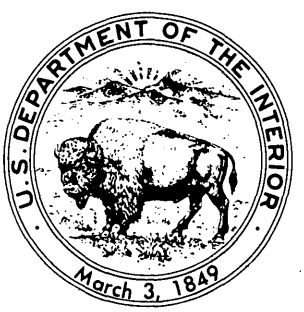
Land Use/Land Cover and Environmental Photointerpretation Keys

U.S. GEOLOGICAL SURVEY BULLETIN 1600



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By George L. Loelkes, Jr., Gordon E. Howard, Jr., Eddie L. Schwertz, Jr., Phillip D. Lampert, and Stephan W. Miller

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PREFACE

In 1975, the U.S. Geological Survey initiated production of land use and land cover and associated maps for the United States. Documenting the land use categories shown on the maps and providing insight into the environmental effects of land use have been long-standing user requirements. This USGS publication illustrates the various land use categories in order to provide the user with a means of interpreting these categories from aerial photographs. Comments on potential environmental impacts are included.

Geographic areas to be used for this publication were reviewed in depth. Missouri was selected because land use and land cover map compilation for that area was complete. We reviewed and considered several well-known and respected thematic maps in an attempt to identify meaningful regions in the State which would be viewed as a framework for developing land use and land cover category documentation. Among these maps were Kuchler's Potential Natural Vegetation map of the United States, Lobeck's Physiographic Provinces, Fenneman's Physical Divisions, and Hammond's Classes of Land Surface Form in the Forty-Eight States. While all of these maps portray basically similar themes, each addresses only a specific characteristic relating to the surface of the land. None of the maps provides a logical framework for all the land use and land cover categories. Accordingly, it was decided to use the USGS Land Use and Land Cover maps of Missouri to select the locations of specific land use and land cover patterns illustrated in this publication.

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By George L. Loelkes, Jr.[1], Gordon E. Howard, Jr.[2], Eddie L. Schwertz, Jr.[1], Phillip D. Lampert[1], and Stephan W. Miller[1]

ABSTRACT

The preparation of land use maps requires a basic understanding of photointerpretation principles, land use taxonomy, and the proper use of mapping specifications. Each of these topics is developed in sufficient detail to ensure that the reader is exposed to these basics. Since the use of the land can present different environmental impacts, the potentials for environmental degradation are analyzed. Perhaps the most difficult tasks involved in land use mapping is recognition of the different land use types. Aerial and ground photographs, when combined with narrative descriptions, can provide a ready reference for the photointerpreter. Over 230 illustrations and narrative descriptions meet this need.

SECTION 1: INTRODUCTION

This publication has been jointly prepared by the U.S. Geological Survey and the Environmental Protection Agency (EPA) as a means of disseminating information on the U.S. Geological Survey land use and land cover mapping effort and the potential effects of land use on the environment. Primarily, the guide is intended for use by land resource and environmental planners and managers who utilize land use and land cover maps in decisionmaking.

This guide serves as a learning tool for the use of remote sensing technology and land use and land cover classification and mapping, (table 1-1), as well as an environmental guide and photointerpretation key to help users better understand the photographic recognition features of the various land use and land cover categories. It documents the existence of various Missouri land use and land cover categories as they are portrayed on the maps produced by the U.S. Geological Survey. Finally, it provides a set of environmental keys which can be correlated with various land use and land cover categories and patterns (figure 1-1).

The guide is designed to demonstrate the applicability of land use and environmental keys; to develop data acquisition techniques for compilation of the keys; and to indicate the potential effects of various land uses on the environment.

Ultimately, it may be possible to produce a series of regionally oriented guides to provide land use and land cover and environmental keys for the United States.

The State of Missouri was chosen for the first guide for several reasons. Missouri contains a variety of topographic forms, vegetative cover, agricultural practices, and urban areas of various sizes and patterns. Second, the land use and land cover and associated maps of the State of Missouri had been completed. Finally, since the authors work in Missouri, the cost of acquiring photographs and field data could be kept to a minimum.

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[1]U.S. Geological Survey, National Mapping Division, Geographic Investigations Office, Rolla, Mo.

[2]U.S. Environmental Protection Agency, Environmental Photographic Interpretation Center, Warrenton, Va.

Table 1-1.--USGS Land use and land cover classification system for use with remote sensor data

(Anderson and others, 1976, p. 8)

Level I		Level II	
1	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications, and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Built-up Land
2	Agricultural Land	21	Cropland and Pasture
		22	Orchards, Groves, Vineyards, Nurseries and Ornamental Horticultural areas
		23	Confined Feeding Operations
		24	Other Agriculture Land
3	Rangeland	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
4	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
5	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
6	Wetland	61	Forested Wetlands
		62	Nonforested Wetlands
7	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
8	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground Tundra
		84	Wet Tundra
		85	Mixed Tundra
9	Perennial Snow or Ice	91	Perennial Snowfields
		92	Glaciers

MISSOURI

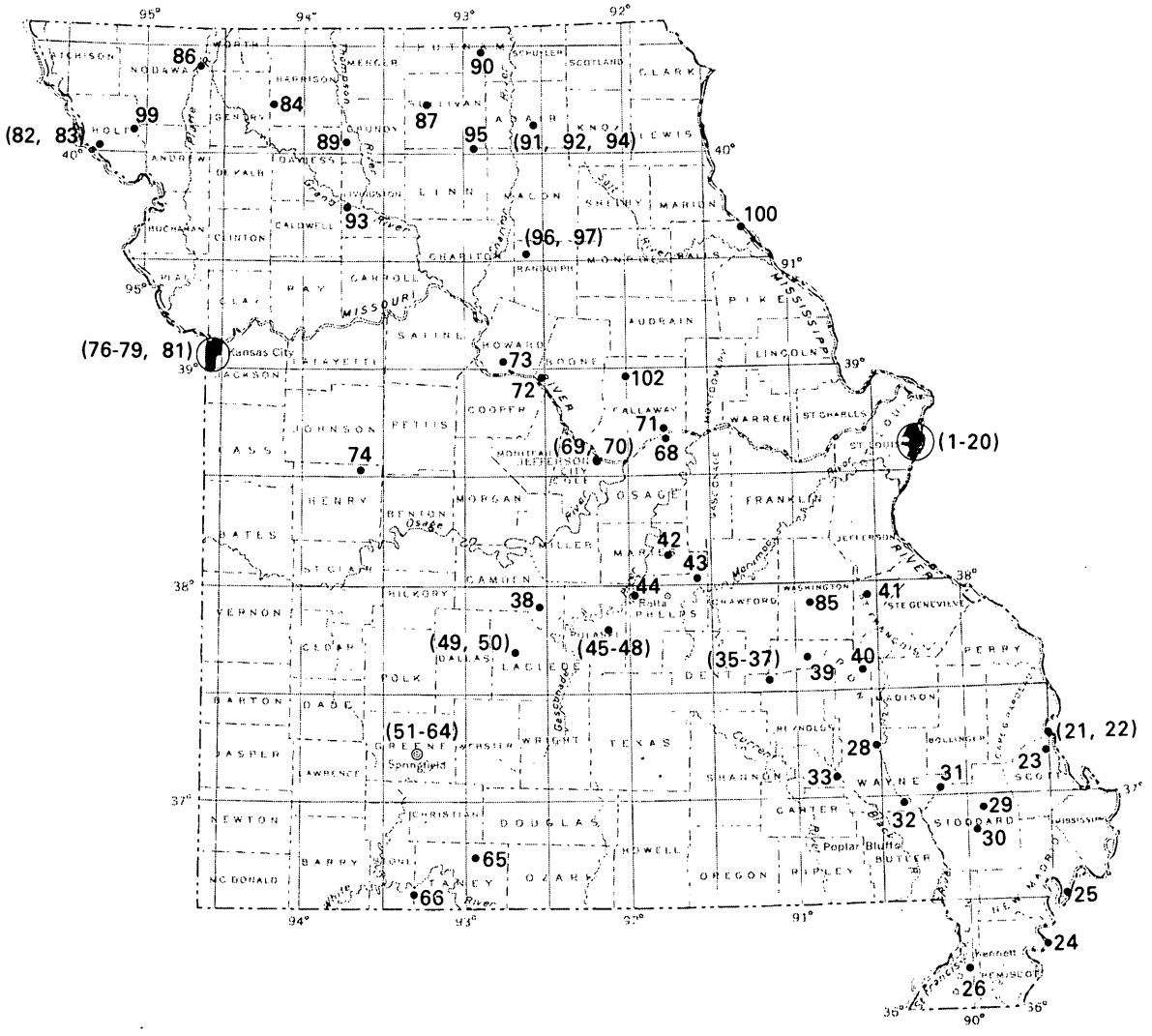


Figure 1-1.--Photointerpretation keys--site locations.

