non-consumptive. However, sometimes it reduces the availability of water for other uses. For example, water retained in a reservoir to allow boating is not available for irrigating agricultural crops. When water is released to increase streamflow downstream to support river barge traffic, that may conflict with recreational water uses.



Credit: Bob Savannah, USFWS

WATER RIGHTS

As a natural resource, water—and its availability—has always been a major social and economic concern. Historically, civilization flourished around rivers and major bodies of fresh water. Mesopotamia, often referred to as the “cradle of civilization,” was situated between two major rivers, the Tigris River and the Euphrates River. In Kansas, many towns were located along major rivers or at the junction of two rivers, such as Junction City.

Water demand already exceeds supply in many parts of Kansas, with many more areas expected to experience this imbalance in the future. The framework for allocating water resources to water users is known as “water rights.”

The right to use Kansas water is based on the principle of “first in time—first in right.” In times of shortage, that means the earliest water rights or permit holders have first rights to use the water. The maintenance of water right and permit records allows Kansas water to be apportioned fairly. The Water Appropriation Act affects all Kansans. Farmers who use irrigation to grow crops are required to obtain a permit and make yearly reports of water use. City dwellers who drink, wash with, or play in city-provided water are able to do so because the city has one or more water rights.

It is illegal for individuals in Kansas to use water without holding a water right or a permit to appropriate (use) water from the Kansas Department of Agriculture’s Division of Water Resources (DWR). The exception is water used solely for domestic purposes—water primarily used for the household, watering livestock on pasture, or watering up to two acres of lawn and gardens. No state permit is needed for that class of water usage. However, a county may require a permit to drill a water well for domestic purposes and a state permit is required to plug (fill in) a water well.

The Division of Water Resources provides management of the state’s water resources by administering 28 state laws, including the Kansas Water Appropriation Act, and statutes concerning construction of dams, levees, and other changes to streams within Kansas. The Division of Water Resources also administers the state’s four interstate river compacts and coordinates the national flood insurance program in Kansas.

WATER QUALITY

“Human activity has profoundly affected rivers and streams in all parts of the world, to such an extent that it now extremely difficult to find any stream which has not been in some way altered, and probably quite impossible to find any such river.”

H.B.N. Hynes, Canadian freshwater biologist

Water is the most common solvent found on Earth. In its liquid form, water dissolves many types of substances. The substances that will mix with and dissolve in water are known as hydrophilic (water-loving) substances. This means that water can absorb many substances, some of which can make the water unusable for specific purposes. Substances such as oil, that do not mix well with water, are known as hydrophobic (water-fearing). Such substances may be transported by water but are still chemically separated from the water molecules.

WATER WORDS

Hydrophilic– water-loving; substances that will mix with and dissolve in water, such as salt.

Hydrophobic– water-fearing; substances that do not mix well with water, such as oil.

WATER POLLUTION

There are two types of water pollution: point source pollution and nonpoint source pollution.

Point source pollution refers to pollution from a human activity that can be identified and controlled. Point source pollution is discharged into water through an identifiable point, such as a pipe, ditch, tunnel, or container. The primary types of point source pollution are sewage discharge and discharge of wastes from industrial or manufacturing operations.

Nonpoint source pollution comes from sources that cannot be easily identified or located. Examples of nonpoint sources would include sediment carried off a field or construction site by surface water runoff and residues, such as oil or antifreeze left by vehicles in a parking lot or on a highway. If those materials enter a river or stream after a rain, they can impact water quality and the lives of aquatic organisms, yet there may be multiple sources rather than one identifiable source of the pollutants.

In Kansas, suspended solids, sometimes referred to as sediment, are the largest single category of nonpoint source pollution (as measured by volume or weight).⁴ Suspended solids typically consist of solid organic or mineral particles that do not dissolve in the water. Instead, they are suspended in the water and move more slowly than the water itself, giving the water a cloudy or muddy appearance. Whenever the water slows enough to allow those particles to stop moving, they are deposited as sediment, either down lower on the slope of the land's surface or downstream in a body of water, such as a stream or lake. Sources of suspended solids include natural erosion and any activities that disturb natural vegetation, remove or disturb topsoil, or alter the terrain. The water can also carry nutrients and chemicals attached to soil particles, which may dissolve in the water and impact water quality. Before it is used for human consumption, surface water must be treated to remove sediment and other suspended solids, dissolved substances in the water, and harmful microorganisms.

Sediment– solid organic or mineral particles transported by water and deposited wherever the water slows enough to allow the particles to stop moving.

TYPES OF POLLUTION

Point source pollution– water pollution from human activity originating from an identifiable source.

Nonpoint source pollution– pollution from source(s) not easily identified or located.

FEDERAL WATER QUALITY LEGISLATION

In 1948, Congress passed the Water Pollution Control Act. It was the first attempt by the federal government to exert control over water quality issues, which continued to be managed by the states even after the legislation was enacted. In 1956, amendments to this legislation provided for federal financial support for the construction of wastewater treatment plants and direct federal regulation of waste discharges. Additional legislation passed in 1965, the Water Quality Act, established water quality standards for interstate waterways.

The objective of the 1972 Clean Water Act is to “restore and maintain the chemical, physical and biological integrity of the nation’s waters.” This legislation required that discharges of pollutants into the nation’s waters be eliminated by 1985 and that all waters of the United States be “fishable and swimmable.” The act was amended in 1977 to add programs dealing with nonpoint source pollution, which makes up as much as 60 percent of the pollution of the nation’s surface water.

FEDERAL WATER QUALITY LAWS

1948– Water Pollution Control Act; established federal-state cooperation over water quality issues but limited federal enforcement authority.

1956– amendments to 1948 law; provided federal financial support for wastewater treatment and federal regulation of waste discharges.

1965– Water Quality Act; directed states to develop water quality standards for interstate waterways.

1972– Clean Water Act (Federal Water Pollution Control Act Amendments); established basis for current water quality standards and extended protection to all surface waters of the United States; emphasized eliminating major visible sources of pollution and required states to establish water quality standards.

1974– Safe Drinking Water Act; established to protect quality of U.S. drinking water whether from above ground or underground sources and authorized EPA to establish safe standards of purity.

1977– amendments to Clean Water Act; established basic structure for regulating discharges of pollutants into the waters of the United States and gave EPA authority to implement pollution control standards.

1987– amendments to Clean Water Act; mandated states adopt numeric criteria for toxic pollutants in water and addressed nonpoint sources of pollution.

MEETING WATER QUALITY STANDARDS

Under the Clean Water Act, states are required to adopt water quality standards against which pollution levels within their water bodies are measured. If a water body fails to meet the applicable state water quality standards for its designated use, the state is required to list it as "impaired," specify what reductions are needed to achieve the standards, and implement a restoration plan.

The state of Kansas pioneered watershed based planning, which identifies the relationships that exist between surface water, groundwater, and land uses. Kansas uses the twelve major river basins and the smaller watershed units within each of the river basins to establish designated uses for each body of water in the state. Water quality is maintained to protect those uses.

It is not easy to compare water quality between states because there are inconsistencies among the ways that states assign designated uses and the criteria developed to protect those uses. For example, part of the Missouri River that forms a portion of the state boundary between Kansas and Missouri has a primary recreational use in Kansas and a secondary recreational use in Missouri. Because of this discrepancy between the states, Missouri can allow discharges at levels such that the identical stretch of water is not impaired in Missouri but is impaired in Kansas.

DESIGNATED USES OF KANSAS SURFACE WATER

Agricultural water supply— agricultural uses including irrigation and livestock watering.

Aquatic life support— maintenance of the ecological integrity of lakes, wetlands, and ponds, including the sustained growth and propagation of aquatic, semiaquatic, or terrestrial wildlife.

Domestic water supply— use, after appropriate treatment, for the production of potable water (water suitable for drinking).

Food procurement— obtaining edible forms of aquatic or semiaquatic life for human consumption.

Groundwater recharge— replenishing fresh or usable groundwater resources.

Industrial water supply— use for nonpotable purposes by industry, including withdrawals for cooling or processes.

Recreational use— divided into primary and secondary contact recreational uses.

- **Primary contact**—recreational uses from April 1 through October 31 of each year, during which some inadvertent ingestion of water is probable; includes boating, mussel harvesting, swimming, skin diving, waterskiing, and windsurfing.
- **Secondary contact**—recreational uses during which the ingestion of surface waters is not probable; includes wading, fishing, trapping, and hunting.

Source: KDHE

KANSAS WATER QUALITY PROGRAMS

In response to the federal legislation, states instituted programs to monitor water quality and address any problems. In Kansas, the Kansas Department of Health and Environment is responsible for designating stream uses, establishing water quality standards that support those uses, and ensuring compliance with the standards. Every two years, federal law requires the Kansas Department of Health and Environment to report the status of water quality in the state through the Kansas Water Quality Assessment Report.

The Kansas Surface Water Quality Standards, established by the Kansas Department of Health and Environment, provide specific water quality goals for surface waters in the state. Designated use categories are: agricultural water supply, aquatic life support, domestic water supply, food procurement, groundwater recharge, industrial water supply, and recreation. The surface water quality standards that apply to a specific body of water vary according to the water's designated use(s), with the most protective standards applying if there is more than one designated use.

Monitoring is conducted on each body of water. If monitoring indicates that a river segment or other body of water is consistently violating the standards, the body of water is designated as "impaired," which requires the establishment of a maximum amount of pollution that a water body can receive without violating the standards—known as the "total maximum daily load" or TMDL. The quality of surface water in Kansas is being improved by using tools such as TMDLs to target and reduce water pollution.

WATER CONSERVATION

"We think of our land and water and human resources not as static and sterile possessions but as life-giving assets to be directed by wise provision for future days."

Franklin D. Roosevelt, 32nd President of the United States

Water conservation is essential to assure that a sufficient, long-term supply of water is available for Kansans for many years in the future. Current state policy regarding water conservation is guided by the principle that the privilege to use water carries with it the responsibility to use the water wisely. A philosophy of sharing a limited supply among those using a water source in drought or other emergency conditions before imposing regulations also shapes current policies.

WATER CONSERVATION PLANS

The Chief Engineer, Division of Water Resources, may require a water right owner to adopt and implement a water conservation plan. In addition, the Chief Engineer may require and enforce conservation measures for domestic users and may delegate this authority to municipalities that have approved conservation plans. The Chief Engineer currently requires plans from water users who have had difficulty staying within their authorized quantity and those who appear to have problems with the feasibility of their intended use of the water.

The Kansas Department of Agriculture, the Division of Water Resources, and the Kansas Water Office cooperatively review water conservation plans for municipal, irrigation, and

Water Overview

industrial users. The Kansas Water Office provides, or arranges to provide, technical assistance to water users who are required to adopt and implement water conservation plans. Assistance in developing water conservation plans is also provided by Kansas State University, local groundwater management districts, and by the Kansas Rural Water Association (KRWA).

As of 2004, assistance provided to irrigation and municipal users who were required to adopt and implement conservation plans had resulted in the development and implementation of water conservation plans for over 500 public water suppliers in the state. In addition, over 800 irrigators in Kansas have approved water conservation plans in place. Previous evaluations have shown that conservation plans can be effective if properly implemented. Recent droughts have raised questions regarding enforcement authority from additional public water suppliers that want to address domestic use during times of drought. However, there is no comprehensive state monitoring or enforcement of the goals and initiatives outlined in conservation plans.

PERSONAL WATER CONSERVATION

The earth is covered with water yet only 1 percent is available for drinking water. Unfortunately, that water is often taken for granted. In the United States, over 40 percent more water is used than needed to carry out cooking, washing, flushing, watering, and other tasks. The largest use of household water is to flush the toilet, followed by water for bathing.



Source: USDA NRCS

WATER FOR FUTURE USES

"All things, including weather and rainfall, change fast, and our memories are short. When it rains, we forget about the dust bowl; when it is dry, we forget about floods."

Alfred Stefferud, editor, 1955 Yearbook of Agriculture

Water is essential for all known forms of life. Understanding the water cycle is critical to understanding issues related to both water quality and water quantity. With only 1 percent of the earth's water available for drinking water, maintaining the quality of that water is crucial. It is also important to take steps to ensure that future generations will have adequate water supplies.

Kansas would be a much different place without the existing water resources. The people of Kansas have a responsibility to work together to ensure that water resources are protected and used wisely. The future of the state depends on it! ■

WATER CONSERVATION TIPS

Repair leaky faucets, indoors and out. One leaky faucet can use up to 4,000 gallons of water per month.

When washing dishes by hand, save up to 15 gallons of water by soaking dirty dishes in the sink or dishpan before rinsing them off.

Only run dishwashers with a full load

Take short showers instead of baths. Showers use an average of 5 to 7 gallons per minute, three times less than the water needed for a bath. To cut water use even more, install a low-flow showerhead that uses just 3 gallons per minute.

Turn off the water to brush teeth. This can save up to 4 gallons of water each brushing.

Repair leaky toilets to save more than 50 gallons of water per day. To check for leaks, add 12 drops of food coloring to the toilet tank. If color appears in the toilet bowl one hour later, the tank is leaking.

Water the lawn and garden in the morning when evaporation is lowest.

Using a barrel covered with a screen, collect rainwater for watering plants.

Sweep down decks and driveways instead of hosing them down.

ENDNOTES

1. "Groundwater Glossary", The Groundwater Foundation, <<http://www.groundwater.org/gi/gwglossary.html>>.
2. The Groundwater Foundation, <<http://www.groundwater.org/gi/depend.html>>.
3. "Groundwater Facts", The Groundwater Foundation, <<http://www.groundwater.org/gi/GWBASICS2.pdf>>.
4. Daniel L. Devlin and Kent A. McVay, *Suspended Solids: A Water Quality Concern for Kansas*, Kansas State University, February 2001, MF-2501, <<http://www.oznet.ksu.edu/library/h20ql2/mf2501.pdf>>.

REFERENCES

Smith, Deborah Takiff, ed. *Agriculture and the Environment: The 1991 Yearbook of Agriculture*. Washington, D.C.: U.S. Government Printing Office.

Stefferd, Alfred, ed. *Water: The Yearbook of Agriculture 1955*. Washington, D.C.: U.S. Government Printing Office, 91st Congress, 2nd Session, House Document No. 91-254.

U.S. Geological Survey. 2007. <<http://www.usgs.gov>>.

TEACHER RESOURCES

BOOKS:

* *Teachers & Advanced Readers; AR - Accelerated Reading Level*

A Cool Drink of Water

Kerley, Barbara. 2006

Did a Dinosaur Drink This Water?

Wells, Robert E. 2006

Down the Drain: Conserving Water

Oxlade, Chris. 2005 (AR - 5.2)

A Drop Around the World

McKinney, Barbara Shaw. 2004 (AR - 5.1)

A Drop around the World: Teacher's Guide *

Malnor, Carol. 2004

A Drop of Water

Wick, Walter. 1997 (AR - 5.8)

Earth

Van Rose, Susanna. 2005

Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools *

Mitchell, Mark K. 2000

The Incredible Water Show

Frasier, Debra. 2004 (AR - 3.7)

The Life and Times of a Drop of Water

Royston, Angela. 2005 (AR - 3.7)

The Magic School Bus Wet All Over: A Book About the Water Cycle

Relf, Pat. 1996 (AR - 3.1)

Watching Water Birds

Arnosky, Jim. 2002 (AR - 5.3)

Water and the Weather

Olien, Rebecca. 2005 (AR - 2.9)

Water Bugs

Taylor, Barbara. 2003 (AR - 4.7)

The Water Cycle

Harman, Rebecca. 2005 (AR - 5.5)

The Water Cycle

Kalman, Bobbie. 2006 (AR - 4.2)

Water on the Move

Slade, Suzanne. 2007 (AR - 5.2)

Water Music

Yolen, Jane. 2004 (AR - 4.2)

Weather

Cosgrove, Brian. 2004 (AR - 7.6)

Weather

Wyatt, Valerie. 2000 (AR - 5.7)

Weather and Climate

Silverstein, Alvin. 2007 (AR - 7.6)

The Wonder in Water

Swanson, Diane. 2005 (AR - 6.0)

WEBSITES:

Drinking Water for Kids (and Teachers)

U.S. Environmental Protection Agency

www.epa.gov/safewater/kids/index.html

H₂OUSE Water Saver Home

California Urban Water Conservation Council

www.h2ouse.org

Kansas Water Office

www.kwo.org

Water Science for Schools

U.S. Geological Survey

<http://ga.water.usgs.gov/edu/index.html>

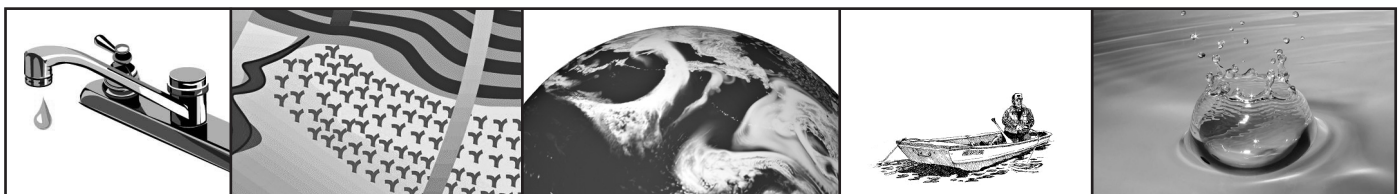
WaterWise Resource Action Program

www.getwise.org

(Materials also available in Spanish)

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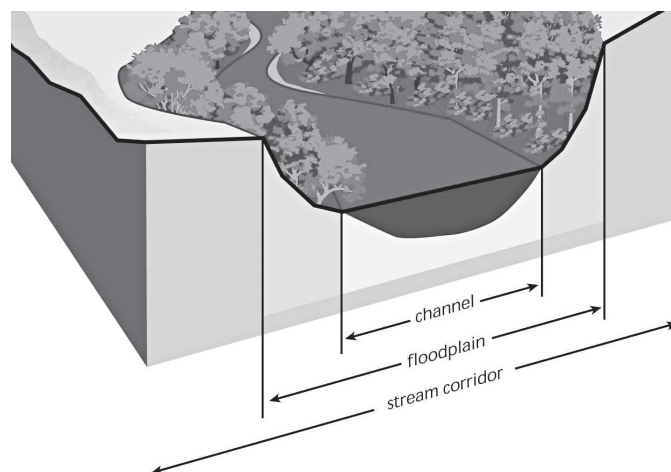




Unit 7) Streams & Rivers

The U.S. Geological Survey defines all bodies of water flowing in a line as "streams," making no distinction between streams and rivers. Even so, most people use the term "river" to describe larger streams with tributaries. A stream (or river) is a body of water confined within two banks and a bed (bottom). A stream provides a physical path for flowing water through a depression, called a channel. The flow of a stream or river refers to the movement and volume of water that forms the channel of a stream. The sides, or banks, of the channel, are described as "right" or "left"—determined by which side of the water they are on when you are facing downstream. The slope of a streambank or riverbank describes the angle of the bank when compared to a flat surface. The volume of water passing a specific point in a stream's channel during a specified length of time is the "discharge," generally measured in meters per second.

Though once considered part of the Great American Desert, there are 134,458 miles of streams and rivers in Kansas. This includes 120



Stream Labels

Source: FISRWG

INTRODUCTION

- KANSAS HISTORY

CLASSIFYING STREAMS AND RIVERS

- NAMES
- STREAM ORDER
- DEVELOPMENTAL STAGE

WATERSHEDS AND RIVER BASINS

- WATERSHEDS
- WATERSHED COMPONENTS
- RIVER BASINS

KANSAS RIVERS

- ORIGINS
- EXPLORING RIVERS IN KANSAS

KANSAS STREAMS

- STREAM ORIGINS
- STREAM CHARACTERISTICS
- CLASSIFYING KANSAS STREAMS

RIPARIAN AREAS

- NATURAL RIPARIAN AREAS
- RESTORING AND STABILIZING STREAMBANKS

THE STREAM ECOSYSTEM

- AQUATIC LIFE
- FISH
- MAMMALS
- REPTILES, AMPHIBIANS & TURTLES

- BIRDS
- DOMESTIC LIVESTOCK

WATER MANAGEMENT

- SURFACE WATER
- WATER COMPACTS
- FLOOD MANAGEMENT

WATER QUALITY

- HISTORICAL USES
- FEDERAL LEGISLATION
- HUMAN IMPACTS ON STREAMS AND RIVERS
- BACTERIA IN SURFACE WATER

CHANNELS OF LIFE

CAREER PROFILES

- KEN SHERRADEN, BIOLOGIST
- LEE ROLFS, ATTORNEY, KANSAS DEPARTMENT OF AGRICULTURE

SHOWCASE

- SMOKY HILL RIVER

ENDNOTES

REFERENCES

TEACHER'S RESOURCES

Streams & Rivers

miles of streams and rivers that form the state's borders and another 134,338 miles of streams and rivers inside the state's boundaries.

The Great Seal of the state of Kansas, reproduced in the center of the state flag, reflects the importance of streams and rivers in the state's history. The state seal, adopted by the Kansas Legislature in 1861, depicts "commerce" with a river and steamboat. Agriculture, representing the "basis of the future prosperity of the state," is portrayed on the state seal by a settler's cabin and a man plowing with horses. Although tractors have replaced horses and steamboats no longer travel up Kansas rivers, both agriculture and the state's streams and rivers are still very important to the state's economy and the health and well-being of the state's citizens.



"To the lost man, to the pioneer penetrating a new country, to the naturalist who wishes to see the wild land at its wildest, the advice is always the same—follow a river. The river is the original forest highway. It is nature's own Wilderness Road."

Edwin Way Teale, naturalist, writer, and photographer

Streams and rivers are critical links in the hydrologic (water) cycle. They are the links between precipitation (rain, ice, or snow) that falls over land and the water in the oceans. Water from rain, ice, or snow that does not soak into the soil becomes runoff, draining into nearby streams.

Those streams flow downhill, forming larger streams and rivers. Water in the rivers eventually flows into the oceans, the main reservoirs for the world's water supplies.

Rivers, streams, and associated riparian areas are vital natural resources. They provide drinking water for people and animals, as well as water for personal uses (showering, washing clothes, etc.), irrigation (lawns, golf courses, and agricultural crops), cooling systems for industrial equipment, the generation of electricity, and recreational activities, such as canoeing, camping, and fishing. Riverbeds and nearby floodplains provide materials for building roads and other construction purposes.



Missouri River, Leavenworth County

Credit: John Charlton, KGS

DREDGING

Sand and gravel are dredged (mined) from riverbeds and nearby floodplains to provide materials for construction purposes and building roads. According to the Kansas Geological Survey, people living in the corridor from Topeka to Kansas City use more than two million tons of sand and gravel each year. In many Kansas rivers, the amount of sand that may be removed is limited to the amount of recharge—sand that will accumulate and gradually fill in the empty space over time.

KANSAS HISTORY

Streams and rivers played an important role in the development of the United States. In the absence of roads, early explorers and settlers followed streams and rivers. As the country expanded, rivers became the "highways" used to transport people and goods back and forth between the frontier and cities and towns.

Rivers played an important role in the exploration of the state of Kansas. When the United States acquired the Louisiana Purchase in 1803, President Jefferson sent Meriwether Lewis and William Clark up the Missouri River to the northwest to find a route to the Pacific Ocean. One result of Lewis and Clark's explorations was the Oregon Trail, which crossed northeast Kansas. The southwestern region of the Louisiana Purchase was first explored by Lt. Zebulon Pike's expedition in 1806. Lt. Pike's orders included finding the source of the Arkansas River and an overland route to Santa Fe. Pike's expedition paved the way for the Santa Fe Trail, which followed the Arkansas and Cimarron rivers across central and western Kansas.

Rivers played a role in the development of Kansas as well. The Kansas River was a supply route for Fort Riley, where the first territorial capital of Kansas was located. In 1855, a steamboat from Cincinnati, Ohio, ran aground on a sandbar in the Kansas River near the townsite of New Boston, Kansas. The steamboat was carrying building materials for the development of a new town in central Kansas. Instead, the people onboard were convinced to stay where they had run aground and New Boston was renamed "Manhattan." Kansas rivers were used to transport many materials in the mid to late 1800s. For example, the railroad ties used to build railroads across central and western Kansas were made from trees harvested in the mountains of Colorado. Then the railroad ties were bundled together and floated down the Arkansas River to points as far east as Great Bend, Kansas.

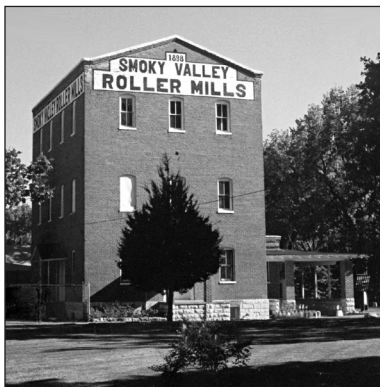
In Kansas, early settlers used the power of the water flowing in rivers and streams to operate gristmills, flour mills and sawmills. The first mill in the state was located at Auburn, operating around the

LEWIS AND CLARK TRAIL

As early as 1792, Thomas Jefferson proposed an expedition to find a water route to the Pacific Ocean in the northwest. Once the United States acquired the Louisiana Purchase, the expedition became a reality. On May 14, 1804, Meriwether Lewis and William Clark started up the Missouri River on their way to the Pacific Ocean.

Today, K-7 (Kansas Highway 7) follows the Lewis and Clark Trail from Leavenworth to White Cloud. In places, the bluffs along the Missouri River rise more than 200 feet. Along those bluffs, the Four-State Lookout at White Cloud offers a panoramic view of the Missouri River and four states: Kansas, Missouri, Nebraska, and Iowa.

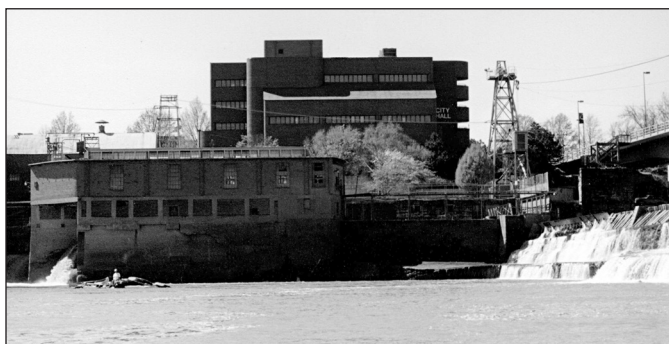
clock—as a sawmill during the day and grinding corn at night.¹ The father of William F. (Buffalo Bill) Cody was a partner in a mill at Valley Falls, erected in 1855 on the Grasshopper River (later renamed the Delaware River). That mill started out as a sawmill, developed into a gristmill, later operated a cotton gin, and added a woolen mill before it closed. Today, the millstones from those early mills can be found in the Valley Falls public parks. In the early days of Kansas, the federal government established five mills at military posts and two at Indian missions.² Traces of early dams and mill sites can still be found across Kansas. Once a year, the Smoky Valley Roller Mill at Lindsborg hosts a "Millfest." This mill, located on the Smoky Hill River, was built in 1898 and operated until 1955. Restoration was completed in 1981. It is located on the site of an earlier mill built in 1872. Other Kansas mills built in the 1870s that are still open to visitors include the 1875 Drinkwater & Schriver Flour Mill at Cedar Point on the Cottonwood River and the Old Oxford Mill in Sumner County, built on the Arkansas River in 1874.



Smoky Valley Roller Mill, Lindsborg

Credit: Tom Jaderborg;

Hydroelectric power, harnessing the forces of water to produce electrical energy, started in the mid-1800s. The United States is second only to Canada in the production of energy from hydropower, although other countries depend on hydroelectric power for a much higher percentage of their energy needs. Today, according to the U.S. Geological Survey, hydroelectric plants produce around 10 percent of the energy produced in the United States. The only hydroelectric facility in Kansas is the Bowersock Mills & Power Company on the Kansas River in Lawrence. Built in 1874, power production began at the facility in 1888. Some of the turbines in use at the Bowersock facility have been producing electricity since 1920 and are believed to be the oldest active electrical power-producing units in the United States.

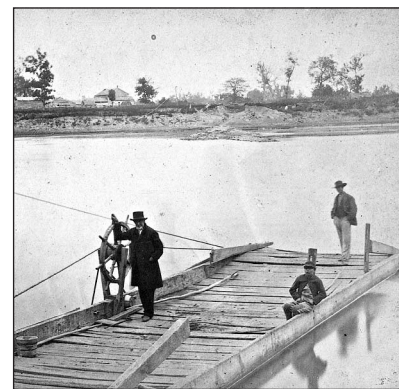


Bowersock Mills & Power Company, Lawrence

Courtesy: Bowersock Mills & Power Company

In Kansas, the location of towns and cities depended upon the availability of water. Some of the earliest towns were located at the sites of river crossings or early ferries. Ferries, which transported people, animals, and goods from one side of the river to the other, were used in Kansas before bridges were built. At one time, there

were at least 400 licensed ferries in the state of Kansas, including 103 ferries on the Kansas River.³ Early towns were also established at the junctions of rivers or streams. Junction City is located at the "junction" of the Republican and Smoky Hill rivers. Many towns and counties took their names from the rivers, such as Republic County (Republican River), Cottonwood Falls (Cottonwood River), Salina (pronounced *suh-line-uh*) on the Saline (pronounced *suh-lean*) River, and Great Bend, which is located on a natural bend of the Arkansas River. In Kansas, the Arkansas River is generally pronounced *ar-kansas* even though it is pronounced *ar-kan-saw* by many outside the state of Kansas.



River Ferry, 1867

Source: Kansas State Historical Society

CLASSIFYING STREAMS AND RIVERS

"A river seems a magic thing. A magic, moving, living part of the very earth itself."

Laura Gilpin, American landscape photographer

According to the Kansas Secretary of State's office, there are more than 50,000 streams large enough to be named in the state of Kansas. There are several ways to classify streams and rivers, including by size (water flow) and age.

NAMES

All "linear flowing bodies of water" are classified as "streams" in the U.S. Geological Survey's official standard for geographic name use—the Geographic Names Information System (GNIS). However, when Kansas streams were first given names, large streams were usually designated as "rivers" and their tributaries were called "creeks." A tributary is a stream that flows into a larger body of water, such as a larger stream, a river, or a lake. In other areas of the United States, a smaller stream might be called a "brook" or "run," rather than "creek."

Kansas streams have some very interesting names, such as Chigger Creek, Granny Branch, Monkey Run, and Blaze Fork. There is a stream name for every letter in the alphabet, beginning with Acker Creek and ending with Zenithscab Creek. All but a few of the streams in Kansas are called creeks. There are 42 Dry Creeks and 42 Sandy Creeks but only 34 Rock Creeks and 20 Mud Creeks in the state. There are 14 Lost Creeks but only one Lost Shirt Creek. There are 10 streams named School Creek but Spring Creek is the most popular name, with 78 streams named Spring Creek in the state of Kansas.

STREAM ORDER

Robert E. Horton is considered by many to be the father of modern hydrology, the science of water resources. During the 1930s, Horton introduced a system called "stream order" which labels tributaries within a river system according to how many levels of other tributaries have contributed to their flow. For example, a small stream with no tributaries would be a "first order" stream. When two "first order" streams join together, the result is a "second

UNDERSTANDING STREAM ECOSYSTEMS

Stream—a body of water confined within two banks and a bed (bottom); provides a physical path for flowing water through a channel.

River—often used to describe a larger stream with many tributaries.

Tributary—a stream that flows into a larger body of water, such as a larger stream, river, or lake.

Stream corridor—the stream valley; the ecosystem that includes the stream and the land, plants and animals associated with that stream or river.

Floodplain—the relatively level area bordering a stream or river that is covered by water during moderate to severe flooding.

Riparian—situated along or near the bank of a body of water, such as a stream or river; includes the adjoining floodplain.

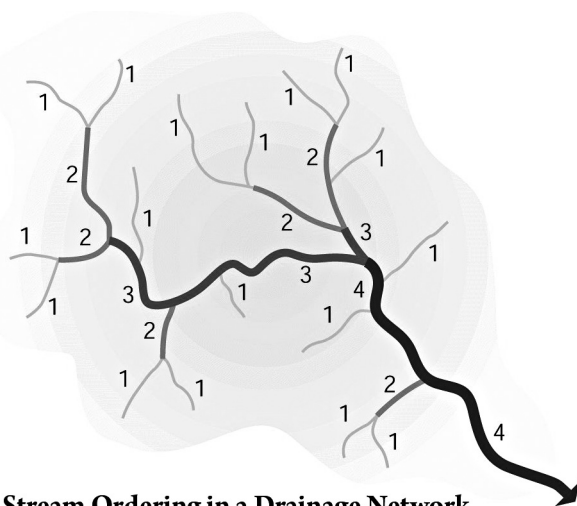
Riparian area—an area of vegetation supported by an adjacent stream, river, or other body of water.

Riparian buffer—strips or small areas of land in permanent vegetation that trap sediment, filter nutrients, and provide habitat for wildlife.

Riparian forest buffer—an area of trees and shrubs located adjacent to streams, lakes, ponds, and wetlands.

Filter strip—a strip of grasses, legumes, forbs, or small grains planted to filter potential contaminants in runoff moving toward surface waters.

order" stream; a "third" order" stream results from the joining of "second order" streams, and so on. Beginning with the "second order," streams may have multiple lower ranked tributaries. In general, the size of a stream's watershed (drainage basin) increases as the "order" designation goes higher. When two or more streams meet and begin flowing together or form a new stream, the place where the streams join together is called their "confluence." Above their confluence a



Stream Ordering in a Drainage Network

1 = first order stream; 2 = second order stream; etc.

Source: FISRWG

Confluence—the place where two or more streams meet and begin flowing together.

few miles southeast of Emporia, the Cottonwood and Neosho rivers are "fourth order" streams. Below the confluence, the Neosho River becomes a "fifth order" stream. The Mississippi River is classified as a "tenth order" stream, the highest order designated for any river in North America. ⁴

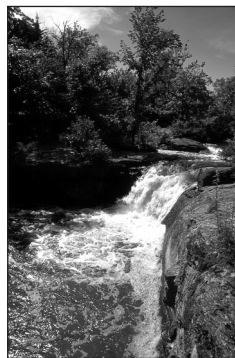
DEVELOPMENTAL STAGES

Every stream and river goes through similar developmental stages—youth, maturity, and old age. The time required for a stream or river to pass through each stage depends on the climate and the composition and structure of the rock through which the water flows. As a river or stream erodes its banks and channel, it changes the landforms it passes through and alters its own course. The slopes of the banks decrease as those features erode, causing the stream to widen and slow down. When the water slows down, it deposits material. As water flows around this material, the river or stream begins to meander, widening the valley in which it flows. These forces act on a stream or river and its watershed topography over time.

In the natural life cycle of a stream, rivers and streams are classified as "youthful," "mature," and "old age," according to specific characteristics. Kansas rivers and streams fall into all three classifications.

Generally, "youthful" rivers and streams are found at higher elevations where the slope of the land is steeper and water flows downhill very fast. Rapids may develop over rocks or round boulders and there may be waterfalls. The channel of a youthful river is shaped like a "V" with steep banks. Youthful rivers may be near the headwaters (the origin) of an older and larger river hundreds of miles away. In Kansas, the small streams in the upper areas of the Flint Hills would be considered youthful.

THREE STAGES OF STREAMS



**Butcher Falls,
Middle Caney Creek**

Credit: John Charlton, KGS



Wakarusa River, Douglas County

Credit: John Charlton, KGS



Missouri River at White Cloud

Credit: Roberta Spencer

A "mature" river or stream is at the stage in between "youthful" and "old age." The channel of a mature river is U-shaped, rather than V-shaped like the channel of a youthful river. A mature river still erodes the slopes of the banks of the channel, though to a much lesser degree than a youthful river does. Instead, a mature river or stream carves out a wider channel, though not as broad as that of an old age river. The landscape over which a mature river passes is steep enough that the river's slope provides a rapid water flow capable of rolling and bouncing larger pebbles and small rocks along the riverbed. The landscape may be mountainous but "hilly" would often be a better description for the area surrounding a mature river or stream. There are no rapids in the channels of mature rivers, which carry a larger volume of water than youthful rivers and are deeper than the channels of old age rivers or streams. In Kansas, the middle segments of medium-sized streams, such as Mill Creek in Wabaunsee County and Soldier Creek in Shawnee County, would be classified as mature.

The channel of an "old age" river is wider than it is deep and the landscape around such a river is generally flat, with wide floodplains. One of the characteristics of an old age river is the presence of S-shaped meanders (bends). The Mississippi River is an example of an old age river, with slow-moving water that carries suspended sediment (particles that travel in the water at a slower speed than the water itself), giving the water a muddy appearance. During floods, the water flow of an old age river is capable of moving large boulders and large structures, such as houses. Flooding associated with old age rivers often results in extensive property and agricultural damage and the loss of life. In Kansas, the Republican, Big Blue, Little Blue, Smoky Hill, and Kansas rivers would be classified as old age rivers.

Landform—a natural physical feature of the earth's surface.

WATERSHEDS AND RIVER BASINS

"Rain! whose soft architectural hands have power to cut stones, and chisel to shapes of grandeur the very mountains."

Henry Ward Beecher, American author and clergyman

WATERSHEDS

Everyone lives in a watershed, no matter where they live. A watershed is an area of land that drains toward a downhill point. That point can be a stream segment, a river, a pond, a lake, or the lowest place within the watershed (where rainfall always collects). Since gravity directs the movement of water, land with higher points of elevation separates the watersheds.

Precipitation patterns, topography (terrain), soil types, and land use patterns are features that make each watershed unique. The treatment of natural resources—the soil, water, air, plants, and animals—influences what happens in each watershed.

WATERSHED COMPONENTS

A watershed has two, sometimes three, basic components: tributaries, a main channel and, in some cases, a delta. A watershed contains a network of tributaries, streams that collect water and flow into larger streams. Each of the drainage areas, or smaller watersheds, contributes to the watershed of the larger stream or river. The second component of a watershed is its main channel. The main channel transports most of the water and other materials collected in the drainage area. The main channel consists of the main stream and

WATERSHEDS AS HYDROLOGIC UNITS

The United States Geological Survey developed a classification system for dividing regions into hydrologic units. Each hydrologic unit (watershed) is assigned a "hydrologic unit code" (HUC). In Kansas, each watershed has been designated as an HUC 8, HUC 11, or HUC 14. HUC 8 watersheds are the largest, designated with eight numbers. Smaller watersheds within the HUC 8 watersheds are designated as HUC 11 watersheds. HUC 14 watersheds are smaller watersheds within the HUC 11 watersheds. Based on these classifications, there are 90 HUC 8 watersheds, 355 HUC 11 watersheds, and 2,020 HUC 14 watersheds in the state of Kansas.

the larger tributaries. When precipitation falls in a watershed, the amount of water that reaches the main channel is determined by the size of the drainage area, the number of tributaries, the soil's ability to hold water, the climate, the number and size of water storage areas (wetlands, ponds, and lakes), and the slope (angle of the downward slant) of the stream's channel. As Luna Leopold wrote, "The joining of channels as more and more tributaries enter a main or master stream means that the drainage area increases downstream, so channels get progressively larger as discharge is enhanced by continued additions."⁵ The third feature of a watershed is the network of branches that may form at the mouth of a stream. A stream that flattens out (and slows) near its junction with a big body of water may deposit silt, sand, or fine rock particles the water has been carrying. Water flows around these deposits, creating a broad network of branches called a delta.

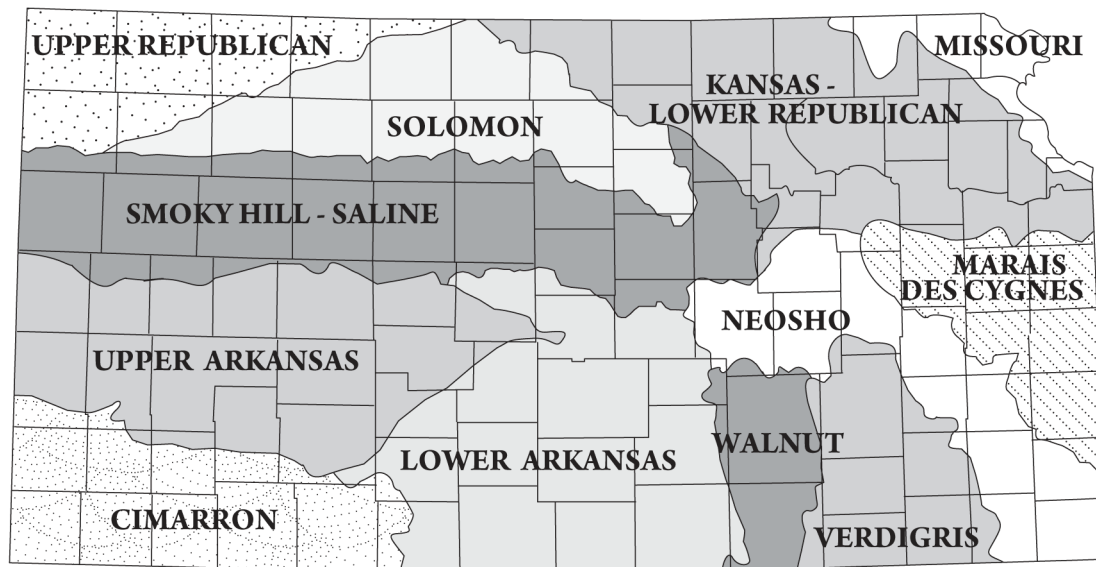
RIVER BASINS

A river basin is also a watershed or a portion of a larger watershed. A bird's-eye view of a river basin would show that as the water moves downstream in the river basin, many drainage channels form a pattern of branches with the smaller streams joining together to form progressively larger streams. There are twelve major river basins in Kansas: the Cimarron, Kansas Lower-Republican, Lower Arkansas, Marais des Cygnes, Missouri, Neosho, Smoky Hill-Saline, Solomon, Upper Arkansas, Upper Republican, Verdigris, and Walnut river basins. Each of these river basins can be divided into several smaller watersheds based on topography. Each of the twelve river basins is also part of a larger multi-state river basin or watershed—either the Missouri River basin or the Arkansas River basin. To distinguish between the two "Missouri River" basins, remember that the smaller of the two only covers about 1,600 square miles in the northeast corner of Kansas. It includes part or all of only four Kansas counties—Doniphan, Atchison, Leavenworth, and Wyandotte counties. The larger Missouri River basin covers part or all of several states, including Kansas.

From the largest viewpoint, the state of Kansas is part of the Mississippi River basin. This river basin covers 41 percent of the continental United States. It originates as an outlet stream from Lake Itasca in northern Minnesota. This tiny stream goes on to become one of the world's greatest river systems, draining 1.25 million square miles (all or parts of 31 states and two Canadian provinces) before it finally reaches the Gulf of Mexico. Just think—rain that falls in Kansas can eventually reach the Gulf of Mexico!

State and federal agencies, organizations, and individuals are involved in identifying and resolving water resource issues in Kansas.

MAJOR RIVER BASINS IN KANSAS



Source: KGS

In 1985, the Kansas Water Office adopted the 12 major river basins as planning areas. State law requires that public input is included in the basin planning process. Basin advisory committees, made up of citizens located within each of the 12 major river basins in the state, were established in 1985 to meet that requirement. Each committee has 9 or 11 members representing seven core categories of water use. The committees meet at least four times a year.

KANSAS RIVER BASINS

MISSOURI RIVER
SUBBASINS

Kansas-Lower Republican
Missouri
Marais des Cygnes
Smoky Hill-Saline
Solomon
Upper Republican

ARKANSAS RIVER
SUBBASINS

Cimarron
Lower Arkansas
Neosho
Upper Arkansas
Verdigris
Walnut

MISSOURI VS. ARKANSAS RIVER BASINS



Source: U.S. Geological Society

KANSAS RIVERS

"In rivers, the water that you touch is the last of what has passed and the first of that which comes; so with present time."

Leonardo da Vinci, Italian artist

Kansas lies within the drainage basin of the Mississippi-Missouri river system. Two major rivers in the state are the Kansas River, a tributary of the Missouri River (which is a tributary of the Mississippi River), and the Arkansas River, a major tributary of the Mississippi River.

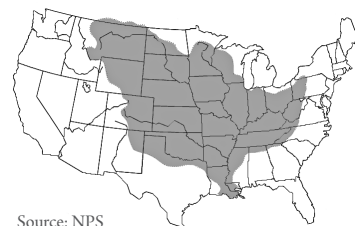
The largest bodies of water in Kansas were created by building dams on rivers. Milford Lake, the largest lake in Kansas, was built in the 1960s by constructing a dam across the Republican River. Tuttle Creek Lake, the second-largest lake in Kansas, is a long, winding reservoir behind Tuttle Creek Dam



Tuttle Creek Lake

Source: USFWS,
Wetlands Mapper

MISSISSIPPI RIVER BASIN AND SUBBASINS

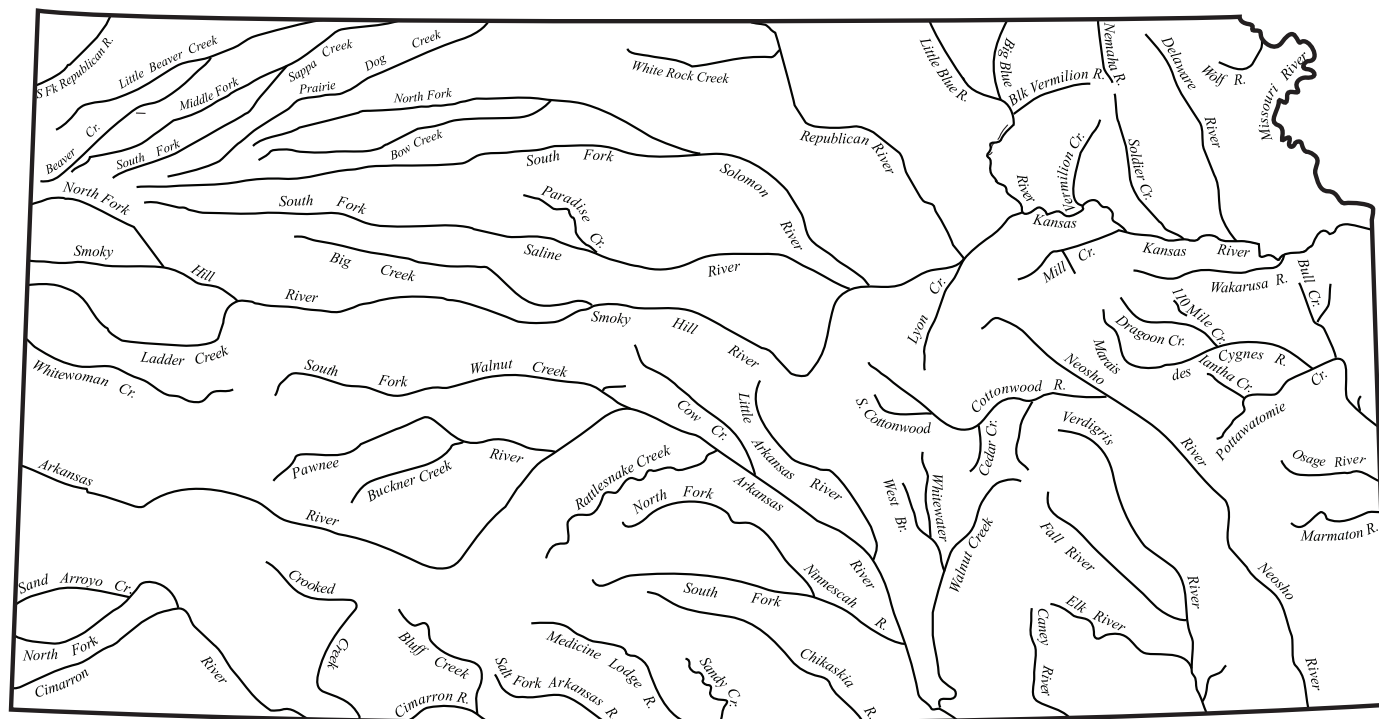


Source: NPS

MISSISSIPPI RIVER SUBBASINS:

Missouri River basin
Upper Mississippi River basin
Arkansas-Red-White River basin
Ohio River basin
Tennessee River basin
Lower Mississippi River basin

MAJOR RIVERS IN KANSAS



Source: KGS

on the Big Blue River. Lakes or reservoirs have been built on most, but not all, of the major rivers in Kansas. Although there are dams on their tributaries, lakes or reservoirs do not impound the Arkansas or Missouri rivers in Kansas. There are no man-made dams on the Cimarron River.

ORIGINS OF RIVERS IN KANSAS

The rivers in Kansas were formed by erosion due to water runoff. During the Pleistocene Era, from one to two million years ago to just 20,000 years ago, the physical features seen today were added to the Kansas landscape. Most of Kansas was fairly flat at the beginning of that time period, commonly referred to as the Great Ice Age. Only two sheets of glacial ice reached Kansas during the Great Ice Age, and those glaciers only extended into the northeastern corner of the state. However, glaciers in the Rocky Mountains also contributed to the formation of streams and rivers in Kansas. When those glaciers and the sheets of glacial ice north of Kansas began to retreat (melt), the water formed channels (streams). As in a delta, those streams spread sediment over the surface of the land. Later, dust storms lifted any loose particles and then re-deposited them, creating some of the most fertile soils in the world across Kansas. In some places, those wind-blown deposits reached a depth of more than 100 feet. In northeastern Kansas, they formed bluffs 60 to 100 feet thick along the Missouri River. Water from the melting glaciers flowed around the sediment and rock deposits and cut new channels in the landscape. Prior to this time, rivers through Kansas ran from north to south. During the Ice Age, Kansas streams began flowing eastward to southeastward, making their way to the Mississippi River. Streams trapped by physical features, such as the Walnut River on the west slope of the Flint Hills, may flow in a different direction, but all Kansas streams and rivers eventually drain into the Mississippi River. Floodplains formed when a river moved from one side of a valley

to another, changing the course (path) of the channel, or during flood events, when sediments were deposited on land adjacent to the channel.

EXPLORING RIVERS IN KANSAS

The **Kansas River** is named after the Kansa Indians who lived along its banks. The river is formed by the junction of the Smoky Hill and Republican rivers at Junction City, Kansas. The Kansas River flows 170 miles downstream to Kansas City, where it empties into the Missouri River. In the early days of Kansas, the Kansas River was a major transportation "highway." In the 1800s, the unpredictable nature of the river and its shallow, braided course during periods of low flows made navigation difficult. Today, the Kansas River is classified as a navigable stream but no commercial navigation operates on the river. Eighteen federal reservoirs operated by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation impound (collect and store) water on most of the major tributaries of the Kansas River. The river itself is impounded by Bowersock Dam, a low hydroelectric dam at Lawrence. The Kansas River drains over 60,000 square miles—over 34,000 square miles in Kansas and 26,000 square miles in Nebraska and Colorado. The Kansas River is also referred to as the Kaw River.

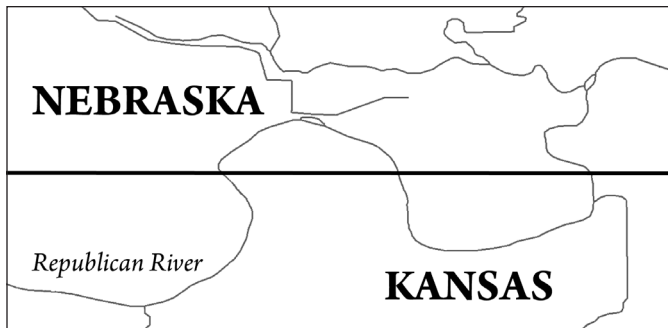
At 1,460 miles, the **Arkansas River** is the longest tributary to the Mississippi-Missouri river system. It originates near Leadville, Colorado, and carves out areas of scenic beauty, such as the Royal Gorge near Canon City, Colorado. This river travels through Kansas before entering northeastern Oklahoma where several other rivers join the Arkansas River. Then the river crosses the state of Arkansas, where it empties into the Mississippi River 600 miles north of New Orleans. Europeans discovered the Arkansas River before they found the Mississippi River. In 1541, the Spanish explorer Francisco Vasquez de Coronado crossed the Arkansas River near present-day

Streams & Rivers

Dodge City, Kansas. In Kansas, the Arkansas River drainage is divided into two river basins: the Upper Arkansas and Lower Arkansas river basins. Several counties (Barton, Rice, Rush, Stafford, Pawnee, Ford, Edwards, and Kiowa) are divided between the two river basins.

The **Missouri River** begins in Montana and travels through North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri before joining the Mississippi River. It is the longest river in the United States - 2,540 miles long and 200 miles longer than the Mississippi River. The Missouri River forms the boundaries between several states, including northeastern Kansas and Missouri. It passes through Kansas City, Kansas. Before the spread of railroads, the Missouri River was the primary means of transporting goods and people. The Missouri River drains nearly all of the northern Great Plains and a small portion of southern Alberta, Canada.

The **Republican River** was named for the "Republican" Pawnee Indians who lived along its banks. In the late 1700s, French traders who mistakenly thought that their form of government was a republic named them "Republican." The Republican River is the main source of water for Milford Lake. This river actually flows into northwest Kansas from Colorado, flows north out of Cheyenne County crossing the state border into Nebraska, re-enters the state in Jewell County, crosses back into Nebraska a second time, and then flows back down into Kansas in Washington County. This explains why the Republican River drainage is divided into two river basins—the Upper Republican river basin in northwest Kansas and the Kansas-Lower Republican river basin in north-central and northeastern Kansas. On a Kansas map, the two river basins do not appear to be connected. The Republican River is approximately 550 miles long, including 100 miles in Kansas, and is a part of the multi-state Missouri River watershed.



Multi-State View of the Republican River

Source: USFWS, Wetlands Mapper

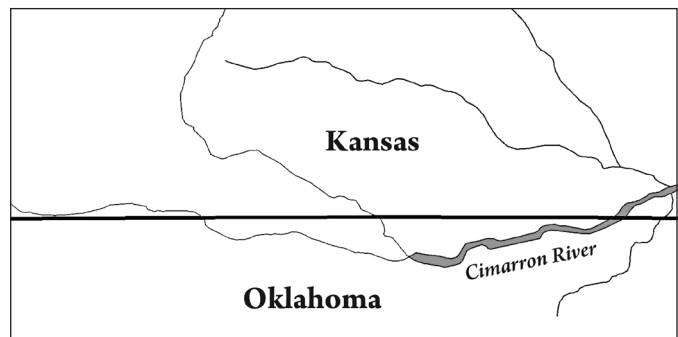
The **Smoky Hill River** rises (originates) in eastern Colorado, enters Kansas in Wallace County, and flows eastward through the state. At Junction City, the Smoky Hill River joins the Republican River to form the Kansas River. In the early to mid-1700s, the Smoky Hill River and the Kansas River were considered one stream, known as the "River of the Padoucas" because the Padouca Indians (the Siouan name of the Comanche) occupied the area. It was first identified as the Smoky Hill River in 1806 but no one knows why or who gave it that name. It is possible the name originated from the word "Kansas" in an Indian dialect, meaning "smoky water." Two dams on the river form Kanopolis Lake and Cedar Bluff Reservoir. The Smoky Hill River is 530 miles long and has a drainage area of 57,727 square miles. One of the major tributaries is the Saline River, which rises near the Sherman – Thomas county line in northwest

Kansas. The confluence of the Saline River and the Smoky Hill River is located east of Salina. The Smoky Hill River is in the Smoky Hill – Saline river basin, which stretches approximately 250 miles from the Colorado state line to Junction City. This river basin is a part of the multi-state Missouri River watershed.

The **Solomon River** begins as two streams, the North Fork and the South Fork, which merge to form one river. There are dams on each of the forks of the Solomon River, forming Kirwin Reservoir on the North Fork and Webster Reservoir on the South Fork. The Glen Elder Dam, which forms the Wacanda Reservoir, is located below the confluence of the North and South Forks of the Solomon River. The Solomon River drains into the Smoky Hill River in Dickinson County. The Solomon River is 496 miles long, including both forks. It is part of the multi-state Missouri River watershed.

The **Marais des Cygnes River** was officially named by the United States Board of Geographic Names in 1971. Marais des Cygnes comes from the French language and means "marsh of the swans." Trumpeter swans, which were historically common in the Midwest, are thought to have used the wetlands adjacent to the Marais des Cygnes River during the spring and fall migrations. According to the U.S. Geological Survey, the source of this river (the head) is the junction of Elm Creek and One Hundred and Forty Two Mile Creek in Lyon County. The Marais des Cygnes River runs through the middle of the Marais des Cygnes National Wildlife Refuge, administered by the U.S. Fish and Wildlife Service. The river is impounded by Melvern Lake, which was built for flood control and to provide water for area communities. The Marais des Cygnes River is 140 miles long. It is part of the Marais des Cygnes river basin in Kansas, included in the multi-state watershed of the Missouri River.

The name of the **Cimarron River** is taken from the Spanish word "cimarron," which means "wild or unruly." The Cimarron River begins in the mountains of New Mexico and then goes through southeastern Colorado. It enters Kansas in two branches, which unite in Grant County. In Meade County, the Cimarron River exits Kansas and dips down into Oklahoma, just below the state line, for about 25 miles before re-entering Kansas in Clark County. In Commanche County, the river flows southeast back into Oklahoma where it empties into the Arkansas River. The Cimarron River is often dry as it passes through Colorado, Kansas, and Oklahoma. For about 100 miles, the Santa Fe Trail followed the valley of the Cimarron River. The Cimarron River is 698 miles long and is part of the Arkansas River watershed.



Multi-State View of the Cimarron River

Source: USFWS, Wetlands Mapper

The name of the **Neosho River** comes from the Osage Indian word "neosho," meaning "water within." This river was also known as the Six Bulls River and the Grand River. In the early 1900s, the Neosho River flooded 57 times in 34 years, with the worst flood coming in 1951. In 1950, the U.S. Congress authorized development of seven lakes for flood control in the Neosho River system, four in Kansas and three in Oklahoma. Even before the John Redmond Reservoir in Kansas was completed in 1965, it was used for flood control on the Neosho River. Council Grove Lake was also formed by constructing a dam on the Neosho River. Marion Reservoir was built on the Cottonwood River, a tributary of the Neosho River, but Cedar Point Reservoir, also on the Cottonwood River, was deauthorized and will not be built. The Neosho River is a tributary of the Arkansas River and part of the Mississippi River watershed. It is about 460 miles long, including about 300 miles in Kansas. Within Kansas, the river has a drainage area of approximately 5,100 square miles and is the principal river in the Neosho river basin.

The **Verdigris River** begins in Kansas with several small streams that come together and form the river. The lowest point in Kansas, just 679 feet above sea level, is found south of Coffeyville where the river crosses into Oklahoma. The Verdigris River had a number of fur trading houses along its course in the early days. The Treaty of 1834 with the Cherokee Indians named the Verdigris River as part of the boundary of their lands. The U.S. Army Corps of Engineers built two dams on the Verdigris River, forming Toronto Lake in Kansas and Oologah Lake in Oklahoma. In Kansas, there are three additional reservoirs on tributaries of the Verdigris River: Fall River Lake, Elk City Lake, and Big Hill Lake. The Verdigris River is about 270 miles long; just over half of the river's course is in Kansas. In Oklahoma, the Verdigris River is part of the McClellan-Kerr Arkansas River Navigation System (MKARNS) for 50 miles above its junction with the Arkansas River.

ARKANSAS RIVER NAVIGATION SYSTEM

In 1946, Congress passed legislation authorizing an Arkansas River navigation system from Catoosa, Oklahoma, to the Mississippi River, known since 1971 as the McClellan-Kerr Arkansas River Navigation System (MKARNS). At the time construction began (1950), this was the largest civil works project ever undertaken by the U.S. Army Corps of Engineers. The MKARNS system is 445 miles long and includes 18 locks and dams. In 1971, the first barges traveled the entire length of the system. In 1986, the first international ocean-going vessel to travel up the Mississippi River and through the entire length of the MKARNS system arrived at the Tulsa Port of Catoosa, Oklahoma. This port is located on the Verdigris River, which the MKARNS system uses for 50 miles before connecting to the Arkansas River at Muskogee, Oklahoma. The newest lock and dam in the MKARNS system was dedicated on July 16, 2004.

The headwaters of the **Walnut River** are located near Cassoday in northeastern Butler County. This river flows to the south-southwest. The river's watershed covers approximately 2,009 square miles, including most of Butler County, 40 percent of Cowley County, and parts of Harvey, Marion, Chase, Greenwood, Sedgwick, and Sumner counties. Tributaries to the Walnut River include the Whitewater River, the Little Walnut River, and Timber Creek. The Walnut River is impounded by El Dorado Lake, completed in 1981 by the U.S. Army Corps of Engineers. The Walnut River is 147 miles long. It carries

water from the Flint Hills into the Arkansas River at Arkansas City, Kansas. The Walnut River is the principal river in the Walnut River basin, which is part of the Arkansas River watershed and the larger Mississippi River watershed.



Near the Walnut River Headwaters

Credit: Douglas S. Helmke, KRWA

There are many other important rivers in the state of Kansas, including those that are impounded by reservoirs or lakes, such as the Big Blue, Little Blue, Wakarusa, Ninnescah, Delaware, Elk, and Fall. Some Kansas rivers are tributaries to the larger rivers and only cross a few counties, such as the Pawnee, Chikaskia, Whitewater, Medicine Lodge, and Black Vermillion rivers. These rivers are important natural resources with interesting histories. For example, the Delaware River was originally called the Grasshopper River. Following the devastating grasshopper invasion of the state in 1874, the state legislature renamed the river in 1875.

KANSAS STREAMS

"Just as the water of a river near its mouth, in its final form, is composed largely of many tributaries, so an idea, in its final form, is composed largely of later additions."

Willy Ley, science writer

STREAM ORIGINS

Most Kansas streams originate inside the state. Like the rivers in Kansas, most streams were formed by erosion due to water runoff. Some streams do originate from the flow of water out of large springs and springs do contribute to the volume of water flowing in many streams. In Kansas, however, the runoff of surface water contributes the largest volume of water to Kansas streams.

STREAM CHARACTERISTICS

A stream is a product of its watershed. The watershed's climate, topography (terrain), geology, vegetative cover, and land use all combine to determine the three physical characteristics of a stream: dimension, pattern, and profile. Dimension refers to the cross-sectional shape of a stream channel. Pattern is the configuration of the meanders (bends) and profile is the stream's slope (drop in elevation). In Kansas, land use and landcover varies, from prairie grasslands and fertile croplands in rural areas to asphalt streets and concrete parking lots in cities and towns. The topography of the land in Kansas changes dramatically as elevations in the different areas of the state range from 697 to 4,039 feet above sea level. These factors combine to create different volumes, frequencies, and velocities of water runoff, as well as variations in the resistance to erosion in stream and river corridors. The differences in stream characteristics have

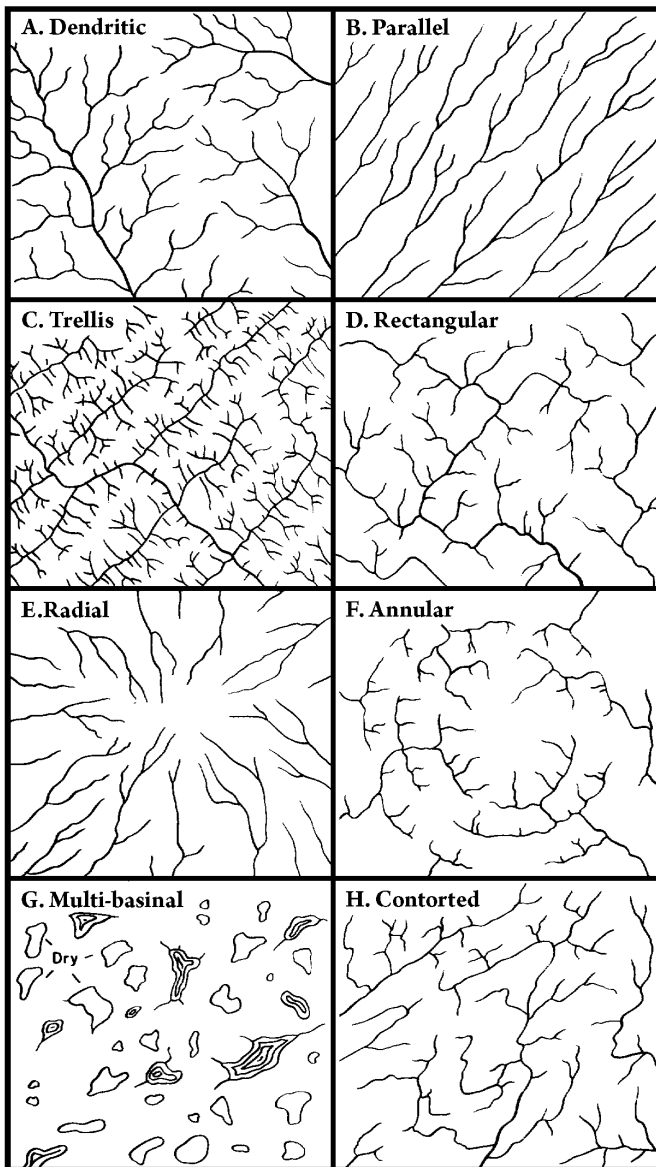
PHYSICAL CHARACTERISTICS OF A STREAM

Dimension— cross-sectional shape (for example, U- or V-shaped).

Pattern— configuration of the meanders (bends).

Profile—slope (drop in elevation).

STREAM PATTERNS



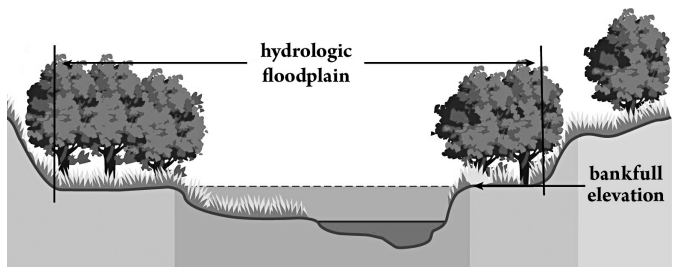
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KANSAS STREAMS AND RIVERS

Intermittent streams	110,225 miles
Perennial streams	23,731 miles
Canals and drainage ditches	382 miles
Total interior stream miles	134,338 miles
Border stream miles	120 miles
Total stream miles in Kansas	134,458 miles

Source: State Conservation Commission

BANKFULL FLOW



Source: FISRWG

STREAM CLASSIFICATIONS

Ephemeral— normally dry; flows only after it rains or snow melts.

Intermittent— flows most of the year but usually dry during one or two months.

Perennial—flows throughout the year; may be dry during an extended drought.

helped develop a wide variety of stream corridors across the state.

Eight variables determine the form and structure of a stream: channel width, depth, velocity, discharge, slope, roughness of channel materials, sediment load, and sediment size. A change in any one of these variables can lead to changes in other variables, resulting in changes to the dimension, pattern, or profile of the stream.

The flow of a stream or river refers to the movement and volume of water that forms the channel of a stream. One of the most important factors affecting the physical characteristics of a stream is referred to as "bankfull flow," a measurement of the maximum volume of water in a stream or river at the moment of highest flow. The bankfull flow transports sediment and excess water from the watershed. It forms the stream's channel, determining width, depth, and shape. Bankfull flow varies from stream to stream but the frequency of these events is similar for most Kansas streams. Based on completed surveys of Kansas streams, on average, a bankfull flow is likely to occur once every 14-18 months, according to the Kansas State Conservation Commission.

CLASSIFYING KANSAS STREAMS

Based on the periods of water flow, Kansas streams can be classified as ephemeral, intermittent, or perennial. Ephemeral streams are normally dry and flow only during or shortly after a rainfall or snowmelt event. Intermittent streams flow most of the year but are normally dry during one or two months of each year. Perennial streams flow throughout the year but may be dry during periods of extended drought. Approximately 80 percent of Kansas stream miles are intermittent or ephemeral.

RIPARIAN AREAS

"Any river is really the summation of the whole valley. To think of it as nothing but water is to ignore the greater part."

Hal Borland, American author

Riparian areas are areas of streamside vegetation, including plants and trees along the streambank and in the adjoining floodplain, the relatively level area of land bordering a stream channel that is covered

NATURAL RIPARIAN AREAS IN KANSAS

Riparian meadows—composed of water-tolerant grass species; usually found along small streams in upper portions of watersheds.

Riparian forests—wide variety of tree species in canopy with small trees and shrubs in the understory; more common in the eastern one-third of the state.

Riparian shrublands—composed of shrubs or small trees; usually associated with intermittent streams that flow most of the year.

Riparian woodlands—limited number of canopy trees, along with shrubs and grasses; common along perennial streams in central and eastern Kansas.

with water during moderate to severe floods. Riparian areas are distinguished from upland areas (higher ground) by vegetation, soils, and topography. The width of natural riparian areas, and the plant community, depends on the terrain, soil type, and available moisture. In general, natural riparian areas along perennial streams are wider than those found along intermittent or ephemeral streams because the water table within those riparian areas is normally maintained at relatively constant and shallow depths during the plants' growing season.

NATURAL RIPARIAN AREAS

Kansas has four types of natural riparian areas: riparian meadows, riparian shrublands, riparian woodlands, and riparian forests.

Although riparian meadows are more common in western Kansas, they can be found throughout the state. Usually, they are found along small headwater streams in upper portions of watersheds. The riparian meadow plant community is composed of grasses which are more water-tolerant than other native grass species. Species such as prairie cord grass, switchgrass, and sedges make up the vegetative community of most riparian meadows. Bulrushes, cattails, smartweed, or spikerush may occur if the riparian area is extremely wet.

Riparian shrublands are usually associated with intermittent streams. In these areas in Kansas, the plant community typically consists of sandbar willow, false indigo, roughleaf dogwood, or buttonbush. Although saltcedar (tamarisk) may be found in riparian shrublands, this small tree or shrub has been declared an aquatic nuisance species in Kansas and other states. Saltcedar was first imported into North America in the 1800s as an ornamental plant and was also used for windbreaks and erosion control. According to the Kansas Department of Wildlife and Parks, saltcedar is now found in 49 counties in Kansas. Large saltcedar plants can use up to 200 gallons of water a day, depleting water resources and altering the ecosystem of a riparian area.

Riparian woodlands are normally composed of cottonwood, black willow, ash, elm, or box elder trees. A more open canopy cover in these riparian areas allows for the growth of grasses and shrubs in the understory. Riparian woodlands can be found throughout the state, but are more common along perennial streams in central and eastern Kansas.

Riparian forests are more common in the eastern one-third of the state. Riparian forests contain a wide variety of tree species

depending on their location in the state. Tree species commonly found in Kansas riparian forests include silver maple, cottonwood, black walnut, green ash, red oak, bur oak, elms, box elder, hickories, hackberry, and sycamore.

Small trees, shrubs, and vines are found in the understory

of riparian forests in Kansas. Harvesting mature trees in a riparian forest can improve the health of the forest while providing economic benefits to the landowner. The negative impacts of harvesting operations can be reduced through planning and applying practices such as minimizing the number of stream crossings, crossing streams at a 90-degree angle, and limiting cutting to no more than 25 percent of the streamside forest when harvesting immediately adjacent to a stream.



Stranger Creek near Tonganoxie

Credit: John Charlton, KGS

RESTORING AND STABILIZING STREAMBANKS

The true meaning of streambank restoration is to return a riparian area to its original state. This is not always possible or may not even be the best option. Most Kansas streams do not have the same dimension, pattern, or profile they had prior to European settlement. Therefore, the challenge of restoration efforts is to attain the best possible condition that a particular riparian area is capable of achieving under present circumstances. In most cases, this means establishing permanent vegetation by planting grass and trees in the riparian area. Historically, a particular stream may not have had trees along the banks. However, where the channel has cut into the banks of a river or stream, establishing trees will help reduce the erosion. The root systems of trees reinforce the soil similar to how concrete is reinforced with rebar.

In long, sandy stream systems, such as the Republican River, trees are a vital component of healthy riparian vegetation. Along reaches (stretches) of this river that do not have trees, the channel is more than twice as wide as that of adjacent reaches with forested riparian areas.

Streambank stabilization is the slowing or stopping of erosion along a streambank. Riparian restoration alone is not enough to solve some streambank erosion problems. Along many streams, the banks are eroding too quickly for riparian plantings to become established. In these areas, the streambank must be stabilized prior to riparian restoration. On large streams, this may include installing rock structures such as bendway weirs or rock vanes, low rock structures designed to slow the velocity of the water and redirect the water flow away from the streambank. Since the entire streambank is not covered with rock, there is room for riparian vegetation to be established between the rock structures. As the speed of the water becomes slower, sediment is deposited near the streambank and

STREAMBANK EROSION

Large eroded streambanks can contribute more than 50,000 tons of sediment to a stream or river each year. That is enough soil to fill an area 10 feet high, 20 feet wide, and almost one mile long.

Source: Soil Conservation Commission

Streams & Rivers

vegetation will become established naturally. This process can be accelerated with additional plantings. Vertical streambanks may be re-shaped to provide a sloped surface for planting a mixture of appropriate grasses and trees. To stabilize the streambank, unrooted cuttings from willow, cottonwood, or sycamore trees can be used to establish new trees. Live willow stakes, placed on lower portions of the streambank, can produce roots over six feet long in just three or four months.

Permits may be required for any project that will change the dimension, pattern, or profile of a stream or when a project will be placing any type of fill (rock or soil) in a stream channel. Approval from one or more government agencies must be received before beginning any streambank stabilization or restoration project. Depending on the location and size of the project, the appropriate agencies might include the U.S. Army Corps of Engineers, the Kansas Department of Agriculture's Division of Water Resources, the Kansas Department of Wildlife and Parks, or the Kansas Department of Health and Environment.

THE STREAM ECOSYSTEM

"The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little we know about it. The last word in ignorance is the man who says of an animal or plant: 'What good is it?'"

Aldo Leopold, American ecologist and forester

Many diverse organisms play an important role in a stream's ecosystem. These organisms include plants, animals, fish, insects, and macroinvertebrates. When carefully studied, each organism—even the smallest of worms and bugs—reveals something about how it meets the challenges of its environment and where it fits in the web of life in a stream.

AQUATIC LIFE

A river or stream is filled with small organisms known as macroinvertebrates that are visible but often go unnoticed. These organisms are easily collected and studied, providing an opportunity to research changes that occur over time. Macroinvertebrates found in streams and rivers include clams and worms, as well as the aquatic stages of many insects. Other insects cling to rocks or burrow into silt. Benthic (bottom-dwelling) macroinvertebrates are small organisms that live in, crawl upon, or attach themselves to the bottom of a body of water. Most benthic macroinvertebrates in flowing water are aquatic insects such as stonefly nymphs, mayfly nymphs, caddisfly larvae, and midge larvae. Streams with silt or mud bottoms support invertebrate species, such as tube-building worms, burrowing mayflies, "blood worms" (midge larvae), mussels, and clams. These organisms are an important part of the river ecosystem and aquatic food chain.



Jackson Heights High School Students

Credit: Roberta Spencer



Mussels

Credit: Curtis Wolf

FISH

The type of fish living and reproducing in a stream or river identifies whether the stream is a cold water, cool water, or warm water fishery. Cold water fish include species such as trout and salmon, which are members of the trout family. These species live in well-oxygenated streams that have a swift current. Trout grow best in water temperatures between 50 to 65 degrees Fahrenheit. They are insectivores, feeding only on insect species like mayflies and stoneflies. Trout are not native to Kansas. However, the Kansas Department of Wildlife and Parks stocks trout by releasing hatchery-raised fish in many locations around Kansas for sport fishing.

The smallmouth bass is a typical species found in cool water fisheries, stream segments that are marginal for trout. Bass prefer a habitat of riffles and deep pools. Their activity is normally restricted to one pool where the bass feed on insects or crayfish flushed out by turtles and bottom-feeding fishes.

Warm water species, such as largemouth bass, crappie, bluegill, and catfish, are found where water temperatures are higher. Warm water fish eat mainly invertebrates (animals such as insects or worms that do not have a backbone). However, the largemouth bass—one of the most popular sport fish in North America—is a predator that feeds on almost any animal that swims or falls into the water, including fish, crayfish, large insects, frogs, snakes, or mice. Catfish are omnivores, eating both plants and animals. Channel catfish are found in nearly all the streams and rivers in Kansas.

The 135 species of fish found in Kansas includes 116 native and 19 introduced (non-native) species. The number of native fish species in Kansas exceeds those native species found in any state farther west or directly north of Kansas. Some of the native fish species found in Kansas are typical of prairie streams. On the other hand, Kansas is the western limit of the range of many fish species found in the forested regions of the eastern United States. No species of fish



Trout

Credit: Ken Hammond, USDA



White Crappie

Credit: Ken Hammond, USDA



Largemouth Bass

Credit: Ken Hammond, USDA



Catfish

Credit: Bob Savannah, USFWS

EATING HABITS

Carnivore—eats animals.

Herbivore—eats plants.

Insectivore—feeds primarily on insects.

Omnivore—eats both plants and animals.

KANSAS FISH SPECIES

ENDANGERED

- Arkansas River Shiner
- Arkansas River Speckled Chub
- Pallid Sturgeon
- Sicklefin Chub
- Silver Chub

AQUATIC NUISANCES

- Asian Carp (Bighead Carp, Black Carp, and Silver Carp)
- Round Goby*
- Rudd
- Ruffe*
- White Perch

**listed but not found in Kansas yet*

Source: Kansas Department of Wildlife and Parks

lives only in Kansas but a few species are more abundant here than in any other state. Five fish species have disappeared from the wild in Kansas and another five fish species are listed as "endangered." Five species of fish are listed as aquatic nuisance species, non-native fish that can threaten native species by disrupting the natural ecosystem. At this time, the white perch is the only fish that is an aquatic nuisance species affecting other fish populations in Kansas.

Fishing is a Kansas tradition. However, all streams in Kansas, other than the Arkansas, Missouri, and Kansas rivers, are under private ownership of the adjoining landowners. This means that, unless otherwise posted, anglers must obtain permission to fish in these streams, even from roadways, bridges, or railroad rights-of-way. Through the FISH (Fishing Impoundment and Stream Habitat) program, the Kansas Department of Wildlife and Parks provides public access to more than 83 miles of streams on private land. The Arkansas, Missouri, and Kansas rivers are public property up to the normal high-water line; however, anglers must obtain permission before crossing private property to fish in those rivers.

MAMMALS

Riparian areas are areas of streamside vegetation supported by the adjacent stream or river. The combination of cover, water, and food resources in riparian areas make them desirable habitat for large mammals such as mule deer and white-tailed deer. Other mammals, such as the otter, ringtail, raccoon, beaver, muskrat, swamp rabbit, short-tailed shrew, and mink, normally live in riparian areas. Riparian areas also provide tall dense cover for roosts, water, and abundant prey for a number of bat species, including the little brown bat, big brown bat, and pallid bat.



Otter

Source: USDA NRCS



Deer

Credit: Ken Hammond, USDA



Bat

Source: USDA NRCS



Raccoon

Credit: Bob Savannah, USFWS



Beaver

Credit: Bob Savannah, USFWS

Certain animal activities also influence stream corridors and riparian areas. For example, beavers build freestanding lodges that act as dams and cause ponds to form within a stream channel or in a floodplain. These ponds kill much of the existing vegetation, although they do create wetlands and open water areas for fish and migratory waterfowl. If appropriate woody plants in the floodplain are scarce, beavers extend their cutting activities into other areas, which can significantly alter riparian and stream corridors. In Kansas, beavers generally dig their dens in streambanks rather than building lodges that dam up streams or rivers.⁶ Beaver cutting changes the mix of tree species found in that area, increasing the number of trees that grow rapidly, such as alder, willow, and poplar.

REPTILES, AMPHIBIANS, AND TURTLES

Nearly all amphibians (salamanders, toads, and frogs) depend on aquatic habitats for reproduction and surviving extreme temperatures. Amphibians start their life in the water in a larval state (with gills), called tadpoles in frogs and toads. There are 30 species of amphibians found in Kansas, including the barred tiger salamander—designated as the state amphibian in 1994. Although reptiles (lizards and snakes) lay their eggs on land, many of the 76 species of reptiles found in Kansas are found in stream corridors and riparian habitats. The eastern hognose snake, which lives along rivers and streams in eastern Kansas and is listed as a "threatened" species in Kansas, eats only toads. There are 15 species of turtles found in Kansas, most of which are aquatic species. The state turtle of Kansas, the ornate box turtle, is a terrestrial (land-dwelling) turtle.



Turtle

Source: USDA NRCS

BIRDS

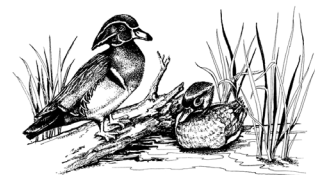
Birds are the most commonly observed terrestrial wildlife in riparian corridors. Nationally, over 250 species have been reported using riparian areas during some part of the year.⁷ Birds make up the majority of the animal species found in Kansas, with the Kansas Department of Wildlife and Parks reporting that there have been 468 bird species confirmed in the state. Because they can fly, birds can change locations and use different areas during different seasons.

Both migratory and resident bird species use stream corridors in Kansas, including species that forage for insects on foliage (vireos and warblers) or on the ground or in trees (thrushes and woodpeckers). Other bird species forage for seeds on the ground (doves, orioles, grosbeaks, and sparrows). Some bird species, such as the wood duck, eat seeds from aquatic plants, seeds that fall into the water, insects, and small crustaceans. In the winter, bald eagles are attracted to areas of open water, including along the Arkansas River in Wichita and the Kansas



Canada Geese

Credit: Tim McCabe, USDA



Ducks

Source: USDA NRCS



Bald Eagle

Source: USDA NRCS

Streams & Rivers

River in Lawrence. Other migrant bird species nest on sandbars and gravel areas in rivers, such as the least tern and piping plover, which were first reported nesting on the Kansas River in the mid-1990s.

DOMESTIC LIVESTOCK

Stream corridors provide water for domestic livestock, in addition to providing protection from the weather (cooling shade in the summer or shelter from harsh winter winds). Many stream corridors produce vegetation for grazing animals, including domestic livestock. However, unless carefully managed, livestock can overuse these areas, causing a loss in vegetative cover that contributes to streambank erosion and alters the composition and diversity of species found in the stream corridor and associated riparian areas. Farmers and ranchers manage livestock use of riparian areas by limiting grazing periods or timing grazing periods to coincide with the availability of certain vegetation. Farmers and ranchers may also limit access to streams for watering, provide alternative water supplies or shelters, or stabilize in-stream watering points to reduce the potential for erosion or bacterial contamination of the water from livestock waste.



Horses

Credit: Tim McCabe, USDA

WATER MANAGEMENT

"The most delicate and yielding of our necessities, water, can be the most powerful destroyer, swallowing everything."

James Broughton, poet, playwright, and filmmaker

SURFACE WATER

The water in streams, rivers, ponds, and lakes is called "surface water." Precipitation provides most of the surface water for the streams and rivers in Kansas. The distribution of surface water across the state of Kansas reflects the variation in the climate across the state. Annual runoff, water that moves across the land's surface, varies greatly—from 0.1 inch in western Kansas (less than 0.6 percent of annual precipitation) to approximately 10 inches (25 percent of annual precipitation) in eastern Kansas.⁸

In Kansas, surface water cannot be diverted from a stream or river and used without a water right or permit issued by the state of Kansas through the Kansas Department of Agriculture's Division of Water Resources. Minimum desirable streamflows may also be established to maintain and protect instream water uses. The purpose of a minimum desirable streamflow is not to keep the stream flowing through all climatic conditions, such as severely dry periods or extended droughts. Instead, minimum desirable streamflows allow the Chief Engineer of the Division of Water Resources to manage the diversion and uses of water to protect the flow of water. When the supply of surface water in a designated stream or river is not sufficient to satisfy all existing water rights and maintain the established minimum desirable streamflow, steps may be taken to reduce the amount of water available for diversion and other uses. An area may even be closed to new appropriations, meaning no new water rights or permits will be issued in that specific area. In Kansas, minimum desirable streamflows have been established at 33 locations on 23 streams and rivers.

Over 20 separate national, state, and local governmental agencies address water or water-related issues in Kansas. The involvement of so many agencies is, in part, a reflection of the many ways in which water is used. A single water resource often has multiple designated uses. Since many Kansas streams and rivers drain into lakes and reservoirs, they may simultaneously provide flood control, energy production, wildlife habitat, a recreational resource, drinking water, and an irrigation water supply. Each use has quality and quantity issues relating to it. These uses often affect each other, and may also be impacted by other uses both upstream and downstream, such as navigation or waste removal.

WATER COMPACTS

Surface water flows between states. Water compacts are legal agreements between states on how to equitably divide and distribute the water supply of a river or river basin. Kansas is a member of the Republican River Compact, the Blue River Compact, and two Arkansas River Compacts, one with Colorado and one with Oklahoma. In 1998, the state of Kansas filed suit against the state of Nebraska over the administration of water rights under the Republican River Compact, signed in 1943 by Colorado, Kansas, and Nebraska. In 2003, the states reached a settlement that requires Nebraska to limit the number of new wells in the Republican River basin in that state, leaving water in the river to reach Kansas.