SECTION 2: REMOTE SENSING FOR LAND USE INTERPRETATION

What is Remote Sensing?

Remote sensing can be defined as the acquisition of information by a detection device that is not in physical contact with the object or phenomenon under study. Remote sensors for land analysis are of two major types: photographic and nonphotographic.

Photographic sensors produce an image directly on a film emulsion from reflected electromagnetic radiation of wave lengths in the visible and near-infrared portions of the electromagnetic spectrum. The common camera is the best-known photographic sensor.

In comparison, nonphotographic sensor images are captured by a suitable detector and stored as electronic impulses by a recording device. Nonphotographic sensors operate in the ultraviolet, visible, infrared, and microwave portions of the electromagnetic spectrum.

Nonphotographic sensors can be further classified as passive or active. Nonphotographic, passive remote sensing systems detect energy emitted or reflected as radiation from a given scene. The system produces, transmits, and records no energy of its own. Two of the most frequently used nonphotographic, passive remote sensing systems are multispectral scanners, such as those on board the Landsat satellites, and the thermal infrared scanners used to detect temperature contrasts in water bodies, forest fires, and home insulation efficiency analyses (thermograms).

Nonphotographic, active remote sensing systems transmit their own electromagnetic signals at objects and then record the energy reflected or refracted back to the sensor. Radar remote sensing devices are the most commonly used nonphotographic active remote sensors. Radar sensors are particularly well suited for imaging landscapes obscured by clouds.

The illustrations used in section 6 were obtained with conventional photographic cameras. The reader should refer to available textbooks on remote sensing or photogrammetry for more specific information or details on photographic or nonphotographic sensors (see "Selected References").

Resolution

Resolution refers to the minimum separation between two objects at which the objects appear distinct and separate on an image. The greater the ability of the remote sensor system to distinguish separate objects, the greater the image resolution. Image quality is a function of the remote sensor system's component resolving powers. The combined effect of the system components, such as camera focal length, shutter speed, film type, and sensor altitude (together with other factors such as Earth curvature or atmospheric haze), contributes to the overall resolution of the image.

Although the term "resolution" is used to describe the capabilities of photographic sensors to produce sharply defined images, it is also used to refer to the capabilities of nonphotographic sensor systems to produce sharply defined images. However, unlike photographic sensor systems in which resolution is expressed as line pairs per millimeter, nonphotographic sensor resolutions are expressed in a variety of ways (see Reeves, 1975).

The theoretical maximum resolution of a sensor system is rarely achieved in actual operation. Although resolution is admittedly an important aspect in mission planning, one should remember that resolution is the minimum separation between two objects for which the images appear distinct and separate; it is not the size of the smallest object that can be seen on an image. With the knowledge of the smallest objects that will have to be identified and their spacing characteristics, one can plan a mission (Sabins, 1978, p. 22-25).

Although most planners and natural resource agency personnel believe that scale is the most important factor in producing thematic map products, it should be noted that remote sensor system resolution is usually more critical than the original photographic or nonphotographic scale. The scale of an image can be enlarged or reduced; however, nothing can be done to increase the degree of detail captured as a function of the remote sensor system resolution once the mission has been completed.

Scale

Scale refers to the mathematical relationship between a distance on an image and the corresponding distance on the Earth. The larger the scale, the closer the image size is to the actual size of the object. For example, a scale ratio of 1 inch on the photograph equals 1 inch on the Earth means that an exact one-to-one relationship exists. This relationship can be expressed as a ratio

with a colon (1:1) or as a representative fraction, with the numerator referring to the measurement on the photograph and the denominator referring to the measurement on the Earth's surface. When referring to scale, it is important to remember that the relationship expressed is a ratio. Therefore, it does not matter whether one uses inches, miles, or any other unit of measurement; only that the same units be used for both the image and its corresponding distance on the Earth's surface.

Camera scale is also the ratio of the focal length of the camera to elevation of the camera above the terrain being photographed. Mathematically, the scale is calculated as follows:

$$\text{Scale} = \frac{H-h}{f}$$

H = aircraft altitude above mean sea level

h = mean ground elevation

f = focal length

For example, suppose an aircraft is flying at an altitude of 22,000 feet above mean sea level (msl), with a 6-inch (0.5 foot) focal length camera, over an area with a mean ground elevation of 2,000 feet. Inserting these values into the above equation yields the following results. Accordingly, the scale of this photograph is 1/40,000.

$$\text{Scale} = \frac{(22{,}000 \text{ ft.} - 2{,}000 \text{ ft.})}{0.5 \text{ ft.}} = \frac{20{,}000}{0.5} = 40{,}000$$

It should be noted that different focal lengths or different altitudes of the aircraft will result in different photographic scales. For example, if the camera focal length in the preceding example were increased to 12 inches, the scale would become 1:20,000. Suppose it was necessary to obtain the larger scale photographs but a 12-inch focal length camera was not available. The larger scale photographs could be obtained using a 6-inch focal length camera by reducing the flying altitude to 12,000 feet msl. However, every time the scale is increased by a factor of two, four times as many photographs are required to cover the same area.

Remote Sensing Platforms

The term "remote sensing platform" refers to objects, structures, or vehicles upon which remote sensing devices are mounted. Remote sensing platforms can range from truck booms, to aircraft, to Earth-orbiting satellites. The decision to use a particular platform is primarily a function of the altitude, stability, and temporal requirements for a specific remote sensing project.

Although there are three main categories of remote sensing platforms--ground-based, aircraft, and spacecraft--only aircraft and spacecraft will be addressed in this section.

Even though it is quite common to have both photographic and nonphotographic sensors (such as multispectral scanners, thermal scanners, and radar) mounted on aircraft, photographic sensors are carried on board spacecraft to a far less extent than on aircraft. Some notable exceptions include cameras which were carried into space on board Apollo flights, Skylab, and the Space Shuttle.

The list of specific types of aircraft and spacecraft platforms is very long. The reader should refer to the Manual of Remote Sensing (Reeves, 1975, pp. 539-588) for descriptions of these platforms.

Photographic images are classified according to platform type as either aerial photographs or satellite photographs. Aerial photographs can be further categorized as low-, medium-, or high-altitude photographs. Although the specific values for each of the three ranges differ from user to user, a practical method of altitude classification takes into consideration aircraft operational characteristics and the suitability of the final photographs for topographic and/or planimetric mapping.

Most fixed-wing propeller-driven aircraft operate below 24,000 feet msl. Aerial photographs acquired below 24,000 feet msl will generally have a medium to large photographic scale. Photographs obtained below this altitude can be classified as low-altitude aerial photographs. Photographs acquired above 24,000 ft. msl will have a medium to small photographic scale and are most often classified as high-altitude photographs.

Photographs of the Earth have been taken on the Gemini, Apollo, and Skylab missions. For example, Skylab was placed in orbit about 270 miles (435 km) above the Earth. On board Skylab was a six-lens multispectral camera system with a 6-inch focal length and an Earth terrain camera system with an 18-inch focal length. Both of the camera systems were used extensively to test different film/filter combinations from space.

Nonphotographic remote sensors have been mounted on a variety of aircraft and spacecraft platforms. Since this guide is

aimed toward the use of conventional aerial photography and its interpretation, the topic of nonphotographic remote sensors will not be covered in depth. In addition to the photographic sensors onboard Skylab, five nonphotographic sensors were operated: an infrared spectrometer, a multispectral scanner, a microwave-scatterometer, an altimeter, and an L-band radiometer.

Landsats 1, 2, and 3 have been equipped with a return beam vidicon (RBV) television camera and multispectral scanning (MSS) system.

Figures 2-1, 2-2, 2-3, and 2-4 illustrate scale and ground resolution differences from four different remote sensor platforms.[2] Figure 2-1 is an MSS band 5 image from Landsat 1 taken from approximately 570 miles (918 km)--ground resolution approximately 200-250 m, approximate scale 1:1,000,000 (Sabins, 1978, p. 69). Figure 2-2 is a black-and-white reproduction of a color-infrared (CIR) satellite photograph obtained from Skylab 2 at approximately 270 miles (435 km) with an 18-inch focal length camera--ground resolution 30-40 m, approximate scale 1:950,000. Figure 2-3 is a black-and-white reproduction of a high-altitude CIR photograph taken from approximately 65,000 feet msl with a 6-inch focal length camera--ground resolution 4-5 m, approximate scale 1:130,000. Finally, figure 2-4 is a black-and-white USGS aerial photograph taken from an altitude of approximately 15,000 feet msl with a 6-inch focal length camera--ground resolution 1-2 m, approximate scale 1:30,000.