FLOOD MANAGEMENT

During an average year, at least one Kansas stream has severe flooding. Numerous floods on Kansas streams, such as those in 1935, have resulted from storms that occurred either entirely or partly outside the state. Other floods result from widespread rainfall on saturated soils, such as the 1951 floods that extended over nearly one-half of the state. Occasionally, intense local storms produce extremely large quantities of runoff, which was the case in the June 1981 flood of Great Bend and the September 1977 flooding of the Kansas City metropolitan area. Regional floods can result from moderate to heavy rainfall lasting several days and occurring over a wide geographic area. As smaller streams empty into larger streams or rivers, the main channel receives large volumes of water. Flooding continues over a long period for some distance along the main channel, which is what happened during the spring and summer of 1993 when much of the eastern two-thirds of the state of Kansas experienced flooding. However, the level of flooding in 1993 was significantly reduced due to the federal reservoirs built for flood control on Kansas rivers and streams following the floods of 1951. In 1993, no lives were lost in Kansas due to the flooding even though the Federal Emergency Management Agency (FEMA) declared 57 counties to be disaster areas and there was nearly \$286 million in flood-related damages in the state.

THE FLOODS OF 1951

From July 9–13, 1951, some areas in the Kansas River basin received over 18 inches of rain while other areas averaged eight inches. One hundred sixteen cities and towns were affected by flooding, including more than 3,000 businesses and over 22,000 residences. In the Kansas River basin, the flood demolished nearly 2,500 residences, destroyed nearly 350 businesses, and damaged over 10,000 farms. Losses exceeded \$725 million. At today's values, that would be approximately \$5 billion.

Dam failures can also result in flooding, generally impacting property immediately downstream. In 2005, the U.S. Army Corps of Engineers began a project to bring the Tuttle Creek Dam up to current standards for earthquake and flood resistance. The goal of the project was to strengthen the dam, which forms Tuttle Creek Lake, so that it could withstand a moderate to strong earthquake. Very small earthquakes occur routinely in Kansas in deep fault zones, including the Humboldt fault zone located 12 miles from Tuttle Creek Dam. These microseismic earthquakes are detectable with specialized equipment but result in little or no evidence at the earth's surface. However, stronger earthquakes have occurred in the Manhattan area, including an 1867 earthquake with a magnitude of 5.1 centered near Wamego, Kansas. In 1906, an earthquake with a magnitude of 4.7 was centered in the Manhattan area while in 1929, the area surrounding Manhattan experienced a series of earthquakes measuring from 3.2 to 4.2 on the Richter scale.

To manage floodwaters and reduce flood-related damage, both structural and non-structural measures are used in Kansas. Flood control projects, such as the construction of dams and levees, are examples of structural measures. In 1953, the state legislature passed the Kansas Watershed District Act, which establishes watershed districts to construct, operate, and maintain "works of improvement on streams to assist in managing floodwater, erosion and sediment damages that occur in the watersheds of rivers and streams in Kansas." According to the State Association of Kansas Watersheds, there are 85 separate watershed districts in 43 Kansas counties. Since 1953, those watershed districts have built more than 1,300 watershed dams in Kansas, with another 1,200 planned. Watershed dams hold water back and release it slowly, allowing the water to soak into the ground and recharging groundwater supplies in addition to providing flood control. Flood control is also provided by the reservoirs built in Kansas by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. Funding for flood control projects, multipurpose small lakes, and the construction and maintenance of watershed dams is provided by the state of Kansas, the U.S. Department of Agriculture's Natural Resources Conservation Service, the State Conservation Commission, and other state and federal agencies. Some cities have also built levees, embankments to prevent flooding along rivers and streams, using local and federal funds.

To reduce the potential for flood damage, local governments may take non-structural measures, such as preventing development from occurring in flood-prone areas, removing structures that are likely to be damaged during flooding, and protecting or restoring riparian areas and wetlands. Managing flood-prone areas for multiple purposes can reduce the risk of damage from future floods while providing recreational, water quality, and wildlife habitat benefits. Other examples of non-structural measures taken to reduce flood damage include forecast and warning systems and evacuation planning.

WATER QUALITY

"Soil and water are the very foundation of our agriculture and of our whole Nation. It is therefore the responsibility of every American—every individual and every group—to work together to see that these resources are used wisely and protected for the use of generations that will follow."

Clinton P. Anderson, U.S. Secretary of Agriculture, 1945–1948

HISTORICAL USES

The history of civilization is linked to the availability of water for human needs. Ancient civilizations were forced to relocate when water supplies dried up or were polluted. Hippocrates, an ancient Greek physician, was one of the first to recognize that environmental factors, such as polluted water, could cause disease or illness.

When the colonists arrived in America, settlements clustered in areas where freshwater supplies were abundant. By 1790, nearly four million people lived in the United States, mainly along the eastern seaboard. At that time, the Mississippi River was the western boundary of the country. In 1790, farmworkers accounted for nearly 75 percent of the U.S. work force. During the next century, that number dropped to about 40 percent as the Industrial Revolution spread to the United States and machines replaced manual labor. People moved from rural areas to cities to work in factories. The population of the country kept growing, from 9.6 million people in 1820 to nearly 106 million in 1920. By 1900, there were 38 cities with more than 100,000 residents compared to only nine such cities in 1860.⁹

Until the mid-1800s, each household or business handled the disposal of garbage and human waste by dumping it into streets, alleys, ditches, or streams. Time and natural elements eventually broke down the waste materials or carried it farther downstream. As cities grew, raw sewage, dirt, grease, trash, and organic matter accumulated at a faster rate than it could decompose. This led to the development of the first sanitation sewers, which collected waste from large areas. However, most of the early sewers concentrated the waste and discharged it through fewer outlets, merely changing the location of the problems.

During the Industrial Revolution, factories were located near sources of clean water, a key resource in most manufacturing processes. Industrial wastes were discharged (dumped) into streams and rivers, creating additional quality problems in the nation's waters. As the population continued to grow rapidly, water quality problems increased.

Even though it became a state in 1861, Kansas did not experience a large population increase until after the Civil War. Early on, water problems in Kansas were usually related to quantity, rather than quality.

However, even rural states like Kansas experienced water quality problems. The conversion of grasslands into croplands increased erosion, which added sediment in streams and rivers. Animal waste from increased numbers and concentrations of domestic livestock contributed to the contamination of surface waters. The disposal and treatment of human waste also needed attention. In 1968, according to the U.S. Department of Agriculture, 43,000 communities in the United States still lacked an adequate sewage system and 33,000 still lacked a public water system.¹⁰ Almost all of those communities were in rural areas, many in Kansas.

SURFACE WATER MILESTONES

1899– Rivers and Harbors Act; prohibited dumping refuse or building structures in navigable waters without approval from federal government.

1927– first water pollution survey in U.S.; conducted by the Izaak Walton League of America.

1948– Water Pollution Control Act of 1948; established federal–state cooperation over water quality issues but limited federal enforcement authority.

1956– 1948 law amended to provide federal regulation of waste discharges.

1951– record flooding in Kansas.

1953– Kansas Watershed District Act; established districts to manage floodwaters.

1963– State Water Plan Act; directed Kansas Water Resources Board (renamed Kansas Water Office in 1981) to present a comprehensive state water plan to the Kansas Legislature.

1965– Water Quality Act; directed states to develop water quality standards for interstate waterways.

1972– Clean Water Act (as amended); addresses all pollution sources affecting the waters of the United States.

1981– establishment of the Kansas Water Authority board, which is responsible for approving the State Water Plan, regulations, legislation, and federal contracts proposed by the Kansas Water Office.

1982– State Water Resources Planning Act; requires Kansas Water Office to develop and implement the State Water Plan for the management, conservation, and development of the water resources of the state.

1985– first basin advisory committees appointed in all twelve river basins in Kansas.

1998– Kansas Water Quality Buffer Initiative; provides financial incentives to install riparian forest buffers and grass filter strips to improve water quality in high priority watersheds.

FEDERAL LEGISLATION

The first water pollution legislation in the United States was the Rivers and Harbors Act of 1899, which prohibited dumping refuse or constructing structures (dams, bridges, piers, etc.) in navigable waters without federal approval. However, the act made no provisions for obtaining such approval, issuing permits, or enforcing the legislation.

In 1922, concerned about the deteriorating conditions of America's top fishing streams, sportsmen formed the Izaak Walton League of America to combat water pollution and other environmental issues. In 1927, President Calvin Coolidge asked members of the organization to conduct the nation's first water pollution survey.

The federal government began to control and manage water quality through passage of the Water Pollution Control Act in 1948, which was amended in 1956 to regulate waste discharges. The Water Quality Act, passed in 1965, set water quality standards for surface waters that flow beyond the borders of just one state. The Clean Water Act, passed in 1972 and amended in 1997, addresses all sources of pollution in all waters of the United States.

Since the enactment of these laws, the states have established programs to monitor water quality and address problems. In Kansas, the Kansas Department of Health and Environment monitors streams and rivers and reports violations of the surface water quality standards (specific water quality goals set for each body of water in the state).

HUMAN IMPACTS ON STREAMS AND RIVERS

Since erosion is a natural process, also occurring along the banks and channels of rivers and streams, there will always be some sediment or suspended solids in streams. Although not considered a human health hazard, suspended solids can lead to undesirable water quality conditions by clouding the water and reducing light penetration. This, in turn, reduces photosynthesis and affects aquatic life and plant growth. Conservation practices can improve water quality by reducing the amount of sediment or suspended solids in streams, rivers, and other bodies of water. Anything that slows the water will cause the particles to settle (stop floating and sink to the bottom). In Kansas, filter strips or riparian buffers next to rivers and streams are effective in removing soil particles from runoff. Planted to grass or other permanent vegetation, these areas trap sediments (both mineral and organic), absorb and transform potential pollutants into nontoxic compounds, and provide food and habitat for wildlife. Filter strips and riparian buffers also create corridors for wildlife movement and may recharge groundwater supplies.

To restore water quality in high-priority watersheds, the state of Kansas enacted the Kansas Water Quality Buffer Initiative in 1998. Administered by the State Conservation Commission, the program provides financial incentives to landowners in selected counties who install riparian forest buffers and grass filter strips through the U.S. Department of Agriculture's Conservation Reserve Program (CRP).

Human activities may add materials to surface water that affect its suitability for aquatic plants and animals or human uses. Any additions that affect odor, color, taste, clarity, or chemical composition of the water may have a negative effect on organisms.

RIPARIAN FOREST BUFFERS

Doyle Derrick owns several farms in Brown and Doniphan counties. He planted 93 acres (approximately 20,000 trees) of riparian forest buffers north of Sparks in 2003 and another 53 acres in 2004. Some might say that Derrick's vision for his Doniphan County land is "nuts," and it is—walnuts. In the past 25 years, he has planted over 100,000 walnut trees. "Trees are ideal," says Derrick, "and Doniphan County has some of the best soil for growing them." When pressed to say exactly why he is planting thousands of walnut trees, Derrick simply states, "I like walnuts. And they make a good log."

The Natural Resources Conservation Service (NRCS) office in Troy, and the Doniphan County Conservation District helped design Derrick's riparian forest buffers as part of the Conservation Reserve Program (CRP) and the Kansas Water Quality Buffer Initiative.

URBAN IMPACTS

Urban (non-agricultural) applications of fertilizers, pesticides, and herbicides often exceed agricultural applications when compared on a per square foot basis.

Stormwater runoff is the largest source of pollution to Kansas streams and lakes.

In urban areas, 75 percent of the water entering streams comes from storm sewers.

In high population density areas, 70 percent of the surfaces are impervious (paved or roofed) and 50 percent of all rainfall never touches the soil.

Source: KSU

Some materials form a filmy or oily layer on the surface of the water or cause a physical mess. Others are invisible, but may alter the chemistry of the water and stimulate excessive growth of some plants or algae, crowding out and reducing oxygen and nutrients available to other species. For example, phosphorus encourages plant growth. It is used as fertilizer for agricultural crops, lawns, and gardens and is also found in many detergents. When overused or disposed of improperly, phosphorus will attach to soil particles and may eventually work its way into surface waters. There, excess phosphorus in the water can turn sandbars into weed patches, cover clean rocks with slime and moss, and turn clear water cloudy due to an overabundance of microscopic plant life. The added plant life produces more dead plant material and the decomposition of the additional plant matter robs the water of its oxygen supply, which—in the worst cases—can suffocate fish and aquatic animals.

Atrazine, a common herbicide used in producing agricultural crops, is another potential water contaminant. For brief periods in the spring, a number of rivers, streams, and lakes in eastern Kansas sporadically exceed the maximum containment level for atrazine concentrations in Kansas surface water. Agricultural producers are addressing concerns over atrazine, phosphorus, and other pesticides and fertilizers through a variety of management practices designed to keep potential contaminants from reaching surface waters. Per square foot of application, urban (non-agricultural) applications of fertilizers, insecticides, and herbicides often exceed agricultural applications.

BACTERIA IN SURFACE WATER

Surface water often contains a variety of pathogens including viruses, fungi, protozoa, and bacteria. Bacteria represent the largest number of organisms present in surface water. Bacteria are easily grown under laboratory conditions and can be monitored and used as indicators of human health risks. Human health risks generally occur when there is fecal (solid waste) contamination from human sources. Waste from animals, such as domestic livestock, pets, and wildlife, can also pose risks to human health. Fecal coliform bacteria are always present in the digestive tract of warm-blooded animals and are found in their waste. The Kansas Department of Health and Environment monitors fecal coliform bacteria levels in surface water, using those levels as an indicator of other fecal contamination and evaluating the risk of disease associated with drinking, swimming, or using the water in other ways. If the levels of fecal coliform bacteria are high in water,

there is a high probability that there are other fecal pathogens present. Bacterial levels in water vary widely depending upon the time of year, rainfall, environmental conditions, and the distance between the source(s) of contamination and the body of water. Typically, bacterial levels in water decrease as the distance from the source(s) of contamination increases. Fecal coliform bacteria are associated with fecal material, but similar organisms may be found naturally in soil and water or on the surface of leaves.

Monitoring of surface water by the Kansas Department of Health and Environment found that 75 percent of Kansas streams and 7 percent of lakes were impaired by bacterial contamination. Proper collection, treatment, and disposal of human and animal wastes can reduce bacterial levels in surface waters. Practices that reduce the rate and volume of runoff and allow vegetative buffer areas to filter the water before it enters a river or stream can reduce bacterial survival and protect surface waters.

CHANNELS OF LIFE

"The care of the rivers is not a question of the rivers but of the human heart."

Tanaka Shozo, 19th century Japanese conservationist

All streams and rivers have a beginning and an end but the water in those streams and rivers never reaches a final destination. It only changes form as it is recycled through the hydrologic cycle. Kansas rivers and streams are an important part of this state's history and continue to be valued natural resources. They provide Kansans with one of life's essential nutrients—water. It is the responsibility of Kansas citizens to be stewards of these natural resources so that future generations can have safe, clean water to enhance their lives. ■

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Career Profile:

KEN SHERRADEN

Biologist (Retired), Natural Resources Conservation Service

Ken Sherraden first noticed his interest in the animals and wildlife around him when he was in the third grade. "My father bought me a copy of Roger Tory Peterson's *A Field Guide to Western Birds* so I could start bird watching as a hobby," Sherraden says. "That passion grew into a career." Sherraden recently retired as a biologist with the Natural Resources Conservation Service (NRCS).

The U.S. Congress established NRCS, formerly known as the Soil Conservation Service, in 1935 to assist private landowners in conserving soil, water, and other natural resources. At the time, the extended drought of the Dust Bowl era led to dust storms and created many problems for farmers who were trying to plant crops in Kansas and other Midwestern states.

Today, NRCS employs people in many different disciplines such as agronomy, rangeland management, agricultural engineering, and soil science who are working toward the same conservation goals. As a biologist, Sherraden was involved in many different types of conservation projects to protect natural resources. One task was to conduct studies to assess the impact that these projects have on humans and on the environment. For example, an environmental assessment must be completed before any natural resources project is started. The assessment requires many studies to evaluate how important the area is to the environment and wildlife, as well as how future development might change the current conditions. These studies once required many different people and a lot of time. Today, technology has enabled fewer people to conduct the same studies in much less time. "Technology has allowed information to be at our fingertips," Sherraden said. "This drastic change has enabled NRCS to provide better service to the public."

An education with a strong interest in math and science is important to being a good biologist, according to Sherraden. He also said a person in his former position, besides having an interest in the environment, must be good at working with people. A biologist with the NRCS spends 90 percent of his or her time working with people. NRCS works with agricultural producers to develop environmentally friendly practices that can prevent water and soil erosion and ensure good water quality. Most farmers understand the benefits of being good stewards to their land, Sherraden said.



Courtesy: Ken Sherraden

Career Profile:**LEE ROLFS****Attorney, Kansas Department of Agriculture**

United States of America founding father Benjamin Franklin once said, “When the well is dry, we learn the worth of water.” It is Lee Rolfs’ job to ensure that Kansans have enough water in their wells—and all Kansas water sources—both for today and in the future.

“Having an adequate supply of clean, usable water is one of the most important issues facing Kansas, the United States, and the world,” Rolfs says. “Usable water is essential to all phases of our lives, and there is no substitute.”

Rolfs is a staff attorney for the Kansas Department of Agriculture’s Division of Water Resources based in Topeka. His primary responsibility for the last 29 years has been to help enforce the laws of the state that regulate the use of water. He also helps oversee the water compacts and agreements that regulate water use between Kansas and other states.

Rolfs developed an appreciation for agriculture from his grandfathers who farmed and ranched. He attended grade school and junior high school in Topeka and graduated from high school in Hays.

After graduating from the School of Law at the University of Kansas, Rolfs served a two-year clerkship with the Kansas Supreme Court. He then became Kansas’ first water attorney to represent the state.

The effects of precipitation, and the differences in water use, are obvious as one travels across the state. There could be green, lush pasture in the east, while a city in western Kansas is enacting water conservation regulations.

Kansas has one of the best systems of any state to determine who has the rights to a water source, according to Rolfs. The Department of Agriculture has issued more than 30,000 active water rights and permits that allow people to use water for irrigation, to serve residents of cities, for industry, power plants, recreation, and other uses. Each year, every permit holder must report how much water they used, and the Division of Water Resources verifies they are providing accurate data.

Rolfs says he is sometimes flooded with work relating to water.

“I am extremely lucky to have had a wide variety of issues come through my office since I started practicing water law. New issues continue to arise on a daily basis. I have answered questions about water laws from the public and from other attorneys, appeared in administrative and court hearings, and testified before the Kansas Legislature,” Rolfs says.

Two of his most attention-getting cases involved proceedings before the U.S. Supreme Court involving neighboring states and shared rivers. In one case, Kansas sued Nebraska for failing to share the waters flowing in the Republican River as the compact agreement between the states provided.

“That case was taken care of in five years—the parties agreed how to settle the issues,” Rolfs says. “Nebraska now has to limit its water use from the Republican River.”

In the other case, Kansas sued Colorado.

“Colorado failed to live up to an agreement it made with Kansas in 1949 to fairly share the waters that flowed in the Arkansas River that runs from Colorado to Kansas,” Rolfs says. “The Supreme Court determined that Kansas was correct; Colorado was ordered to pay Kansas more than \$34 million for the damage it caused to our state.”

The Arkansas River case hasn’t been completely finished, Rolfs says. It has been going on for nearly 22 years, but he’s hopeful it will end soon.

“In Kansas, as well as in many other places, the water supply continues to decrease as the demand for water increases,” Rolfs says. “As more people want to use water, the number of disagreements over water increases.”

Like the water itself, discussions about water rights will continue to flow.



Credit: Kansas Department of Agriculture

TEACHER RESOURCES**Books:**

AR - Accelerated Reading Level

Dog of Discovery: A Newfoundland's Adventures with Lewis and Clark

Pringle, Laurence P. 2004 (AR - 7.6)

Mesopotamia

Farndon, John. 2007

Mesopotamia

Shuter, Jane. 2005 (AR - 6.9)

Minn of the Mississippi

Holling, Holling Clancy. 1978 (AR - 5.6)

Mississippi River: A Journey Down the Father of Waters

Lourie, Peter. 2004 (AR - 6.5)

On the Trail of Lewis and Clark: A Journey Up the Missouri River

Lourie, Peter. 2004 (AR - 6.1)

Paddle-to-the-Sea

Holling, Holling Clancy. 2004 (AR - 5.4)

Plants on the Trail with Lewis and Clark

Patent, Dorothy Hinshaw. 2003 (AR - 7.7)

Streams and Rivers Showcase:**SMOKY HILL RIVER**

The Smoky Hill River starts its 530-mile run in the foothills of the Rocky Mountains and drains 57,727 square miles. The river rises (originates) in two places in eastern Colorado—the north fork in Kit Carson County and the south fork in Cheyenne County. Both branches of the river run east into Wallace County, Kansas, where they meet near Russell Springs and begin flowing together. From there, the Smoky Hill River flows eastward through central Kansas. East of Salina, the Saline River drains into the Smoky Hill River as does the Solomon River in Dickinson County. At Junction City, the confluence of the Smoky Hill and Republican rivers forms the Kansas River.

FOSSILS

In the late Cretaceous period, a shallow sea covered western Kansas. As organisms living in the warm seawater died, they sank to the sea floor and formed a thick mud, later covered by other sediment and compressed. Underwater currents helped shape the sea floor, which was exposed when the sea eventually receded. In depressions where water flowed eastward, wind and water carved out deep river valleys through the limestone and sandstone deposits that once formed the sea floor. The chalk beds of northwestern Kansas, home to some of the richest fossil beds in the world, are famous for their marine fossils. Dinosaur fossils have also been found in western Kansas. Fossil hunters continue to explore the Smoky Hill river valley in search of new specimens.

WATER SOURCE

During his expedition across the southern region of the Louisiana Purchase in 1806, Lt. Zebulon Pike was one of the first to record the name of the river as the Smoky Hill River. American Indians, including the Comanche, Kiowa, Sioux, and Arapaho, used the Smoky Hill river valley as their hunting grounds and fiercely opposed the presence of travelers pouring west. In east-central Kansas, the Santa Fe Trail followed the river from Junction City to Ellsworth. The discovery of gold near Denver in 1858 led to widespread use of the Smoky Hill Trail which followed the river. The government used that trail to move troops and supplies and since the trail was the quickest way to reach the gold fields in Colorado and later California, much of the emigration to those areas went over the Smoky Hill Trail or the Butterfield Overland Trail. The Atchison–Denver route of the Butterfield Overland Despatch, a stage and freight line in operation from 1865–1870, followed the Smoky Hill River valley. Military forts were established along the Smoky Hill River to protect traffic along these routes as well as early Kansas settlers and those building railroads through Kansas. These forts included Fort Harker near Kanopolis, Fort Ellsworth, Fort Hays, and Fort Wallace near Sharon Springs.

Recognized as a water source for early travelers, the Smoky Hill River also attracted those seeking to establish towns in central and western Kansas. Towns along the Smoky Hill River include Abilene, Salina, Lindsborg, Ellsworth, and Sharon Springs. Kanopolis Lake, one of the oldest lakes in Kansas, and Cedar Bluff Reservoir were built on the Smoky Hill River to control flooding and provide irrigation and municipal water supplies. Many cities and communities also draw water from alluvial aquifers in the Smoky Hill river valley.

**Monument Rocks**

Credit: Cindy Hart

TEACHER'S RESOURCES (CONTINUED)***River of Life***

Miller, Debbie S. 2000 (AR - 3.4)

A River Ran Wild

Cherry, Lynne. 2002 (AR - 4.7)

Rivers and Lakes

Oxlade, Chris. 2003 (AR - 6.1)

Rivers: Nature's Wondrous Waterways

Harrison, David L. 2002 (AR - 4.2)

Rivers: Sculptors of the Land

Frahm, Randy. 2002 (AR - 6.6)

Swift Rivers

Meigs, Cornelia. 2004 (AR - 7.0)

The Technology of Mesopotamia

Faiella, Graham. 2006 (AR - 7.8)

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Gray, Dianne E. 2006 (AR - 6.0)

Water Power

Webster, Christine. 2005 (AR - 4.7)

A World in a Drop of Water: Exploring with a Microscope

Silverstein, Alvin and Virginia B. Silverstein. 1998

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Discovering Lewis & Clark®

www.lewis-clark.org

Hydroelectric Power Water Use

U.S. Geological Survey

<http://ga.water.usgs.gov/edu/wuhy.html>

River Basins of Kansas – Sunflower Journeys

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<http://www.ktwu.washburn.edu/journeys>

Science in Your Watershed

U.S. Geological Survey

<http://water.usgs.gov/wsc/index.html>

StreamStats – U.S. Geological Survey

<http://water.usgs.gov/osw/streamstats/index.html>

Surf Your Watershed

U.S. Environmental Protection Agency

<http://cfpub.epa.gov/surf/locate/index.cfm>

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Unit 8) Ponds & Lakes

It is hard to imagine the Kansas landscape without any ponds or lakes, even though almost all of these bodies of water are the result of human efforts. In Kansas, lakes and ponds have been built to meet a variety of human needs, including the needs for drinking water, water to irrigate agricultural crops, and water for recreational activities, as well as to reduce flood damages and the impact on human lives due to flooding. At the same time, ponds and lakes provide wildlife habitat and enhance the natural environment.

There is a story behind each pond or lake in Kansas—why it was built, who built it, and when it was built. Those stories bring understanding to the history of the state, and assist in addressing present concerns and planning for future needs.

Building Dam for Erosion Control Franklin County, 1936

Source: Library of Congress;
Arthur Rothstein, photographer



"A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature."

Henry David Thoreau, American author and naturalist

Ponds, lakes, and reservoirs play an important role in the ecology of Kansas. They serve as wildlife habitat, municipal water supplies, recreational areas, and are used for irrigation, power generation, and flood control. From the smallest farm ponds to the largest reservoirs, these bodies of standing water vary in size, purpose, history, and their role in the environment. Bodies of water, no matter what the size, can have a significant impact on the homes, communities, and natural areas that surround them.

KANSAS BY THE NUMBERS

LAKES	40 state fishing lakes more than 200 community lakes
RESERVOIRS	24 federal reservoirs 2 built for power generation
PONDS	over 150,000 (privately owned)

INTRODUCTION

- **DEFINING CHARACTERISTICS**

LAKES, PONDS AND RESERVOIRS

- **LAKES**
- **PONDS**
- **RESERVOIRS**
- **BUILDING RESERVOIRS**

POND AND LAKE ECOSYSTEMS

- **VEGETATION**
- **FISH**
- **BIRDS**
- **OTHER ANIMALS**

WATERSHED MANAGEMENT

- **AGRICULTURAL PRACTICES**
- **THE IMPACT OF DEVELOPMENT**

MULTIPURPOSE WATER

CAREER PROFILES

- **ALICE MCCLAIN, OWNER, MCCLAIN EXCAVATING**
- **GARY KEEHN, DIRECTOR, BANNER CREEK RESERVOIR**

SHOWCASE

- **CHENEY RESERVOIR**

ENDNOTES

REFERENCES

TEACHER'S RESOURCES

DEFINING CHARACTERISTICS

What is the difference between a pond, a lake, and a reservoir? There are many definitions of each body of water, from scientific and geologic definitions to cultural and societal definitions. What one person may call a lake may fit the technical definition of a pond. While there is no clear-cut way to identify beyond debate what the difference is, there are some general guiding factors.

First, a lake is larger and deeper than a pond. Lakes are usually over ten acres in size, while ponds are smaller than ten acres. Lakes are too deep for plants to grow to the surface except around the shore, while ponds are shallow enough to allow sunlight to reach the bottom so rooted plants may grow even in the deepest sections. There are also differences in water temperatures between lakes and ponds. Ponds generally have a uniform water temperature from top to bottom that may change with the air temperature. Lakes, on the other hand, have more stable water temperatures but develop distinct layers with different water temperatures. In addition, ponds experience very little wave action while lakes have enough surface water exposed to the wind to develop waves.

COMPARING CHARACTERISTICS
PONDS • usually smaller than 10 acres in size • shallow enough that plants may root in the bottom • uniform temperature that changes with air temperature • little or no wave action
LAKES • usually over 10 acres in size • deeper than a pond • too deep for plants to grow to the surface, except around the shore • stable temperature (does not change with air temperature) • distinct layers with different water temperatures • develop waves
RESERVOIRS • usually formed by building a dam on a river or stream • built for collection and storage of water for multiple purposes • generally refers to large lakes built by the U.S. Bureau of Reclamation or the U.S. Army Corps of Engineers

A reservoir is a man-made body of water, typically formed by building a dam on a river or stream and used for the collection and storage of water. By definition, then, a small man-made farm pond can be called a reservoir, but generally the term “reservoir” is used to describe the large lakes built for multiple purposes: flood control, drinking water, irrigation, and recreational activities. The actual names attached to most of these large lakes were a result of legislation passed by the U.S. Congress.

LAKES, PONDS AND RESERVOIRS

“Earth and sky, woods and fields, lakes and rivers, the mountain and the sea, are excellent schoolmasters, and teach some of us more than we can ever learn from books.”
John Lubbock, British statesman

LAKES

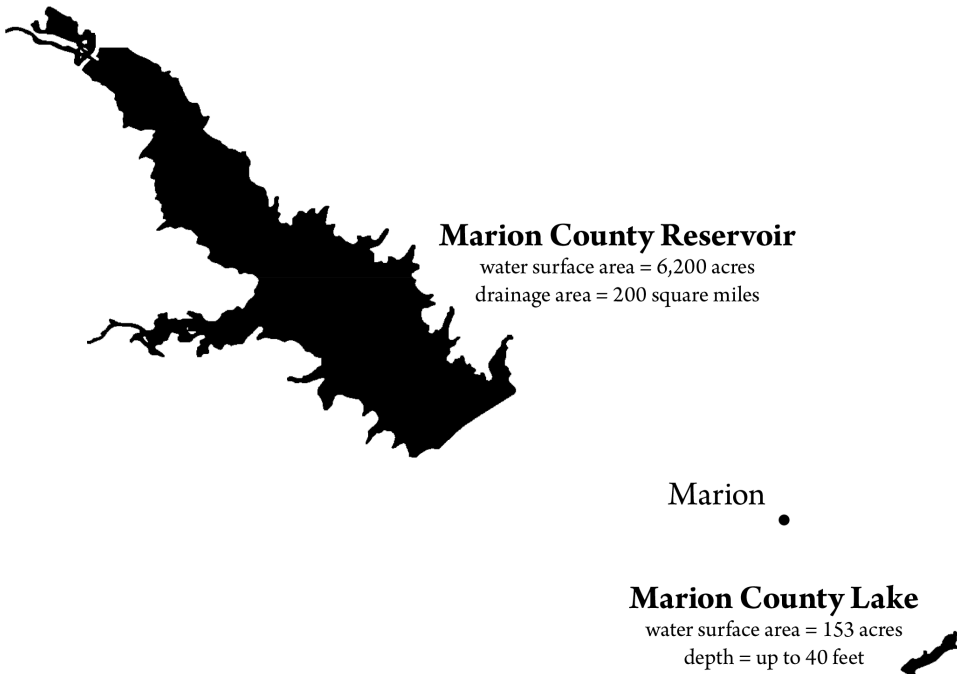
Kansas has hundreds of public and private lakes within its borders, including 26 large reservoirs, 40 state fishing lakes, and more than 200 community lakes owned by local governments. Another way to define a lake, based on the cultural definition of a lake, is that lakes generally have names. In Kansas, other than the large lakes referred to as reservoirs, the primary purpose of lakes is for flood control, recreational activities such as boating and fishing, and wildlife habitat.

In Kansas, lakes are generally filled by surface runoff. Therefore, lake size is directly related to both the size of the watershed and regional precipitation. The watershed is the area of land that water flows across or under on its way to a stream, river, lake, or pond. A lake’s watershed consists of all the land that drains to that particular lake. There are more lakes in southeastern Kansas because of the greater precipitation and surface runoff in this region. With more lakes, each lake has a smaller watershed area. In western Kansas, on the other hand, there are fewer lakes so each lake tends to have a larger watershed area, which somewhat compensates for the smaller amount of precipitation.



Scott State Fishing Lake
Credit: Barbara A. Shelton, KGS

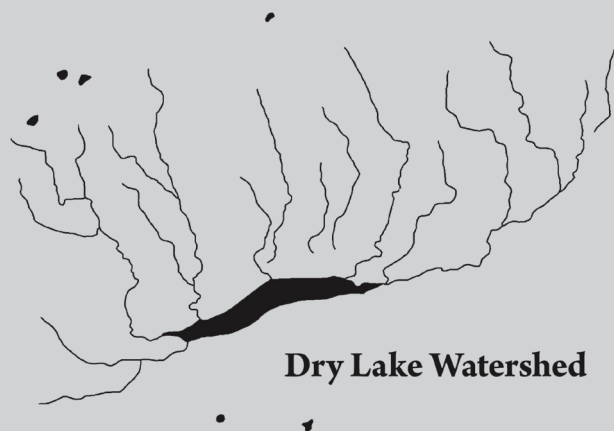
SIZE COMPARISON – MARION RESERVOIR AND MARION COUNTY LAKE



Source: USFWS, Wetlands Mapper

DRY LAKE

Dry Lake, a privately owned lake in southeastern Scott County, is dry most of the time. When the lake is full, water covers about 200 acres.



Source: USFWS, Wetlands Mapper

PONDS

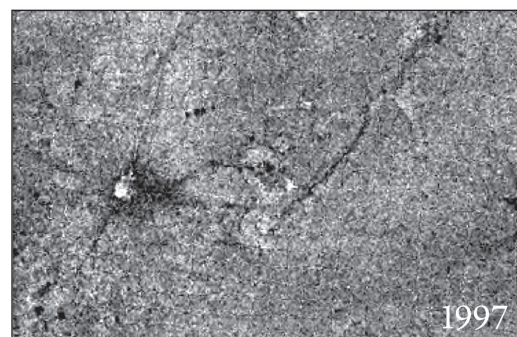
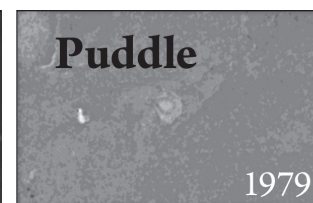
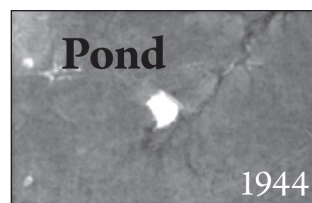
Many bodies of water referred to as lakes are actually ponds. Ponds cover less than 10 acres and are not as deep as lakes. Rooted plants may grow across many shallow ponds. The shallower depths of most ponds also means that seasonal changes affect ponds much more than deeper bodies of water like lakes and reservoirs. A pond may dry up during dry weather and can freeze over (or freeze solid) in the winter.

There are many kinds of ponds. They can be natural depressions or created by humans to hold water for agricultural or other purposes. Farmers build ponds to control flooding, to supply water for livestock and wildlife, and to supply water for irrigation. Some animals, like beavers, even build dams to form ponds. According to the Kansas Department of Wildlife and Parks, there are over 150,000 privately owned farm ponds in the state of Kansas.

One of the unique characteristics of a pond is its temporary nature if it is not maintained to hold water. Left untouched, a pond can slowly change over time, going through several stages in a process called succession. In the first stage, the young stage, a pond has open water with a clear bottom. Small plants begin to grow on the bottom and line the shore. In stage two, small animals such as fish, snails, and dragonflies discover enough food to live in the pond. Plants become



Credit: Richard Sleezer

POND SUCCESSION

Credit: Richard Sleezer

abundant and emergent plants grow out further into the pond. The pond starts to fill in with organic debris as plants and animals die and sink to the bottom. A pond reaches stage three when the emergent vegetation grows all the way across the pond's surface. It becomes a marsh (wetland) at this point. In stage four, dead and decaying material completely fills in the pond so that it now becomes either a grassy prairie or a forest. At this stage, the pond has completed its cycle of succession, a process that may take hundred of years.

RESERVOIRS

According to the technical definition of a reservoir—a man-made body of water that stores water for future use—most lakes and ponds in Kansas could be called reservoirs. However, when most people refer to the reservoirs in Kansas, they mean one of the 26 large lakes created by dams built on major rivers and streams. Most of these reservoirs were built in the 1960s for flood control, water supplies for cities and rural areas, irrigation, and recreational activities. The reservoirs range in size from 1,200 to 16,000 surface acres. In Kansas, two federal agencies, the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation, control the water resources of the federal reservoirs. The land resources of the federal reservoirs are usually managed in cooperation with state and local organizations. Over 90 percent of the state parks and wildlife management areas operated by the Kansas Department of Wildlife and Parks are managed in conjunction with the federal reservoirs. Coffey County Lake and



Wilson Lake Dam

Source: U.S. Army Corps of Engineers

La Cygne Reservoir, two of the large lakes usually identified as Kansas reservoirs, were built to provide cooling water for power generation plants and are not federal reservoirs.

BUILDING RESERVOIRS

Most of the reservoirs in Kansas are only about 50 years old. The creation of these large lakes changed the natural and human landscape of Kansas in significant ways. Thousands of acres of land, most of which was used for agricultural purposes, was replaced with standing water, thus removing habitat for land-dwelling animals and adding habitat for birds, fish, and other aquatic life. The river valleys below the reservoirs were protected from floods like those of 1951, which destroyed public and private property and caused millions of dollars in damages in Kansas.

There were human costs for the changes to the natural landscape of Kansas made by the development of the reservoirs. Many of the dams

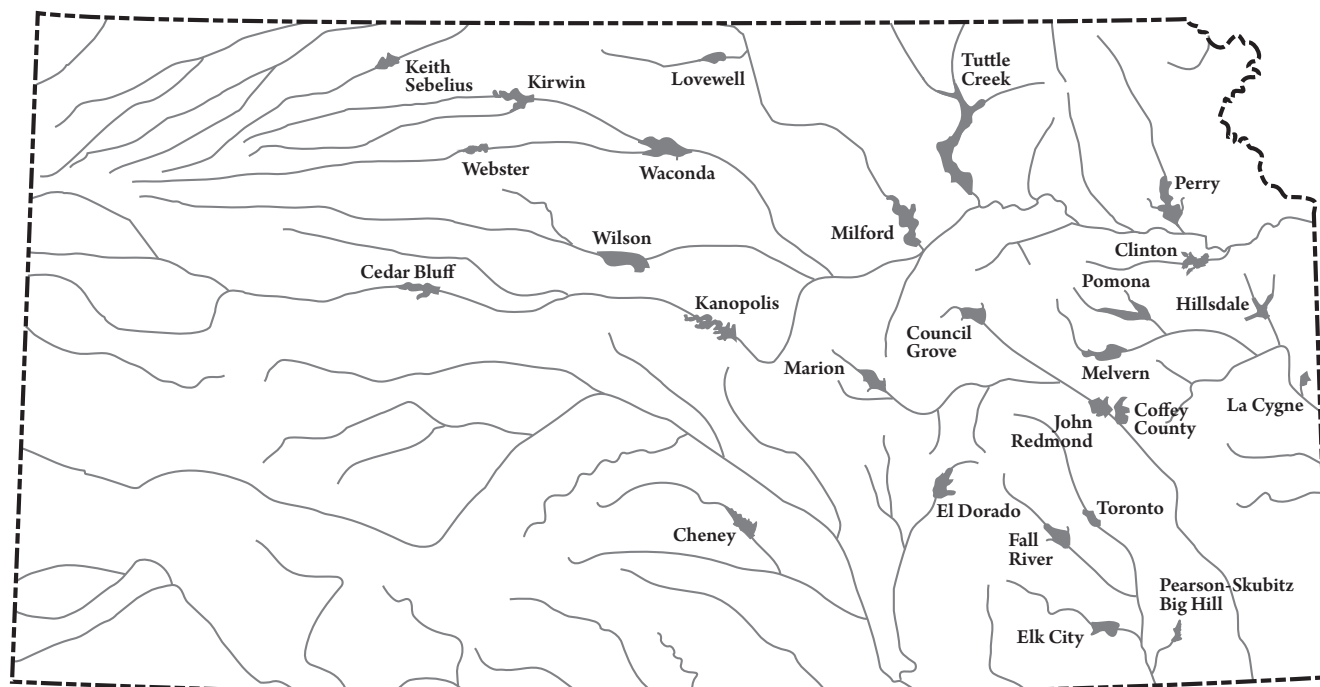


Kanopolis Lake, 1960s

Credit: Edward A. Almquist

and reservoirs built in Kansas were controversial, pitting the need for flood protection of downstream cities and property owners against the rights of area landowners and the costs to small towns and close-knit communities. After all, the lakes displaced land inhabited by more than just wildlife. Thousands of people were forced to relocate their homes. Entire towns, such as Alida and Broughton, disappeared under lake waters. In other places, part or all of entire towns moved to higher ground. Railroads, highways, electric lines, cemeteries, churches, schools, and businesses were relocated. Families who had farmed the same land for generations lost their homes and their land. Though not everyone agrees that the dams—and, thus, the reservoirs—were the best solution for flood control, most people acknowledge the positive impacts of these man-made bodies of water. Engineers report that the savings from reduced flooding over the past 50 years exceed the costs of building and developing the dams and reservoirs. In addition, many of the communities near the reservoirs

KANSAS RESERVOIRS



Source: KGS

KANSAS RESERVOIRS**U.S. BUREAU OF RECLAMATION**

Cedar Bluff Reservoir
 Cheney Reservoir
 Keith Sebelius Reservoir
 Kirwin Reservoir
 Lovewell Reservoir
 Waconda Reservoir
 Webster Reservoir

**U.S. ARMY CORPS OF ENGINEERS –
KANSAS CITY DISTRICT**

Clinton Lake
 Hillsdale Lake
 Kanopolis Lake
 Melvern Lake
 Milford Lake
 Perry Lake
 Pomona Lake
 Tuttle Creek Lake
 Wilson Lake

**U.S. ARMY CORPS OF ENGINEERS –
TULSA DISTRICT**

Council Grove Lake
 El Dorado Lake
 Elk City Lake
 Fall River Lake
 John Redmond Reservoir
 Marion Reservoir
 Pearson-Skubitz Big Hill Lake
 Toronto Lake

**KANSAS CITY POWER & LIGHT COMPANY
AND KANSAS GAS & ELECTRIC**

Coffey County Lake
 La Cygne Reservoir

have benefited by having additional sources of water and from the recreational activities that take place on the public lands surrounding the reservoirs.

POND AND LAKE ECOSYSTEMS

"Birds have wings; they're free;

they can fly where they want when they want.

They have the kind of mobility many people envy."