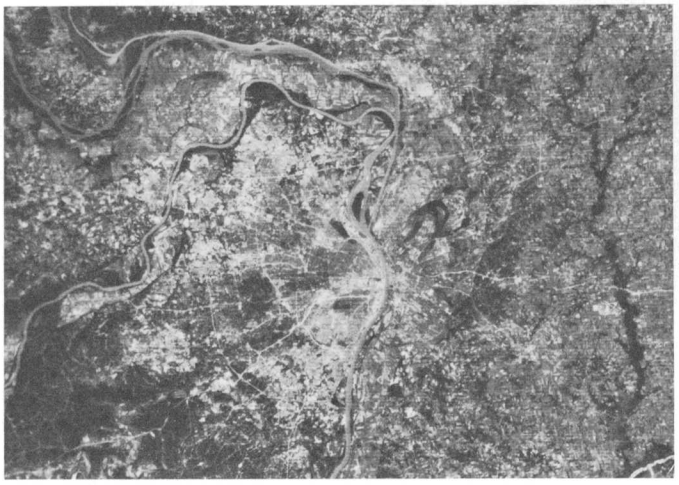


Figure 2-1.--Portion of a Landsat 1 MSS Band 5 image of St. Louis, Mo., (near center of image) October 20, 1972, (approximate scale: 1:1,000,000).

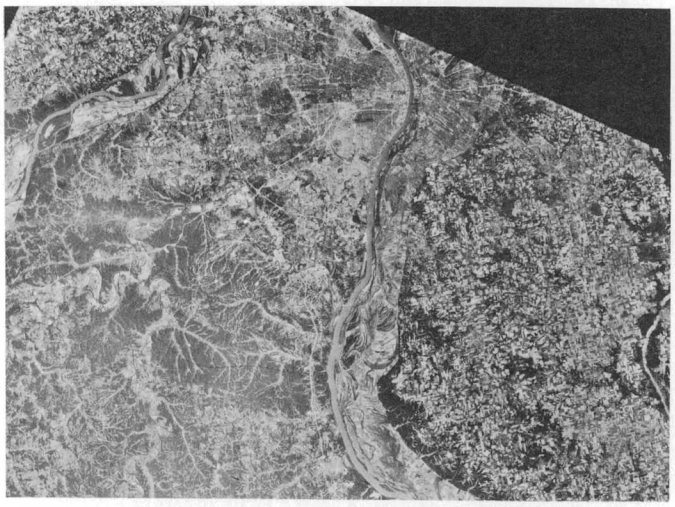


Figure 2-2.--Black-and-white reproduction of a portion of a Skylab 2 color-infrared satellite photograph of St. Louis, Mo., (top-center of photograph) September 6, 1973 (approximate scale: 1:950,000).

Figure 2-3.--Black-and-white reproduction of a portion of a NASA high-altitude, color-infrared photograph of St. Louis, Mo., October 9, 1974, (approximate scale: 1:130,000).

Note that as the remote sensor altitude decreases, the photographic resolution increases, and the ground resolution (the smallest recognizable object size) increases.

At present, detailed land use mapping relies most heavily on high-resolution aerial photographs. Satellite photographs and spacecraft multispectral scanner images, for

[2]Ground resolution refers to the smallest object size or distance on the ground which can be identified. As a "rule-of-thumb," ground resolution is four times the overall system resolution (detection resolution).

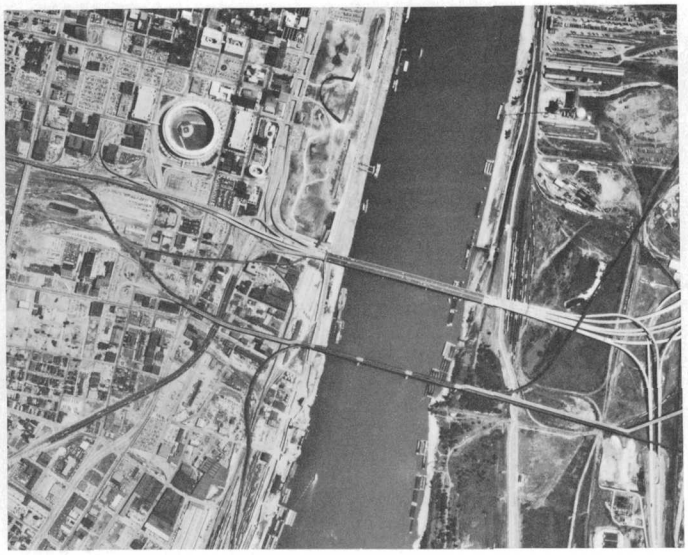


Figure 2-4.--Portion of a black-and-white vertical mapping photograph of downtown St. Louis, Mo., July 30, 1974, (approximate scale: 1:30,000).

example, Landsat images, are used for more generalized land cover mapping (see table 1-1, Level I categories).

As explained in the following section, the primary photographic data source for the USGS national Land Use and Land Cover Level II mapping program is either NASA "U-2" high-altitude color-infrared (1:120,000- to 1:130,000-scale) photographs or 1:80,000-scale black-and-white USGS quad-centered photographs.

Aerial Film Types

Photographic film consists of a cellulose acetate or polyester base coated on one side with a light-sensitive layer (the emulsion) and on the other side, with an antihalation backing--a light-absorbing coating which prevents backscatter of the photographic image beyond its proper boundaries. Silver halide crystals suspended in a gelatin are the main active ingredients in the film emulsion.

During the time that the camera shutter is open, light strikes the emulsion and the image of the scene is recorded on the film as a reversed, or negative, image. The amount of light reaching the film base determines the film density (opaqueness) for any specific area of the film. The greater the amount of light reflected from an object, the more dense the film's area for that object. When positive images are printed from the negative film, the dense areas of the negative hold back light and produce light tones on the print, whereas the less dense areas allow more light to be transmitted to produce darker tones on the print.

The resolving power of the film affects the final resolution of the photograph. Among the factors that affect the film resolution is the size of the silver halide crystals or grains, which determines the exposure time required for correct density and contrast. Earlier, it was noted that the amount of light reaching the film base determines the film density for any specific area of the film. As the size of the silver halide crystals in the emulsion increases, the amount of light required to produce the correct density and contrast decreases. A fast film having rather large silver halide crystals in its emulsion layer requires a short exposure time. However, the large silver halide crystals reduce the film's ability to produce sharp images (film definition) and therefore reduce resolution.

The motion, particularly forward speed, of the remote sensor platform also has a bearing on choice of film speed. To compensate for the degrading effects of image motion, one must use a fast shutter speed and therefore a fast film to reduce blurring. However, as noted above, fast films have lower resolutions.

In general, black-and-white films have higher resolution than color or color-infrared films of comparable camera speed.

The most common type of film used for aerial mapping and photointerpretation is panchromatic film (see figure 2-5). Since panchromatic film is sensitive to the same wavelengths as the human eye (about 0.36 to 0.72 micrometers), the relative tonal values of objects on panchromatic photographs are similar to those seen by the human eye--a characteristic which facilitates the photo-identification process. Although panchromatic film is excellent for distinguishing between objects of different colors, it lacks sensitivity in the green portion of the electromagnetic spectrum, thus making distinctions between vegetative cover types difficult. Panchromatic film is the least expensive of the aerial films to process and develop.

Color aerial films are basically of two types--reversal and negative films. Reversal films, after the first stage of developing, are positive transparencies. Negative films, however, yield a negative transparency. A black-and-white reproduction of a color photograph (see figure 2-6) can be used for comparison with a panchromatic print (see figure 2-5).

Today's color aerial films have improved speeds, definition, and less granularity. When used with appropriate filters to reduce haze effects, color aerial films increase the photointerpreter's ability to distinguish and identify forest types, degree of sediment load

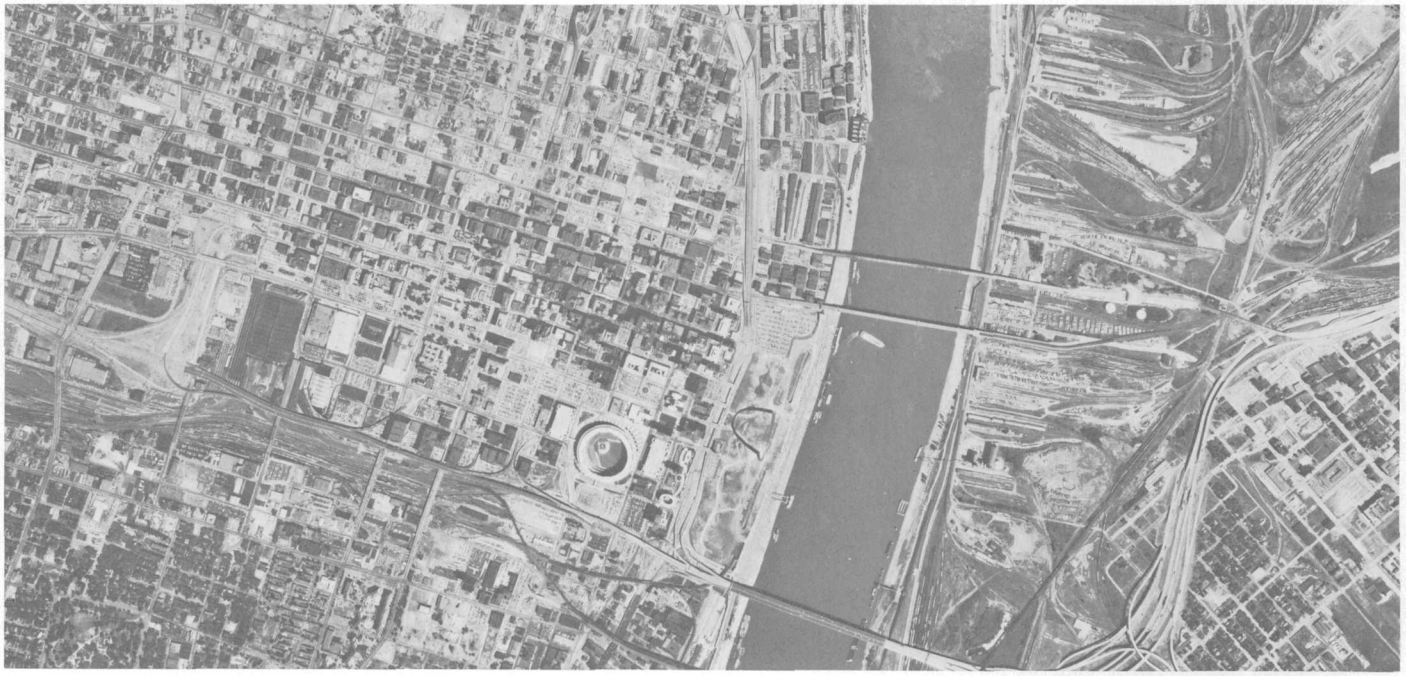


Figure 2-5.--Black-and-white mapping photograph of downtown St. Louis. Notice the dark gray tones of the buildings and the light gray tones of nearby parking areas.

Figure 2-6.--Black-and-white reproduction of a color photograph of downtown St. Louis. Notice the lack of vegetation associated with the central business district (CBD).

in water bodies, and other landscape and manmade features exhibiting distinctive colors.

Aerial color-infrared (CIR) film, originally known as "camouflage detection film" and occasionally referred to as "false-color film," is sensitive to both the visible and reflected infrared portions of the electromagnetic spectrum (approximately 0.4 to 0.9 micrometers). Therefore, instead of being sensitive to blue, green, and red reflected light, its emulsion is sensitive to green, red, and infrared light when exposed through the required yellow (minus-blue) filter.

Aerial color-infrared film has excellent haze-penetrating capability because the yellow filter eliminates the scattered blue wave lengths comprising most of the haze. In addition, since it is more sensitive to the near-IR portions of the spectrum, it is very useful in distinguishing land cover types based on different moisture contents. For this reason, it is used to discriminate camouflaged areas and diseased vegetation from healthy vegetation. Healthy vegetation appears red to magenta on CIR photographs whereas diseased vegetation appears darker red.

Color-infrared film is also helpful in identifying land/water interfaces, deciduous versus evergreen forest types, wetland areas (grayish-green to dark magenta colors), silt-

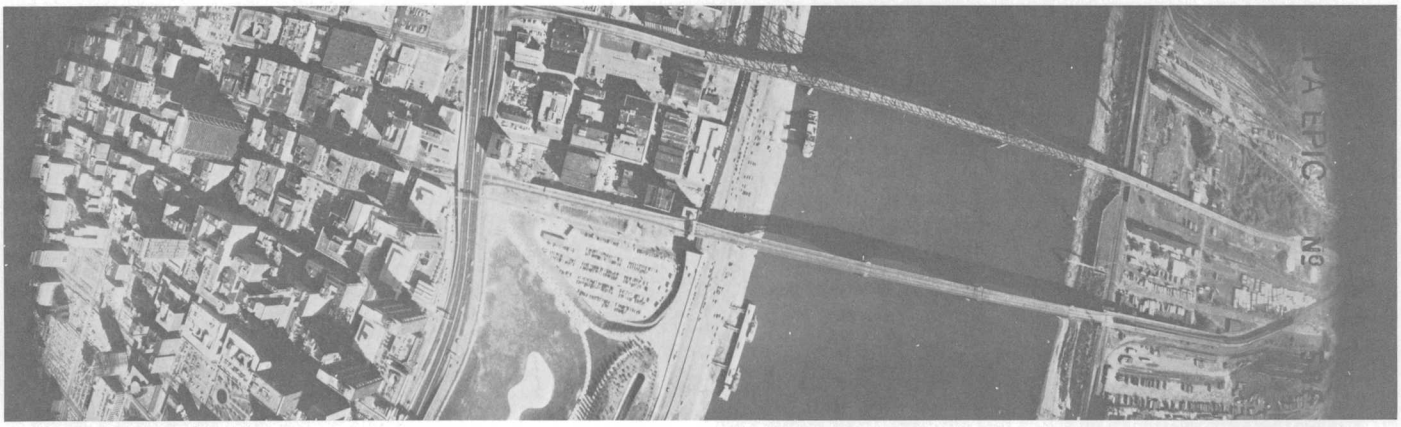


Figure 2-7.--Black-and-white reproduction of a color-infrared photograph of downtown St. Louis taken 3 months later. Note the loss of detail in shadow areas.

laden (light blue to white) versus clear water (dark blue to black) bodies, and delineating central business district (CBD) areas (bluish white) (Sabins, 1978, p. 44; Richason, 1978, p. 202-204). A black-and-white reproduction of a color-infrared photograph (see figure 2-7) may be compared for tonal differences with the panchromatic print (see figure 2-5) and the black-and-white reproduction of a color print (see figure 2-6).

Aerial Cameras

Aerial cameras can be classified by use (mapping, reconnaissance, or special), type (frame, panoramic, strip, or multiband), angular field of view (normal angle--up to 75°, wide angle--75° to 100°, super-wide angle--over 100°), and focal length (short--up to 6 inches, normal--6 to 12 inches, long--over 12 inches) (see Slama, 1980, p. 187-277). Probably, the most important distinction in cameras concerns their use--particularly mapping versus reconnaissance cameras.

Mapping cameras, often referred to as metric or cartographic cameras, are equipped with high-quality lenses to obtain the highest possible resolution and to reduce photographic distortions. Accordingly, the resulting photographs allow precise photogrammetric measurements. Aerial mapping cameras generally are of the frame type; that is, a camera in which an entire frame or format is exposed simultaneously through a lens that is a fixed distance from the film plane. Their total field of view (angular coverage) across the diagonal is from 90° to 120°; that is 45° to 60° either side of the vertical position of the camera. Aerial mapping frame cameras generally use a 9- x 9- inch (23- x 23-cm) film format size.

The black-and-white photograph shown in figure 2-4 was taken with an aerial mapping frame camera. Section 6 of this guide, "Photointerpretation Keys for Missouri," contains various photographs taken with aerial frame mapping cameras.

Reconnaissance cameras are designed to provide maximum image resolution and only moderately good positional accuracy. These cameras are primarily used for intelligence gathering, land use change detection, and environmental monitoring. Reconnaissance cameras can be of the frame type or the panoramic type (see Reeves, 1975, p. 282-283). The large-scale photographs in the photointerpretation keys (Section 6) were acquired with cameras housed in an Enviro-pod. The Enviro-pod contains two KA-85A panoramic reconnaissance cameras. The cameras have a 3-inch focal length, 40° x 130° angular coverage (that is, 40° front-to-back along the flight line and 130° side-to-side perpendicular to the flight line), and a 70-mm-wide film. The cameras are mounted in a two-section aluminum housing. The camera in the forward section takes vertical photographs, while the camera in the rear section takes forward oblique photographs 45° down from the flight horizon. Figure 2-8 shows the Enviro-pod camera system strapped to a Cessna 172 aircraft.

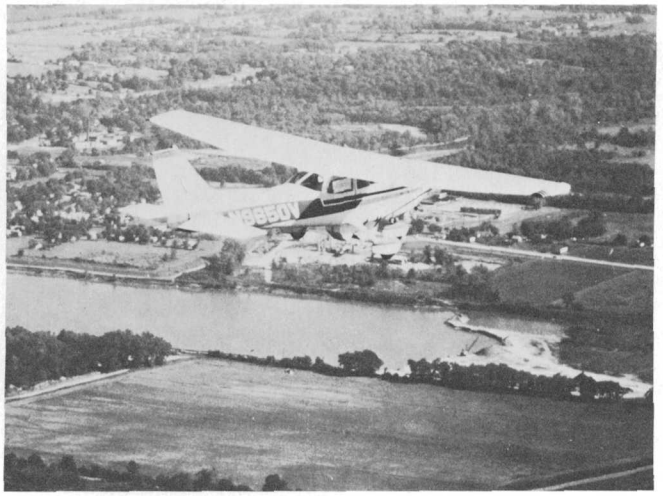


Figure 2-8.--Cessna 172 aircraft with Enviro-pod camera system.