Roger Tory Peterson, American naturalist and ornithologist

Limnology is the study of inland waters, such as ponds, lakes, and streams. It deals with the ways plants and animals in inland waters interact with their environment and all the environmental factors that influence those ecosystems.

Limnology—the scientific study of lakes and other bodies of fresh water.

VEGETATION

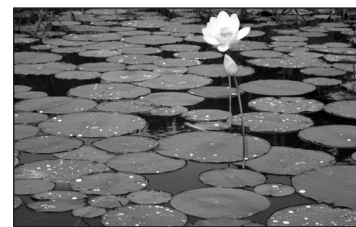
Aquatic plants are beneficial to ponds and lakes and provide the basic foundation for all life on the water. They offer shelter for fish, birds, frogs, and other animals, as well as places for insects to live. Algae, worms, insects, snails, and small fish living among aquatic plants become food sources. Plants produce oxygen and filter runoff by absorbing nutrients, such as nitrogen and phosphorus. The many different species of plants that live in ponds and lakes can be divided into four classes: emergent, submerged, floating-leaf or free-floating, and algae. Emergent plants are rooted in soil that is underwater most of the time. These plants grow up through the water, so that stems, leaves, and flowers emerge in the air above the water level. Emergent plants, such as cattails and bulrush, provide cover for fish, nesting places for birds and other animals, and protect the shorelines by stabilizing sediments. Submerged plants are largely underwater plants with only a few floating or visible leaves. These include pondweeds, elodea, watermilfoil, and coontail. Floating-leaf and free-floating plants may or may not be rooted in the bottom of the lake or pond. They have leaves, and often flowers, that float on the surface of the water while most of the plant remains underwater. The most common floating-leaf plant is the water lily.

Duckweeds and lotus are also floating-leaf plants. The fourth class of plant life is algae. Algae are the smallest and most important food producers in the aquatic environment, forming the base of the food web in a pond or lake. During photosynthesis, algae release



Pond Ecosystem

Credit: Tom Kelley, USFWS



American Lotus

Credit: Cindy Baldwin

THERMAL STRATIFICATION

Due to the heat-absorbing properties of water, the lakes and reservoirs in Kansas and other Midwestern states can form distinct temperature zones—strata—from the surface down to the sediment at the bottom of the lake. The heat comes from direct sunlight on the water. The degree of thermal stratification (number of distinct parallel layers) within a lake or reservoir will vary based on the amount of sunlight available, the level of water mixing due to wind and wave action, and the speed of water flowing through the lake. Strong differences in water temperature at various depths will occur when lakes and reservoirs are subject to intense solar heating in the spring and there is little or no mixing of water due to wind, wave action, or runoff. Strata with large differences in temperature will not mix easily. Once a warm layer forms in a standing body of water in the spring or summer, it will not mix with a lower, cooler layer until fall, when water temperatures in the upper layers drop. In a strongly stratified lake or reservoir, this may mean that the bottom layers of water will be cut off from any sources of oxygen. With no access to new sources of oxygen, oxygen in the lower layers of a lake is rapidly depleted through decomposition of organic matter at the bottom of the lake or reservoir. Fish and other aquatic life are limited to the strata where there is adequate oxygen for their survival. In the fall, when the temperature of the upper layers drops to near the temperature of lower layers, the water layers are able to mix again. Often, this process is called the "turning over" of a lake, reservoir, or deep pond.

Pond Plants



Floating-leaf

Submerged

Emergent

Source: USDA NRCS

oxygen—increasing the amount of dissolved oxygen in the body of the water. Even though these plants are usually single-celled and microscopic, they can occur in such abundance that they change the color of the water and give it a distinctive odor. Algae contain chlorophyll and other pigments, giving "pond scum" (another name for algae) a distinctive appearance.

Excessive vegetation can become a problem in impounded waters like ponds, lakes, and reservoirs. Abundant vegetation can affect the fish population because small fish can hide in the vegetation, which can lead to the overpopulation of certain species. Too much vegetation can also interfere with fishing, swimming, and boating. Dead and decaying vegetation can produce offensive odors. A more serious problem results from the oxygen deficiency caused by decaying vegetation. This can occur at almost any time of year but is most common in mid-summer or in mid-winter. Summer problems occur after periods of hot, calm, cloudy weather. During these times, photosynthesis is greatly reduced, often resulting in aquatic plants dying and decomposing. Winter problems occur when a lake or pond freezes over and a layer of snow covers the ice, blocking out sunlight and preventing the production of oxygen through photosynthesis.

TYPES OF AQUATIC PLANTS

Algae— smallest aquatic plants; usually single-celled and microscopic.

Emergent— rooted in soil that is underwater most of the time; plant parts such as leaves, flowers, and stems grow above water.

Floating-leaf or free-floating—may or may not be rooted in soil; most of the plant is underwater with only floating leaves or flowers visible on the surface of the water.

Submerged—underwater plants rooted in soil with only a few floating or visible leaves.

FISH

Kansas ponds and lakes provide habit for many vertebrates, including fish. There are 135 species of fish in Kansas, including largemouth and smallmouth bass, crappie, channel and flathead catfish, white and striped bass, bluegill, Kentucky (spotted) bass, rainbow trout, and walleye. Fishing is a popular sport across the state and brings revenue to many communities near favorite fishing spots. To keep up with the demand, four state fish hatcheries produce millions of fish each year to stock private and public lakes and ponds. The pond facilities of the Kansas Department of Wildlife and Parks are among the largest in the United States. This agency developed the methods used in producing channel catfish, which now lead all other species in commercial aquaculture in the United States. Several other species of fish are also raised in private commercial fish farms in Kansas.



Walleye

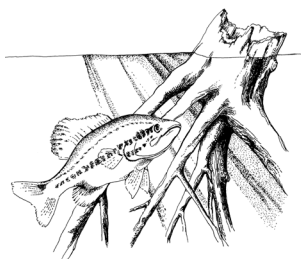
Credit: Bob Savannah, USFWS



Algae

Credit: Mary Anne Stoskopf

All fish need food, water, shelter, and a spawning area. In a pond or lake's food web, the green plants manufacture food for plant-eating animals (herbivores). These small animals are eaten by small carnivores (flesh-eating animals), such as smaller fish and dragonflies. Medium-sized fish eat the smallest carnivores and then are consumed by larger fish. Shelter is provided for fish by structures in the water. Old wood and trees located in the water may shelter fish or provide spawning areas. Each species of fish has different requirements for spawning areas and materials. The spawning areas are essential for fish reproduction.



Source: USDA NRCS

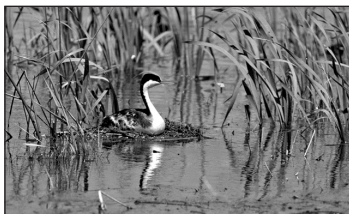
BIRDS

Many of the 468 bird species found in Kansas can be seen around lakes and ponds. Kansas is in the Central Flyway of the North American continent. Many migratory birds visit Kansas during the spring and fall migrations. In the spring, there is usually an abundance of water in small ponds and lakes, providing food and resting areas for migrating species. Following a hot, dry Kansas summer, many of those bodies of water may be low on water in the fall so many bird species stop at the larger lakes and reservoirs during the fall migration. Long-legged wading birds, such as herons, sandpipers, killdeer, and other shorebirds, feed on small aquatic animals, frogs, and fish in shallow areas and along the shorelines. Waterfowl (ducks and geese) feed on aquatic plants, insects, and crustaceans, swim on ponds and lakes, and build nests nearby. Hawks and owls hunt near ponds and lakes while other raptors, such as eagles, dive for fish in lake waters and build nests in trees near or over the water. Songbirds, blackbirds, swallows, and other bird species come to ponds and lakes to drink or hunt insects, such as mosquitoes.



Great Blue Heron

Credit: Jonas N. Jordan, U.S. Army Corps of Engineers



Western Grebe

Credit: Tim McCabe, USDA



Swainson's Hawk

Credit: Paul Kerris, USFWS



Swallow

Credit: Wayne Stoskopf

OTHER ANIMALS

Lakes and ponds provide habitat for many different animals, large and small. Reptiles and amphibians, such as turtles, snakes, frogs, and salamanders, are common in aquatic environments. Amphibians live mainly in water or damp places and usually lay their eggs in water. The typical life cycle of an amphibian includes a stage in which the larvae or tadpoles live exclusively in the water. Reptiles, such as snakes and turtles, find protection from weather extremes in aquatic environments, including ponds and lakes. Aquatic environments

provide both water and food for mammals. Common mammals found near Kansas ponds and lakes include deer, coyotes, raccoons, beavers, and muskrats. Private lakes and ponds also provide critical water supplies for domestic animals, such as cattle and horses.

Wildlife populations are dependent upon the quality of their habitat. The carrying capacity of an area is defined as the greatest number of organisms that can be supported by the area without damaging that area. Some habitats have a higher carrying capacity than others because of a more abundant food supply, more space, greater accessibility to water, or a more diverse vegetative growth suitable for shelter or protection. Wildlife species are interdependent with one another as well as with their environment. If one species is removed, the balance of the ecosystem is disturbed. All plants and animals living in an area derive their energy and nourishment from the soil, the air, the water, and the sun. Lakes and ponds provide unique habitats for wildlife. Many organisms and animals have adapted to the continually changing aquatic environments provided by lakes and ponds and to the broad changes in temperature that may occur in such waters.



Snapping Turtle

Credit: Bob Savannah, USFWS



Coyote

Credit: Bob Savannah, USFWS

WATERSHED MANAGEMENT

"In nature there are neither rewards nor punishments; there are consequences."

Robert Green Ingersoll, American orator

All of the animals and plants which live near the ponds, lakes, and reservoirs of Kansas are dependent upon the quality of the land and the water, and they all affect the quality of the land and the water as well. People who live, work, and play in the watershed heavily impact the quality of the environment. Water runoff flows downhill to the lowest point, which usually means it ends up in a stream, lake, or pond. Pollution resulting from natural and human activity finds its way into the water resources of that region, threatening the quality of the habitat for all living creatures.

Management of the area within the watershed of a lake can provide water protection for the entire life of a pond or lake. Any activity that reduces the amounts of sediment, nutrients, or other potential pollutants carried by surface runoff into a body of water protects the water quality of that pond or lake. Many people are working to protect water quality in the state of Kansas, including agencies such as the State Conservation Commission (SCC). The SCC works with 85 watershed districts within the state to administer programs that improve water quality, reduce soil erosion, conserve water, and reduce flood potential.

AGRICULTURAL PRACTICES

Farmers and ranchers work to protect the water downstream from agricultural areas in many ways. They use soil and water conservation practices designed to reduce soil erosion and the loss of nutrients from cropland. Some conservation practices are designed to reduce surface water runoff, which may reduce the amount of water available to fill ponds and lakes. Farmers and ranchers also maintain ponds and dams by planting grasses around the areas to trap sediment and nutrients, filtering the water and delaying the succession process.

Ponds & Lakes

During dry periods, sediment that has accumulated in shallow ponds may be removed to prepare critical livestock watering ponds to hold water when the rains do come. Dams are inspected and repaired when necessary to extend the life of the ponds.



No-till Corn

Credit: Gene Alexander, USDA

THE IMPACT OF DEVELOPMENT

The areas around lakes and reservoirs are popular sites for homes and businesses. However, development near lakes can be detrimental to the lakes for a variety of reasons. During the construction phase of development, soil erosion can cause sediment and nutrient levels to rise when there is runoff. Once an area is developed, the increase in impervious surfaces (paved or hard-packed gravel areas) also increases the amount of surface runoff. In addition, the activities occurring around houses, shops, and parking areas in developed areas can result in pollution of lake waters. Potential pollutants from urban and developed regions include nutrients from septic systems that are not working properly and lawn and garden fertilizers; metals, oils, and other chemicals from machinery and cars; pesticides from lawns

and gardens; and salt used to clear roads and parking areas during the winter. These sources of pollution are referred to as nonpoint source pollution, because they originate from various sources over a wide land area and enter bodies of water through surface water runoff. Point sources of pollution can be traced back to discharges through specific pipes, channels, ditches, etc. Point sources of pollution include improperly treated municipal and industrial wastewater discharges. The point of discharge may be into a river or stream that flows into a lake or reservoir.

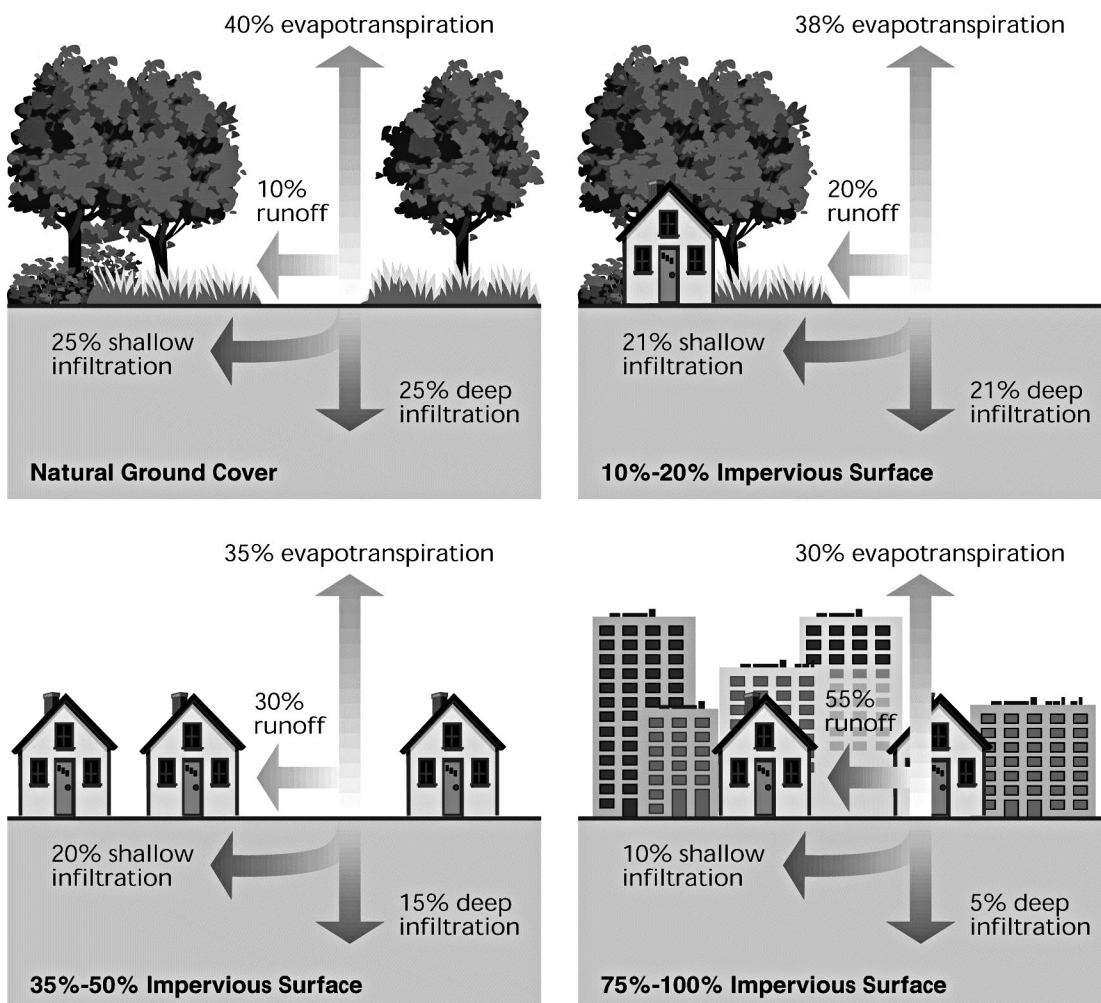
MULTIPURPOSE WATER

"We make the world we live in and shape our own environment."

Orison Swett Marden, American writer

Even though most of them are man-made, the ponds, lakes, and reservoirs of Kansas are important natural resources. Farmers and ranchers use ponds to provide drinking water for their livestock or to irrigate their crops. Birds and animals depend on ponds and lakes for their food, water, and shelter. Communities rely upon reservoirs for drinking water, flood protection, and recreation. Through a commitment to conservation, the citizens of Kansas can ensure future generations enjoy these vital water resources. ■

IMPACT ON SURFACE WATER RUNOFF



Source: FISRWG

ENDNOTES

1. "2001 Environmental Quality Incentives," U.S. Department of Agriculture Natural Resources Conservation Service, <<http://www.nrcs.usda.gov/programs/eqip/2001summaries/KSEQIP%20doc.pdf>>.

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TEACHER RESOURCES

BOOKS:

AR - Accelerated Reading Level

101 Facts about Lakes

Barnes, Julia. 2003 (AR - 5.5)

Animals of Rivers, Lakes, and Ponds

Donovan, Sandra. 2003 (AR - 4.6)

Butternut Hollow Pond

Heinz, Brian J. 2006 (AR - 3.9)

Dams

Oxlade, Chris. 2005 (AR - 6.9)

Food Chains in a Pond Habitat

Nadeau, Isaac. 2002 (AR - 4.9)

Journey into a Lake

Johnson, Rebecca L. 2004

Lakes: Timeless Reservoirs

Frahm, Randy. 2002 (AR - 6.4)

Life in a Freshwater Lake

Jackson, Kay. 2005 (AR - 5.8)

The Magic School Bus at the Waterworks

Cole, Joanna. 1999 (AR - 3.7)

Pond & River

Parker, Steve. 2005 (AR - 7.6)

Pond Seasons

Alderson, Sue Ann. 1997 (AR - 4.4)

Pond Watching with Ann Morgan

Ross, Michael Elsohn. 2000 (AR - 7.5)

Rivers, Lakes, Streams, and Ponds

Beatty, Richard. 2003 (AR - 8.7)

Career Profile:

ALICE MCCLAIN

Owner, McClain Excavating

Alice McClain lives a big life.

And she has literally and figuratively cleared a path across Kansas, working as one of the few female heavy equipment operators.

A resident of Goff, McClain grew up on a farm with four sisters and no brothers. "I was the fourth girl out of five, so I learned early how to run the farm equipment," she says.

The skills she acquired on the family farm serve her well: McClain now owns and operates McClain Excavating, a business enterprise that she married into. Her workforce specializes in running heavy construction equipment—like bulldozers and track excavators—to do jobs like digging ponds, building terraces, and clearing trees.

As a business owner, there is more office time than if she were just running a track excavator, but everything contributes to knowing how best to improve the land. "I spend time on paperwork for payment to government offices and billing individuals. I learned on the job how to stake out waterways and terraces, how to tell grade."

McClain Excavating works closely with the Natural Resources Conservation Service on improvement projects, following their recommendations and guidelines. "Their projects are meant to help the land," she says. "I have learned through running the equipment and everything that goes with it how to help whatever field we are in."

There aren't many females driving heavy equipment, she admits, but stresses the importance of finding what you like to do when you choose a path—never mind what society defines as the norm. "Whatever a person ends up doing in their life for a career has to be something that you really enjoy," she says. "Myself, I gain a lot of personal satisfaction from doing a job well done, and I'm not sure I could do that if I didn't like what I do."



Courtesy: McClain Excavating

Career Profile:**GARY KEEHN***Director, Banner Creek Reservoir*

In May 2007, Gary Keehn became the director of Banner Creek Reservoir, a lake constructed west of Holton in the mid-1990s. Keehn supervises daily operations of the lake and conducts field inspections to ensure compliance with county, state, and federal regulations and laws. He coordinates recreational activities, such as horseshoe, volleyball, and disc golf tournaments, along with recreation programs for cities, schools, and other organizations.

Before he became the director of the Jackson County lake, Keehn taught science at Jackson Heights High School north of Holton. Insects and reptiles filled his “living” science classroom. In addition to his unique indoor classroom, Keehn used hands-on teaching methods that made for memorable, lifelong lessons about the environment. While teaching, he designed and developed a 15-mile hiking and biking trail around Banner Creek Reservoir as well as four nature trails. Today, Keehn’s classroom is outdoors at Banner Creek Reservoir and his students are campers, scout troops, and other lake visitors.

Keehn grew up in Soldier, Kansas, and graduated from Jackson Heights High School. He received his bachelor of science degree at Baker University, with an emphasis in wildlife management and environmental education. However, Keehn says, he didn’t really think he would become a high school science teacher. “When I left Baker, I thought I was going to do research on my own and work for some state or federal agency,” Keehn says. “Then I was offered a job by the YMCA Storer Camps in Michigan to teach environmental education and run two nature centers. My time there really made me realize how environmental and outdoor education can open the eyes of students and adults to their own lives.”

While teaching, Keehn used field trips to streams, rivers, and ponds to teach students about those ecosystems. “I have been able to take what is normal to most people—the enjoyment of being outdoors—and have it become an empowering thing for students,” Keehn says. “The knowledge of these outdoor habitats can empower them to have control of what happens around them in our natural waterways.”

Prior to teaching at Jackson Heights, Keehn taught at Highland High School where he developed a wildlife management class that traveled throughout northeast Kansas counting fish and wildlife populations. Under his leadership, students participated in projects that included biological monitoring and water quality sampling of the Delaware River and sampling of the Missouri River for zebra mussels, listed as an aquatic nuisance species in the United States.

Keehn and his students won numerous awards. Twice, the Kansas Association of Conservation Districts named Keehn Teacher of the Year. He was named the 1995 Wildlife Conservationist of the Year by the Kansas and National Wildlife Federation. Keehn coached several Envirothon teams that competed well on the state level. (The Envirothon is an outdoors science quiz bowl competition for high school students.) In addition, many of Keehn’s students took their science class activities and expanded those, winning FFA and 4-H awards.

It is obvious that Keehn loves the outdoors and passes on that passion. Keehn says that every student can have an effect on his or her surroundings. “They may not all think they are environmentalists, but they can have enough knowledge to keep them interested in protecting our natural areas in many other ways.”



Credit: Roberta Spencer

TEACHER'S RESOURCES (CONTINUED)***Salamander Rain: A Lake & Pond Journal***

Pratt-Serafini, Kristin. 2001

Song of the Water Boatman and Other Pond Poems

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Ponds and Lakes Showcase:**CHENEY RESERVOIR**

Cheney Reservoir is located in south-central Kansas within the north fork of the Ninescah River valley. When it was constructed by the U.S. Bureau of Reclamation in the 1960s, the primary purpose of the reservoir was to provide a water supply for the city of Wichita. Today, Cheney Reservoir provides between 60 and 70 percent of the total municipal and residential water use in Wichita. Other uses of the reservoir complex include habitat for fish and wildlife, recreational uses, and flood control. The reservoir complex consists of over 9,500 acres of surface water, over 5,000 acres of wildlife area, and a state park with nearly 2,000 acres. Cheney State Park includes a marina and boat ramps, camping facilities, areas for fishing and hunting, and hiking trails. The Ninescah Sailing Association sponsors regattas and races at Cheney Reservoir, which is nationally recognized as a sailing lake.



Credit: Lisa French, Cheney Lake Watershed, Inc.

WATER SUPPLY FOR THE CITY OF WICHITA

In the early 1960s, with a population of around 250,000 people, it was becoming apparent that Wichita needed to supplement its main source of water, the Equus Beds aquifer. For more than 50 years, Wichita's primary source of supply had been groundwater pumped from the city's well field in the Equus Beds aquifer, a part of the regional High Plains aquifer. After pumping began in the well field on September 1, 1940, water levels and storage volumes in the aquifer began declining. By supplementing Wichita's public water supply with surface water from Cheney Reservoir, the longevity of the natural aquifer increased.

Wichita and area residents, now numbering over 350,000 in the city alone, want to ensure the longevity and quality of both the aquifer and the reservoir. The U.S. Geological Survey conducted studies monitoring Cheney Reservoir's water quality, particularly when Wichita residents noticed taste and odor problems. In 1994, the Citizens Management Committee and the City of Wichita instituted improvements in the Cheney Reservoir watershed, including incentive payments to farmers and landowners who implement and maintain specific management practices. These voluntary management practices include nutrient and pest management plans as well as waste utilization plans for animal and household waste systems. Actions to reduce the transportation of sediments into the reservoir include the installation of terraces and waterways, grass plantings, and implementation of no-till or reduced tillage cropping practices. These actions have resulted in reducing the sediments entering the reservoir by more than 20,000 tons per year and have prevented an estimated 98,000 tons of waste from entering the watershed annually.¹

NOTES:

NOTES:





Unit 9) Wetlands

Wetlands provide significant ecological, economic, and social benefits. They provide many environmental functions that would be costly and difficult to replicate with man-made systems. Many wetlands offer income from products harvested there, such as hay or timber, or fees collected from those who visit wetlands. Wetlands provide places for hunting, fishing, bird watching, photography, and other recreational activities. Over 90 percent of the wetlands in Kansas are found on private property. State and federal agencies own or control 28,766 acres of wetlands in Kansas.

"Nature does nothing uselessly."

Aristotle, Greek philosopher, 4th century B.C.

INTRODUCTION

KANSAS WETLANDS

- FORESTED WETLANDS
- SHALLOW FRESHWATER MARSHES
- FLOODED BASINS
- WET MEADOWS
- OTHER WETLANDS

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- CHANGING ATTITUDES

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CAREER PROFILES

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SHOWCASE

- CHEYENNE BOTTOMS

REFERENCES

TEACHER'S RESOURCES

WETLAND WORDS

Hydro – from an Ancient Greek prefix meaning "water."

Hydrologic regime – when and how a wetland receives water.

Hydrophytes – water-tolerant plants found in wetlands.

Hydric – contains little or no oxygen.

Wetlands are very different from Kansas' other biomes. They are transition areas that lie between terrestrial and aquatic ecosystems. Three characteristics—hydrologic regime, hydrophytes, and hydric soils—are the criteria generally used to determine if an area is a wetland. These criteria all contain the root word *hydro*, which is Greek for water. "Hydrologic regime" refers to when and how a wetland receives water. A wetland has standing water or wet soils during at least part of the growing season of most years. These wet conditions hinder the growth of plants that are not adapted to wet conditions and causes the vegetation to change to water-tolerant plants called "hydrophytes." Common hydrophytes include cattails, bulrushes, sedges, saltgrass, willows, and cottonwoods. The standing water also causes the soil chemistry and soil bacteria to adapt and become "hydric," which means that the soil contains little or no oxygen.

Cattails

Source: USDA NRCS



KANSAS WETLANDS

"The marsh, to him who enters it in a receptive mood, holds, besides mosquitoes and stagnation, melody, the mystery of unknown waters, and the sweetness of Nature undisturbed by man."

Charles William Beebe, ornithologist, explorer, and author

There are four main types of wetlands located in Kansas: forested wetlands, shallow freshwater marshes, flooded basins or playa lakes, and wet meadows.

KANSAS WETLANDS

Forested wetlands – also known as riparian forests; generally located in temporarily flooded areas or shallow depressions that provide water to support tree species.

Shallow freshwater marshes – found in distinct depressions or around the perimeter of deep water; soils are saturated and there is usually standing water for extended periods.

Flooded basins – also called playa lakes; naturally occurring shallow depressions or sinkholes that hold water during wet years but may be dry at other times.

Wet meadows – lowland prairies that do not drain well; soils stay saturated even though standing water is only present for short periods of time.

FORESTED WETLANDS

A forested wetland supports many tree species. These wetlands are generally located in temporarily flooded areas or in shallow depressions. Often forested wetlands are adjacent to other types of wetlands. The soils are moist enough to support tree species that are absent in the adjacent uplands due to the lack of water there. Tree species that are commonly found in forested wetlands are cottonwood, green ash, pin oak, black willow, and hackberry. Cattails and smartweed are also well adapted to these areas. Forested wetlands provide habitat for black-winged damselflies, salamanders, gray tree frogs, wood ducks, raccoons, white-tailed deer, crayfish, and crayfish snakes. Most of the small wetlands in eastern Kansas are good examples of forested wetlands.



Barred Tiger Salamander

Credit: Bob Gress, GPNC



Wood Duck

Credit: Kayleigh Bitter



White-tailed Deer

Credit: Cheryl Payton, USACE

SHALLOW FRESHWATER MARSHES

A shallow freshwater marsh is found in distinct depressions or around the perimeter of deepwater habitats. The soils are saturated and there is often standing water for extended periods of time. Plant life is dominated by emergent species that are rooted in the soil but



Source: USDA NRCS

have stems and leaves growing above the water, such as grass, arrowhead, cattails, spikerushes, and bulrushes. Submergent plant species, those that grow underwater except for the flowers, may be present if there is adequate standing water for their survival. The Marais des Cygnes and Neosho wildlife areas in Kansas are good examples of shallow freshwater marshes.

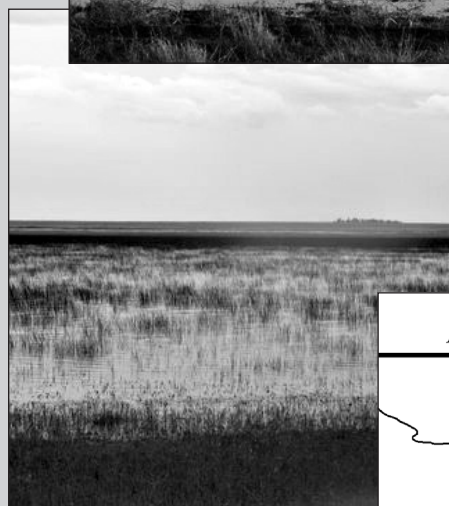
FLOODED BASINS

Flooded basins are most commonly called playa lakes in Kansas. They are naturally occurring shallow depressions or sinkholes, occasionally referred to as buffalo wallows. Playa lakes usually contain a layer of clay which helps with water holding capacity. During wet years, they support perennial wetland plants such as spikerush and cattails. During dry years, they support annual wetland plants such as smartweed and barnyard grass. Kansas is home to approximately 10,250 playa lakes, found primarily in the western half of Kansas. Over 99 percent of the playa lakes in Kansas are privately owned. These wetlands are very important to Kansas because scientists have gathered data that suggests playa lakes are the primary source of recharge for the Ogallala Aquifer.

LAKE LOUISE

Vance and Louise Ehmke, Healy, own the largest playa lake in Lane County. The 172-acre wetland, affectionately called Lake Louise, fills with water about once every 20 years.

On a rise south of the wetland, the Kansas State Historical Society has found evidence of 11 different native cultures—going back 10,000 years—who camped near the wetland to hunt there.



Credit: Louise Ehmke



Source: USFWS, Wetlands Mapper

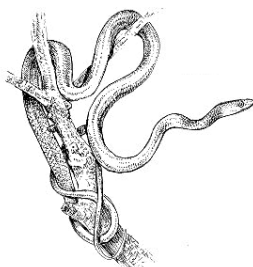
WET MEADOWS

Wet meadows are lowland prairies that do not drain well; therefore, the soils remain saturated most of the year. Standing water is usually present for only short periods during the growing season. Soils in wet meadows have a high clay content and are usually very rich in organic matter or saturated sands. Plants that grow well in wet meadows include foxtail, prairie cordgrass, eastern gamagrass, and sedges. Very few trees are adapted to grow in wet meadows. Animals that make their homes in wet meadows include crayfish, crayfish frogs, killdeer, common snipe, pectoral sandpipers, and rodents, which in turn attract snakes such as ribbon snakes, garter snakes, and massasauga rattlesnakes. Kansas wet meadow examples include road ditches, pond areas, retention basins that catch runoff water, and edges of larger wetland areas.



Killdeer

Credit: Kendra Goering



Rough Green Snake

Credit: Bob Savannah, USFWS

OTHER WETLANDS

Other types of wetlands, some of which may be found in Kansas, include salt marshes, streambed wetlands, groundwater seeps, prairie potholes, swamps, tidal marshes, montane wetlands, fens and bogs (peat forming), vernal pools, and rainforest wetlands.

THE IMPORTANCE OF WETLANDS

"Human subtlety will never devise an invention more beautiful, more simple, or more direct than does Nature, because of her inventions, nothing is lacking and nothing is superfluous."

Leonardo da Vinci, 15th century Italian engineer, painter, and sculptor

ENVIRONMENTAL BENEFITS

Wetlands provide many ecological and environmental benefits. Wetlands provide habitat for one-half of the fish, one-third of the birds, one-fourth of the plants, and one-sixth of the mammals on the U.S. Threatened and Endangered Species lists. Kansas wetlands provide a crucial stopover for migrating birds in the Central Flyway of North America. The migratory birds can sometimes fly thousands of miles with little or no rest and use energy from stored body fat. When their fat reserves are depleted, the birds stop to rest and replenish their energy at wetland areas such as Cheyenne Bottoms and Quivira National Wildlife Refuge, both recognized as wetlands of international



Whooping Crane

Credit: Bob Gress, GPNC

WETLANDS FACT

Wetlands provide habitat for one-half of the fish, one-third of the birds, one-fourth of the plants, and one-sixth of the mammals on the United States' Threatened and Endangered Species lists.

importance. The wetlands are on the list of international importance not only because of the resting area and food supply they offer, but because they are extremely important to the life cycle of migratory birds since 75 percent of all waterfowl breed only in wetlands.

Wetlands also provide flood protection and improve water quality. The roots of wetland plants bind soil and water together to help protect water resources and surrounding lands from floodwaters. Often called natural sponges, wetlands absorb water during heavy rainfall, then slowly release it downstream. This process protects adjoining areas from flooding and protects the soil from eroding and washing away. Wetlands also serve as buffers between streambanks and water bodies. This buffer area helps improve water quality by absorbing and filtering nutrients, suspended materials, and other pollutants from the water before it gets to the stream or lake.



American Avocet

Credit: Bob Hines, USFWS



Canada Goose

Credit: Ken Hammond, USDA

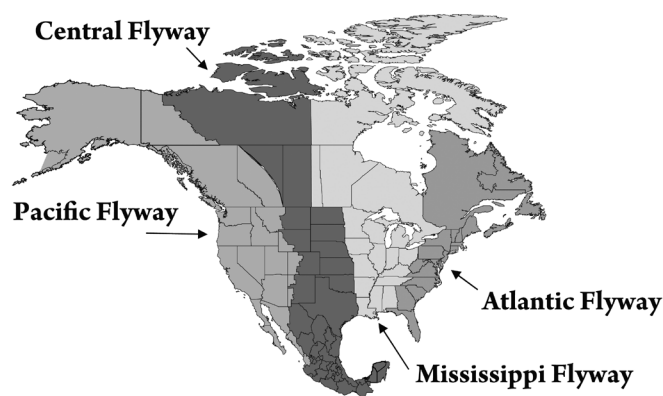
KANSAS WETLANDS OF INTERNATIONAL IMPORTANCE

Cheyenne Bottoms, including both the state-owned Cheyenne Bottoms Wildlife Area and The Nature Conservancy's Cheyenne Bottoms Preserve, was designated as a Wetland of International Importance in 1988. It was the first non-federal area in the United States to receive this recognition. Cheyenne Bottoms is located in Barton County.

In 2002, **Quivira National Wildlife Refuge** was designated as a Wetland of International Importance. Quivira National Wildlife Refuge is located in Stafford County.

In the United States, only 22 sites have been recognized as Wetlands of International Importance.

NORTH AMERICAN MIGRATORY BIRD FLYWAYS



Source: USDA

Wetlands

Wetlands provide environmental benefits beyond soil and water quality. Wetland plant communities store excess carbon within the plants and soil instead of releasing it into the atmosphere as carbon dioxide. This process is called carbon sequestration.

ECONOMIC BENEFITS

Wetland areas have provided many economic opportunities in Kansas. Before the availability of oil and gas, peat was used as an energy source and provided income for those who owned wetlands with peat bogs. Peat forms when plant material, usually in a marshy area such as a wetland, is inhibited from decaying fully by the acidic environment in the soil. Under the right conditions, peat is the earliest stage in the formation of coal. Most modern peat bogs formed in high latitudes after the retreat of the glaciers at the end of the last ice age some 9,000 years ago. They usually grow very slowly, at the rate of only about one millimeter per year. Today peat is rarely used as an energy source because of the convenience of other, more modern energy sources.

Although peat bogs no longer generate income, wetlands can still be a source of income for agricultural producers. Many well-maintained wet meadows with abundant grass species can supply pasture for livestock grazing or support hay production. Forested wetlands, when carefully managed, can be a valuable source of wood products.

The great diversity and abundance of wildlife found in wetland areas means there is income potential from fees collected from hunting leases and access to wildlife areas that include wetlands. Visitors at



Credit: USDA NRCS

many state and federally controlled wetland wildlife areas pay access fees for the privilege of participating in recreational activities such as photography, bird and wildlife viewing, and canoeing. They also purchase hunting and fishing licenses, which support the maintenance of wildlife habitat in Kansas.



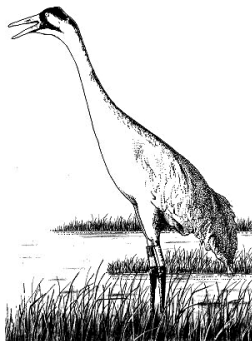
Credit: Paul Kerris, USFWS

SOCIAL BENEFITS

The social benefits of Kansas wetlands are vast. Wetlands offer space to enjoy the outdoors and provide the opportunity for aesthetic appreciation of one of Kansas' most diverse natural resources. Wetlands are among the richest and most biologically productive environments on earth. They provide habitat for some of Kansas' most unique flora and fauna. Even though only approximately 1 percent of Kansas' land area is in wetlands, the diversity of wildlife in or near those wetlands greatly exceeds that of the other 99 percent of Kansas' lands. Plants and animals that live in wetlands can adjust to the wet and dry cycles and flourish in the Kansas climate while less adaptable species, requiring permanent water for survival, suffer the consequences of their rigid habitat requirements.

Sandhill Crane

Credit: Bob Savannah, USFWS



WETLANDS HISTORY

"The wisest mind has something yet to learn."

George Santayana, Spanish-born American philosopher

DRAINING WETLANDS

In the past, the value of wetlands was not understood. They were not protected as an important natural resource. In America's past, many believed that wetlands were useful only if they were drained and the land used for the production of agricultural crops. One of the first large-scale drainage projects was undertaken by the Dismal Swamp Drainage Company in Virginia and North Carolina, which employed a young surveyor named George Washington. The "swamp projects" began the massive draining of wetlands on the east coast, which spread into the Midwest and Kansas as settlers looking for land to farm moved west.

Clay tile pipes, used to make subsurface drains to remove water from low areas and wetlands so that land can be converted to production agriculture, have been used in the United States for nearly 175 years. In 1835, the era of modern agricultural engineering began when the first factory for making clay tile pipe segments opened in Seneca County, New York. In 1835, John Johnston used tile drainage. He is generally recognized as the first person in the United States to use tile drainage. By 1880, there were 1,140 tile factories in the U.S.; most were located in Illinois, Indiana, and Ohio. The increase in the production of clay tile pipes made it easier to drain larger areas of wetlands faster and significantly sped the conversion of wetlands into cropland and areas for development.



Great Dismal Swamp, 1906

Source: Library of Congress

THE FEDERAL GOVERNMENT'S ROLE

The U.S. government assisted in the drainage of wetlands. The Swamp Land Acts of 1849, 1859, and 1860 gave 65 million acres of wetlands owned by the federal government to 15 states for reclamation, which, at that time, meant drainage. In the 1930s, the federal government's role in land drainage was accelerated through the emergency public works programs. These programs were designed to counter the effects of the Great Depression by creating jobs. Many of these jobs involved implementing conservation practices on public lands, including the drainage of wetlands. Today, many of those projects would not be approved as conservation

McPHERSON VALLEY WETLANDS

Nearly 100 years ago, the McPherson Valley wetlands, located primarily in the southern half of McPherson County, were drained like many of the nation's wetlands. However, unlike other wetland areas now lost to development, the McPherson Valley has become part of an unprecedented experiment in restoring a significant wetland area.

It is commonly believed that the McPherson Valley wetlands were at one time either part of a large inland sea, which dried up, or the original streambed and drainage area of the Smoky Hill River, which changed course to flow north into the Kansas River system rather than south into the Arkansas River system at some point in time. No matter which theory is correct, the result was a large wetlands complex consisting of a series of depressions, marshes and shallow lakes stretching from just northwest of McPherson nearly 18 miles to the southern border of McPherson County and on into what is now Harvey and northern Sedgwick counties.

Prior to 1900, the wetlands complex in McPherson County covered approximately 35,000 acres and boasted 9,000 surface acres of water held in 52 separate wetlands. The largest of these areas - still known as the Big Basin - covered approximately 2,000 acres and typically held water at a depth of three feet or less. With its eastern edge located two miles west of McPherson, the basin is approximately three miles wide and seven miles long. North of it is an area known locally as the Little Basin. A series of marshes and small lakes known as the Chain of Lakes, so named because of their appearance as irregularly shaped links on a chain, stretched south of the Big Basin. One of those lakes, Lake Inman, is the largest natural lake remaining in the state.

Before their destruction, the McPherson Valley wetlands were considered equal in importance to Cheyenne Bottoms. It was the only wetlands area in the state where giant Canada geese nested prior to their near extinction at the turn of the 20th century.

In the late 1800s, McPherson County was a popular destination for hunters from eastern cities, including Chicago and St. Louis, drawn by the huge flocks of geese and other migratory birds, as well as other game, which frequented the wetlands. It was said that within an hour, a man could shoot a week's worth of food in its marshes and lakes. Local citizens in the Conway and Inman area supplemented their farming income by guiding hunters. Hunting clubs were established on the shores of both Lake Inman and Lake Farland, and newspapers of the day featured pictures of hunters standing beside their day's harvest. But, the wetlands also posed problems for the county's residents. Swarms of mosquitoes bred in the marshes and pools. There were newspaper reports of large numbers of small animals drowning in the Big Basin and the resulting stench when rain events caused the basin to flood. Most importantly, the waterlogged area was seen as a potential source of valuable farmland if it could be drained. This view of wetlands as waste area was voiced by the United States Department of Agriculture as late as 1919 when it noted in its yearbook that Kansas had 296,000 acres of wetlands "in need of drainage."

McPherson County Commissioners contracted with Harvey County resident John Schrag, a respected self-trained engineer, to attempt drainage of the Big Basin. Schrag began purchasing property in and around the basin in 1901 and designed a system of dikes and ditches to drain the area into Blaze Fork Creek. Using a horse-drawn slip (a blade and scoop) and a Fresno (a larger blade and scoop), he and his sons began the earth work and in 1912 began draining the area into the Blaze Fork. In 1916, he designed and built a steam shovel to provide the power necessary to deepen the outlet ditch into Blaze Fork Creek. His system worked, and both the Little Basin and Big Basin were effectively drained for farming except for a few isolated depressions and Kubin's Clear Pond. While Schrag was successful in draining the basin, farmers who lived along the Blaze Fork experienced flooding as the basin no longer acted as a natural reservoir, but dumped more water into the Blaze Fork during major rain events than its streambed could handle. The farmers organized the Blaze Fork Drainage District and built their own ditch which blocked Schrag's. Judgments from the resulting lawsuits caused the Blaze Fork to be deepened and straightened, with the Schrag family doing the work, and a series of ditches and dikes were built up and down what is now known as the Blaze Fork ditch. By the mid-1930s, the drainage and destruction of the McPherson Valley wetlands was complete, with the exception of about 500 acres including Lake Inman and a few other isolated lakes and low spots, and the area was converted into productive farmland. At the time, John Schrag and his sons were considered to have achieved a monumental engineering feat.