Although the cameras exposed color reversal film, the illustrations appearing in this guide are produced in black-and-white. Normally, exposures were made from an altitude of approximately 2,500 feet above mean ground level. Since the cameras have a 3-inch focal length, the scale at the center of each vertical photograph is approximately 1:10,000. Away from the center of the photograph, particularly near the sides, the scale becomes smaller and distortions increase significantly.

Since special-purpose cameras such as multiband cameras and special-effects cameras will not be discussed in this guide, the reader may wish to refer to Reeves, 1980, pages 187-232, for further information.

Although it is desirable to have mapping and/or reconnaissance aerial photographs, one should not overlook the utility of the hand-held camera. Photographs obtained from these cameras can be used to document land use changes and to verify photointerpretations. The traditional viewing angles offered by these cameras are more easily related to the understanding of land use and land cover categories. Therefore, the photointerpretation keys will often display ground-level or low-altitude snapshots of the objects being described to further assist the user in recognizing a particular land use or land cover type.

Photointerpretation

Photointerpretation is the detection, identification, description, and assessment of the significance of objects and patterns on a photograph. With respect to land use mapping, photointerpretation requires that land areas be identified and assigned (classified) to a category in accordance with a land use classification scheme. In addition, the photointerpreter must follow specification guidelines for minimum area size and/or width measurements, density of occurrence (for example, four structures per 10 acres), and other relevant criteria to ensure consistent cartographic delineation of land use types.

The U.S. Geological Survey uses the classification scheme developed by Anderson and others (1976) and the mapping specifications (guidelines) as presented by Loelkes (1977).

Almost everyone can recognize and subsequently classify natural and manmade (cultural) features or objects from a vertical aerial photograph. Through our visual experiences, we unconsciously assemble a mental image library of recognition characteristics that describe the outward or physical appearance of an object--either natural or manmade. Typical characteristics are patterns, size, shapes, tones (gray-scale values on black-and-white photographs) or colors, textures (degree of roughness as exhibited on the photograph), shadows, and site associations.

Pattern. One of the most intriguing recognition characteristics of natural and manmade features are the patterns they make when viewed from the air. For example, an orchard planted in evenly spaced rows displays a characteristic grid pattern. The pattern of houses is significantly different for older, inner-city residential neighborhoods when compared to newer, suburban residential neighborhoods. Common terms used to describe landscape patterns include linear, circular, rectangular, square, concentric, radial, symmetrical, regular, irregular, random, and busy or congested.

Some features may be discernible as patterns at only certain scales. For example, an orchard becomes a texture at a smaller scale and a series of orchards may once again reveal a pattern at an even smaller scale.

Size. Both relative and absolute size aid in identifying features; for example, note the relative size differences between shrubs and trees and the absolute size difference between two parking lots. Because of the number of people who arrive each day, a shopping center requires more parking spaces than an industrial plant. Relative size comparisons are possible from an unscaled photograph; absolute size measurements require that the photographic scale be known or calculated.

Shape. Manmade objects tend toward straight linear shapes while natural features such as rivers or lakes tend toward irregular shapes with generally irregular boundaries. Easily recognized shapes include tennis courts, ball parks, shopping malls, highway cloverleafs, and schools. The terms used to describe shapes generally parallel the terms used to describe patterns.

Tone and Color. Photographic tone is the characteristic shade of gray exhibited by black-and-white photographs and is a function of light reflectance characteristics. Once a photointerpreter learns the different reflectance characteristics of objects, he or she can use this knowledge to help identify different land use types. For instance, cultivated fields tend to be darker than fallow fields, deciduous forests are lighter than evergreen forests, and commercial areas are lighter than residential areas. In general, higher moisture content yields darker tones.

Although the human eye can separate only 200 gray-scale values, it can separate over 5 million color combinations based on hues, values, and chromas (Reeves, 1975, p. 268). Because it is harder to learn to recognize objects by their tones (values) of gray than by color, it is easily understood why many interpreters prefer color photography. For example, Heller reported that the accuracies with which tree species could be identified were 17 percent higher on large-scale color transparencies than on panchromatic prints of the same scale (Lintz, 1976, p. 144).

Texture. Photographic texture is a function of the size of objects photographed and the scale of the photograph. Texture refers to the degree of roughness exhibited in a photograph.

On black-and-white aerial photographs, it is the arrangement of tonal repetition in objects which produces the texture characteristic. On large-scale photographs (for example, 1:4,800), individual tree crowns might be recognized, while on smaller-scale photographs (1:24,000 and smaller), the tree crowns are so small that only a texture appear. In general, coniferous forests exhibit a smoother texture than deciduous forests. Likewise, pasture provides a smoother texture than rangeland. Commonly used terms for texture are coarse, medium, smooth, fine, and mottled.

Shadow. Although most aerial photographs are obtained within 2 hours of solar noon, any shadows cast by objects can further aid in identification of an object. For example, the shadow cast by a cross helps to identify a church, or the shadows cast by communication towers, monuments, trees, bridges, or oil tanks can also provide information to help verify their identity.

Shadows may also help to determine the size and height of an object. Knowing the scale and Sun angle of a photograph, one can measure the length of a shadow and calculate an object's height. If a shadow is cast by an object of known height (for example, a TV tower), a ratio calculation can approximate the unknown height of another object.

Site Association. Natural and manmade features often occur in certain places or in proximity to other objects. For example, willow trees are natural occurrences on floodplains or river sandbars. Likewise, cultural landscapes follow certain patterns of development. Elementary schools are located away from main traffic arteries, while shopping centers and other commercial establishments are found along or at the junction of major transportation routes. Heavy industry locates near railroads or along navigable waterways. High schools frequently have recreation areas and sports fields.

Interpretation Aids

The photointerpreter should not restrict identification of objects on photographs solely to the photographs. Any additional information should be used that will aid in the identification process. Reference materials, comparative photographic coverage, magnifiers, and stereoscopic viewing can each play a beneficial role in photointerpretation and verification.

Reference Materials. Perhaps one of the most useful sources of auxiliary reference information is the mental image library which a photointerpreter acquires by residing in a specific geographic area. However, the job of the photointerpreter normally extends well beyond his own geographic area. Lacking personal knowledge, one can refer to available planning and resource studies, maps, checklists, photointerpretation keys, or recognition manuals.

Planning and resource studies are usually available from local or regional agencies. Quite often, planning agencies have compiled various thematic maps, such as land use maps, which can also be of assistance to the photointerpreter.

Topographic maps, which present the horizontal and vertical positions of natural and manmade features, are readily available from the U.S. Geological Survey through its National

Cartographic Information Centers (NCIC) and through selected dealers in most larger cities. Topographic maps are very useful in identifying elevation interrelationships; for example, the occurrence of wetland tree species in low-lying, moist areas. Topographic maps further assist the photointerpreter by displaying detailed natural and manmade features from which additional significant information can be derived.

Checklists can give natural or manmade features which may occur in a geographic area or which are known to occur in proximity to one another. For example, Avery (1977, p. 24-25) has prepared a list of the kinds of features commonly occurring on aerial photographs. In addition, checklists are generally available for most natural resource professions (for example, see Avery, 1978, p. 13).

Photointerpretation keys illustrate recognition characteristics of particular features or groups of objects.

There are two types of photointerpretation keys: selective and elimination. Selective keys, of which this guide is an example, provide typical illustrations and descriptions of features in a specific category. The photointerpreter selects the key example that most nearly agrees with the object to be identified.

Elimination keys require the photointerpreter to follow a step-by-step elimination process from the general to the specific until the possible identification has been narrowed to one choice. This type of key is also called a dichotomous key (Avery, 1977, p. 25-26).

Finally, recognition manuals have been used primarily by the military to assist photointerpreters with recognition of military equipment: airplanes, ships, tanks, etc. More recently, recognition manuals have become available for natural resource features like tree species and for certain types of manmade features. For example, the State of Texas prepared a recognition manual for use in determining substandard housing structures (Texas Office of the Governor, 1972).

Stereoscopic Viewing. Stereoscopic viewing permits the photointerpreter to view objects in three dimensions and, because of the magnification of the viewing instrument, at a slightly larger size. With binocular vision, the photointerpreter views objects from slightly different angles with each eye, which the brain interprets as relative distance. People having vision in only one eye are unable to view an object from two angles simultaneously, and therefore do not possess stereoscopic depth perception. Binocular vision can be simulated through use of aerial photographs taken of the same area from two different positions. The area common to both photographs can then be viewed in three dimensions.

The ability to view an object or feature stereoscopically adds yet another dimension to photointerpretation, particularly in identifying and differentiating vegetative types. Selected stereopairs have been included in the photointerpretation keys (section 6) where three-dimensional viewing would assist in identification.

Magnification. Quite often, even though a photograph's resolution has captured sufficient object detail, the photointerpreter is unable to recognize an object because of the photo's small scale. Magnifying equipment can enlarge the object and thereby add to the photointerpreter's ability to identify various features.

Comparative Coverage. Certain vegetative features (for example, deciduous trees) can be more easily identified if comparative photographic coverage exists. Since deciduous trees lose their leaves, comparative late fall or winter photographs faciliate the differentiation of deciduous from coniferous trees.

In addition to using seasonal photography, the photointerpreter may have access to color, color-infrared, or different-scale photographs. Therefore, the availability of comparable coverage should always be investigated.

Summary

Land use and land cover interpretation from remote sensing products requires knowledge of system components and characteristics of conventional aerial photographs--resolution, scale, platforms, and film and camera types. An understanding of how components interrelate to produce the final product is a key to successful photointerpretation.

Land use and land cover interpretation requires assignment of features to land use and land cover categories. The following section is devoted to this topic.

SECTION 3: LAND USE AND LAND COVER CLASSIFICATION SYSTEMS

Background

Development of a regional comprehensive plan for natural resources is based, at least partially, on such factors as land use, soils, slope zones, geology, and drainage areas. Land use information, a main ingredient to the planning function, is an example of data generally not contained in a form suitable for correlation. Since land uses change faster than any other factor usually included in the planning process, land use information must be made available as quickly as possible.

Federal, State, and local agencies, as well as private consultants, have been producing land use and land cover maps for many years. These maps were compiled for specific programs or projects and have used a variety of land use and land cover classification schemes. These classification schemes were, for the most part, designed to meet the requirements of a particular program or project, and have such a diversity of content as to make them difficult to combine into a single comprehensive map.

U.S. Geological Survey Land Use And Land Cover Classification System

Knowledge of the character and utilization of land resources must be available if land resource-related problems are to be understood and controlled. In order to adequately inventory land resources, however, a classification system is needed to ensure that the data on cover characteristics and discernable activities related to land resources are objectively and consistently classified. Such a classification system has been developed by the U.S. Geological Survey for the national land use and land cover mapping program.

Land use surveys have been conducted for centuries, primarily for taxation. Agencies at all levels of government currently collect land use-related data for planning and analysis of land resource utilization. Such data are necessary if problems related to environmental degradation, loss of agricultural lands, wetlands, and wildlife habitats are to be reconciled with the need for sustained economic growth and energy development. Unfortunately, the result of many past inventory efforts has been duplication of effort and, conversely, data that subsequent to its first use, are of very limited value even when used for similar purposes.

Development of the Land Use and Land Cover Classification System

The need for standardization among various agencies and recent developments in remote sensing and data processing technologies precipitated the U.S. Geological Survey's involvement in formulating a land use and land cover classification system. In 1971, an Inter-Agency Steering Committee on Land Use Information and Classification was formed including representatives from USGS in the Department of the Interior, the National Aeronautics and Space Administration (NASA), the Soil Conservation Service (SCS) of the Department of Agriculture, the Association of American Geographers, and the International Geographical Union.

The Committee sought to develop a classification system that would accommodate data from remote sensors on high-altitude aircraft as well as from conventional sources such as topographic maps or ground surveys. Although the Committee was formed to standardize classification used by Federal agencies, it was clear that a standard system could also provide a base for local, regional, State, and other agencies to use in formulating more detailed, compatible classification systems.

From the work of the Committee, as well as from consultation with States and other public agencies that had worked with classification systems employing remotely sensed data, the late James R. Anderson, USGS, developed a prototype for a national system. The system was designed with consideration of other classification systems and inventory efforts in use by the Federal government. This included the land use coding scheme promulgated by the Bureau of Public Roads in 1965, the Inventory of Major Land Uses conducted by the Economic Research Service of the Department of Agriculture, and the Conservation Needs Inventory of the SCS. The original version of the USGS classification system was published in Circular 671 in 1972.

Previously, the USGS had tested several classification systems in a series of pilot projects including the Census Cities Project, the Central Atlantic Regional Ecological Test Site (CARETS) study, the Phoenix Pilot Project, and the Land Use Mapping Project for the Ozarks Regional Commission. The latter project utilized high-altitude photographs and 1:250,000-scale topographic maps for the mapping effort. Many of the techniques involved in this project evolved into those used in the national land use and land cover mapping program now carried on by the USGS.

The categories of land use and land cover in Circular 671 were delineated to the second level of detail. Land use was defined as man's activities related to land resources, and land cover, as vegetation or artificial structures covering the landscape. The distinction is important, particularly for this classification system which, in contrast to other systems, attempted to cover all elements of the landscape in an equitable degree of detail.

Circular 671 suggested that Level I land use and land cover categories could be mapped using satellite imagery alone. Level II categories would require high-altitude aerial photographs (1:40,000 to 1:120,000) and the supplemental data which could be obtained from topographic maps. Level III categories would require medium-altitude photographs (1:20,000) combined with information from detailed topographic maps and other supplemental data sources. Level IV categories would require low-altitude large-scale photographs (larger than 1:20,000), but actually most data would be obtained from supplemental sources such as detailed large-scale maps or ground surveys.

The classification system proposed in Circular 671 was revised after several years of additional testing and research. The revised system is presented in USGS Professional Paper 964 (Anderson and others, 1976; see table 1-1 preceding). Like the prototype system, the revised classification system provides a Level II delineation of land use and land cover categories. General criteria for developing the classification system include the following considerations:

(1) The minimum level of interpretation accuracy in identifying land use and land cover categories from remote sensor data should be at least 85 percent.

(2) The accuracy of interpretation for the several categories should be about equal.

(3) Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.

(4) The classification system should be applicable over extensive areas.

(5) The categorization should permit vegetation and other types of land cover to be used as surrogates for activity.

(6) The classification system should be suitable for use with remote sensor data obtained at different times of the year.

(7) Effective use of subcategories that can be obtained from ground surveys or from using larger scale or enhanced remote sensor data should be possible.

(8) Aggregation of categories must be possible.

(9) Comparison with future land use and land cover data should be possible.

(10) Multiple uses of land should be recognized when possible.

The categories of land use and land cover presented in Professional Paper 964 (Anderson and others, 1976) are being used for the national land use and land cover mapping program. Operational definitions of the classes and specifications for the national land use mapping effort are provided in USGS Open File Report 77-555 (Loelkes, 1977).

Characteristics of the USGS Classification System

The USGS classification system is compatible at the more generalized levels with previously developed classification systems and inventory efforts. An important difference between the USGS system and others is the fact that the system is designed to support extensive surveys of land use and land cover with consistent and uniform delineation of all elements of the landscape. This is in contrast to other systems in which one or a few land use and land cover types are differentiated in great detail while others are omitted or classified as miscellaneous.

An example of such a system is the Standard Land Use Coding (SLUC) system developed by the Bureau of Public Roads in conjunction with the Urban Renewal Administration (see table 3-1). This system based its classes upon economic activity and utilized, insofar as possible, the codes and description activities employed by the standard classification system of the U.S. Department of Commerce. The resultant system was extremely detailed so that groups of classes could be formed to meet the specific needs of different communities. Data for this system were generally collected through field survey methods or local knowledge of an area.

The SLUC system has been employed successfully in urban areas for community, transportation, and other forms of urban planning. Unfortunately, this classification system does not provide enough categorical detail for land areas which do not have an established economic activity related to the land resource. Such areas are simply aggregated into the category of "undeveloped land and water areas." For the purpose of land resource management and environmental impact assessments, this obviously does not provide enough detail. Wetland areas, wildlife habitat areas

Table 3-1.--Standard land use code (SLUC)-first and second level categories

(U.S. Urban Renewal Administration, 1965, p. 30)

Code	Category	Code	Category
2	Manufacturing	26	Paper and allied products--manufacturing
		27	Printing, publishing, and allied industries
		28	Chemicals and allied products--manufacturing
		29	Petroleum refining and related industries
3	Manufacturing (continued)	31	Rubber and miscellaneous plastic products--manufacturing
		32	Stone, clay, and glass products--manufacturing
		33	Primary metal industries
		34	Fabricated metal products--manufacturing
		35	Professional, scientific, and controlling intruments; photographic and optical goods; watches and clocks--manufacturing
		39	Miscellaneous manufacturing; NEC*
4	Transportation, communication, & utilities	41	Railroad, rapid rail transit, and street railway transportation
		42	Motor vehicle transportation
		43	Aircraft transportation
		44	Marine craft transportation
		45	Highway and street right-of-way
		46	Automobile parking
		47	Communication
		48	Utilities
		49	Other transportation, communication, and utilities, NEC*
5	Trade	51	Wholesale trade
		52	Retail trade--building materials, hardware, and farm equipment
		53	Retail trade--general merchandise
		54	Retail trade--food
		55	Retail trade--automotive, marine craft, aircraft, and accessories
		56	Retail trade-apparel & accessories
		57	Retail trade--furniture, home furnishings, and equipment
		58	Retail trade--eating and drinking
		59	Other retail trade, NEC*
6	Services	61	Finance, insurance, and real estate services
		62	Personal services
		63	Business services
		64	Repair services
		65	Professional services
		66	Contract construction services
		67	Governmental services
		68	Educational services
		69	Miscellaneous services
7	Cultural, entertainment, & recreational	71	Cultural activities & nature exhibitions
		72	Public assembly
		73	Amusements
		74	Recreational activities
		75	Resorts and group camps
		76	Parks

*Not elsewhere coded.

associated with particular vegetative cover types, and other diverse types of land cover conditions are not differentiated in the SLUC system.