By the mid-1900s, the importance of wetland areas was more clearly understood. In 1989, the McPherson Valley Wetlands project launched with the purchase of 160 acres in the Big Basin and a goal of acquiring and restoring at least 5,000 acres of the historic wetlands. The work has centered on the key areas of the Big Basin, Little Basin and Kubin's Clear Pond (where the project headquarters are located), an area two miles south of the Big Basin, and an area near Inman stretching from Lake Inman to historic Lake Farland, located southeast of Inman, which had been completely drained.

By 2007, the McPherson Valley Wetlands consisted of 4,260 acres of land, including 1,760 acres of restored wetlands, managed by the Kansas Department of Wildlife and Parks. The results have been impressive. In addition to the increasing numbers of geese and ducks that stop over and nest in the McPherson Valley Wetlands, other rare species which have been seen in the area include: whooping cranes, white-faced ibis, peregrine falcons, snowy plovers, piping plovers, the least tern and bald eagles. The area has also seen an increase in upland game birds.

When it began, the project was unprecedented in its size and scope. Scientists are watching the restoration progress and utilizing extensive monitoring of the changes in waterfowl and other wetland animal populations in an effort to add to the knowledge of marsh ecology.

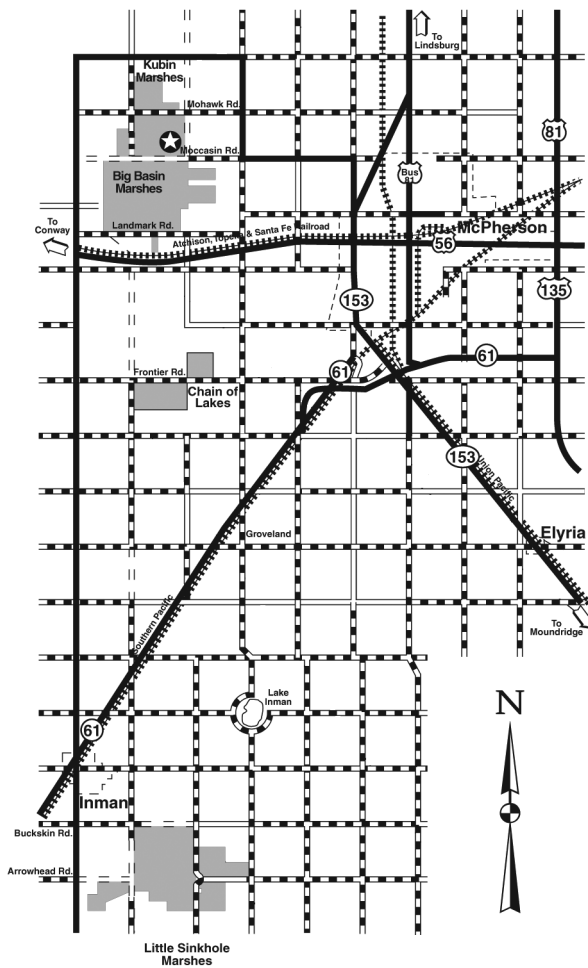
McPHERSON VALLEY WETLANDS



(left to right): Building Drainage Canal; Restoration at Farland Lake (2006); Aerial View (2007); Pheasant Nest with Eggs

Source: Kansas Department of Wildlife and Parks

MAP OF MCPHERSON VALLEY WETLANDS



Source: Kansas Department of Wildlife and Parks

projects. The drainage projects of the 1930s resulted in severe declines in wetland acres across the United States and in Kansas.

CHANGING ATTITUDES

In the 1970s, public understanding of the ecological value of wetlands increased and the federal government's policies on the conversion of wetlands to other land uses began to change. Federal legislation enacted in the mid-1980s slowed the conversion of wetlands for agricultural purposes and encouraged the restoration and protection of wetlands. Now there are federal regulations protecting some wetlands areas from being filled in and requiring mitigation (restoration or construction of new wetlands in a different location) of many wetlands affected by construction or development. In Kansas, there are no state regulations on wetlands but there are policies and programs to facilitate the protection of wetlands. Federal and state programs, such as the Wetlands Reserve Program and the Riparian and Wetland Protection Program, assist landowners in enhancing and restoring wetlands all across the state of Kansas.

WETLANDS CONSERVATION

"To cherish what remains of the Earth and to foster its renewal is our only legitimate hope of survival."

Wendell Berry, novelist, farmer, and philosopher

At one time, open prairie wetlands accounted for nearly a quarter of the total surface area of the Midwest. The estimated amount of wetlands in the conterminous United States in the 1780s was 221 million acres; in 1997, it was an estimated 105.5 million acres. According to the Natural Resources Conservation Service, it is estimated that there were approximately 841,000 acres of wetlands in Kansas in the 1780s and that only 435,400 acres of wetlands remained by 1980 (over 50 percent). Of the approximately 443,000 acres of wetlands now in Kansas, the state and federal government owns or directly controls 28,766 acres. The remaining acres are privately owned, found mostly in the middle of agricultural lands.

Nationally, significant progress has been made in reducing the rate of loss in wetland acres in the United States. There was an estimated 80 percent reduction in the wetland acres lost between 1986 and 1997 when compared to the previous decade. Across the United States, the losses from 1986 to 1997 were attributed to urban development (30 percent), agriculture (26 percent), silviculture - the cultivation and management of forest trees (23 percent), and rural development (21 percent). Today, reducing losses in wetland acreage remains a priority, along with promoting the restoration (and function) of impaired wetlands.



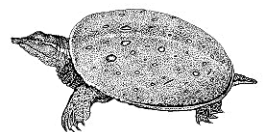
Playa Lakes, Scott County

Credit: Rolfe Mandel, KGS

IMPACTS ON WETLANDS

All impacts, whether due to human activities or natural processes, can affect the function of a wetland and the composition of the species that live there.

Many man-made features pose threats to the health of wetlands. Practices that disrupt the natural hydrologic cycle in wetlands include drainage, dredging and stream channelization, depositing fill material, building dikes and dams, construction, and mining. When the natural physical features of a wetland area are changed, the wetland's water filtering and holding capacities are diminished. Areas that once held and slowed floodwaters no longer perform that function. As runoff moves more rapidly, it can erode the soil, carrying sediment and nutrients into streams and lakes. Changes in a wetland's water holding capacity can destroy aquatic plant and animal life and alter the biodiversity of an area by disrupting the food chain. The survival of every plant and animal that lives within a wetland community depends on the other plants and animals that live there.



Spiny Softshell Turtle

Credit: Bob Savannah, USFWS



Great Blue Heron

Credit: USACE

WETLAND LOSSES

Compared to the previous decade, U.S. losses in wetland acres were reduced by 80 percent between 1986 and 1997.

From 1986 to 1997, wetland losses in the United States were attributed to:

Urban development	30%
Agriculture	26%
Silviculture	23%
Rural development	21%



Source: USFWS

When a wetland's water storage capacity is diminished, ground-water supplies may also be affected.

Wetlands also face many threats from natural processes that alter the earth's physical systems. These physical processes occur naturally without human interaction and change the way land holds water and the amount of water land can hold. Natural physical processes include erosion, changes in sea levels, droughts, hurricanes and other storms, or overgrazing by wildlife. When water levels in wetlands change due to drought or storms, it affects the plant and animal species that live there. Wetland plant and animal communities are adapted to live in specific conditions. They need just the right mix of water and land to survive.

PROTECTING KANSAS WETLANDS

"The joy of looking and comprehending is nature's most beautiful gift."

Albert Einstein, physicist

Knowledge about the ecological value of wetlands has increased. Today, the importance of wetlands to the Kansas environment and the state's economy is widely recognized. Properly functioning wetlands provide water quality benefits, such as filtering nonpoint source pollution or collecting debris and other pollutants. Re-establishing wetland areas and creating alternative solutions to improve water quality is expensive and time-consuming. Protecting and enhancing Kansas wetlands involves the cooperation of private landowners and state and federal agencies. Continuing these efforts is vital to the future of Kansas. ■

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Books:

* *Teachers & Advanced Readers; AR - Accelerated Reading Level*

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A Pocket Guide to Great Plains Shorebirds*

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Starting Life: Duck

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Career Profile:**BRIAN HANZLICK***Natural Resource Officer, Kansas Department of Wildlife and Parks*

By the time he was five or six years old, Brian Hanzlick knew that he wanted to be a game warden when he grew up. Now a natural resource officer with the Kansas Department of Wildlife and Parks (KDWP), Hanzlick attributes his career choice to being around his uncle's friends who were game wardens and biologists. Hanzlick's family lived near a creek in Russell County and he grew up hunting, fishing, trapping, and interested in "anything that dealt with the outdoors." He pursued a degree in natural resource management through the College of Agriculture at Kansas State University, working for KDWP while attending college. After a two-year stint working in Colorado, he returned to Kansas. Today, he mainly works with agencies throughout the Midwest and the states surrounding Kansas, as well as the U.S. Fish and Wildlife Service. He has statewide jurisdiction and can enforce any state or federal law.

As a law enforcement officer, Hanzlick participates in both state and federal investigations—hunting down people who violate fish and wildlife laws and take advantage of the natural resources. "We deal with everything from little lizards to leopards," says Hanzlick. "In one case, we cold-camped in Stafford County for seven days—all day and all night—to break up a major deer poaching ring involving people from North Carolina. Later, after testifying in North Carolina, we went to Florida to confiscate a leopard as part of an investigation into an illegal operation back in Kansas City."

The challenge of catching poachers by understanding their methods drives Hanzlick, although his job encompasses much more. He assists KDWP biologists in enhancing wildlife areas and collecting biological research materials. However, he says that the most rewarding part of his job is the educational component—working with young people, teaching safety and trying to get them interested in the outdoors. In his work in the outdoors, he does not see many young people—a trend that KDWP is working to reverse.

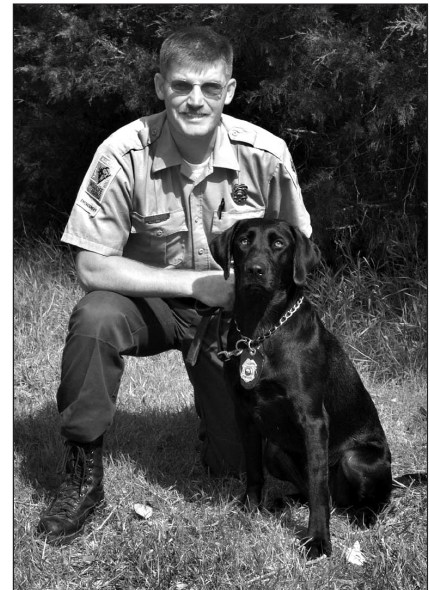
Hanzlick enjoys working in a rural area where most of his law enforcement tips come from honest hunters and farmers and ranchers. His equipment includes a four-wheel drive pickup, a 4-wheeler, airboats, "go-devil" boats (marsh boats made to go in muddy areas), a jet ski, and a regular "lake" boat. Even so, he says that the most fun part of his job is working with the KDWP canine that lives with his family. Hanzlick and the dog spent eight weeks and over 400 hours training in tracking, evidence recovery, and wildlife detection. In addition to working investigations and crime scenes, the team presents demonstrations to a wide variety of audiences. "You have to be a people person, able to talk to both large and small groups," says Hanzlick.

Hanzlick recommends students concentrate on the sciences, math, and writing, as well as presentation and communication skills. As part of his job, he writes the reports used by lawyers to prosecute crimes. He also testifies in federal court. "You want to prove the crime was committed so you have to be really accurate and have confidence in yourself."

Hanzlick's assigned counties (Barton, Rush, and Ness) includes the Cheyenne Bottoms Wildlife Area, which hosts from 200 to 800 or 1,000 hunters on opening day of duck season. According to Hanzlick, the three major hunting seasons in Kansas are duck, pheasant, and deer seasons. Opening days of all three seasons generate money for many rural communities in Kansas.

"Ninety percent of the people I work with are very good people," says Hanzlick, who enjoys working out of his home and having flexible hours. He spends much of his spare time at his family's sporting events and activities. However, it is obvious that he still loves hunting, fishing, trapping, and "anything that deals with the outdoors."

Note: In 1987, KDWP's certified law enforcement officers—formerly known as game wardens or game protectors—became known as natural resource officers.



Courtesy: Brian Hanzlick

TEACHER'S RESOURCES (CONTINUED)***Starting Life: Frog***

Llewellyn, Claire. 2003 (AR - 4.2)

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Wetlands Journey

Weaver, Jeanne. 2007

What is a Reptile?

Kalman, Bobbie. 1998 (AR - 5.3)

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The Wildlife Detectives: How Forensic Scientists Fight Crimes Against Nature

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Career Profile:**MARY PAT HADDICAN***Birder and Quivira National Wildlife Refuge Volunteer*

People from all over the world come to Quivira National Wildlife Refuge just to see the birds that migrate through central Kansas. Although she had never visited Quivira, Mary Pat Haddican decided to move to St. John, Kansas, when she retired—based on Quivira's reputation for birding (bird watching). Now she can go birding at one of the best places in the country anytime she wants.

Haddican was raised in Satanta, Kansas, and earned degrees in chemistry from the University of Kansas and law from the University of Kansas School of Law. She worked as a patent attorney for an oil company in Houston, Texas. When a colleague returned from a birding trip to Africa, Haddican decided that taking a birding trip sounded like an interesting vacation. Her first birding trip to Arizona got her hooked. While living in Texas, she enjoyed birding at Big Bend National Park in west Texas, southern Arizona, and even studied owls during a trip to Montana.

"All a beginning birder needs is a decent pair of binoculars and a field guide. Just start noticing birds," Haddican said. "There are birds all over the place, but we usually don't see them even if they're right in front of us." Because Kansas is located in the Central Flyway, many birds that are not native to Kansas stop over at Quivira National Wildlife Refuge (NWR) during the spring and fall migrations. As a result, birders can find shorebirds in central Kansas in numbers that exceed those in many other parts of the country.

The U.S. Fish and Wildlife Service named Haddican the 2006 Volunteer of the Year at Quivira NWR. In addition to her weekly visits, she helps with the shorebird counts during the spring and fall migrations. In fact, that is how she became involved with Quivira NWR as a volunteer. When there was an opening for a volunteer to do the shorebird counts, the superintendent approached Haddican, telling her that since she was out there all the time anyway, she might as well be doing the shorebird counts.

Haddican also helps monitor the whooping crane migration through the refuge. During the whooping crane migration, staff and volunteers watch for whooping cranes every morning and evening. Detailed records and photographs have been kept of the movements of all the whooping cranes in the United States. At one time, there were only 14 whooping cranes in existence. Today, the species has come back from the brink of extinction and 338 whooping cranes were recorded in the wild in a recent count.

In the fall of 2006, Haddican experienced a spectacular sight when she was covering the evening watch for whooping cranes. "It was getting dark and nothing was happening. A group of people from Wichita were out there on the wildlife drive watching the thousands of sandhill cranes with me," Haddican said. "All of a sudden, a group of five birds started coming towards us. The whooping cranes—three adults and two young—landed in the water very near to where we were standing. We were just staring, with our mouths open. It was the most whooping cranes I had ever seen in one group." According to Haddican, most whooping cranes travel in family groups, usually two adults with one young bird. As it quickly turned dark, Haddican notified the refuge staff of the location of the whooping cranes. The next morning, the birds were still there and detailed information was recorded about the individual birds.

Haddican also participates in the annual Christmas bird counts at Quivira NWR. Year after year, these December or January counts are held in the same locations, providing a long-running record of bird population changes and other information. In addition to helping with birding activities, Haddican volunteers with the city of St. John—planting and weeding flowerbeds, working in the parks, and helping the city's forester. She is active in the Kansas Ornithological Society, an organization for birders in the state of Kansas, and the Friends of Quivira.

"Quivira is not just birds," Haddican said. "It's also wildflowers, butterflies, dragonflies, snakes, and other wildlife. Dragonfly watching is getting to be very popular. Quivira NWR is a great birding spot, an incredible natural resource, and an example of how beautiful Kansas is. I really try to emphasize what a treasure Quivira is." Her enthusiasm is contagious and her volunteer work helps maintain that treasure for Kansans and people all over the world.



Courtesy: Mary Pat Haddican

**Whooping Crane**

Credit: Bob Gress, GPC

WEBSITES:**Kansas Department of Wildlife & Parks**<http://www.kdwp.state.ks.us/>

Cheyenne Bottoms Wildlife Area
(Locations>Wildlife Areas>Region 3)

McPherson Valley Wetlands
(Locations>Wildlife Areas>Region 4)

National Wetlands Inventory

U.S. Fish & Wildlife Service

www.fws.gov/nwi/**Quivira National Wildlife Refuge**www.fws.gov/quivira/**Shorebird Sister Schools Program**

U.S. Fish & Wildlife Service

<http://66.241.214.202/index.cfm>**Wetlands**

U.S. Environmental Protection Agency

www.epa.gov/owow/wetlands

Wetlands Showcase:

CHEYENNE BOTTOMS

The Cheyenne Bottoms basin is located in central Barton County. It includes two internationally recognized wetland areas that attract visitors—both birds and people—from around the world. The Wetlands and Wildlife National Scenic Byway passes through the basin on the north and east sides.

The basin is an oval-shaped natural area about 13 miles long (east to west) and six miles wide (north to south). It includes approximately 41,000 acres of land, covering nearly 64 square miles. Cheyenne Bottoms Wildlife Area, owned and managed by the Kansas Department of Wildlife and Parks, covers 19,857 acres within the larger basin. The Nature Conservancy's Cheyenne Bottoms Preserve, 7,300 acres, borders the state-owned property on the north and west sides. The remainder of the land in the basin—a mixture of cropland, pastures, and wetlands—is privately owned. The city of Hoisington and the historic communities of Redwing and Boyd lie inside the Cheyenne Bottoms basin.

On the north, west, and south sides, rocks rise abruptly from the floor to form the 100-foot walls of the basin. Two streams, Blood Creek and Deception Creek, cut through the basin's walls and periodically replenish the wetlands in the basin with floodwaters.

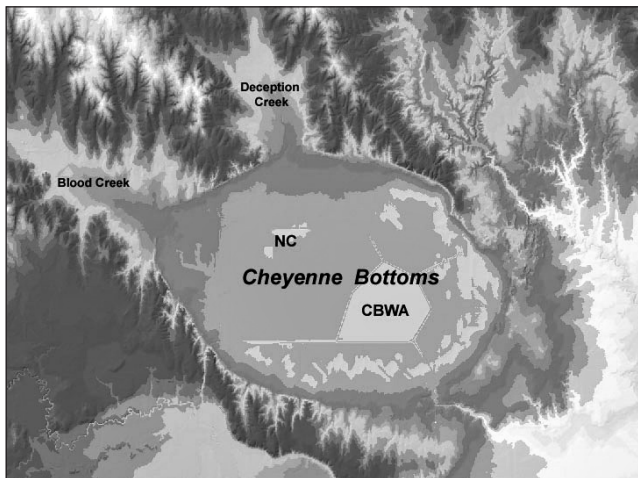
The term "Cheyenne Bottoms" is generally attributed to the Cheyenne Indians' association with the basin.

CHEYENNE BOTTOMS BASIN

In ancient times, Blood Creek was connected to the upper Smoky Hill River. Water from the Smoky Hill River flowed down Blood Creek, through the Cheyenne Bottoms basin, and into the Arkansas River. Sometime between 100 million years ago and just 5 million years ago, movements far below the surface of the earth dropped the floor of the Cheyenne Bottoms basin. Geologic forces that created the Rocky Mountains and other features of the High Plains formed a divide between Blood Creek and the Smoky Hill River, which began to drain into the Kansas River. The forces of wind and water erosion on the newly formed Rocky Mountains supplied fine-grained silt and sand that filled in the ancient streambed through the Cheyenne Bottoms basin. Sand dunes formed on the north and east sides of the basin, enclosing the area more completely.

According to the Kansas Geological Survey, sediments in core samples show that there have been wetlands in the Cheyenne Bottoms basin for as long as 100,000 years. Fossils in the sediments include trees, animals, and pollen from marsh plants and grasses. There is also evidence of intermittent dry periods, times when the area was dry enough to ignite and burn.

In 1806, Lt. Zebulon Pike camped on the north side of the Cheyenne Bottoms basin during his explorations of the southwestern region of the Louisiana Purchase. In 1821, the opening of the Santa Fe Trail just south of the basin increased awareness of the area's existence. From 1821 to 1880, the Santa Fe Trail was a vital commercial and military highway to the southwest. Military trails connecting forts which were built to protect traffic along the Santa Fe Trail skirted the perimeter of the Cheyenne Bottoms basin.



Elevations – Cheyenne Bottoms Basin

Credit: Andy Schmidt, NASA EPSCoR at ESU

Prior to the 1860s, buffalo, deer, elk, and antelope migrated through the basin, drifting into the sheltered basin during fierce winter storms. As the plains were settled, cattle also drifted into the basin in search of protection, grass, and water during severe winter weather. In the spring, ranchers from the southwest (today's states of Texas and New Mexico) came to Cheyenne Bottoms hoping to find that part of their herds had survived the brutal blizzards.

Following passage of the Homestead Act in 1862, land in the Cheyenne Bottoms basin transferred from the federal government into private ownership through homestead claims or the purchase of land awarded to the railroads as an incentive to construct railroads throughout Kansas.

RANCHING AND FARMING

Most of the land in the lowest areas of the basin, especially any land that tended to stay wet, was used for haying and grazing. Other areas were planted to crops, a practice that continues today. There were several large cattle ranches in the Cheyenne Bottoms basin. In the early 1880s, the Uhl and Carney Ranch—located near the southwestern corner of the basin and stretching north to Hoisington—covered over 8,000 acres of land. Beginning in 1886 and continuing into the late 1890s, this ranch hosted international greyhound coursing meets attended by thousands of people. The Brinkman Ranch—another early ranch in the basin—was located south of Redwing, which is where cattle were loaded onto railroad cars for transport to the Kansas City Stockyards.

Periodically, the Cheyenne Bottoms basin would experience a drought. When the area was dry, cattle would graze large areas during the day and cowboys tending the cattle would drive them to water tanks at night. A large concrete tank, filled each day by hauling water in a horse-drawn wagon from a farm over a mile away, can still be seen in the southeast corner of Cheyenne Bottoms Wildlife Area.

Since grazing and haying were the predominant agricultural uses for the area, the landowners and neighbors cooperated in the annual spring burning of the wetlands. Each property owner was responsible for protecting his own buildings and property by burning off or plowing up strips of ground before the whole

Cheyenne Bottoms (continued)

area was set on fire. The neighbors took turns managing the annual spring burning, which removed dead plant materials and encouraged the growth of new grasses and plants that cattle would eat. The fire would eventually burn itself out but small fires might flare up for as long as a month. It was much safer to plan and manage the burning of the area rather than risk having a lightning strike start an uncontrolled fire.

A GRAND LAKE

In the early 1890s, central Kansas entered a dry period and investors formed the Grand Lake Reservoir Company to turn Cheyenne Bottoms into a reservoir for irrigation. They constructed a canal from the Arkansas River to the Cheyenne Bottoms basin, which is lower in elevation than the river. The next time the Arkansas River ran at flood stage, water flowed downhill through the canal and filled Cheyenne Bottoms—including property not covered by the project's flood easements. Proposals for an even larger lake surfaced and construction began on a related project to build a huge water wheel that would have generated electricity for nearby towns. Then the drought ended and plans for the irrigation reservoir were abandoned. The state of Kansas owns a portion of the original 1890s canal, which is used when the Kansas Department of Wildlife and Parks transfers water from the Arkansas River to Cheyenne Bottoms Wildlife Area.

OIL FOUND AT CHEYENNE BOTTOMS

Drilling started in 1917 on the first "successful" oil well in Barton County. The well, known as the Sooy No. 1, was located in the Cheyenne Bottoms basin. The drilling took six years, partially due to flooding in the basin. In Kansas, the Sooy No. 1 was the first well west of Butler County to bring oil to the surface. On a single Sunday, over 10,000 people were reported to have visited the site to watch oil flow out of the hole, but not enough oil was produced to justify completing the well.

Saltwater (brine) was mixed with the oil brought to the surface. At the time, saltwater disposal was not a concern and the hole was not plugged (properly sealed). The hole (an open shaft over 3,500 feet down into the ground) was covered with dirt until the 1960s. Several similar open holes in the Cheyenne Bottoms area were also plugged at that time. Before that, when conditions were right,

saltwater flowed from some of the unplugged holes, changing the chemistry of the soil and making it less productive.

In 1942, Mr. Sooy's estate sold the site of the Sooy No. 1 oil well, along with other land purchased for oil exploration in the Cheyenne Bottoms basin, to the state of Kansas. The success of the Sooy No. 1 also sparked additional exploration that led to the development of the petroleum industry in Barton, Russell, and other central Kansas counties.

WATERFOWL HUNTING

Cheyenne Bottoms has always drawn waterfowl hunters. In the 1880s, commercial (market) hunting became common in the area. Wagonloads of ducks and geese were harvested and shipped to restaurants and markets in the eastern United States. In 1904, an estimated one-half million ducks were harvested in the Cheyenne Bottoms basin. Market hunting at Cheyenne Bottoms declined following the passage of state legislation in 1905 that established the Kansas Fish and Game Department and gave state game wardens the power to enforce hunting and fishing laws.

Over the years, hunters formed gun clubs and leased the rights to hunt on specific parcels of land. In 1904, members of the Black Swamp Shooting Club actually camped on their leased land during prime hunting periods to keep trespassers from hunting there. Other early groups included the Hoisington Gun Club, the Mallard Gun Club, and the Barton County Sportsmen's Association. Today, groups and individuals continue to lease or own private land in the Cheyenne Bottoms basin for the hunting privileges.

PLANS FOR FEDERAL REFUGE

In 1923, Frank Robl of Ellinwood began banding ducks and geese—catching the birds and placing a small engraved metal ring around their legs before releasing them. This allowed him to track the birds' migration patterns and proved that Cheyenne Bottoms was an important site along the Central Flyway. (The Central Flyway is the pathway migratory birds follow during their spring and fall flights between their breeding and wintering grounds.)

In 1927, a two-day, 14-inch rain flooded Blood and Deception creeks and filled the Cheyenne Bottoms basin with water. In 1927 and 1928, the water in the basin attracted enormous numbers of waterfowl. That, along with data collected by Robl, helped convince the U.S. Congress that a federal wildlife refuge should be planned at Cheyenne Bottoms. In 1930, Congress passed legislation providing \$250,000 for the project but nearly all of the federal funding was diverted to another project. The remaining funds were spent on property title searches and engineering studies, but once that money was gone, plans for the Cheyenne Bottoms project were placed on hold.

In 1937, Congress passed the Federal Aid in Wildlife Restoration Act, also known as the Pittman-Robertson Act. This legislation placed a federal excise tax on sporting arms (guns) and ammunition. Still in effect today, the U.S. Fish & Wildlife Service collects this money and uses it to assist state wildlife agencies with projects for wildlife habitat restoration. In 1942, the Kansas Forestry, Fish, and Game Commission began using this new funding source to acquire land in the Cheyenne Bottoms basin.



Pelicans at Cheyenne Bottoms

Credit: Dr. Dan Witt

Cheyenne Bottoms (continued)

WORLD WAR II BOMBING RANGE

In 1942, the U.S. Army Air Corps leased an area of privately owned land approximately four miles wide and six miles long in the Cheyenne Bottoms basin to provide bombing and gunnery practice during World War II. The land was leased for the “duration of the war” and the military began using the bombing range in 1943.

The Army Air Corps placed targets on the leased land, including large pyramid shapes, airplanes made of thin wood, and 5-6 foot tall silhouettes of towns and buildings. Aircraft flew in from Salina, Pratt, Walker, Hays, Great Bend, and other airbases in Kansas for training. While 10-pound sacks of flour were used for target practice, live ammunition was also used on the bombing range for both daytime and nighttime runs. The targets built to resemble buildings were used for high altitude bombing practices and trained crews who later flew over cities in Japan. At night, people who lived very close to Cheyenne Bottoms lived behind special “blackout” shades, as any escaping light could have caused a pilot to mistake their house as a target.

On the south side of the bombing range, the military trained on the ground, aiming machine guns at large radio-controlled airplanes or canvas targets pulled behind other planes. The machine guns were mounted on concrete stands that are still visible on the state-owned property.

While few people outside the Cheyenne Bottoms basin realized the extent of the military's activities there, area citizens had front row seats for the action. Mock air fights between fighter jets and bombers were described in the Hoisington newspaper but no photographs were published due to concerns about the presence of spies in the United States. Sometimes, the action was a bit too close for comfort as bombs landed in farmers' fields, next to country schoolhouses, and bounced across roadways outside the bombing range. Machine gun shells went through silos and homes—including the parsonage of the Christian Church in Hoisington. Duck hunters gave up hunting when their decoys were strafed and farmers reported being peppered with machine gun fire while working in their own fields or bringing their cows in for milking—all of which happened outside the military's bombing range.

Amazingly, there were no serious injuries among the civilians in the area. When a fighter pilot spotted two young boys hiding under a pyramid-shaped target south of Redwing, he canceled target practice for the day. The boys (now retired) reported that they missed over 30 recesses for skipping school that morning and inconveniencing the U.S. military.

STATE LAND ACQUISITION

In October 1942, the state of Kansas announced the first purchase of land for a waterfowl refuge at Cheyenne Bottoms—6,800 acres from the Sooy estate. The state leased the land, already inside the boundaries of the bombing range, to the U.S. Army Air Corps until after World War II ended.

In 1943, the Kansas Legislature passed a law giving the Kansas Forestry, Fish, and Game Commission the power of eminent

CHEYENNE BOTTOMS HISTORY TIMELINE

100 million–5 million years ago—formation of the Cheyenne Bottoms basin.

100,000 years ago—wetlands exist in basin.

1806—Pike's expedition crosses Cheyenne Bottoms.

1862—Homestead Act.

1886—greyhound coursing meets organized at Cheyenne Bottoms.

1896—construction of canal from Arkansas River to form Grand Lake Reservoir.

1897—first federal waterfowl hunting laws passed.

1905—Kansas Fish and Game Department established; first hunting licenses issued in Kansas.

1917–1923—drilling of Sooy No. 1 oil well.

1927–1928—floodwaters form 20,000–30,000 acre lake in basin.

1930—Congress passes legislation for federal wildlife refuge.

1937—Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act).

1942—U.S. Army Air Corps leases land for bombing and machine gunnery ranges.

1942—state's land acquisition begins.

1950—construction of dikes and “lakes” begins.

1956—first duck hunting season at Cheyenne Bottoms Waterfowl Refuge and Public Shooting Area (now known as Cheyenne Bottoms Wildlife Area).

1965–1966—U.S. Army Corps of Engineers plans brine lake in Deception Valley.

1988—designated “Wetland of International Importance” and “Hemispheric Shorebird Reserve.”

1990s—major renovation project.

2006—groundbreaking for Wetlands Education Center.

2007—water at highest levels since 1927–1928.

Cheyenne Bottoms (continued)

domain: the power to condemn land when the owner chooses not to sell. Landowners in the Cheyenne Bottoms basin, particularly those whose land was included in the military's bombing range, were left with few options. They had no idea how long the war would last, when they would be able to use their property again, or what condition the land would be in after the military left the area. In addition, the state was threatening to use the power of eminent domain against those who did not want to sell their land. Against that backdrop, the state's acquisition of land in the Cheyenne Bottoms basin continued at a steady pace, and by 1948, the state had purchased most of the 17,000 acres it planned to acquire.

CHEYENNE BOTTOMS WATERFOWL REFUGE AND PUBLIC SHOOTING AREA

Until the 1950s, there was only one area known as Cheyenne Bottoms. That changed when the Kansas Forestry, Fish, and Game Commission and the U.S. Fish and Wildlife Service announced plans to convert the land acquired by the state into a waterfowl refuge. The plans called for the erection of a series of dikes that would form lakes ranging in depth from six to eight feet, the largest of which would cover more than 3,000 acres. Part of the area would be open for hunting migratory waterfowl and fishing would be a big feature of the refuge.

The project included the construction of 23 miles of dikes, which formed the five lakes. The dikes were topped with roads: driving areas that allowed the public access to the lakes and hunting and refuge areas.

New structures and channels to transfer water from the Arkansas River to the refuge area moved the water through Wet Walnut Creek. On the creek, a concrete dam (with locks) allowed the state to divert water flowing down the creek into a canal running from the creek to the refuge. The channel connecting the creek to the inlet canal at the refuge included a portion of the canal built in the 1890s. This system is still in use. It is a 24-mile journey for water diverted from the Arkansas River at a point southwest of Great Bend to Cheyenne Bottoms Wildlife Area.

The state also constructed an outlet canal for the new refuge, which required the building of seven bridges. The outlet canal—still in use today—allowed the state to release water when the refuge was flooding, to drain areas for seeding crops to attract waterfowl, or to reduce stocks of undesirable fish in certain lakes. Released water eventually makes its way back to the Arkansas River.

On October 13, 1957, the Kansas Forestry, Fish, and Game Commission dedicated Cheyenne Bottoms Wildlife Refuge and Public Shooting Area. The cost of the project, about \$2.8 million, was paid for by the sales of Kansas hunting licenses and funding through the Federal Aid in Wildlife Restoration Act (the Pittman-Robertson Act).

DECEPTION VALLEY BRINE LAKE

In 1965, farmers in Deception Valley, along Deception Creek just north of the Cheyenne Bottoms basin, uncovered plans that would have seriously damaged both Cheyenne Bottoms Waterfowl Refuge in Barton County and Quivira National Wildlife Refuge

in Stafford County. On the north rim of the Cheyenne Bottoms basin, the U.S. Army Corps of Engineers was planning to build a dam and fill the new lake with saltwater (brine) from Rattlesnake Creek near St. John, Kansas, over 50 miles away. (Rattlesnake Creek is the primary source of water for Quivira National Wildlife Refuge.) The lake would serve as an evaporation pond and eventually would have been filled with salt, rather than water. The purpose of the master plan, which involved other dams on the Rattlesnake and diversions of water affecting both Quivira National Wildlife Refuge and the Arkansas River, was to reduce the salinity of the Arkansas River for municipal and industrial uses downstream. The brine lake (saltwater evaporation pond) would have covered 20,000-50,000 acres of high-quality farmland and eliminated any flow of water into the Cheyenne Bottoms basin through Deception Creek.

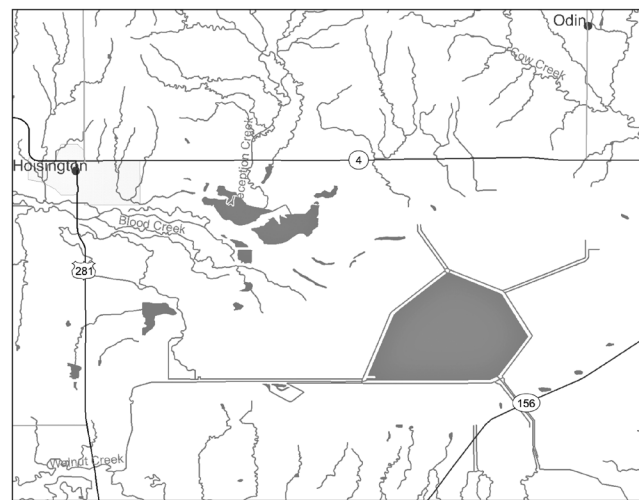
The Deception Valley farmers pooled resources, hired an attorney to fight the plan, and eventually succeeded in their opposition to the Deception Valley Brine Lake. Instead, the Corps of Engineers developed plans involving Clark and Comanche counties to address the water quality issues.

CHEYENNE BOTTOMS WILDLIFE AREA

Over the years, many changes have taken place on the state-owned property now known as Cheyenne Bottoms Wildlife Area. The term "pools" replaced "lakes" and some pools were designated refuge areas (with no public access). Fishing became a minor use of the area, limited mainly to the inlet and outlet canals or areas of deeper water.

For much of its history, the Cheyenne Bottoms area was dry—on average, two out of every five years. Migratory birds stopped at rivers or other wetlands during those dry periods. As many of those alternatives disappeared over time, maintaining the remaining areas, such as those found in the Cheyenne Bottoms basin, became very important.

While Cheyenne Bottoms remained one of the top waterfowl hunting areas in the Central Flyway (and still is today), there was a growing awareness of the importance of the area to other migratory birds, particularly shorebirds. Shorebirds spend the



Map of Cheyenne Bottoms

Source: USFWS, Wetlands Mapper

Cheyenne Bottoms (continued)

winter in South America and nest in the Arctic, flying nonstop for as long as 60 hours and traveling as far as 2,500 miles before stopping to feed and refuel at Cheyenne Bottoms.

In 1988, Cheyenne Bottoms Wildlife Area was designated as a "Wetland of International Importance" and a "Hemispheric Shorebird Reserve." It was the first non-federal area to receive such designations. The Nature Conservancy's Cheyenne Bottoms Preserve is now included in the designations.

Cheyenne Bottoms Wildlife Area underwent extensive renovation during the 1990s that increased the ability to conserve water, manipulate water levels and manage the area to meet wildlife needs during peak migration periods and dry spells.

Today, Cheyenne Bottoms Wildlife Area is recognized as the most important ecosystem in Kansas. More bird species are seen there than anywhere else in the state: 100 species of birds breed and nest on the area, 95 species winter on the area, and 65 species are permanent residents. It is estimated that 45 percent of the shorebirds in the Western Hemisphere stop at Cheyenne Bottoms during the spring migration. These birds go on a feeding frenzy at Cheyenne Bottoms, trying to quickly regain up to 50 percent of their lean weight in order to arrive at the Arctic and be assured of breeding and nesting success.

Many shorebird species are attracted to Cheyenne Bottoms by the area's abundance of midge larvae—commonly referred to as "bloodworms." Bloodworms are the "caterpillar" stage of the midge and appear blood red because of the high concentration of hemoglobin in their bodies. At Cheyenne Bottoms, bloodworms have been found in unusually high densities—as high as 50 per square inch. The bloodworms feed on nutrients from bird droppings.

A new Wetlands Education Center is being built along U.S. 156 on the east side of the Cheyenne Bottoms Wildlife Area. The center will expand the research and education programs offered in Cheyenne Bottoms.

FACING THE FUTURE

The pioneers who settled in the Cheyenne Bottoms basin enjoyed the hunting and fishing opportunities provided by the area. They learned to live with the intermittent dry spells and periodic floods, while building their lives, homes, farms, and new towns around the opportunities offered by Cheyenne Bottoms. As the times and needs of the country changed, both the people and the basin adapted.

The area had experienced many changes even before the state built the first dikes that divided the area into pools in the 1950s. Today, it is hard to imagine that plans were in place over a century ago to develop the area as a large reservoir, but part of the canal built back then to transfer water from the Arkansas River into that lake is still in use today. Today, it is hard to imagine that the federal government used an internationally recognized wetland as a bombing range, but back in the 1940s, the water-filled bomb craters provided habitat for ducks and geese. Once manipulated to improve fishing opportunities, the state now manages water levels to provide mudflats for feeding grounds for migrating shorebirds.

Some things have not changed all that much. Area residents still mark the changing of seasons by the first flights of ducks and geese. Local landowners and residents keep a close eye on sandhill cranes, whooping cranes, and eagles when the birds pass through the area. Dry periods—and wet periods—affect both the state-owned property and the crops and pastures of area farmers and local landowners. In 2007, an exceptionally wet spring and summer covered the Cheyenne Bottoms with water, at levels last seen in 1927 and 1928.

The people who live and work in the Cheyenne Bottoms basin have always placed a high value on the ecosystem now recognized worldwide. As priorities for the area continue to change, new challenges and opportunities will be created to sustain that ecosystem and educate future generations about the importance of the Cheyenne Bottoms.

NOTES:





Unit 10) Aquifers

Water is necessary for all life, yet many people take it for granted, especially when it is conveniently available for drinking water and other purposes. Water is often unappreciated until it is unavailable or in short supply. In Kansas, many of the water resources are hidden from view—stored in natural underground areas called aquifers.

"Water is the basis of life and the blue arteries of the earth!"
Sandra Postel, American environmentalist

Groundwater, water that can be pumped from a well, is stored underground in a body of rock or other materials called an aquifer. The area included in an aquifer is often determined by underground geologic formations. The storage capacity of an aquifer is determined by its area and qualities of the rock or sediments in the aquifer, including the ability of water to flow through the

WATER WORDS

Aquifer – a natural underground storage area for groundwater.

Groundwater – water that is stored underground.

Porosity – the capacity of a rock formation to absorb and store groundwater.

Permeability – the ability of a material to allow liquid to pass through it.

Water table – the top elevation of water in an aquifer.

INTRODUCTION

TYPES OF AQUIFERS

- UNCONFINED AQUIFERS
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WATER FOR THE FUTURE

CAREER PROFILES

- MAHBUB ALAM, IRRIGATION AND WATER MANAGEMENT SPECIALIST
- LOU HINES, CEO, WESTERN SPRINKLERS, INC.

SHOWCASE

- OGALLALA AQUIFER

REFERENCES

TEACHER'S RESOURCES

materials. Aquifer materials may be consolidated, such as rock, or made of unconsolidated materials, such as sand or gravel that are not cemented together. In the rock layers, the rocks are filled with pores or holes that allow the rocks to absorb and store water.

Porosity, the capacity of a rock formation to absorb and store groundwater, is determined by the number and size of the pores. Pores can be microscopic or as large as caverns. Permeability is a description of the ability of fluids to move through porous rock or sediment, directly related to a combination of the size of the pores and the degree to which the pores are interconnected. Materials that allow water to pass through them easily are said to be permeable; those that permit water to pass through only with difficulty or not at all are impermeable.

TYPES OF AQUIFERS

"The work an unknown good man has done is like a vein of water flowing hidden underground, secretly making the ground green."

Thomas Carlyle, Scottish essayist and historian

There are two major types of aquifers beneath most of the land surface of the United States: unconfined and confined.

UNCONFINED AQUIFERS

Unconfined aquifers are the most common. These aquifers do not have rock layers over the top of them that trap or confine the water. Unconsolidated materials, such as sand, gravel, and sediment, cover unconfined aquifers. Water in unconfined aquifers is often considered very young, in geologic time, because it may have arrived recently by percolating through the soil and aquifer layers. The discharge and recharge rates of an unconfined aquifer depend on the hydrologic conditions on the earth's surface above the aquifer, such as rainfall

AQUIFERS IN THE UNITED STATES

Unconfined— most common; water percolates down into the aquifer through the materials covering it; affected by conditions at the earth's surface, such as rainfall and temperature; water flows freely so gravity and atmospheric pressure establishes the water table.

Confined— also known as artesian aquifers; water is trapped beneath impermeable materials under pressure; when an opening is created in the aquifer, pressure causes the water to rise above the top of the aquifer.

and temperature. Water in an unconfined aquifer is free to flow and establish an equilibrium level affected by gravity and atmospheric pressure.

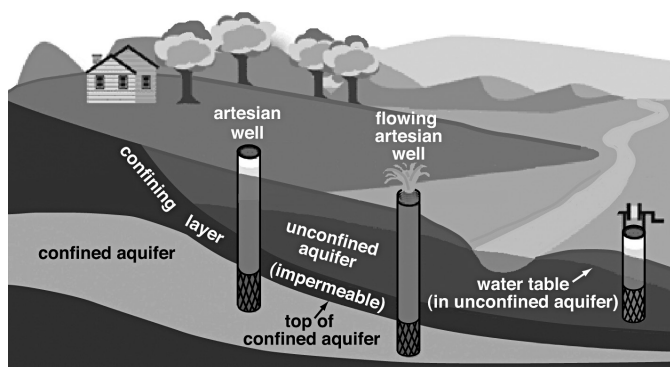
The top elevation of water in an aquifer is called the water table. It may rise or fall depending on precipitation trends. The water table is somewhat parallel to the land surface above the aquifer but it is not always a consistently straight line. When a well is drilled into an unconfined aquifer, the driller will encounter water when the well reaches the water table, which is the approximate level at which water will stand in the well.

CONFINED AQUIFERS

Confined aquifers, sometimes called artesian aquifers, exist where the groundwater is trapped beneath layers of impermeable materials. Water in confined aquifers may be very old, having arrived millions of years ago. Water in a confined aquifer may be under pressure.

A well in a confined aquifer is called an artesian well. When a well is drilled into the aquifer, pressure forces the water upwards. The water in these wells rises above the top of the aquifer because of the pressure; the level to which it rises is called the static water level. If the water level rises above the land surface, a flowing artesian well occurs. Southwestern and central Kansas were once home to numerous flowing artesian wells. The artesian valley of Meade County had a number of flowing wells, and water in one Meade County well rose as high as 17 feet above the land surface. Because of lowered groundwater levels, most of those wells no longer flow at the surface. However, a flowing artesian well still exists at Meade County State Lake. There are also flowing artesian wells in other parts of the state, such as northeastern Stafford County and western Marion County.

CONFINED AND UNCONFINED AQUIFERS



Source: KGS

KANSAS AQUIFERS

Alluvial aquifers— largest and most productive aquifers in Kansas; formed during recent geologic time; found in clay, silt, sand, or gravel deposited by running water in the bed of a stream or on its floodplain.

Bedrock aquifers— water trapped in layers of solid rock; most serve as local sources of water; water quality may vary.

Glacial drift aquifers— found in glacial debris that traps and holds water or in ancient river valleys buried by debris left behind when the continental glaciers melted and receded from northeastern Kansas; do not cover large areas.

KANSAS AQUIFERS

"Look deep, deep into nature, and then you understand everything better."

Albert Einstein, physicist

IDENTIFYING AQUIFERS

There are hundreds of aquifers in Kansas, depending on how the specific aquifers are identified and described. When names of water-bearing rock formations are used in the names of aquifers, it can become confusing. Geologists often define rock layers according to their nature and origin. The smallest possible layer of rock that can be mapped and described over a wide area is called a formation. For example, the Dakota Formation is a layer of sandstone and shale that lies beneath the western two-thirds of Kansas. However, hydrologists use the term "Dakota aquifer" to describe several geologic formations, including the Dakota Formation.

Hydrologists view aquifers according to function and interaction. In a single aquifer, hydrologists may include several geologic formations that were deposited at about the same time in geologic history and have water deposits that are interconnected. The High Plains aquifer in western and central Kansas is a hydrologic feature that includes geologically defined units, such as the Ogallala Formation, and various other units that can be defined either geographically or geologically, such as the Equus Beds aquifer and the Great Bend Prairie aquifer.

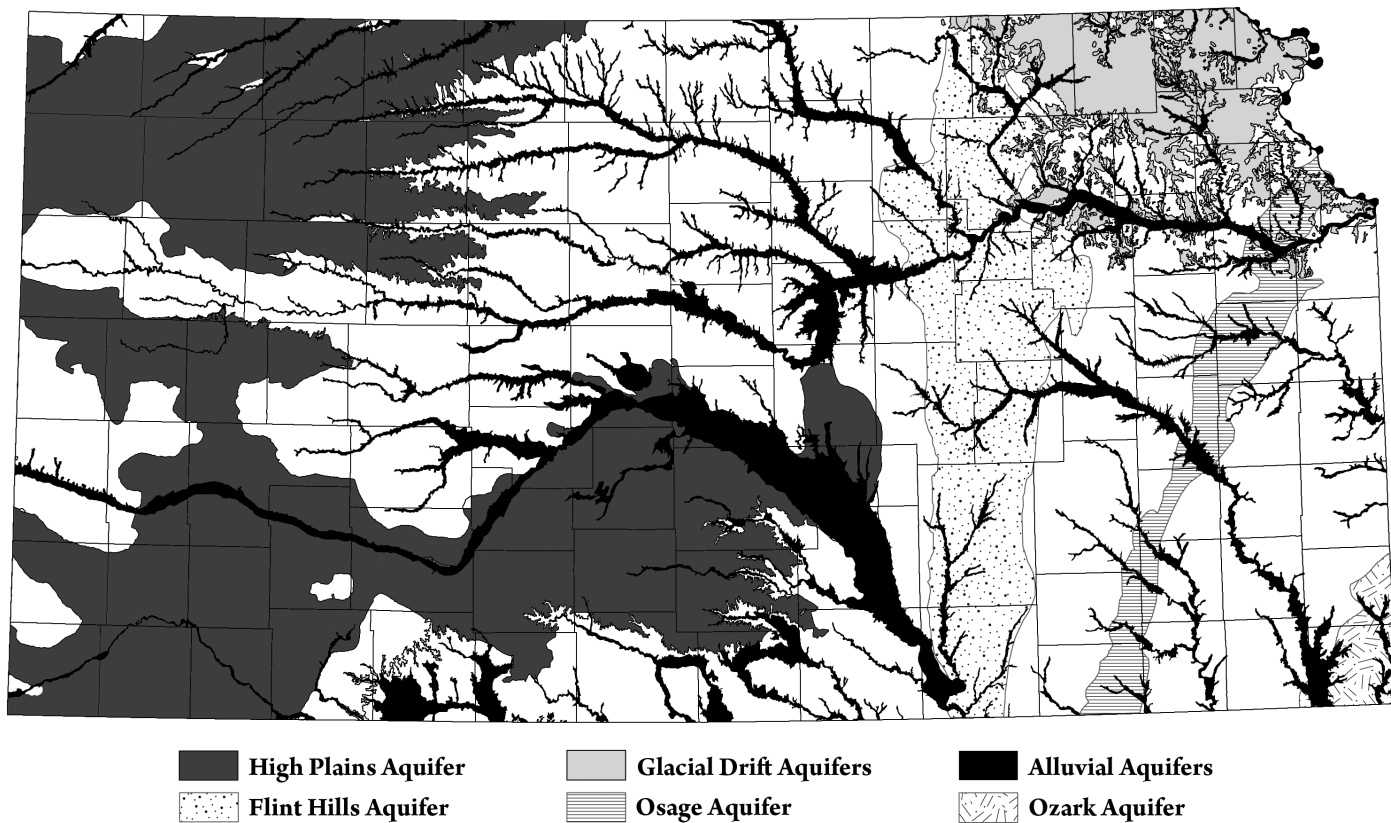
Aquifers in which wells can produce a few gallons per minute (gpm) may be adequate for domestic or livestock water supplies, but they would be inadequate for irrigation or municipal supply use where well yields of thousands of gallons per minute may be required. Likewise, aquifers that discharge water over significantly long periods

DAKOTA AQUIFER



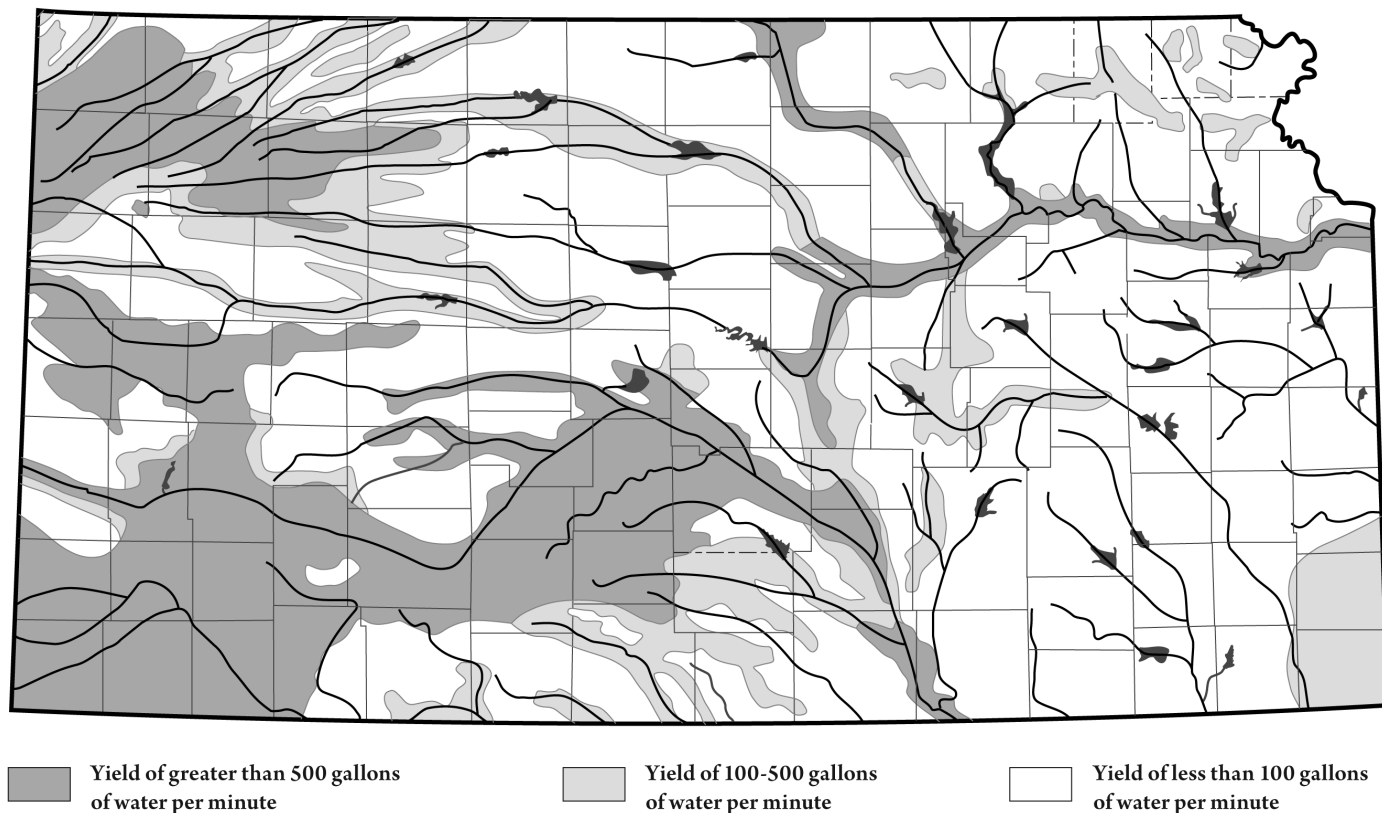
Source: KGS

KANSAS AQUIFERS



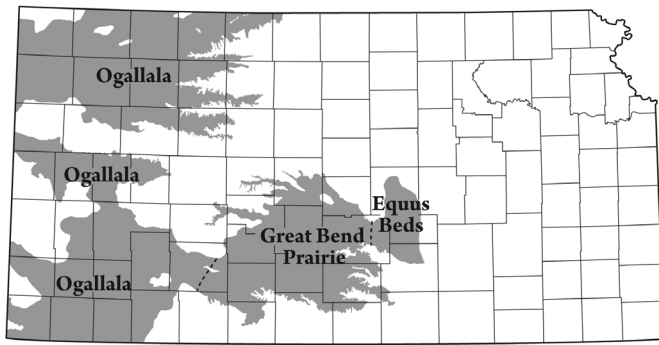
Source: KGS

GENERAL AVAILABILITY OF GROUNDWATER IN KANSAS



Source: KGS

HIGH PLAINS AQUIFER IN KANSAS



Source: KGS

of time may see the water table fall so that some wells stop producing water for a short time period. In both cases, the water-bearing formations may still be called aquifers.

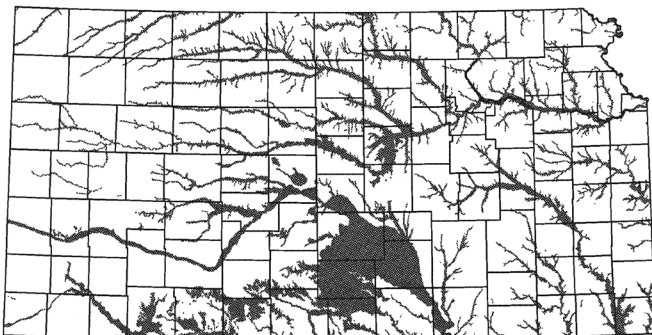
In addition, like mountain peaks, underground features tend to be named by the person who first discovers them. The names of aquifers and rock formations may reflect the background of the person who defined and named the feature.

ALLUVIAL AQUIFERS

Alluvial aquifers are the largest and most productive aquifers in Kansas. In an alluvial aquifer, the water table is usually fairly close to the earth's surface and, in many stream and river valleys, the water in the aquifer is directly connected to the surface water flowing in the stream or river. Most aquifers in Kansas are alluvial aquifers, formed by alluvium. Alluvium is sediment that is loosely arranged but not cemented together—clay, silt, sand, or gravel that was deposited during recent geologic time by running water in the bed of a stream or on its floodplain. These materials, which are not layered, are very permeable. In parts of eastern Kansas, alluvial aquifers are the only significant sources of groundwater. In western Kansas, alluvial aquifers often lie above or intersect with other aquifers.

All the major rivers and many of the smaller streams in Kansas have alluvial deposits associated with them. Rivers, such as the Arkansas and Republican rivers, have material that eroded during the formation of the Rocky Mountains so more coarse sand and gravel deposits are commonly found there. Smaller streams may have more silt or clay material resulting from the erosion of the limestone and shale found in the drainage area of the streams. The thickness of the alluvial material is highly variable, reaching up to 300 feet deep in some of the major river valleys such as the Arkansas.

KANSAS ALLUVIAL AQUIFERS



Source: KGS

THE HIGH PLAINS AQUIFER

The High Plains aquifer is a major regional hydrologic unit that underlies parts of eight states, including Kansas. The High Plains aquifer can be broken down into different geologic aquifer units formed at different times in various locations. The Kansas portion of the High Plains aquifer includes the Ogallala aquifer, Great Bend Prairie aquifer, Equus Beds aquifer, and various alluvial and sand dune aquifers. Streams flowing within, into, or through the state were the main sources of the water trapped in these alluvial aquifers.

The High Plains aquifer is the main source of groundwater for a region that supplies a major portion of the food supply for the United States and the world. The economy of the region depends on the successful production of crops and livestock. Although there was some irrigation beginning in the 1880s, dryland farming (dependent on natural precipitation) was common until after the extreme droughts during the 1930s. Groundwater irrigation intensified in the 1940s and again following a severe drought in the 1950s. The development of center pivot irrigation systems in the 1960s increased the number of wells that were drilled for irrigation purposes.

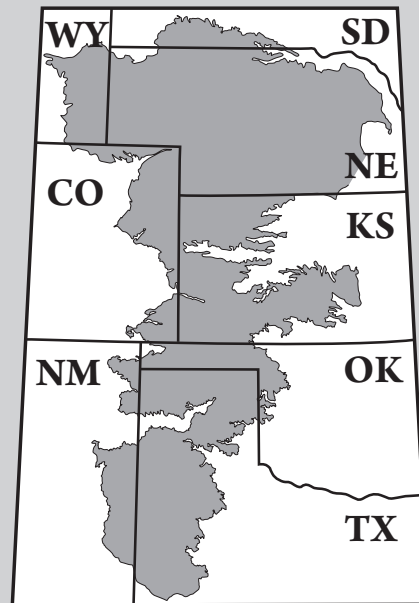
In a center pivot irrigation system, water is pumped from a well through a line of water-distribution pipes mounted on wheels, which rotate or pivot in a circle around the center of the irrigated area.



Irrigation Circle

Credit: USGS

More than 90 percent of the water pumped from the High Plains aquifer is used for irrigation of crops. This aquifer provides about 30 percent of the groundwater used for irrigation in the United States.



Source: KGS

In Kansas, productive alluvial aquifers are associated with the Kansas River (in the river valley from Junction City to Kansas City), the Republican River (from within Republic County to near Clay Center), and the Missouri River (near the junction of the Missouri River and Kansas River at Kansas City). Alluvial aquifers in other river valleys in Kansas, such as the Smoky Hill, Solomon, Saline, Neosho, Marais des Cygnes, and Verdigris, are also important sources

of groundwater. The High Plains aquifer is a major regional aquifer, which can be broken down into separate aquifer units. Alluvial aquifers included in the Kansas portion of the High Plains aquifer include the Ogallala aquifer, Great Bend Prairie aquifer, and the Equus Beds aquifer.

BEDROCK AQUIFERS

The solid rock layer(s) underneath any unconsolidated sediment or soil is bedrock. Bedrock aquifers are the only local sources of groundwater for people living in much of eastern Kansas and parts of central Kansas. Bedrock aquifers are found in the Permian limestones in the Flint Hills, Pennsylvanian sandstones and limestones in eastern Kansas, the sandstones in the Codell Formation in central and west-central Kansas, the Mississippian limestones and the older Ordovician and Cambrian limestones and sandstones in extreme southeastern Kansas. These aquifers— including the Flint Hills, Osage Cuestas, and Ozark aquifer systems— may produce enough water to serve local communities, in addition to individuals living in rural areas.

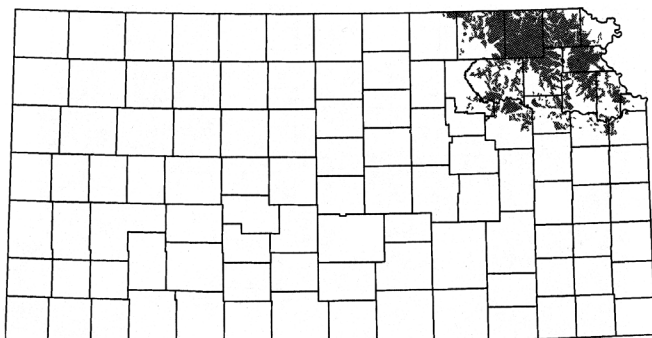
The quality of water in the Dakota aquifer, an important bedrock aquifer in the western two-thirds of Kansas, varies depending upon location. In much of southwestern Kansas, the Dakota aquifer lies beneath the Ogallala Formation of the High Plains aquifer. In places, water moves between the aquifers. In parts of central Kansas, the Dakota aquifer lies above saltwater-bearing aquifers, which recharge the Dakota aquifer and make the Dakota aquifer's water unusable.

GLACIAL DRIFT AQUIFERS

During one of the ice ages, about 750,000 years ago, the northeast corner of the state was invaded by continental glaciers that scraped up and transported large quantities of material ranging in size from boulders to clay. When the ice melted and the glaciers receded, this material was left behind, especially in low-lying areas. These deposits are now common in an area north of the Kansas River to the Nebraska state line and east of Tuttle Creek Lake to the Missouri River. The pore space in this alluvium is excellent at trapping and holding groundwater. These aquifers, however, do not cover large areas.

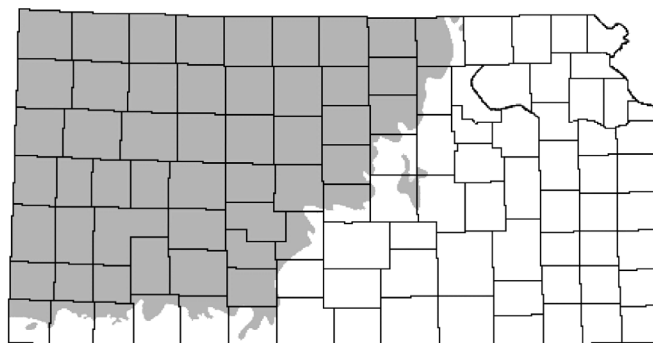
Some of the most prolific water-bearing formations are buried valleys—ancient river valleys partially filled with alluvium that was covered by glacial debris. The materials that filled and buried the valleys range from clay to sand and gravel, and the poorly sorted, coarse-grained deposits at the bottoms of the valleys yield large quantities of generally good-quality water. The buried valleys may be up to several miles wide, 400 feet deep, and tens of miles long.

GLACIAL DRIFT AQUIFERS IN KANSAS



Source: KGS

DAKOTA AQUIFER IN KANSAS



Source: KGS

Depth to reach the water is commonly between five and 50 feet, but may exceed 100 feet. Because these valleys are buried, they are difficult to locate. Published reports, water and oil and gas well records, test drilling, and other techniques are used to map the aquifers.

WATER QUALITY

"We forget that the water cycle and the life cycle are one."

Jacques Yves Cousteau, ocean explorer

Water is never found in a pure state in nature. Both groundwater and surface water may contain many components, including minerals, microorganisms, gases, and inorganic and organic materials. Some are present naturally and others are a result of human activities. The chemical nature of water continually changes as it moves through the water cycle, also called the hydrologic cycle. The most important natural changes in groundwater chemistry occur in the soil. Groundwater may dissolve substances it encounters or it may deposit some of its components along the way. The eventual quality of the groundwater depends on the kinds of rock and soil formations through which it flows.

GROUNDWATER QUALITY IN KANSAS

The quality of water available from aquifers varies. Most aquifers contain freshwater—water suitable for human consumption—but many Kansas aquifers contain and transport poor-quality water or brine, water with a high salt content. These aquifers do not provide water that is usable for human water supplies.

The chemical quality of the water in most alluvial aquifers is acceptable for most purposes. However, saltwater from Permian formations is known to leak into shallow groundwater in the Solomon and Smoky Hill river valleys in Saline and Dickinson counties, in the Cimarron River in southwest Kansas, in the Ninnescah River in south-central Kansas, in the Arkansas River valley downstream from Great Bend, and other areas. Similarly, the Dakota aquifer discharges saltwater into the Saline and Smoky Hill rivers in Russell County and the Solomon River in Mitchell

WATER QUALITY

Brine— water with a high salt content; also known as saltwater.

Total dissolved solids (TDS)— a measurement of the total quantity of minerals in water.

Aquifers

and Ottawa counties. High concentrations of total dissolved solids, a measurement of the total quantity of minerals in water, also are known to be present in the upper Smoky Hill River valley in Logan County and in the Arkansas River alluvial aquifer.

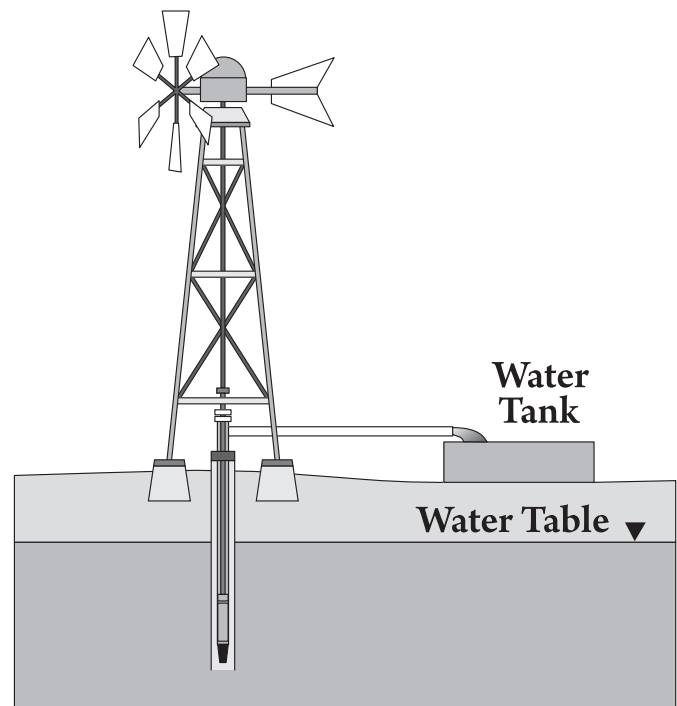
High concentrations of iron, manganese, sulfate, nitrate, chloride, sodium, and total dissolved solids occur in the groundwater in parts of northeastern Kansas. Many of these concentrations result from natural interactions between water and the geological formations, such as the movement of poor-quality water from bedrock surrounding the buried river valleys associated with glacial aquifers. Generally, the only problems that result from these high concentrations are scale deposits, appearance, or taste problems. However, high nitrate concentrations may cause a dangerous condition called cyanosis in infants and some young livestock.

PROTECTING AQUIFERS

Aquifers may be layered, just like the underground rock formations. Any type of opening, such as a water or oil well, that goes through one aquifer to reach a deeper aquifer must be carefully constructed and sealed so that water does not flow between the aquifers. Water quality problems may occur in freshwater supplies when water flows between aquifers if one aquifer produces poor-quality water. This is a common problem in much of central and southeast Kansas.

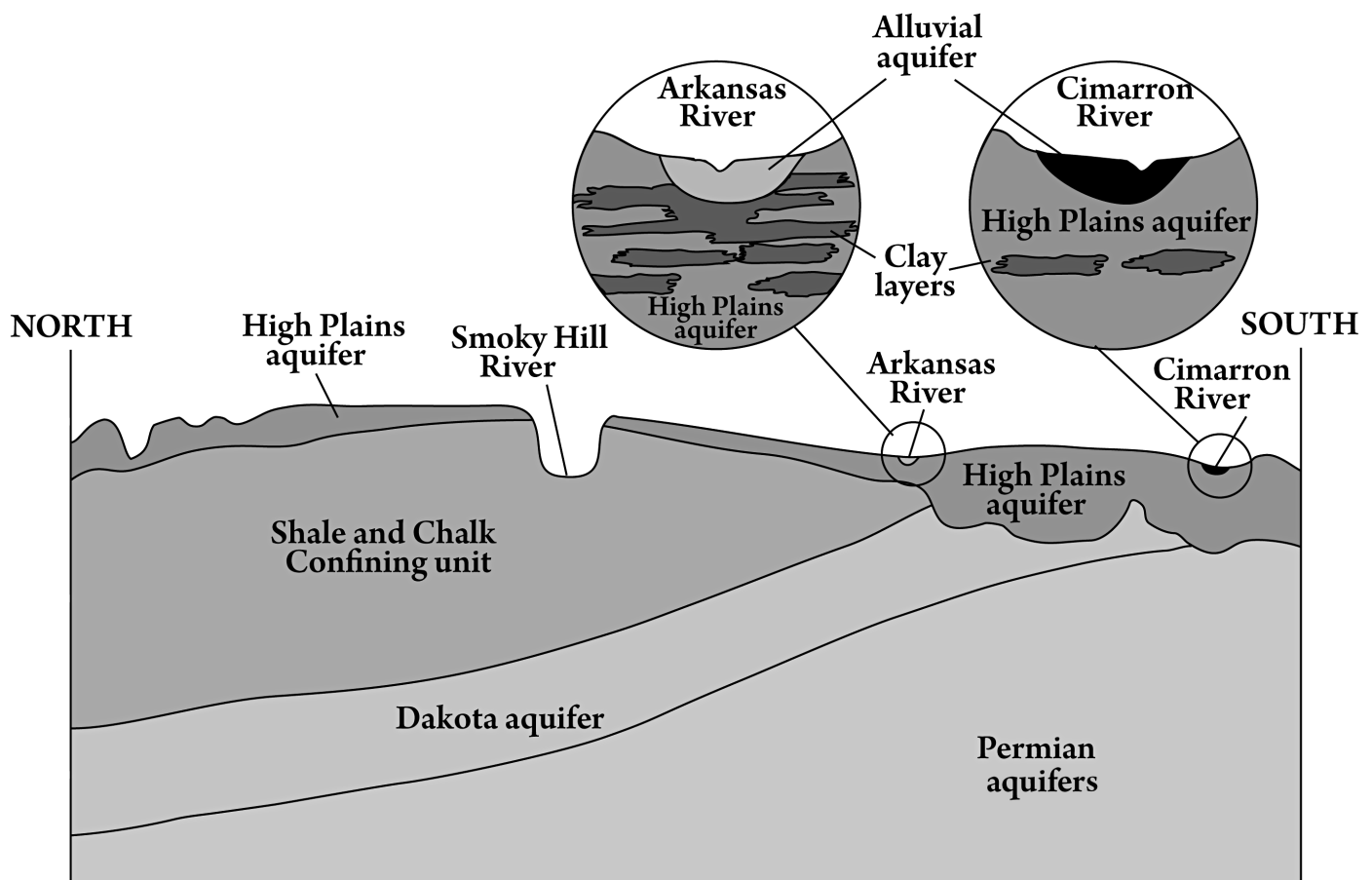
When there is an opening into an aquifer, the potential exists for water quality to be affected. A well, whether drilled to produce water or for monitoring water quality or water levels, provides a

WATER-PUMPING WINDMILL



Source: K-State Research and Extension

WESTERN KANSAS AQUIFERS



Source: KGS

GROUNDWATER SPEED

Water moves at a much slower speed in central and western Kansas aquifers than water flowing across the earth's surface. At the rate of about 1 foot per day, it will take approximately 15 years for groundwater to move a mile or almost 500 years to cross a typical Kansas county.

Source: KGS

direct opening into the aquifer. The construction of the well and the barriers that are constructed to prevent access to the opening are very important. In the past, many wells were drilled and later abandoned. The Kansas Department of Health and Environment (KDHE) estimates that more than 250,000 abandoned wells and test holes exist in Kansas. Kansas law now requires the proper plugging of all abandoned wells and test holes. The construction and plugging of water wells is regulated by KDHE while the Kansas Corporation Commission regulates the plugging of abandoned oil and gas wells.

Mining activities, such as the strip mining of coal or the dredging of sand and gravel, may include the removal of some, or all, layers of materials above an aquifer. When the materials that usually filter water as it moves deeper underground are removed, other measures must be taken to prevent contaminants from moving into the water in the aquifer.

In much of western and central Kansas, aquifers slope or dip down slightly to the east, resulting in a west-to-east flow of the groundwater. The speed at which the water in these aquifers flows is only about one foot per day, much slower than water would flow across the earth's surface. This means that it will take about 15 years for groundwater to move a mile, or almost 500 years to cross a typical county in Kansas. Even so, precautions must be taken to protect the water in the aquifer for use by future generations.

WATER MANAGEMENT

"All water has a perfect memory and is forever trying to get back to where it was."

Toni Morrison, American novelist

An aquifer is a container of a fixed size that can be emptied if water removal (discharge) exceeds water replenishment (recharge). Aquifers are out of sight, often making them difficult to identify and measure. Aquifers are not uniform in thickness, shape, porosity, or permeability. Determining a precise estimate of an aquifer's area, characteristics, or water content is often impractical, especially when the aquifer is deep underground or its characteristics are extremely variable.

RECHARGE OF AQUIFER WATER

Recharge is the movement of water into an aquifer. The primary source of natural recharge is precipitation. Other natural sources of recharge might include seepage from streams, ponds, or lakes or movement of water from one aquifer into another. Recharge determines the amount of groundwater available for use from an aquifer over the long term. The rate of recharge depends on the nature of the rocks, soil, and vegetation that cover the aquifer as well as the climate of the region. The amount of rainfall returned to the atmosphere as a result of evaporation and transpiration of plants ranges from 85 percent in eastern Kansas to as much as 99 percent in some areas of southwestern Kansas. This means that only 1 to 15

BALANCING THE WATER BUDGET

Recharge— water that enters an aquifer.

Discharge— water that is withdrawn or naturally flows out of an aquifer.

Water budget— average balance between recharges and discharges; also known as the water balance.

Sustainable yield— amount of groundwater that can be withdrawn without causing adverse effects to springs, streams, wetlands, or other groundwater-dependent activities.

percent of any rain that falls is available to percolate into an aquifer or flow into streams, wetlands, ponds, or lakes.

Groundwater in very shallow, permeable aquifers may recharge and drain on a time scale of years to decades. Deeper groundwater, sometimes referred to as "fossil water," may be thousands to millions of years old and it may take many years for precipitation at the earth's surface to reach a deep aquifer.

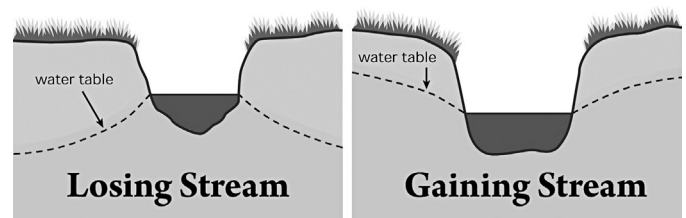
The rate of recharge is difficult to calculate and is made even more difficult by the unpredictability of climatic conditions. Recharge is part of the water balance, or water budget, of an aquifer, which is the average balance between the water that enters the area and the water that is withdrawn or discharges naturally. Hydrologists use water budget calculations in much the same way that homeowners balance their checkbooks or businesses monitor income and expenses. The amount of groundwater that can be withdrawn from an aquifer without causing adverse effects to springs, streams, wetlands, and other groundwater-dependent activities is called the sustainable yield. The sustainable yield is used to monitor and regulate activities that require the use of groundwater.

STREAMFLOW RELATIONSHIP

The general flow of groundwater is downstream. There is a close relationship between streamflow and groundwater in alluvial aquifers, which in turn are often connected to adjacent or underlying aquifers. During times of high streamflow, water often moves out of the stream channel and recharges the alluvial aquifer. When streamflow is low, water may flow back out of the alluvial aquifer and into the stream. This maintains streamflow even in times of little precipitation. However, in locations where the water table in an alluvial aquifer has been lowered, water levels may drop to the point that the aquifer does not replenish the streamflow.

Groundwater contributes to streamflow in many of the streams in eastern Kansas. In western Kansas, however, groundwater levels in many stream valleys have declined to the point where the

STREAM/AQUIFER INTERACTION



Source: FISRWG

Aquifers

groundwater's contribution to the stream is less than in the past. In some places, such as the streams contributing to the Pawnee, Walnut, Smoky Hill, Arkansas, and Solomon rivers, there is no groundwater discharge into the streams and the streams are intermittent, flowing only after runoff from precipitation. This relationship between streamflow and alluvial aquifers, often connected to other groundwater aquifers, emphasizes that groundwater cannot be understood or managed without understanding the larger hydrologic cycle.

CONSERVATION OF WATER RESOURCES

Western Kansas aquifers have been experiencing groundwater decline. While the decline has lessened in recent years, gradual depletion is still occurring in many local areas at the current use rates. Depletion of the groundwater reserves of western Kansas has only a minor direct effect on the availability of water resources in eastern Kansas. However, depletion will cause a loss of economic activity both locally and statewide. Farmers in the affected areas are reducing irrigation water usage through improved management techniques such as the installation of water meters, irrigation scheduling, and improved irrigation efficiency. The most notable evidence of irrigators' efforts is the conversion of flood-irrigated systems to center pivot irrigation, driven in part by a commitment to conservation. In eastern Kansas, many communities' water supplies are from surface water and they have experienced supply shortages during drought years. Population increases in these areas may lead to additional water shortages.



Center Pivot Irrigation

Credit: USGS

Reducing municipal water use is important for several reasons. Since municipal water must be treated before it is distributed to water users (i.e. the public and other water consumers), reducing the amount of water needing to be treated could prolong the life of water treatment systems. Since most surface and groundwater supplies in Kansas are already fully appropriated, reducing per capita consumption may allow a city or town to stay within its water right even with population expansion. Otherwise, additional water rights acquisition may become necessary. The purchase and transfer of water rights is highly regulated and can be quite expensive, in addition to impacting the industries and economy of the affected areas. Every drop saved by every water consumer soon adds up to larger savings for the city or town in many ways.



Hoisington Water Tower

Credit: Wayne Stoskopf

THE IMPORTANCE OF KANSAS AQUIFERS

When comparing the percentage of a state's surface area that is water, only four states have a lower percentage of surface area that is water than Kansas. Precipitation and groundwater make up for the lack of surface water to allow Kansas to be a leading agricultural state while providing the water necessary for the state's population and other industries.

Source: USGS

WATER FOR THE FUTURE

"Soil, water, minerals, vegetation, and animal life—these are the basis of our existence and the measure of our future."

Paul B. Sears, American ecologist and palynologist

At first glance, Kansas may not appear to have much water, certainly not in comparison to other states. According to the U.S. Geological Survey, only four states have a lower percentage of surface area that is water than Kansas. Even so, water is the lifeblood of the agricultural economy in Kansas, a leading agricultural state. Precipitation, in the form of rain and snow, provides much of the water needed to produce food and other agricultural products. Groundwater, stored in aquifers, provides additional water for agricultural, industrial, and municipal water uses. The challenge is to balance the needs of all water uses with the need to conserve water for future generations. Kansans are up to the challenge. ■

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Shoveller, Herb. 2006 (AR - 5.6)

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Nadeau, Isaac. 2003 (AR - 5.5)

Career Profile:**MAHBUB ALAM**

Irrigation and Water Management Specialist
Kansas State University Research and Extension



Courtesy: Mahbub Alam

Mahbub Alam expresses a joy of learning and a passion for his work. Since 1996, Alam has been an irrigation and water management specialist with Kansas State University Research and Extension. He provides leadership and support for irrigation technology and water management educational programs for county extension agents who provide information directly to agricultural producers. His current educational programs focus on evapotranspiration-based irrigation scheduling, subsurface drip irrigation, and the evaluation of center pivot irrigation systems for water distribution uniformity and efficiency. Alam is active in the Ogallala Initiative Project focusing on water use issues in the Ogallala aquifer. On the international scene, he is involved in international agricultural programs and provides assistance to the Department of Irrigation and Drainage at China Agricultural University in Beijing, China, and the Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Alam followed in his father's footsteps and aspired to become an engineer as a young man in Pakistan. As he was graduating from his high school studies, he became aware of an opportunity to study abroad on a U.S. scholarship available to students in developing countries. He learned that he could pursue a degree in agriculture engineering. After passing the necessary tests, he chose to attend the American University of Beirut in Beirut, Lebanon. There, at the age of 18, he combined his love for growing things and engineering into studies with a focus on irrigation.

After obtaining his bachelor's degree in agriculture engineering in 1961, Alam returned to his home country to work on a large project in Bangladesh. His challenge was to design a system that would help protect farmers from flooding during the wet season and from drought during the dry season. He and his team were successful in building dams and a canal system that helped stabilize crop production and the local economy. Seeing the positive results of his work with local farmers energized Alam to become even more dedicated in his work in agriculture engineering and irrigation. Several years later, the civil unrest and war in Pakistan destroyed the project his team had worked so hard on. Fortunately, with help from the U.S. Agency for International Development and the Pakistan government, Alam and his team rebuilt the system, much to the relief of local farmers.

Alam returned to the American University of Beirut in Lebanon in the mid-1970s to pursue a masters degree in irrigation engineering. He persevered through a civil war in Lebanon, including several evacuations, and received his degree in 1978. "I would not trade education and its value for the world," says Alam.

Prior to immigrating to the United States, Alam was the principal scientific officer in charge of the Soils and Irrigation Engineering Division for the Bangladesh Agricultural Research Council in Pakistan. Once in the United States, he worked towards his Ph.D. in irrigation at Colorado State University, earning that distinction in 1985. From 1988 to 1995, Alam was on the faculty at Colorado State University and worked as an irrigation specialist for the Colorado River Salinity Control Project.

Alam still has connections and work in Pakistan. As a result of his work in that region, he was selected as a Fulbright Scholar by the U.S. Department of State in 2003. Alam says, "Education is fascinating. It opens the door to the world. It makes you a better person locally and internationally. It helps you expand your horizons and see connections to the whole world."

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An Atlas of the High Plains Aquifer *

Schloss, Jeffrey A. and Robert W. Buddemeier and Blake B. Wilson
 Educational Series 14, 2000

Online version: www.kgs.ku.edu/HighPlains/atlas/index.html

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Buchanan, Rex and Robert W. Buddemeier

Educational Series 10, 1993

Online version: www.kgs.ku.edu/Publications/Bulletins/ED10/index.html

WEBSITES:

Division of Water Resources

Kansas Department of Agriculture

www.ksda.gov

Equus Beds Information Resource

www.equusinfo.org/

High Plains/Ogallala Aquifer

Kansas Geological Survey

www.kgs.ku.edu/HighPlains/index.shtml

High Plains Regional Ground Water Study

U.S. Geological Survey

http://co.water.usgs.gov/nawqa/hpgw/HPGW_home.html

Kansas Groundwater Management Districts

www.gmdausa.org/ks.htm

Mobile Irrigation Lab

K-State Research & Extension

www.oznet.ksu.edu/mil/

Water Resources Information

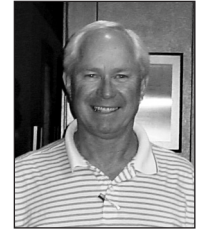
Kansas Geological Survey

www.kgs.ku.edu/Hydro/hydroIndex.html

Career Profile:

LOU HINES

Chief Executive Officer, Western Sprinklers, Inc.



Courtesy: Lou Hines

Lou Hines grew up on a small farm but his vision of agriculture was anything but small. Today, Hines is the chief executive officer of Western Sprinklers, an award-winning international business. Western Sprinklers has been named Dealer of the Year two different times by Valmont Irrigation, manufacturer and distributor of Valley® irrigation systems worldwide.

Growing up on a dairy farm in Nebraska, Hines did not intend to have a career in production agriculture. However, he did learn how to set up irrigation systems as a way of earning tuition money for college. Hines believes strongly in leaving home to seek a higher education in a field that interests an individual. He attended Kearney State College (now University of Nebraska at Kearney)—studying biology, math, and chemistry—never realizing that those studies would eventually help him grow his own business. Hines earned a B.S. in education and spent several years teaching junior high math and science and coaching basketball.