A second major distinguishing characteristic of the USGS system is that it is a hierarchical system. Numerical codes are used for the various categories in the USGS system and the number of digits reflects the level of detail in the classification system being used (table 1-1). The first digit identifies the Level I class, the second digit the Level II class, and so on.

With a hierarchical scheme, the derivation and definition of the categories are more easily understood. Also, the hierarchical nature of the USGS system helps promote development of more detailed classification systems. At Level III, for example, the Level II category "Cropland and Pasture" (21) can be divided into two additional categories--211 (Cropland) or 212 (Pasture).

The State of Florida developed such a system which it adopted for use by State and regional agencies (see table 3-2).

Table 3-2. State of Florida Level I, II, and III, land use codes

(Extracted From Florida Department of Administration, 1976, p. 12.)

Level I	Level II	Level III
100 Urban or Built-up	170 Recreational	171 Swimming Beaches & Shores
		172 Golf Courses
		173 Parks, Zoos
		174 Marinas
		175 Stadiums
		176 Fairgrounds
		177 Community Recreational Facilities
		178 Racing Tracks
		179 Other Recreational
	180 Mixed--Any mixture of Urban or Built-up where no single use predominates	
	190 Open Land and Other	191 Undeveloped Land Within Urban Areas
		192 Inactive Land with Street Patterns but Without Structures
		193 Land Undergoing Active Development Without Indication of Intended Use
200 Agriculture	210 Cropland and Pastureland	211 Row Crops
		212 Field Crops
		213 Improved Pasture
	220 Orchards, Groves (except citrus), Vineyards, Nurseries and Ornamental Horticultural Areas	221 Tropical Fruit Orchards
		222 Deciduous Fruit Orchards
		223 Nurseries
		224 Ornamental Horticultural
		225 Vineyards
	230 Citrus Groves	231 Orange
		232 Grapefruit
		233 Other Citrus

Table 3-3. Sample multilevel land use classification system

(Developed by Geographic Investigations Office, Mid-Continent Mapping Center, Rolla, Missouri, 1980)

Commercial & Services[1]		SIC[2]	SLUC[3]
121 Wholesale Trade			
1211	Motor Vehicles & Automotive Parts	501	511
1212	Drugs, Chemical, & Allied Products	512, 516	5121, 5129
1213	Food & Farm Products	091, 097, 514, 515, 518, 5194	841, 514, 515, 5195
1214	Dry Goods & Apparel	513	513
1215	Electrical	506	516
1216	Hardware, Plumbing, & Heating Supplies	507, 5198	517, 5122
1219	Other Wholesale Trade	502-505, 508, 509, 511, 517, 5191, 5199	518, 5191-5194, 5196, 5197
122 Retail Trade			
1221	Building Materials, Hardware, & Farm Equipment	521, 523, 525-527	521-525
1222	General Merchandise	531, 533, 539	531-535, 539
1223	Food Stores	541-546, 549	541-546, 549
1224	Automotive, Marine, & Aircraft	551-557, 559	551-553, 559
1225	Apparel & Accessories	561-566, 568, 569	561-569
1226	Furniture, Home Furnishings, & Equipment	571-573	571-573
1227	Eating & Drinking	581	581, 582
1229	Other Retail Trade	591-594, 596, 598, 599	591-599
123 Commercial Services			
1231	Business Services	075, 731-737, 739, 893	631-636, 6391-6396, 6399, 6593, 6599
1232	Construction Services	152-154, 161, 162, 171-179 601-605, 611-616, 621-623, 628, 631-633	661, 662
1233	Finance, Insurance, & Real Estate Services	635-637, 639, 641, 651, 653-655, 661	611-616, 619

[1]Only the Commercial and Services categories are presented here; however, a complete classification system was developed

[2]U.S. Executive Office of the President, 1972

[3]U.S. Urban Renewal Administration, 1965

The USGS also worked with the Water Pollution Control Department of Kansas City, Kansas, to develop a classification system for land use at Level IV (table 3-3). In addition, the system was cross-referenced to the Standard Land Use Coding Manual and the Standard Industrial Classification scheme.

It should be noted that a complete subdivision of all categories is not essential.

Table 3-4. Sample Level IV forest classification system

(Same categories would be repeated for Evergreen Forest Land and Mixed Forest Land; from Cook, 1980, exhibit 3, p. 1-2)

41	Deciduous Forest Land
411	10 - 39 Percent Canopy
4111	Sawtimber
4112	Poles
4113	Reproduction
4114	Mixed
412	40 - 69 Percent Canopy
4121	Sawtimber
4122	Poles
4123	Reproduction
4124	Mixed
413	70 - 100 Percent Canopy
4131	Sawtimber
4132	Poles
4133	Reproduction
4134	Mixed

Flexibility of the system allows modifications of the system to support a wide range of applications. For example, for forest management applications, it may be necessary to further subdivide the Level II categories of Deciduous (41), Evergreen (42), and Mixed Forest Land (43). These subcategories could be based on such factors as average stand height, crown closure density, or diameter of trees as indicated by their economic classes (see table 3-4).

For other applications, categories within the classification system can also be aggregated. In these cases, all lower level codes and categories can be grouped together to provide data for more-general codes and categories. As an example, acreage statistics for Level II categories 21, 22, 23, and 24 can be grouped together to provide statistics for Agricultural Land (Level I, code 2).

Summary

Inventories of land use and land cover require a standard classification system to ensure that data are objectively and consistently classified.

The USGS has fully defined a classification system to the second level of detail for the national land use and land cover mapping program. All elements of the landscape are provided consistent categorical detail. In addition, since the classification system is hierarchical in nature, it can be expanded to accommodate the need for greater detail.

With a viable land use and land cover classification system and suitable photographic source materials, one may proceed with the task of compiling a land use and land cover map.

SECTION 4: LAND USE AND LAND COVER MAPPING

Background

Land use and land cover mapping may be defined as "the systematic delineation of man's activities and the surface cover of the land." The maps produced by the USGS are specialized in that they use a unique set of mapping specifications and a classification system. They depict the land use and land cover classification categories and associated maps uniformly for the entire United States (see table 1-1).

The national land use data base was developed with three constraints in mind: (1) the mapped data should be compiled and published at the largest scale possible; (2) the map series utilized as a base must be complete for the entire United States; and (3) the map series used as a base must have a geographical format suitable for computer application.

The standard 1:250,000-scale topographic map series is the largest scale available that also meets the other requirements. Therefore, the 1:250,000-scale map series was selected as the standard base map for land use and land cover mapping. Certain areas, however, have been mapped at the 1:100,000-scale using the same specifications used as for the 1:250,000-scale map compilations.

For future efforts, it has been decided that revision of land use/land cover maps will be completed on the 1:100,000-scale map bases wherever possible. There have also been demonstration projects completed at a scale of 1:24,000. These large-scale land use and land cover mapping projects were limited in size and designed to test utilization of the land use and land cover classification system and specifications at larger scales.

When the land use and land cover program was initiated, the USGS determined which other types of map overlays should be correlated with the land use and land cover maps to provide the user community the greatest effectiveness in problem solving. From the multitude of maps considered, ranging in complexity from county boundaries to detailed soil types, the following map themes were selected: (1) political boundaries, (2) hydrologic units, (3) census county subdivision, (4) Federal land ownership, and (5) State land ownership.

The last two are only prepared when an entire State is compiled. Also, the State land ownership overlay is compiled only when a State furnishes the data.

The associated maps portray natural or administrative information and provide the user with the opportunity to utilize, either individually or collectively, the land use and land cover maps and data to produce graphic or statistical data for the areas portrayed on the associated maps. The mapping system is constructed in such a way that the graphical and statistical land use and land cover data can be related to other resource data sets such as soils, geologic, and hydrologic data as well as demographic and socioeconomic data.