His career in education allowed him to work weekends and summers at something he loved just as much as teaching. He quickly learned that drilling irrigation wells and constructing irrigation systems more than paid his living expenses. In 1975, Hines left teaching to develop his own business, Western Sprinklers, Inc., which specializes in the sales, installation, and maintenance of irrigation systems. With offices in Colby and St. Francis, the company now has networks spanning the globe.

Hines says that the opportunity to enter a field he was fascinated with—and constantly learns more about—has influenced his business decisions. “Today’s technology has increased the efficiency of our water use. Moving from flood irrigation to center pivots increased water efficiency by 50 percent. Now, changes in center pivot irrigation systems have increased the efficient use of water by another 30 percent.”

According to Hines, irrigation provides consumers a safe supply of a variety of inexpensive foods. In addition, per acre yields are generally significantly higher on irrigated cropland than dryland. “If we take irrigation out of Kansas, we will have to turn the recreational areas into farmland. It would be unfair to ask the farmers to cut their water use unless we are willing to do the same for water parks, car washes, irrigation of lawns in town and on golf courses, or lower the amounts of water available for swimming pools and hot tubs. Farmers are, after all, growing food, fiber, forests, and fuel for many nations.”

Hines also values the economic contribution of irrigation. “Irrigation brings in additional gross revenues. Every dollar the agricultural producer receives turns over seven times in the community and contributes to the state’s economy,” says Hines.

Even though he left the education system to pursue a career in business, Hines continues to teach and build teams through business networking. Moreover, although he never intended to return to the family farm, he chose to build a business vitally linked to production agriculture. “Proper management of our water and other natural resources is a huge part of the agriculture business. We are living on the land. It would be most unwise of us to not understand our resources and be aware of how to use them efficiently,” says Hines. “Just as teachers are the caretakers of much of the education of our future and its leaders, agriculture must feed, clothe, house, and fuel the citizens of the future.”

NOTES:

Aquifers Showcase:

OGALLALA AQUIFER

The Ogallala aquifer is the largest aquifer included in the High Plains aquifer, which covers parts of eight states. In fact, the High Plains aquifer system was originally known as the Ogallala aquifer until it was determined that the Ogallala Formation was not the only geological formation in the aquifer system. The Kansas portion of the High Plains aquifer accounts for less than 20 percent of the aquifer's total area, although the aquifer underlies 38 percent of the state. In western Kansas, the Ogallala aquifer is generally identical to the High Plains aquifer. However, the part of the High Plains aquifer extending into south-central Kansas (east of Ford County) is divided into the Great Bend Prairie aquifer and the Equus Beds aquifer.

HISTORY

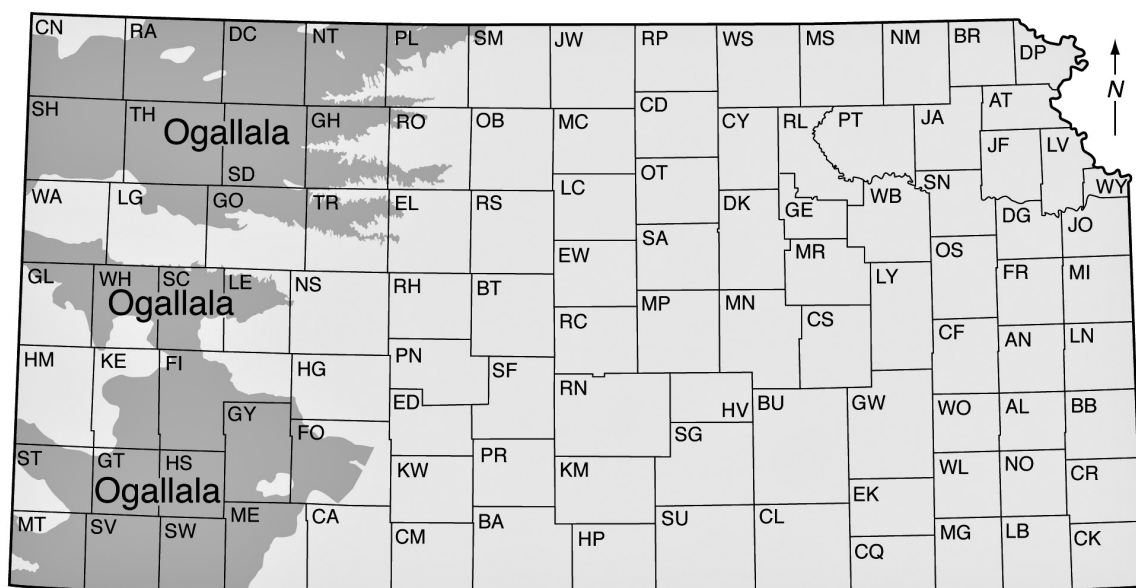
The Ogallala aquifer was named after the town of Ogallala, Nebraska, in 1899. The aquifer formed during the erosion of the newly uplifted Rocky Mountains over 20 million years ago. During this time, streams carried sand and gravel downstream where the sediments formed a sponge-like structure that soaked up rainfall and snowmelt and became what is known as the Ogallala aquifer.

Streams and rivers in western Kansas generally do not provide a reliable source of water since this region receives very little rainfall compared to other areas of the state. When settlers and farmers first came to the region, windmills were used to withdraw water from the aquifer. Crops were dependent on precipitation and often failed. Western Kansas farms were devastated by the extreme prolonged drought of the 1930s. Those conditions led to the development of irrigation technologies that allowed cost-effective drilling and pumping from deep wells. These advancements made it possible for farmers in western Kansas to produce crops despite the lack of rainfall.

In the beginning, irrigation was mainly used to supplement rainfall during dry periods. Another significant drought in the 1950s led to increased irrigation in the 1960s and irrigation became a significant factor in the success of crop production in western Kansas. Irrigation made it possible for crop yields in western Kansas and other states to match or exceed those in states with high annual precipitation, such as Illinois and Ohio. Irrigation provided states such as Kansas and Nebraska the ability to grow the grain needed to feed large livestock operations. Cattle feedlots were located near the grain supplies, which led to the development of beef processing plants and other related industries. Texas, Nebraska, and Kansas became the leading states in beef production. Today, only Texas outranks Kansas in the number of cattle being fed each year.

In Kansas, the Water Appropriation Act became law in 1945. This law established a required permitting process for water wells drilled for non-domestic purposes. Water rights granted by the state give holders the right to use a set quantity of water for a specific purpose each year. In Kansas, water rights are granted on a "first in time, first in right" basis. This principle means that in times of shortage, the earliest water right or permit holders have first rights to use the water. However, later amendments to the law allowed for the establishment of special management areas called Intensive Groundwater Use Control Areas (IGUCAs) where additional actions, rather than only the strict reverse order of priority, can be taken.

By the 1970s, concerns had been raised about the long-term impacts of increased water usage from aquifers all over the United States. Kansas passed legislation, the Groundwater Management District (GMD) Act of 1972, to allow for the local management and regulation of groundwater supplies. The majority of the irrigated acres in the state fall within the boundaries of the five groundwater management districts, three of which regulate water usage in the Ogallala aquifer.



Source: KGS

Ogallala Aquifer (continued)**ECONOMIC IMPACT OF IRRIGATION**

The economic impact of irrigation is significant. Irrigated cropland produces over 21 percent of the total value of crops harvested in Kansas, even though only 14 percent of the harvested cropland is irrigated. About 30 percent of all Kansas farms with harvested cropland include at least some irrigated cropland acres. More than 90 percent of the water pumped from the Ogallala aquifer is used to irrigate crops, such as corn, soybeans, alfalfa, and wheat.

As water levels in the Ogallala aquifer decline or restrictions on water usage are put in place, farmers are faced with difficult decisions. Profit margins are already slim and switching to more efficient irrigation technologies can be expensive. Crops that require less water to grow in western Kansas may not provide the necessary income to sustain a farm family. If irrigated land is converted to dryland, crop production and income will decrease dramatically.

Potential impacts extend beyond the individual farms. Cropland is valued according to its ability to produce crops; therefore, irrigated land is valued higher than dryland. Property taxes would be affected if irrigated land becomes dryland, impacting schools and communities in western Kansas. The decrease in crop production that would result from irrigated land becoming dryland would also result in a decrease in the amount of feed produced near livestock feeding operations. Those feedlots and related industries might choose to move to another area or state closer to necessary feed supplies, resulting in a loss of jobs that would impact the local and state economies in many ways.

Kansas has been grappling with these issues. Groundwater management districts have taken measures to restrict the development of new wells and to decrease the rates of water usage. Water levels and the rate of recharge are constantly monitored and research into aquifer-related issues is ongoing.

Water usage from the Ogallala aquifer actually declined in the 1980s and 1990s. It has stabilized at 1970s levels. However, water levels continue to decline in some parts of the aquifer so additional measures are being considered that will keep the aquifer viable as a water resource for future generations.





Unit 11) Careers in Agriculture

Globally, agriculture accounts for over 36 percent of world employment according to the United Nations' agency specializing in world labor and employment issues. The International Labour Organization reports that agriculture is still the main employer in the poorest regions of the world, such as sub-Saharan Africa where almost 70 percent of the people work in agriculture and agriculture-related jobs.

In the United States, more than one in seven people are employed in the agriculture industry. In Kansas, the number of people employed in agriculture and agriculture-related jobs is slightly higher than the national statistic. Nearly one in five workers in the state of Kansas work in the agriculture industry.

There are more than 250 career fields available in agriculture. In addition to production agriculture, the agriculture profession includes everything from atomic physics, bioengineering, and computers to lasers, robotics, and space satellites. Many of those employed in the agriculture industry do not have a farm background or experience in production agriculture but training in agriculture is often helpful.

THE AGRICULTURE PROFESSION

Agriculture—the application of the physical, biological, and social sciences and the principles of management to food production, preservation and processing, crop and livestock production, marketing, and processing, culture of flowers, turf grass, and ornamentals, life processes of plants and animals, natural resources management, economic development, agricultural education and communication, and related fields.

Kansas State University Undergraduate Catalog 2006-2008

"It may be hard for an egg to turn into a bird; it would be a jolly sight harder for it to learn to fly while remaining an egg. We are like eggs at present. And you cannot go on indefinitely being just an ordinary, decent egg. We must be hatched or go bad."

C.S. Lewis, Irish author and scholar

Every year, the agriculture industry needs more people to fill science, business and communication positions than universities are able to supply. According to the U.S. Department of Agriculture, more than 48,000 jobs are available each year in agriculture. As new technologies emerge, agriculture-related career opportunities incorporate those technological advances.

CAREER EXPLORATIONS

"I think, at a child's birth, if a mother could ask a fairy godmother to endow it with the most useful gift, that gift would be curiosity."

Eleanor Roosevelt, First Lady of the United States, 1933-1945

CAREER OPPORTUNITIES

The agriculture industry is huge, which means that there are thousands of job opportunities for recent college or technical school graduates each year. Many years ago, most agriculture-related careers involved production agriculture - farming or ranching. Today,

INTRODUCTION

CAREER EXPLORATION

- CAREER OPPORTUNITIES
- PREPARATION FOR HIGHER EDUCATION
- U.S. DEPARTMENT OF EDUCATION GUIDELINES

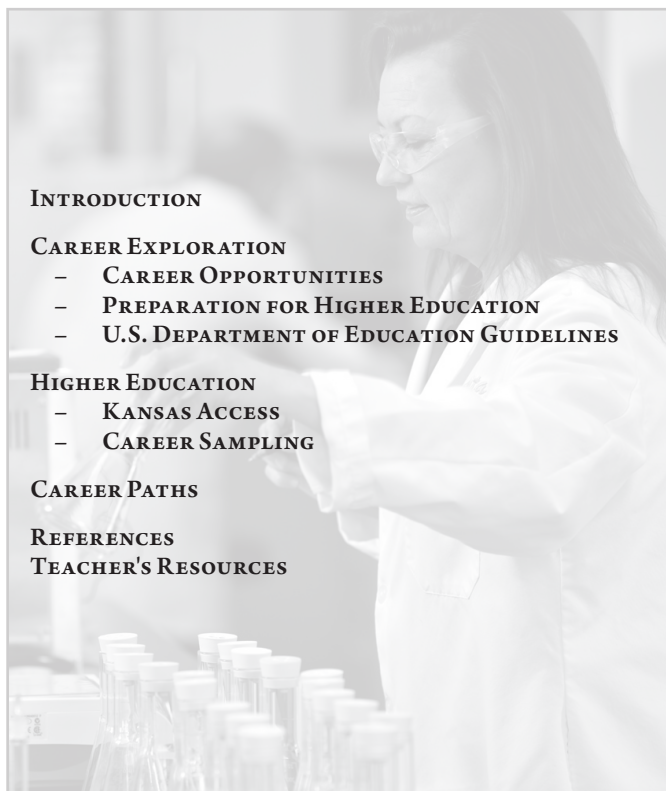
HIGHER EDUCATION

- KANSAS ACCESS
- CAREER SAMPLING

CAREER PATHS

REFERENCES

TEACHER'S RESOURCES



Agronomists Consulting with Wheat Producer

Credit: Scott Bauer, USDA ARS

Careers in Agriculture

however, less than two percent of the jobs in the United States are involved in production agriculture. Agribusiness accounts for twenty percent of the jobs in agriculture.

According to a 2005 study by Purdue University, employment opportunities for U.S. college graduates with expertise in the food, agricultural, and natural resources systems are expected to remain strong through 2010. The study projected over 52,000 job openings for new college graduates from 2005–2010, but only 49,300 qualified graduates to fill those positions. Graduates in agricultural studies were projected to fill 32,300 positions while the remaining 17,000 openings would be filled by graduates from programs of study such as biological sciences, engineering, business, health sciences, communication and applied technologies.

According to the study's projections, agriculture graduates will have the greatest opportunities in management and business, where the expected number of openings will be greater than the number of qualified candidates to fill those positions. Specialties in science and engineering will also offer a large number of new positions. There will also be many opportunities in specialized agriculture and forestry production for niche markets. The number of qualified graduates for agriculture-related positions in education, communication, and governmental services may exceed the number of available positions so competition for jobs in those fields may be greater during the next few years.



Veterinarians Examining Beef Heifer

Credit: Scott Bauer, USDA ARS

Higher Education— the non-compulsory educational level following the completion of high school; generally provided by colleges, universities, and other institutions (such as technical schools) which award an academic degree.

PREPARATION FOR HIGHER EDUCATION

Middle school or junior high is the time to start thinking about pursuing a higher education, whether that means a vocational or technical school or a university. Choices made in middle school can impact a student's ability to get accepted in the college or training program of his or her choice. These decisions can also affect a student's ability to qualify for financial aid, including scholarships, when he or she graduates from high school.

Students should start their path to higher education by pursuing classes in middle school or junior high that will allow them to take college preparatory classes in high school. Even if a student does not plan to pursue a college education, this broad set of classes will help the student earn a better living, contribute to the community, and generally enjoy life. Students often change their minds and if college becomes an option, the necessary coursework will be complete and the transition to a college or university will be much smoother.

Each high school has requirements for graduation. Meeting the requirements for high school graduation does not guarantee admittance to the college or university of a student's choice. For example, the Kansas Board of Regents institutions require high school graduates to qualify for admission to the six state universities: Emporia State University, Fort Hays State University, Kansas State University, Pittsburg State University, the University of Kansas, and Wichita State University. The Kansas Board of Regents adopted a "Qualified Admissions curriculum," meaning that Kansas high school graduates who earn a specific grade point average (GPA) in the courses specified in that curriculum are guaranteed admission to the six state universities. However, there are additional high school coursework requirements for the State Scholar program, which provides state-sponsored scholarships to Kansas high school graduates meeting the financial need requirements. The school

QUALIFIED ADMISSIONS – KANSAS BOARD OF REGENTS

Admission of high school students to Kansas state universities is described by the Qualified Admissions Statute. The state statute does not apply to Washburn University, community colleges, technical colleges or schools, or private colleges or technical schools in Kansas.

State of Kansas students must meet the following requirements to be guaranteed admission to any of the six Kansas state universities (Emporia State University, Fort Hays State University, Kansas State University, Pittsburg State University, the University of Kansas, and Wichita State University):

- Graduate from an accredited high school; AND
- Achieve an ACT composite score of 21 or above (or SAT score of 980); OR
- Rank in the top one-third of their high school's graduating class; OR,
- Complete the Qualified Admissions curriculum with at least a 2.0 grade point average (GPA) on a 4.0 scale.

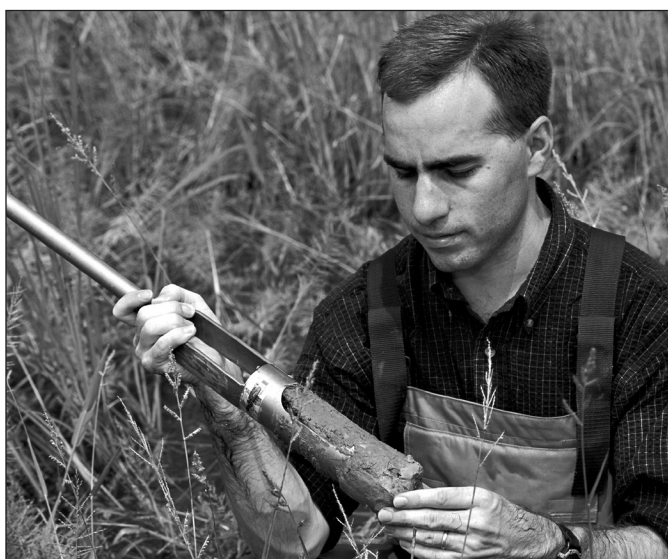


Biologists Collecting Fish

Credit: Scott Bauer, USDA ARS

guidance counselor can help students review the requirements of different colleges and programs in order to choose high school courses that will meet those requirements while offering students a wide variety of opportunities beyond high school.

High school activities are also important in preparing for higher education. Colleges look at student activities to get a better idea of who the student is. Activities often help admissions officials decide if the student would be a good member of their school community or if they could add to the school in some way. Community service projects, school activities, and community involvement demonstrate leadership, good time management, and the ability to work cooperatively – qualities that influence admission as well as selection for scholarships and honors.



Researcher Collecting Soil Core in Wetland

Credit: Peggy Greb, USDA ARS

U.S. DEPARTMENT OF EDUCATION GUIDELINES

The U.S. Department of Education recommends the following courses for students in high school who are considering pursuing a higher education:

English – 4 years

Good reading, writing, speaking and listening skills are essential to do well in college and to succeed in any job. Most employers rate good communications skills as one of the most important factors in getting and keeping a good job.

Mathematics – 4 years

Mathematics teaches logical reasoning and helps develop good problem solving skills.

History & Geography – 2–3 years

Studying the history, government, economics, and geography of the United States and the world helps students better understand past, present and potential future events.

Laboratory Science – 3–4 years

Laboratory science explains the mysteries of the world. Science teaches how to be a careful observer and to use logical reasoning to answer questions.

Foreign Language – 3–4 years

Studying a foreign language can help students understand and communicate with people from other cultures here and abroad. Learning a foreign language is the best way to begin to understand another culture.

Visual & Performing Arts – 1–2 years

Visual and performing arts add to the appreciation of and enjoyment of life. Studying the arts helps develop creativity and gives students the opportunity to express themselves.

Challenging Electives – 1–3 years

Electives are courses each student chooses to complete his or her high school education. If one area of the curriculum, such as science, is of particular interest, students may select an additional science course. Students may choose to explore another area by taking a business course. Agriculture Science is an elective offered at many high schools.

HIGHER EDUCATION

"A dream becomes a goal when action is taken toward its achievement."

Bo Bennett, American businessman

KANSAS ACCESS

Kansans believe in higher education. In Kansas, public institutions of higher learning include the six state universities, 19 community colleges, and 11 area vocational-technical schools/colleges. Most

KANSAS BOARD OF REGENTS

The Kansas Board of Regents governs six state universities and supervises and coordinates 19 community colleges, five technical colleges, six technical schools and a municipal university.

The Kansas Board of Regents' website – www.kansasregents.org – includes a complete listing of all private and public universities, colleges, and private and out-of-state institutions authorized to operate in Kansas, and links to their websites.

Careers in Agriculture

of the community colleges in Kansas offer an associate's degree in agriculture or a specific agriculture program.

Two of the state universities offer bachelor degrees in agriculture: Kansas State University (College of Agriculture) and Fort Hays State University (College of Health and Life Sciences). Kansas State University's College of Agriculture offers 13 bachelor of science programs, 10 master of science programs, nine programs leading to the Ph.D., and a pre-veterinary medicine program. At Fort Hays State University, the Department of Agriculture offers two bachelor of science degrees - Agribusiness and Agriculture. Four areas of specialization are offered with the Agriculture major.

In addition to the public institutions, there are over 20 private two and four-year colleges in Kansas. Many of these colleges also offer programs of study related to agriculture and natural resources, such as McPherson College's Environmental Stewardship major.

Selecting a major is an important decision but many college students decide to switch majors or pursue additional coursework outside their main program of study. Advisors can help identify a program that is the most compatible with individual career goals and interests. Often, course work from several majors is combined to fit individual interests.

KANSAS COMMUNITY COLLEGES

The website of the Kansas Association of Community College Trustees – www.kacct.org – provides information about all 19 public community colleges in Kansas, and links to their websites.

KANSAS TECHNICAL SCHOOLS AND COLLEGES

The Kansas Board of Regents governs five technical colleges and six technical schools in Kansas.

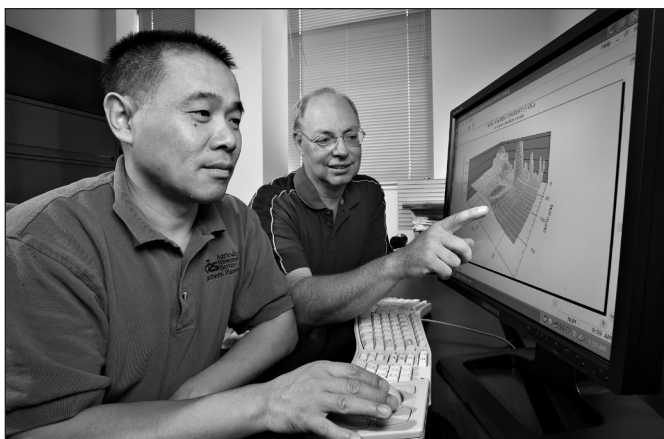
All private and out-of-state institutions operating in Kansas must be authorized by the Kansas Board of Regents. This includes business enterprises offering instruction for business, trade, technical or industrial occupations leading to a certificate, diploma, or academic degree.

The Kansas Board of Regents' website – www.kansasregents.org – provides links to the websites of all state technical colleges and schools, as well as all private institutions authorized by the board.



Entomologists Examining Apples

Credit: Scott Bauer, USDA ARS



Scientists Studying Cropping Sequences

Credit: Stephen Ausmus, USDA ARS



Park Ranger Flagging Tree

Credit: Jonas N. Jordan, USACE

SAMPLING OF AGRICULTURE CAREERS AND HIGHER EDUCATION CHOICES

This is only a sampling of the many educational opportunities in Kansas that prepare students for careers in agriculture and natural resources. This list is not complete. It only includes a few of the degree programs and some, but not all, of the Kansas institutions

offering those degree programs. In addition, several different degree programs might lead to a specific career – not just those included in this sample.

Most community college programs offer students the opportunity to transfer to a university and complete a bachelor's degree in their selected field of study.

CAREER	DESCRIPTION	INSTITUTION OF HIGHER LEARNING	ACADEMIC MAJOR–DEGREE OPTION
Agribusiness Manager	Agribusiness managers study the economic principles that guide business behavior and the economic activities of society. They lead their companies in decision-making. Agribusiness combines the traditional business background with agriculture and the global economy. Career opportunities can be found with farm input manufacturers, food manufacturers, wholesale and retail businesses, the farm credit industry, banks, commodity trading and grain merchandizing firms, and government agencies.	1) Kansas State University 2) Fort Hays State University	1) B.S. in Agribusiness (College of Agriculture) 2) B.S. in Agribusiness (College of Health & Life Sciences)
Fertilizer and Chemical Applicator	Certified commercial applicators work for cooperative associations, fertilizer and chemical companies, farms, and ranches. Responsibilities include working with chemicals, operating application equipment, maintaining accurate records, and maintaining equipment.	Barton County Community College	A.A.S. in Agriculture – Fertilizer & Chemical Application Fertilizer & Chemical Application Certificate
Firefighter	A firefighter rescues people and property from all types of accidents and disasters, including fires; attends emergency incidents such as vehicle accidents, floods, and spills of dangerous substances; and promotes fire safety and enforces fire safety standards. A wildland firefighter's work includes basic firefighting skills and those specific to outdoor conditions, such as prescribed burning, wildfire suppression, and fire preparedness.	1) Hutchinson Community College 2) Butler Community College 3) Dodge City Community College	1) A.A.S. in Fire Science, Wildland option available 2) A.A.S. in Fire Science 2) Fire Science Certificate 3) A.A.S. in Fire Science
Fisheries Biologist	A fisheries biologist conducts research and studies the biology of fish, habitat requirements, population changes, diseases, and food requirements. Many fisheries biologists work for state or federal agencies while others work for corporations, power companies, and aquaculture businesses.	1) Hutchinson Community College 2) Fort Hays State University 3) Kansas State University	1) A.A. in Natural Resource Management – Aquatic option (Wildlife Biology) 2) B.S. in Biology – Fisheries (College of Health & Life Sciences) 3) B.S. or B.A. in Biology – Fisheries, Wildlife & Conservation Biology (College of Arts & Sciences)



Scientists Excavating Roots

Credit: USDA ARS



Ethanol Lab Technician

Credit: ICM, Inc.

KEY

B.S. – Bachelor of Science

B.A. – Bachelor of Arts

A.S. – Associate in Science *

A.A. – Associate in Arts *

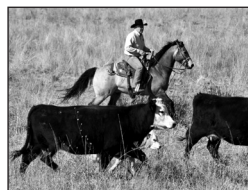
A.A.S. – Associate in Applied Science **

* requires transfer to complete B.S. or B.A.

** prepares students to enter an occupation directly; most students do not transfer into a bachelor degree program.

SAMPLING OF AGRICULTURE CAREERS AND HIGHER EDUCATION CHOICES (CONTINUED)

CAREER	DESCRIPTION	INSTITUTION OF HIGHER LEARNING	ACADEMIC MAJOR–DEGREE OPTION
Forester	Foresters manage, develop, and protect forests and their resources for economic, recreational, and conservation purposes. Their responsibilities might include planting trees, monitoring trees for healthy growth and determining when to harvest trees, appraising timber, managing wildlife habitat, monitoring water quality, or maintaining forest facilities.	1) Cloud County Community College 2) Fort Hays State University 3) Barton County Community College 4) Highland Community College 5) Pratt Community College	1) A.S. in Pre-Forestry 2) Biology – Pre-Forestry* (College of Health & Life Sciences) *requires transfer to complete B.S. 3) A.S. in Pre-Forestry 4) A.A. or A.S. in Pre-Forestry & Conservation 5) A.S. in Mathematics & Science – Pre-Forestry Note: the University of Missouri waives non-resident tuition for pre-forestry students from Kansas and Nebraska.
Heavy Equipment Operator	Heavy equipment operators maneuver scrapers, motor graders, bulldozers, backhoes, front-end loaders, and other heavy equipment. Job opportunities exist with local, state, and federal agencies, general construction companies, and road and highway construction firms.	North Central Kansas Technical College	Heavy Equipment Operation Certificate Note: this is the only training program in the state for heavy equipment operation.
Agricultural Service Technician	Agricultural equipment dealers and agricultural businesses employ skilled service technicians. Agricultural service technicians diagnose, adjust, and repair farm machinery, such as tractors, harvesters, and other farm equipment.	1) Garden City Community College 2) Fort Scott Community College 3) Pratt Community College 4) North Central Kansas Technical College	1) A.A. S. in John Deere Ag Tech Program 2) A.A.S. in John Deere Tech Program 3) A.A.S. in Agriculture Power Technology 4) A.A.S. in Agriculture Equipment Technology Note: manufacturers provide training components and equipment for these programs while agricultural equipment dealers provide internship experiences and often guarantee employment for graduates.
Range Manager	Range managers conduct research on grasslands; study concepts, methods, and ecological principles; and apply range management practices that utilize grassland resources for food production (grazing), watershed protection, recreation, and wildlife.	1) Kansas State University 2) Fort Hays State University 3) Highland Community College 4) Pratt Community College	1) B.S. in Agronomy – Range Management (College of Agriculture) 2) B.S. in Biology – Range Conservation (College of Health & Life Sciences) 3) A.A. in Agronomy 4) A.S. in Agriculture – Range Management
Food Scientist	Food scientists develop, evaluate, market, and manufacture food products. They work for food processing companies, food equipment and ingredient suppliers, and government agencies. They may be involved in research, food inspection, sales and marketing, or the development of regulations.	Kansas State University	B.S. in Food Science (College of Agriculture)



left to right: **Heavy Equipment Operator**

Credit: Larry Rana, USDA

Range Manager

Credit: Stephen Ausmus, USDA ARS

Firefighter

Credit: Bob Nichols, USDA

SAMPLING OF AGRICULTURE CAREERS AND HIGHER EDUCATION CHOICES (CONTINUED)

CAREER	DESCRIPTION	INSTITUTION OF HIGHER LEARNING	ACADEMIC MAJOR—DEGREE OPTION
Veterinarian	Veterinarians diagnose and treat diseases and injuries of all species of animals, including companion animals, wildlife, and domestic livestock. Veterinarians also advise animal owners and promote the health of animals, engage in research, and develop commercial animal health products. They may specialize in the prevention and control of communicable animal diseases. Veterinarians are employed in private practice, government service, or industry.	Kansas State University	Doctor of Veterinary Medicine (College of Veterinary Medicine) Note: requires completion of pre-professional curriculum (undergraduate) and admission to the professional program.
Veterinary Technician	Veterinary technicians perform general veterinary activities under the supervision of licensed veterinarians.	Colby Community College	A.A.S. in Veterinary Technology
Wildlife Biologist	Wildlife biologists perform a wide variety of duties including managing wildlife populations, researching plants and animals and the environments in which they exist, mapping and measuring natural resources, and analyzing satellite images. Wildlife biologists also manage public lands for state or federal agencies, as well as corporate and privately owned lands.	1) Barton County Community College 2) Hutchinson Community College 3) Fort Hays State University 4) Kansas State University	1) A.S. in Pre-Wildlife Science 2) A.A. in Natural Resource Management – Terrestrial option (Wildlife Biology) 3) B.S. in Biology – Wildlife Biology (College of Health & Life Sciences) 4) B.A. or B.S. in Biology – Fisheries, Wildlife & Conservation Biology (College of Arts & Sciences)
Furniture Designer	A furniture designer designs furniture for manufacture. This might include studying market trends; preparing drawings, blueprints, manufacturing specifications and cost estimates; building models or prototypes; and working with both customers and manufacturers.	Pittsburg State University	B.S. in Technology – Wood Technology A.A.S. in Technology – Wood Technology Bachelor of Applied Science in Technology – Wood Technology (designed for technical program graduates with an associate degree) Note: Students in this wood processing program choose an emphasis between wood product manufacturing and residential construction.
Park Ranger	Park rangers manage local, state, and national parks and recreation areas; plan, develop and conduct interpretative programs about historical, natural and scientific features; and serve as law enforcement officers. They are employed by public agencies such as the National Park Service, the USDA Forest Service, and state, city, and county park and recreation departments, as well as private businesses at resorts, lodges, estates, and other areas.	Kansas State University	B.S. in Horticulture, Forestry & Recreation Resources – Park Management & Conservation (College of Agriculture)
Animal Nutritionist	Animal nutritionists formulate diets for domestic, companion, and exhibit animals. They conduct research, advise clients, develop and evaluate products for animals, and are involved in the manufacture and marketing of feed products. They work for feed and pharmaceutical companies, zoos, and livestock industries.	1) Kansas State University 2) Fort Hays State University	1) B.S. in Animal Science or Feed Science (College of Agriculture) 2) B.S. in Animal Science (College of Health & Life Sciences)

SAMPLING OF AGRICULTURE CAREERS AND HIGHER EDUCATION CHOICES (CONTINUED)

CAREER	DESCRIPTION	INSTITUTION OF HIGHER LEARNING	ACADEMIC MAJOR–DEGREE OPTION
Agricultural Producer	Agricultural producers (farmers and ranchers) produce food, feed, fiber, and fuel to meet the needs of the U.S. and for export. Today, farming and ranching involves complex scientific, business, and financial decisions. The type of farm or ranch determines the specific tasks carried out by the agricultural producer. Tasks include working with plants and animals, making managerial decisions, marketing agricultural products, operating machinery, maintaining equipment and facilities, keeping records, and supervising employees. Many agricultural producers are self-employed and enjoy working outdoors.	1) Kansas State University 2) Fort Hays State University Note: Almost all Kansas community colleges offer 2-year degrees or certificates in agriculture programs, as well as transfer opportunities to 4-year degree programs at Kansas State University and Fort Hays State University.	1) B.S. in Agriculture - many specialization options (College of Agriculture) 2) B.S. in Agriculture - many specialization options (College of Health & Life Sciences)
Agronomist	Agronomists deal with interactions among plants, soils, and the environment. They develop new crop varieties, study water movement in the soil, and investigate soil chemistry. They work for seed, crop consulting, lawn care, and agrichemical companies, farm cooperatives, banks, government agencies, and food production companies.	1) Kansas State University 2) Fort Hays State University 3) Barton County Community College 4) Colby Community College 5) Dodge City Community College 6) Hutchinson Community College 7) Pratt Community College	1) B.S. in Agronomy (College of Agriculture) 2) B.S. in Agronomy (College of Health & Life Sciences) 3) A.S. in Agronomy 4) A.S. in Agronomy 5) A.A.S. in Agronomy 6) A.A. in Agronomy 7) A.S. in Agronomy
Horticulturist	Horticulturists work to improve crop yields, quality and nutritional value, resistance to insects, diseases, and environmental stresses, in addition to adapting plants to grow in different climates and soils or for specific food uses or processes. They may work in public gardens, greenhouses, garden centers, residential and commercial landscape installation and care, golf course and sports turf management, or be employed as plant breeders, genetic engineers, crop inspectors, or research scientists.	1) Kansas State University 2) Coffeyville Community College 3) Hutchinson Community College 4) Johnson County Community College	1) B.S. in Horticulture (College of Agriculture) 2) A.A. in Horticulture 3) A.A. in Horticulture 4) A.A.S. in Horticulture 4) Horticulture Certificate 4) Landscape Technician Certificate
Wind Turbine Technician (Windsmith)	Responsibilities of a wind turbine technician would include operating and maintaining wind turbine units, performing mechanical and electrical troubleshooting, making repairs, and preventative maintenance. Positions are available with commercial wind farms and industries related to the production and utilization of wind energy.	Cloud County Community College	A.A.S. in Wind Energy Technology Wind Energy Technology Certificate
Water Plant Operator	A water plant operator controls equipment that filters and purifies water for human consumption and industrial uses. Responsibilities might include operating, repairing and maintaining pumps and valves that regulate the flow of water, testing water samples, recording data, and responding to consumer questions and complaints.	Dodge City Community College	A.A.S. in Environmental Water Technology

CAREER PATHS

"Go confidently in the direction of your dreams. Live the life you have imagined."

Henry David Thoreau, writer, philosopher, and naturalist

The future is bright for Kansas students who seek a higher education. Many of those students who never considered a career in agriculture may find themselves working in an agriculture-related field. Kansas students have access to many technical and academic programs that will prepare them for a variety of careers in agriculture and natural resources.

Small children are often asked, "What do you want to be when you grow up?" As they grow up, the question becomes harder to answer. High school students are asked, "Where are you going to go to school?" Once they have chosen which school to attend, questions still come up concerning their program of study and the career opportunities related to their studies. As long as consumers need food, fiber, and fuel, Kansas students will find opportunities in agriculture-related careers. ■

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Executive Summary: The Key Indicators of the Labour Market. 5th ed. 2007, International Labour Organization. <<http://www.ilo.org/public/english/employment/strat/kilm/download/exsum.pdf>>

Goecker, Allan D., Jeffrey L. Gilmore, Ella Smith, and P. Gregory Smith. *Employment Opportunities for College Graduates in the U.S. Food, Agricultural, and Natural Resources System 2005-2010*. 2005, Food and Agricultural Information System. <<http://faeis.ahnrit.vt.edu/supplydemand/2005-2010/>>

Preparing for College: A Guide for Students, Families, and Educators. Rhode Island Office of Higher Education. <<http://www.ribghe.org/col-prep.htm>>

State Fact Sheets: Kansas. 2007, U.S. Department of Agriculture Economic Research Service. <<http://www.ers.usda.gov/statefacts/KS.htm>>

TEACHER RESOURCES

WEBSITES:

College of Agriculture

Kansas State University
www.ag.k-state.edu

College of Health and Life Sciences

Fort Hays State University
www.fhsu.edu/chls

Career Links in Biology

Fort Hays State University
www.fhsu.edu/biology/careerlinks.shtml

Careers in Agriculture

Florida Department of Agriculture and Consumer Services
www.florida-agriculture.com/consumers/careers.htm

Careers in Biology

Emporia State University
www.emporia.edu/biosci/carebiol.htm

Careers in Botany

Botanical Society of America
www.botany.org/bsa/careers/

Careers in Plant Pathology

The American Phytopathological Society
<http://www.apsnet.org/careers/careers.asp>

CareerZone

New York State Department of Labor
www.nycareerzone.org

Food, Agriculture, and Natural Resources Careers

USDA Living Science
www.agriculture.purdue.edu/USDA/careers/index.html

Kansas State Department of Education

www.ksde.org

Occupational Outlook Handbook

U.S. Department of Labor – Bureau of Labor Statistics
<http://www.bls.gov/oco/home.htm>



Studying Soil Samples

Credit: Scott Bauer, USDA ARS



Measuring Soil Temperatures

Credit: Stephen Ausmus, USDA ARS



Examining Switchgrass

Credit: Scott Bauer, USDA ARS



Measuring Streamflow

Credit: Peggy Greb, USDA ARS

TEACHER'S RESOURCES (CONTINUED)

NOTES:

School to Careers

Iowa Public Television

www.iptv.org/stc

U.S. Department of Education

www.ed.gov



Appendix A) Glossary

A

Acidic Soil: soil with a pH of less than 7.0.

Acre: a unit of area used in land measurement equal to 43,560 square feet or approximately the size of a high school football field excluding the end zones.

Adapt: how animals or plants change to live in a particular ecosystem.

Agriculture: the application of the physical, biological, and social sciences and the principles of management to food production, preservation and processing, crop and livestock production, marketing, and processing, culture of flowers, turf grass, and ornamentals, life processes of plants and animals, natural resources management, economic development, agricultural education and communication, and related fields.

Agricultural Crops: crops produced for human food, livestock feed, or consumer and industrial products.

Agricultural Water Supply: agricultural uses of water including irrigation and livestock watering.

Agroforestry: the integration of tree and shrub plantings into agricultural systems.

Algae: microscopic organisms that contain chlorophyll and other pigments and form the base of the food web in a pond or lake.

Alien Species: undesirable species brought into the North American continent either accidentally or deliberately for a specific purpose; they adapt and increase rapidly, replacing existing natural or introduced species.

Alkali Soil: soil with a pH greater than 8.5 and high levels of sodium. (*Sodic Soil*)

Alkaline Soil: soil with a pH greater than 7.0.

Alluvial Aquifer: an aquifer that was formed in recent geologic time by sediment that is loosely arranged but not cemented together and has a water table that is fairly close to the surface of the land.

Alluvium: sediment that is loosely arranged, but not cemented together, that was deposited during recent geologic time by running water in the bed of a stream or on its floodplain.

Aquatic: living or growing in or on the water.

Aquatic Ecosystem: the ecosystem of a lake, wetland, pond, river, estuary, or other body of water.

Aquatic Life Support: the maintenance of the ecological integrity of lakes, wetlands, and ponds, including the sustained growth and propagation of aquatic, semi-aquatic, or terrestrial wildlife.

Aquatic Nuisance Species: a non-native organism that threatens the diversity or abundance of native species, the ecological stability of impacted waters, or a commercial, agricultural, aquacultural, or recreational activity.

Aquifer: a natural underground storage area for water.

Artesian Aquifer: see *Confined Aquifer*

Artesian Well: a well drilled into a confined aquifer in which the water is under pressure forcing the water upwards.

Atrazine: a common herbicide used in producing agricultural crops.

Autosteer: an automatic guidance system that operates agricultural machinery using GPS for accuracy and GIS information to vary operations at specific sites.

Awns: slender, stiff, bristle-like extensions of a plant, such as the beards on a head of wheat.

Axil: the space between a leaf and the stem to which it is attached.

B

Bacterial Contamination: the alteration of physical, chemical, or biological properties caused by bacteria at concentrations that may adversely affect human health or the environment.

Bankfull Flow: a measurement of the maximum volume of water in a stream or river at the moment of highest flow.

Bedrock: the solid rock layer underneath any unconsolidated sediment or soil.

Bedrock Aquifer: water trapped underground in layers of solid rock; often used as local sources of water.

Bendway Weir: a low rock structure designed to slow the velocity of the water and redirect the water flow away from the streambank. (*Rock Vane*)

Benthic: bottom dwelling.

Biodiesel: an alternative diesel fuel produced from any animal fat or vegetable oil, such as soybean oil or recycled cooking oil.

Biodiversity: the variety of differing organisms that interact in a given area, plus the relative abundance of each.

Biofuel: liquid fuel produced from biomass including ethanol, biodiesel, methanol, and reformulated gasoline components.

Glossary

Biomass: plant matter such as trees, grasses, agricultural crops, or other biological material.

Biome: a large geographic area with a complex of communities characterized by a distinctive type of vegetation maintained under somewhat uniform climatic conditions.

Biotechnology: technology that uses living organisms to add beneficial traits to a product to improve that product or to develop organisms for specific uses.

Black Sunday: name given to April 14, 1935, when one of the worst dust storms in history occurred.

Botany: the study of plants.

Brine: water with a high salt content—usually with more than 10,000 milligrams per liter.

Buffer Strip: a strip of permanent vegetation (grasses, trees, and shrubs) located between cultivated fields and bodies of water for the purpose of filtering nutrients, sediments, and other contaminants from runoff waters. (*Filter Strip*)

Bulb: an underground stem or root, usually surrounded by scale-like leaves, that contains stored food for the shoots of the new plant that grows within it.

Bushel: a unit of measure commonly used to measure grains and oilseeds. One bushel is equal to 60 pounds of wheat or soybeans, 56 pounds of corn or grain sorghum or 27 pounds of oilseed sunflowers.

By-products: see *Coproducts*

C

Canopy: the layer formed by the leaves and branches of the tallest trees in a forest or the foliage of a growing crop; said to be a closed canopy when plant growth shades the areas between the trees or plants; an open canopy allows direct sunlight to penetrate between trees or rows of plants.

Carnivore: eats animals.

Carbon Sequestration: the process of storing excess carbon within plants and soil instead of releasing it into the atmosphere as carbon dioxide.

Carrying Capacity: the greatest number of organisms that can be supported by an area without damaging that area.

Cellulose: a complex carbohydrate which forms the main constituent of the cell wall in most plants.

Center Pivot Irrigation: a system where water is pumped from a well through a line of water distribution pipes mounted on wheels, which rotate (pivot) in a circle around the center of an irrigated area.

Central Flyway of North America: the migration corridor between the Mississippi River Valley and the Rocky Mountains in which migratory birds travel between breeding grounds in the north and wintering grounds in the south.

Cereal Grains: wheat, rice, corn, grain sorghum, rye, oats, barley, millet, and triticale.

Chinook Winds: wind patterns observed where the Great Plains end and the mountains begin which can elevate winter temperatures for a few hours or days, at the end of which the temperatures plummet back to base levels.

Chlorophyll: the name given to the green pigment in plant cells that is responsible for absorbing light energy during photosynthesis.

Christmas Tree Farm: a farm where trees are grown and harvested for use as Christmas trees and related decorations.

Chromosome: a distinct unit of a genome carrying many genes; each chromosome is a long molecule of double-stranded DNA, plus an approximate equal mass of protein; can only be seen during cell division.

Clay: the smallest mineral particles that make up soil, so small that they may only be seen through electron microscopes.

Clean Water Act of 1972: the federal law that established the basis for current water quality standards and extended protection to all surface waters of the United States; emphasized eliminating major visible sources of pollution and required states to establish water quality standards.

Climate: the average weather conditions of a given point during a given set of dates including the average rainfall, temperature, humidity, and wind conditions.

Coarse Grains: corn and grain sorghum.

Commodity: an item with value that can be bought or sold.

Community: all organisms in a particular habitat that are bound together by the food web and other interrelationships.

Condensation: the formation of a liquid from a vapor due to the cooling of the vapor.

Confection Sunflowers: see *Nonoil Sunflowers*

Confluence: the place where two or more streams meet and begin flowing together.

Confined Aquifer: groundwater that is trapped beneath layers of impermeable materials; may be under pressure. (*Artesian Aquifer*)

Coniferous: trees whose seeds develop inside cones; considered softwoods.

Conservation: the wise and intelligent use of natural resources in a way that assures their continuing availability to future generations.

Conservation Practice: a specific treatment, such as a structural or vegetative measure, or management technique used to meet specific needs in planning and implementing conservation.

Conservation Reserve Program (CRP): a conservation program in which landowners plant long-term, resource conserving plants to improve water quality, control soil erosion, and enhance wildlife habitat.

Conservation Tillage: any tillage sequence or tillage and planting combination which minimizes or reduces loss of soil and water by leaving at least 30 percent of the soil surface covered by the residue of the previous year's crops.

Consumers: living organisms that feed on trees and green plants directly and those that consume indirectly by eating other organisms that have already fed on the trees or green plants.

Consumptive Use: a water use that prevents the water from being immediately available for another use.

Continuous Cropping: planting only one crop on the same land for two or more consecutive growing seasons.

Contour Farming: performing tillage and planting operations on the contour—with a slope rather than up and down it—for the purpose of soil conservation.

Coproducts: additional products resulting from an industrial process, such as the livestock feed and carbon dioxide that result from the production of ethanol. (*By-products*)

Cropland: land which can produce a crop for harvest—not including woodlands, marshes, or land suitable only for pasture as they are not considered crops.

Crop Rotation: a planned sequence of growing crops versus continuously growing only one crop on the same area of land year after year.

Crush: the process of separating and extracting oil from oilseeds.

Cultivation: a tillage method performed to prepare land to grow crops or to control weeds.

D

Decay: the progressive deterioration of organic tissues, usually caused by fungal or bacterial organisms, resulting in loss of cell structure, strength, and function.

Deciduous: trees that shed all their leaves every year; includes most broad-leaved trees in North America; considered hardwoods.

Decomposers: organisms that recycle nutrients and make them available for either producers or consumers to use.

Delta: the broad network of branches with water flowing in them created when a stream flattens and slows near its junction with a big body of water and deposits the silt, sand, or fine rock particles the water has been carrying.

Density: number of organisms per unit of space.

Dimension: the cross sectional shape of a stream or river such as U- or V-shape.

Discharge: the outflow from an aquifer or other water body.

Diversion: the physical removal of surface water from a channel.

DNA: Deoxyribo Nucleic Acid; an acid in a cell's nucleus that carries the genetic information; two long chains of nucleotides twisted into a double helix that determines individual hereditary characteristics.

Domestic Water Supply: potable water used for everyday living.

Dormancy: in plants, a period of inactivity during winter or periods of cold.

Dredging: an excavation activity usually carried out at least partially underwater with the purpose of gathering sediment, such as sand or gravel, and depositing it elsewhere.

Dryland: land that is not irrigated.

Dry Mill: an ethanol production process in which the entire corn kernel or sorghum berry is ground into flour before processing.

Drought: a long period of abnormally low precipitation, especially one that adversely affects growing or living conditions.

Dust Bowl: describes the western Great Plains of the United States, which suffered severe wind erosion and drifting soil during the drought years of 1933–1940.

E

E10: a blend of 10 percent ethanol and 90 percent unleaded gasoline.

E85: a blend of 85 percent ethanol and 15 percent unleaded gasoline, for use in flexible fuel vehicles.

Ecofallow: see *Summer Fallow*

Ecology: the study of the relation of organisms or groups of organisms to their environment.

Ecological Succession: see *Succession*

Ecosystem: a natural unit that includes living and nonliving parts interacting to produce a stable system in which the exchange of materials between the living and nonliving parts follows closed paths.

Emergent Plants: plants rooted in soil underwater that grow up through the water, so that stems, leaves, and flowers emerge in the air above the water level.

Emigrant: a person who moved (migrated) away from one region of a country to another region of the same country (as used historically).

Endangered Species: any species in danger of extinction throughout all or a significant portion of its range or habitat.

Environment: the sum of all external conditions and influences, living and nonliving, that affects the development and ultimately the survival of an organism or group of organisms.

Ephemeral Stream: a stream that normally is dry and flows only during or shortly after a storm event such as rainfall or snowmelt.

Glossary

Erosion: the detachment and movement of soil or rock by water, wind, ice, or gravity.

Ethanol: ethyl alcohol; an alcohol made by fermenting and distilling simple sugars.

Evaporation: the process of changing from a liquid to a gas by exposure to air, heat, or both.

Evapotranspiration: the process of transferring moisture from the ground to the atmosphere by evaporation of water from the soil and transpiration from plant leaves.

Evergreen: trees that have leaves year-round; considered softwoods.

F

Fauna: animals.

Fallow: left unplanted.

Feed Grains: grain fed to livestock; often interchanged with coarse grains.

Fertile Crescent: an area of land near the Mediterranean Sea with rich, fertile soil and a favorable climate for growing crops which encouraged the domestication of plants and animals.

Fertilizer: any organic or inorganic material of natural or synthetic origin (other than liming materials) that is added to soil to supply one or more plant nutrients essential to the growth of plants.

Fiber Crops: crops produced for the fiber such as cotton and flax.

Field Border: a strip of perennial grass or legumes along and around the edge of a crop field.

Filter Strip: see *Buffer Strip*

Fishery: a place where fish or other aquatic animals are bred and raised, such as a fish hatchery.

Floating-leaf Plant: a plant that may or may not be rooted in the bottom of a lake or pond with leaves, and often flowers, that float on the surface of the water while most of the plant remains underwater. (*Free Floating Plant*)

Flooded Basin: a wetland that consists of a naturally occurring shallow depression or sinkhole. (*Playa Lake*)

Floodplain: the relatively level area of land bordering a stream channel that is covered with water during moderate to severe floods.

Flora: plants.

Florets: small individual flowers that form a larger flower head, such as in a sunflower.

Foliage: the live leaves or needles of a tree; primarily responsible for photosynthesis.

Food Procurement: the act of obtaining food for human consumption, including edible forms of wildlife.

Food Web: the transfer of energy from one organism to another as an organism is consumed (eaten).

Forages: herbaceous, broad-leaf plants (other than grasses) that are consumed by livestock or harvested for livestock feed, such as brome, alfalfa, and forage sorghum.

Forbs: plants whose stems and broad flat leaves die down to the soil level at the end of each growing season.

Forest: an ecosystem dominated by trees.

Forester: a person who manages forests for the maintenance and reoccurrence of desirable conditions.

Forest Floor: the bottom layer of the forest including fallen branches and leaves, mosses, and woody debris.

Forested Wetland: a wetland that supports many tree species; located in temporarily flooded areas or shallow depressions adjacent to other wetlands.

Forestry: the science of managing and caring for forests.

Formation: the smallest possible layer of rock that can be mapped and described over a wide area.

Fossil Fuels: naturally occurring hydrocarbon compounds that represent the altered remains of organic materials enclosed in rock such as coal, crude oil (petroleum), and natural gas.

Fragmentation: occurs when land is sold in small acreages of 1–20 acres, when roads and interstate highways expand rights of way, and when new water impoundments are developed therefore encouraging individuals to move to the country—reducing land available for food and fiber production and limiting management options. (*Urban Sprawl*)

Free Floating Plant: see *Floating-leaf Plant*

Freshwater: water suitable for human consumption with less than 0.5 parts per thousand dissolved salts.

Fungi: simple plant-like organisms that lack chlorophyll and therefore obtain their nutrition from living on or in other organisms (parasitically), from living with other organisms (symbiotically), or by breaking down dead organic materials (saprophytically).

G

Gene: a DNA segment that contributes to function and appearance; a code that determines the amino acid order of a protein.

Genetics: the science of heredity.

Genome: one complete set of chromosomes; the entire genetic material.

Geographical Information System (GIS): a computerized system used to input, store, retrieve, analyze, and display, in map-like form, spatially referenced geographical information.

Geologic Time: the time of physical formation and development of the earth, especially prior to human history.

Geology: the structure of a specific region of the earth, including its rocks, soils, mountains, fossils, and other features.

Geohydrology: see *Hydrogeology*

Glacial Drift Aquifer: an aquifer found in glacial debris that traps and holds water or in an ancient river valley buried by debris left behind when the continental glaciers melted and receded.

Glacier: a large mass of compacted ice.

Global Positioning System (GPS): a navigational tool based on satellites orbiting the earth and transmitting signals allowing GPS receivers to determine the receiver's location, speed, and direction.

Grains: crops that produce a small hard seed.

Grass: the family of plants characterized by hollow jointed stems and bladelike leaves.

Grassed Waterway: a natural or constructed channel used to carry water from natural precipitation through or from cropland.

Grassland: an area covered with vegetation types dominated by grasses, including tame pasture and rangeland.

Grazing Distribution: the pattern created by livestock grazing an area.

Great Depression: the worldwide economic downturn that began in 1929 and lasted until about 1939.

Great Plains: a major ecological region in the central part of the continent of North America, extending from the Canadian provinces of Alberta, Saskatchewan, and Manitoba south into northeastern Mexico and from western Indiana to the foothills of the Rocky Mountains; in Kansas, commonly used to identify the western two-thirds of the state.

Gross Domestic Product (GDP): the total market value of the goods and services produced by a nation's economy during a specific period of time.

Groundwater: underground water that is generally found in the pore spaces of rocks or sediments.

H

Habitat: the area that provides an organism with adequate food, water, shelter, and living space and the conditions of that environment including the soil, vegetation, water, and food.

Hardwoods: broad-leaved trees.

Hay: fine-stemmed dry forage which is usually seeded with a drill, cut or swathed, and baled to use as livestock feed.

Haylage: partially fermented fodder used as livestock feed that is kept in the succulent and slightly sour condition.

Headwaters: the source from which a river rises.

Heliotropism: the action of plants, such as sunflowers, following the sun from east to west during the day and returning to the east each morning.

Herbicide: a chemical used for weed control that kills plants or inhibits their growth.

Herbivore: eats plants.

Higher Education: the non-compulsory educational level following the completion of high school; generally provided by colleges, universities, and other institutions (such as technical schools) which award an academic degree.

Homestead Act of 1862: the federal law that gave title to 160 acres of undeveloped land to a person who was at least 21 years old who built a house at least 12 feet by 14 feet and lived in it for at least five years.

Horticultural Crops: fruits, vegetables, flowers, and ornamental plants which are considered agricultural crops.

Humus: a rich organic material in soil formed by the decomposition of plants and animals.

Hundredweight: a measure of 100 pounds; grain sorghum is sold by the hundredweight rather than by the bushel like most other grains and oilseeds.

Hybrid: a plant produced by breeding two genetically unlike parents to create an offspring with more favorable characteristics.

Hybrid Seed: seed produced by controlling pollination and allowing only specific genes to be transferred to seed-producing plants, resulting in a plant with specific characteristics that is unable to produce seed for future plants with the same exact characteristics.

Hydric: contains little or no oxygen.

Hydro: from an Ancient Greek preface meaning water.

Hydroelectric Power: electrical energy produced by using the forces of water.

Hydrogeology: the study of groundwater and its relationship to geology. (*Geohydrology*)

Hydrologic Cycle: the complete cycle of water movement from the atmosphere to earth and back again through evaporation, transpiration, condensation, precipitation, percolation, runoff, and storage. (*Water Cycle*)

Hydrologic Regime: refers to how and when a wetland receives water.

Hydrologic Unit Code: a number that identifies drainage basins within a watershed based on a classification system for dividing hydrologic regions.

Hydrology: the study of the waters of the earth, their distribution on the surface and underground, and the hydrologic cycle involving evaporation, precipitation, etc.

Glossary

Hydrophilic: water loving; substances that will mix well with and dissolve in water such as salt.

Hydrophobic: water fearing; substances that do not mix well with water such as oil.

Hydrophyte: a plant adapted to grow in water.

Hydrosphere: the collective mass of water found on Earth's surface, in the atmosphere, and underground in aquifers.

I

Immigrant: a person who moves (migrates) into a different country.

Indian Removal Act of 1830: a federal law providing for an exchange of lands with American Indians residing in any of the states or territories and for their relocation to lands west of the Mississippi River.

Industrial Water Supply: water used for a wide range of purposes by industries, including cooling water for electrical power generation, manufacturing, food preparation, washing of wastes, etc.

Infiltration: the process in which water is absorbed into the soil or becomes part of a body of water.

Inflorescence: the flowering part of a plant that consists of more than one flower, often several distinct individual flowers.

Inorganic: composed of matter that is not animal or vegetable.

Insecticide: a chemical that kills insects.

Insectivore: feeds primarily on insects.

Intermittent Stream: a stream that flows most of the year but normally is dry during one or two months of every year.

Invasive Species: introduced or native species that have increased in numbers and have replaced desirable species; can occur due to changes in management, weather, or the absence of natural controls.

Irrigation: the intentional application of water to the soil, usually for the purpose of crop production.

K

Kinetic Energy: a form of energy represented by matter (mass) in motion such as wind.

Knot: in cut wood, a hard dark-colored patch at a point where a branch or stem formerly grew out of the tree.

L

Lake: a body of water—usually over ten acres in size—that is too deep for plants to grow to the surface, except around the shore.

Landform: a natural physical feature of the earth's surface.

Legume: a family of plants that can convert nitrogen from the air to nitrates in the soil through a process known as nitrogen fixation including many valuable food and forage species, such as peas, beans, soybeans, peanuts, clovers, alfalfas, and sweetclovers.

Life Cycle: the phases, changes, or stages through which an organism passes during its lifetime.

Ligule: a small flap or row of hairs on the inner or upper side of a leaf where it grows out of the sheath.

Limnology: the scientific study of lakes and other bodies of fresh, inland water such as ponds and streams.

Living Snow Fence: rows of trees and shrubs planted to keep snow off roads, reducing snow removal and related energy costs and making the roads safer for winter driving.

Loam: soil that contains equal amounts of sand, silt, and clay.

Loess: the fine-grained sediment left behind by receding (melting) glaciers.

M

Mature Tree: a tree that has reached at least 75 percent of its final height and spread.

Meal: the coarsely ground and sifted grains of a cereal grass or the solid residue left after extracting oil from oilseeds.

Mesopotamia: "land between two rivers," refers to the basins of the Tigris and Euphrates rivers and the geographical area watered by these two rivers.

Milo: grain sorghum.

Mineralization: the process through which a substance is converted from an organic substance to an inorganic substance.

Minimum Desirable Streamflow: the amount of water deemed necessary to establish and maintain the desired minimum streamflow for an identified water course with the purpose of protecting flow from depleted conditions as a result of extensive water appropriation; not intended to keep the stream flowing through all climatic conditions.

Mitigation: restoration or construction in a different location.

Mollisol: a highly fertile soil—enriched with large amounts of organic matter—that can hold large amounts of water and is characterized by its distinctive dark color.

Mulch: a thick cover of decaying plant matter that insulates the soil and aids in the soil's ability to capture and utilize water.

N

Natural Erosion: the wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc.

Natural Processes: physical processes that occur without human interaction.

Natural Resource: a raw material provided by the earth and usually processed into useful products.

Nonconsumptive Use: a source of water that can be treated and used again as surface water.

Nonoil Sunflowers: black-colored seeds with white stripes, approximately 5/8 inch long; used for baking, eating, birdseed, and pet food. (*Confection Sunflowers*)

Nonpoint Source Pollution: pollution from sources that are not easily identified or located.

Nonrenewable Resource: a resource, such as a fossil fuel, that is in limited supply and does not have the capacity to be replaced through natural processes, at least not for many thousands of years.

No-till: a production practice whereby a crop is planted directly into the soil with no mechanical manipulation of the soil, resulting in reduced soil erosion and the preservation of soil nutrients.

Nut Farm: a farm producing nut crops, such as pecan, almonds, or pistachios, from trees planted for that purpose.

Nutrients: substances, such as nitrogen and phosphorus, necessary for growth and development.

O

Oilseeds: soybeans, sunflowers, canola, cotton, and flax.

Oilseed Sunflowers: small shiny black sunflower seeds used to produce oil for baking, frying, and food products.

Orchard: an area of land devoted to the cultivation of fruit or nut trees.

Organic: referring to or derived from living organisms.

Organic Matter: plant and animal material in various stages of decomposition that provides nutrients to soil.

Omnivore: eats both plant and animal materials.

P

Pasture: a unit of grassland which has a fenced perimeter.

Pattern: the configuration of the meanders or bends of a stream or river.

Peat: the earliest stage of coal that forms when plant material is inhibited from decaying fully by the acidic environment in the soil; historically used as an energy source.

Percolation: the process that occurs when gravity pulls excess water down through the soil and rock layers.

Perennial: a plant that lives for several years and usually produces seeds each year.

Perennial Stream: a stream that flows throughout the year but may be dry during periods of extended drought.

Permeability: the ability of fluids to move through porous rock or sediment, directly related to a combination of the size of the pores and the degree to which the pores are interconnected.

Pesticide: a product used to keep plants (or animals) healthy and protect them from weeds and insects.

pH: a measure of acidity or alkalinity based on the way the electrical charges on the surface of soil particles interact with chemical combinations in the soil mixture.

Phosphorous: symbol P; an element that occurs widely in minerals, soils, untreated waters, bones, teeth, and in all living cells, and is a nutrient required for growth and development.

Photosynthesis: the process in green plants and trees in which the cells containing chlorophyll convert sunlight into chemical energy.

Physical Feature: a natural characteristic of a place such as elevation, landforms, or vegetation.

Physical Process: a series of actions, changes, or functions that affect the natural characteristics of a place.

Playa Lake: see *Flooded Basin*

Point Source Pollution: pollution from a human activity that can be identified and controlled that comes from a specific, identifiable source, such as a pipe, channel, ditch, tunnel, or container.

Pollinate: to transfer pollen from an anther to the stigma of a flower.

Pollutant: a chemical or physical substance released in the environment which results in detrimental effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair the environment.

Pond: a body of water less than ten acres in size which is shallow enough to allow rooted plants to grow in the water.

Pool: an area of a stream channel with reduced velocity, little surface turbulence, and deeper water than surrounding areas.

Porosity: the capacity of a rock formation to absorb and store groundwater; determined by the number and size of pores.

Potable: water fit for human consumption.

Prairie: a type of land dominated by grasses with scattered trees and shrubs.

Precipitation: any form of water that falls to the earth's surface such as rain, snow, sleet, or hail.

Precision Agriculture: see *Precision Farming*

Precision Farming: an integrated agricultural management system incorporating several technologies including global positioning systems, geographical information systems, yield monitors, variable rate technology, and remote sensing. (*Precision Agriculture*)

Prescribed Burn: a management technique using a fire that is deliberately set and controlled in a specific area.

Glossary

Primary Contact Recreation Uses: recreational water uses from April 1 through October 31, of each year, during which some inadvertent ingestion of water is probable including activities such as boating, mussel harvesting, swimming, skin diving, waterskiing, and windsurfing.

Producers: plants that make food through photosynthesis such as trees and other green plants.

Profile: a stream's slope or drop in elevation.

Pruning: the selective removal of woody plant parts of any size by using saws, pruners, clippers, or other pruning tools.

Public Land: land that is owned by U.S. citizens and is administered and managed by the local, state, or federal government.

Public Supply: water used for drinking and other purposes supplied to many people by a system operated by a city, public wholesale water supply district, or rural water district.

R

Rain Shadow Effect: the impact of a barrier, such as a mountain range, that causes the clouds to lose their moisture before reaching an area, resulting in that area receiving less rainfall.

Rangeland: land on which the native vegetation is predominately grasses, grass-like plants, forbs, or shrubs; most suitable for grazing.

Recharge: the replenishment of water in an aquifer or other water body.

Regeneration: the renewal of a tree crop through either natural means (seeded on the site from adjacent stands or deposited by wind, birds, or animals) or artificial means (by planting seedlings or direct seeding).

Renewable Resource: a resource that has the capacity to be replaced through natural processes.

Reservoir: a natural or artificial place to store water; sometimes created by a dam.

Residue: plant material, such as stalks, leaves, or straw, left on a field after the crop has been harvested to increase the organic matter in the soil and minimize erosion.

Rhizome: an underground stem that is horizontal and produces roots at the joints.

Riffle: a relatively shallow area in a stream's channel where water flows swiftly over a completely or partially submerged obstruction to produce surface turbulence.

Riparian and Wetland Protection Program: a State Conservation Commission program to address conservation and management of riparian areas and wetlands by providing financial assistance to landowners to implement practices such as streambank stabilization, wetland enhancement, and other innovative practices.

Riparian Area: an area of streamside vegetation on the land adjacent to the banks of streams, rivers, or other water bodies.

Riparian Buffers: strips or small areas of land in permanent vegetation along or near a body of water that trap sediment, filter nutrients, and provide habitat for wildlife.

Riparian Forest: an area of trees and shrubs located adjacent to streams, lakes, ponds, and wetlands.

Riparian Forest Buffer Strips: riparian areas that are planted to shrubs or trees and related plants to slow the flow of runoff and are designed to trap sediment and filter nutrients before they reach the water body.

Riparian Meadow: a riparian area found along small streams in upper portions of watersheds; composed of water tolerant grasses.

Riparian Shrublands: riparian areas usually associated with intermittent streams; consists of shrub-like plants instead of grasses or trees.

Riparian Woodlands: riparian areas common along perennial streams; composed of larger trees with an open canopy allowing for the growth of grasses and shrubs in the understory.

River: often used to describe a larger stream with many tributaries.

Rivers and Harbors Act of 1899: first water pollution legislation in the United States; prohibited dumping refuse or constructing structures in navigable waters without federal approval.

RNA: Ribo Nucleic Acid; a nucleic acid that is similar to DNA in composition but is derived from the DNA code and is single-stranded; delivers genetic information from the nucleus to the rest of the cell and provides the code to manufacture proteins.

Rock Vane: see *Bendway Weir*

Root: the underground portion of a plant that draws food and water from the soil and stores plant food.

Rootstock: any underground stem that will take root at the joints.

Root System: the portion of a plant containing the root organs.

Root Zone: the area and volume of soil around a plant in which roots are normally found.

Row Crop: originally used to describe crops planted in a specific way; includes soybeans, corn, grain sorghum, sunflowers, and cotton.

Ruminant: an animal which has a digestive system containing a four compartment stomach that is able to digest grasses that humans cannot, including cattle, bison, sheep, and goats.

Runoff: rain, ice, or snow that does not soak into the soil, but flows across the land and eventually runs into streams and rivers when the intensity or volume of that precipitation exceeds the absorption and storage capacity of the land's surface.

S

Sand: the largest and most abundant of the mineral particles that make up soil.

Secondary Contact Recreational Uses: recreational water uses during which the ingestion of surface waters is not probable including activities such as wading, fishing, trapping, and hunting.

Sediment: solid organic or mineral particles such as sand, clay, or silt that are deposited in a new location by wind, water, or ice.

Segment: a length of a stream that is relatively homogeneous with respect to physical, chemical, and biological properties.

Shallow Freshwater Marsh: a wetland found in a distinct depression or around the perimeter of deepwater habitat.

Sheath: the lower part of a leaf that fits around the stem.

Shelterbelt: see *Windbreak*

Silage: sweet tasting, easily digestible livestock feed resulting from chopping entire corn or sorghum plants into small pieces during harvest and storing that in an area where it is packed tightly so the plant material will ensile or ferment.

Silt: small powdery mineral particles that make up soil but cannot be seen without magnification.

Silviculture: the art and science of growing and managing forests and woodlands to achieve desired outcomes.

Small Grains: wheat, oats, barley triticale, rye, and rice.

Snag: a standing dead tree.

Sodic Soil: see *Alkali Soil*

Softwoods: conifers and needle-leaved trees.

Soil: the naturally occurring mixture of minerals, organic matter, water, and air that forms the surface of the earth.

Soil Amendment: material added to soil to alter its physical or chemical properties.

Soil Horizon: a specific layer in the soil that has physical characteristics which differ from those of the layers above and beneath this layer.

Soil Order: a system of classifying soils using 12 categories.

Spawning: to produce and deposit fish eggs.

Species: closely related organisms potentially able to breed with one another that belong to a category of biological ranking just below the genus or subgenus category.

Spike: a long inflorescence attached directly to a stem with the newest flowers at the tip.

Spikelet: a small flower spike; the basic unit of the flower cluster of a grass plant.

Splash Erosion: erosion resulting from the impact of raindrops hitting the soil.

Spring: a place where groundwater flows naturally from the earth to the surface of the land.

Stand: a community of plants sufficiently uniform in species, age, arrangement, or condition to be distinguishable as a group from other plants growing in the area.

Starch: a complex carbohydrate that is an energy source.

Static Water Level: the water level in a well when the water is not under pressure from a pump or from natural pressure.

Stewardship: the concept of responsible caretaking based on the premise that people are managers of natural resources and are responsible to future generations for their condition.

Stolon: a long stem or shoot that droops to the ground and may root and form new plants where it touches the soil.

Strata: distinct temperature zones.

Stream: a body of water confined within two banks and a bed that provides a physical path for flowing water through a channel.

Streambank: the sloping ground that borders a stream and confines the water in the natural channel when the water level is normal.

Streambank Restoration: the return of a riparian area to its original state, attaining the best possible condition that a particular riparian area is capable of achieving under present circumstances.

Stream Channelization: a process of planned human intervention in the course, characteristics, or flow of a river or stream.

Stream Corridor: the stream valley and ecosystem that includes the stream and the land, plants, and animals associated with that stream or river.

Streamflow: the movement and volume of water that forms the channel of a stream.

Stream Order: a classification of streams based on the number and type of tributary junctions.

Strip Cropping: the practice of growing two or more crops in alternating strips along contours, often perpendicular to the prevailing direction of wind or surface water flow.

Submerged Plants: underwater plants with only a few floating or visible leaves.

Subsoil: the layer of soil beneath the topsoil.

Succession: the replacement of one plant or animal species over time by another in progressive development. (*Ecological Succession*)

Summer Fallow: the practice of leaving land unplanted during at least one period when a crop would normally be grown with the goal of controlling weeds and storing water or other plant nutrients. (*Ecofallow*)

Surface Water: water that flows across the surface of the land or is stored in a river, lake, or freshwater wetland.

Glossary

Suspended Solids: solid organic or mineral particles that do not dissolve in water.

Sustainable Yield: the amount of groundwater that can be withdrawn from an aquifer without causing adverse effects to springs, streams, wetlands, and other groundwater dependent activities.

Swamp Land Acts of 1849, 1850, and 1860: federal laws that gave 65 million acres of wetlands owned by the federal government to 15 states for reclamation, which—at that time—meant drainage.

T

Tame Pasture: land intentionally planted for grazing, usually seeded to perennial grasses or legumes, such as clover or timothy.

Terrace: a raised, generally horizontal, ridge of soil embankments constructed across a slope following the contour of the land.

Terrain: the surface features of an area of land.

Terrestrial Ecosystems: ecosystems of land plants and animals found on upland surfaces of the continents.

Thermal Stratification: the formation of distinct parallel layers of different temperatures in a lake or reservoir.

Thinning: the process of removing excess and poor quality trees from a stand for the purpose of improving the growth and value of the remaining trees.

Threatened Species: species that are likely to become endangered in the near future.

Tillage: mechanical manipulation of the soil due to management of crop residues, weeds, incorporation of chemicals for crop production, or any combination of these actions.

Tillage Operation: the act of applying one or more tillage actions in a distinct mechanical application of force to all or part of the soil mass.

Timber Culture Act of 1873: the federal law that provided free land to settlers if 40 acres of the homestead claim was planted to trees and kept in growing condition for 10 years (later reduced to 10 acres).

Timberlands: forested areas capable of producing wood for commercial industrial uses.

Tonnage: the number of tons of plant material produced and removed per acre.

Topography: the features on the surface of the land such as hills, valleys, rivers, etc.

Topsoil: the layer of soil at the earth's surface; moved in cultivation.

Total Dissolved Solids (TDS): the total quantity of minerals (salts) in water, usually measured by weight in milligrams per liter (mg/L) or parts per million (ppm).

Total Maximum Daily Load (TMDL): the maximum amount of pollution that a water body can receive without violating the standards and the plan to achieve that goal.

Township: a measure of land established by Congress when it created a uniform way of dividing land—a square area of land, six miles by six miles (an area of 36 square miles) divided into one-mile squares called sections.

Transesterification: a chemical process that separates vegetable oil into methyl esters and glycerin.

Transpiration: the process by which water is pulled from the soil into the roots of a plant, up through the cells of the plant, and eventually out into the atmosphere through tiny openings in the plant's leaves.

Tree: a woody plant that usually grows to more than 12 feet tall and has one main stem.

Tree Crown: the upper branches and leaves of a single tree.

Tree Farm: a privately owned woodland where sustainable forest management is the primary objective.

Tree Plantation: a site planted to trees, often a single species, that are maintained at about the same age and size and are harvested all at once and then replanted.

Tributary: a stream that flows into a larger stream or other body of water.

U

Unconfined Aquifer: an aquifer that does not have rock layers over the top of it that trap or confine the water under pressure; covered by sand, gravel, or sediment.

Understory: the layers of vegetation (smaller trees, shrubs, and plants such as weeds, wildflowers, ferns, and grasses) growing under the canopy trees in a forest.

Urban/Community Forest: a forest category that includes all trees, shrubs, and associated vegetation in and around population areas, ranging from small towns to large metropolitan areas including trees growing on street right of ways, in parks and cemeteries, in recreational areas, and on other public properties.

Urban Sprawl: see *Fragmentation*

V

Variety: a plant with specific genetic characteristics that make it different from other plants of the same species.

Vegetation: the mass of plants that covers a given area.

W

Wastewater: water that has been used, as for washing, flushing, or in a manufacturing process, and therefore contains waste products.

Water: a colorless, odorless, transparent liquid consisting of two parts hydrogen and one part oxygen, H₂O or hydrogen hydroxide.

Water Balance: see *Water Budget*

Water Budget: the average balance between the water that enters an area and the water that is withdrawn or discharges naturally. (*Water Balance*)

Water Compact: a legal agreement between states on how to equitably divide and distribute the water supply of a river or river basin.

Water Cycle: see *Hydrologic Cycle*

Water Quality: the physical, chemical, and biological characteristics of water and how those characteristics relate to a particular use of that water.

Water Right: a permit to use a set amount of water from a specific source for a specific purpose.

Watershed: a sloping area of land that collects, directs, controls, and discharges the flow of rainwater into a river, river system, or body of water.

Water Table: the top elevation of water stored in an aquifer.

Weather: the state of the atmosphere for a given site at a given time.

Well: a vertical excavation into an underground rock formation.

Wetland: a geographic area that is frequently inundated with water and is characterized by hydrophytes, hydric soils, and some saturation or flooding during the growing season.

Wetlands Reserve Program: a voluntary program administered by the U.S. Department of Agriculture that provides technical and financial assistance to landowners to address wetlands, wildlife habitat, soil, water, and related natural resource concerns.

Wet Meadow: a type of wetland located in lowland prairies that does not drain well, characterized by standing water for short periods during the growing season.

Wilderness Area: an area established by the federal government to be managed and preserved in an essentially untouched condition.

Windbreak: a line of trees or shrubs planted at regular intervals, perpendicular to the prevailing winds, designed to reduce wind velocities and thus reduce wind erosion. (*Shelterbelt*)

Winter Wheat: wheat planted in the fall and harvested the following spring or early summer.

Woody Plant: a perennial plant with above ground stems that resemble wood in appearance, texture, or toughness including trees, shrubs, vines, cacti, and yucca.

Y

Yield: the amount of a specified substance produced per unit area.

Yield Monitor: a yield measuring device installed on harvesting equipment.

Appendix B) Measurement & Conversion Factors

UNITS OF MEASURE	
<i>As Used in this Guide</i>	<i>Metric Equivalent</i>
acre	hectare (ha)
cubic foot	cubic meter (m ³)
gallon/Mgallon	liter (L), cubic meter (m ³)
hundredweight	kilogram (kg)
linear foot	meter (m)
mile	kilometer (km)
pound	kilogram (kg) for mass
square foot	square meter (m ²)
ton	tonne (t)

BUSHEL WEIGHTS	
1 bushel (bu) equals	8 gallons (gal)
1 bushel of:	weighs
wheat	60 pounds (lbs)
corn	56 pounds
grain sorghum	56 pounds
sunflowers	27 pounds
cottonseed	32 pounds
canola	50 pounds
edible beans	60 pounds
rye	56 pounds
barley	48 pounds
millet	50 pounds

MASS (WEIGHT) CONVERSION FACTORS		
<i>To convert from</i>	<i>to</i>	<i>multiply by</i>
pound (lb)	kilogram (kg)	0.4535924
ton (2000 lb)	kilogram (kg)	907.1848

MEASUREMENT VALUES	
1 acre	2.47 hectares (ha)
Surveyor's Measures	
1 acre	43,560 square feet
640 acres	1 square mile
1 section	640 acres
7.92 inches	1 link
25 links	1 rod
4 rods	1 chain
10 square chains (160 square rods)	1 acre
80 chains	1 mile
1 Gunther's chain	66 feet
Water	
1 gallon (gal)	8.34 pounds (lbs)
1 million gallons (Mgal)	3.07 acre feet (acre-ft)
1 cubic foot (ft ³)	62.4 pounds (lbs)
1 cubic foot (ft ³)	7.48 gallons (gal)
1 acre-foot (acre-ft)	325,851 gallons (gal)
1 acre-foot (acre-ft)	43,560 cubic feet (ft ³)
1 inch of rain	17.4 million gallons per square mile (Mgal/mi ²)
1 inch of rain	27,200 gallons per acre (gal/ac)
1 inch of rain	100 tons per acre
One acre-foot equals the volume of water needed to cover an area the size of one acre with water one foot deep.	

LENGTH CONVERSION FACTORS

<i>To convert from</i>	<i>to</i>	<i>multiply by</i>
mile (mi)	kilometer (km)	1.60934
inch (in)	millimeter (mm)	25.4
inch (in)	centimeter (cm)	2.54
inch (in)	meter (m)	0.0254
foot (ft)	meter (m)	0.3048
yd (yd)	meter (m)	0.9144

VOLUME CONVERSION FACTORS

<i>To convert from</i>	<i>to</i>	<i>multiply by</i>
cubic inch (in ³)	cubic meter (m ³)	0.00001639
cubic foot (ft ³)	cubic meter (m ³)	0.02831685
cubic foot (ft ³)	liter (L)	28.31684
cubic yard (yd ³)	cubic meter (m ³)	0.7645549
U.S. liquid		
gallon (gal)	cubic meter (m ³)	0.00378541
gallon (gal)	liter	3.785
fluid ounce (fl oz)	milliliters (ml)	29.57353
fluid ounce (fl oz)	cubic meter (m ³)	0.00002957
Rate of Flow		
cubic feet per minute (cfm)	liter per second (L/s)	0.4719
gallon per day (gal/d)	liter per day (L/d)	3.785
million gallons per day (Mgal/d)	thousand gallons per minute	0.6944
million gallons per day (Mgal/d)	thousand acre-feet per year	1.121

AREA CONVERSION FACTORS

<i>To convert from</i>	<i>to</i>	<i>multiply by</i>
square foot (ft ²)	square meter (m ²)	0.09290304
square inch (in ²)	square meter (m ²)	0.00064516
square inch (in ²)	square millimeters (mm ²)	645.16
square yard (yd ²)	square meter (m ²)	0.83612736
square mile (mi ²)	square kilometer (km ²)	2.590
acre (ac)	hectare (ha)	0.4047
acre (ac)	square foot (ft ²)	43,560
acre (ac)	square meter (m ²)	4,046.86
acre (ac)	square mile (mi ²)	0.001562

POWER CONVERSION FACTORS

<i>To convert from</i>	<i>to</i>	<i>multiply by</i>
Velocity		
mile per hour (mph)	kilometer per hour (km/hr)	1.60934
mile per hour (mph)	meter per second (m/s)	0.44704
Permeability		
feet per day (ft/day)	centimeter per second (cm/sec)	0.000352

TEMPERATURE CONVERSION FACTORS

<i>To convert from</i>	<i>to</i>	<i>Formula</i>
degree Fahrenheit (F)	degree Celsius (C)	$5/9 \times (F^\circ - 32)$
degree Celsius (C)	degree Fahrenheit (F)	$(9/5 \times C^\circ) + 32$

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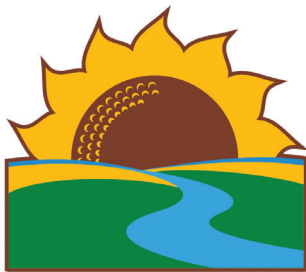
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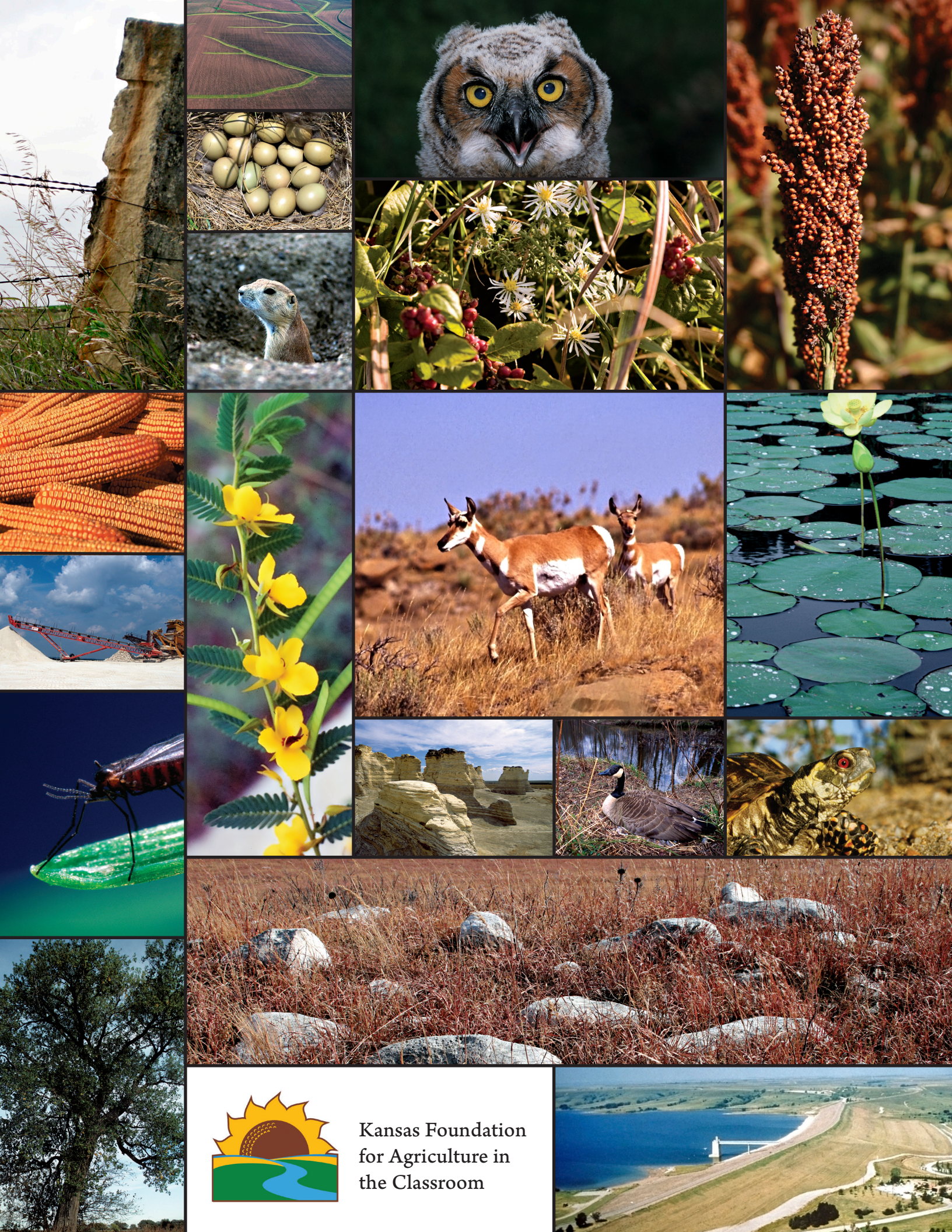
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