Product Preparation

The Geological Survey's land use and land cover and associated maps are compiled in the Western Mapping Center, Menlo Park, Calif.; Rocky Mountain Mapping Center, Denver, Colo.; Mid-Continent Mapping Center, Rolla, Mo.; or Eastern Mapping Center, Reston, Va.

Before an area is authorized for compilation, it is necessary to determine the availability of source materials for the area. The prime source materials for small-scale land use mapping are aerial photographs which meet the following specific requirements: (a) the photographs should not be more than 3 years old; (b) there should be no more than 10 percent cloud or snow cover; (c) photographic scale should be 1:80,000 or smaller; (d) photographs must be tilt correctable when necessary; and (e) photographs should be acquired during leaf-off conditions.

Although all photographic source materials are examined for possible use, the most commonly used in the national land use mapping program are:

1. Color-infrared photographs taken at altitudes between 60,000 and 65,000 feet (scale between 1:120,000 and 1:130,000).

2. Black-and-white panchromatic photographs taken from altitudes of approximately 40,000 feet (scale of 1:78,000).

3. The National High-Altitude Photography (NHAP) program; scheduled to provide high-altitude photographic coverage for the entire United States every 7 years. The photographs collected consist of color-infrared photographs from a camera with an 8.25-inch focal length, and panchromatic high-resolution photographs taken with a 6-inch focal length camera.

For small areas not having photographs meeting the requirements, searches are made from other sources such as the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture.

When mapping land use and land cover at intermediate scales of 1:24,000 to 1:100,000, the photographs should be less than 18 months old at completion of compilation and range in scale from 1:20,000 to 1:60,000, depending on the scale of compilation. The remaining photographic requirements are the same as those for the 1:250,000-scale mapping program.

The source materials needed to compile the associated maps are gathered from various State and Federal agencies. The information needed to compile the political units map and the census county subdivision maps are obtained from Geological Survey topographic maps and the Bureau of the Census. The Geological Survey, Water Resources Division, provides published Hydrologic Unit State Maps at a scale of 1:500,000 from which the hydrologic units maps are compiled. State land ownership maps are compiled under a cooperative agreement with a State only if the source material is furnished by the State in a format acceptable for compilation. The Federal Land Ownership maps are compiled from data obtained from the various Federal agencies whose data will be shown on the finished map.

Other types of maps can be added to this set, such as soils, geology, utilities, highways, and floodplains. When adding other mapped data sets to the original land use and land cover data sets, data should be compatible in scale and content.

Field Activities

Field activities support two distinct phases of compilation of land use and land cover maps. These are (1) precompilation fieldwork, and (2) field checking of compiled sheets.

To accomplish precompilation field activities, the area is reviewed to determine the types and extent of land use patterns to be mapped. Air traverses, flown in a light aircraft at low altitudes (500 to 1,500 ft.) provide the opportunity to obtain low-altitude oblique photographs of the land uses. Data from the photographs are then plotted on a 1:250,000-scale topographic map and used along with a written report to brief the compiler on the area by comparison of the large-scale photographs with the vertical mapping photographs.

Post-compilation field checks allow the interpreter to classify difficult-to-interpret areas and to check the general accuracy of the map. If classification of problem areas cannot be resolved from an aircraft at a low altitude, a ground visit to the site is made. The areas covered by field check photographs are plotted and a field report is written. The necessary corrections are made, and the map is forwarded for final reproduction.

Land Use and Land Cover Minimum Size Specifications

The minimum size specifications for delineation of the 1:250,000- and 1:100,000-scale land use polygons are as follows.

Polygons to be delineated must meet minimum size requirement, regardless of whether they were published at 1:250,000 or 1:100,000. The following categories must have a minimum area of 4 hectares (10 acres): all Urban or Built-up Land (11-17); Confined Feeding Operations (23); Other Agricultural Land (24); Water (52-54); Strip Mines, Quarries, and Gravel Pits (75); and Transitional (76), if urban. All other categories of land use and land cover have a minimum area of 16 hectares (40 acres).

In all categories mapped using a 4-hectare (10-acre) minimum mapping unit, the minimum width of a feature must be 200 m (660 ft.). This minimum width precludes delineation of very narrow or very long 10-acre tracts. All categories mapped using the 40-acre minimum mapping size use 400 m (1,320-ft.) minimum widths. Exceptions to this specification are limited access highways and all "double-line" streams on the 1:250,000-scale base map. Such areas have to have a minimum width of 100 m (300 ft.).

Land Use and Land Cover Delineation

Interpretation of the detail on aerial photographs and transferral of this information to the map base is accomplished by stereocompilation techniques or direct detail transfer. When stereocompilation techniques are used, maps are compiled at 1:250,000 or 1:100,000 scale with the use of a pantograph attached to a photogrammetric instrument (see figure 4-1).

The direct detail transfer technique (also known as monoscopic compilation) uses a modified microfiche viewer with 20x magnification (see figure 4-2). Using this technique, the photograph is scaled to fit the base map. In the case where the scale of a block of photography does not differ in scale by more than 3 percent, it is simpler to enlarge the base map to the average scale of the photograph. Transfer of land use polygon data from the photograph to the base map can be completed by sliding the photograph under the base map and

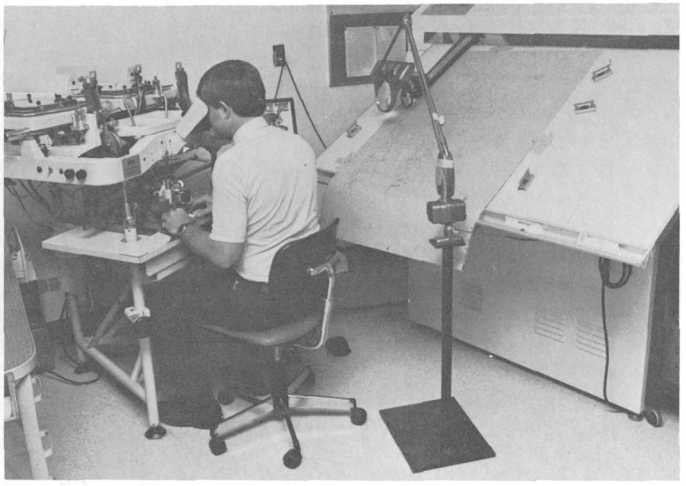


Figure 4-1.--Photogrammetric land use and land cover compilation.

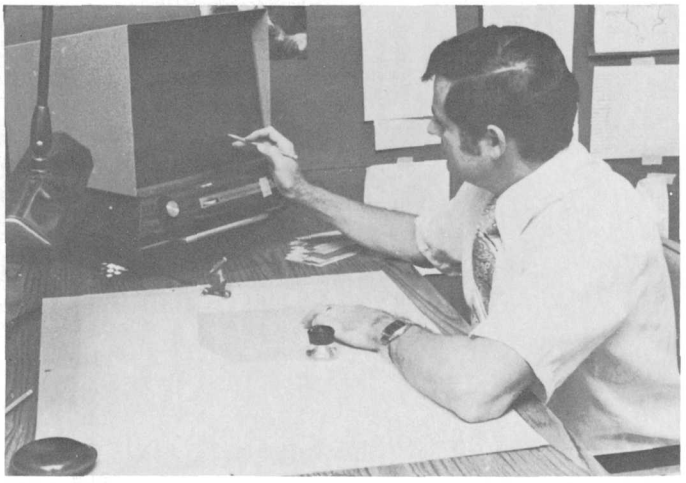


Figure 4-2.--Direct detail transfer land use compilation.

aligning the photographic detail with the map detail. The detail viewed on the screen of a microfiche viewer can then be transferred to the map transparency by coordinating the image with the same image on the photograph positioned under the base map.

Generally, compilation by photogrammetric methods can be completed more quickly than by direct detail transfer; however, more time and effort are required for editing. With editing, the overall time required to compile any given area is found to be approximately equal for monoscopic and stereocompilation methods.

Associated Maps Compilation

Associated maps are compiled on scribe coats at publication scale.

Political units map boundaries follow those county boundaries shown on the base map but must be verified with the County Subdivisions-Townships and Places maps from the Bureau of the Census. Political units map polygons are identified by five-digit codes obtained from the Geographic Identification Code Scheme (U.S. Bureau of the Census, 1972b).

Hydrologic unit boundaries and identifying eight-digit codes follow those shown on the State Hydrologic Unit Maps prepared by the U.S. Geological Survey. A legend of polygon unit names and codes is also compiled at this time from the USGS lists of "Boundary Descriptions and Names of Regions, Subregions, Accounting Units, and Cataloging Units," Water Resources Division, USGS, 1982.

The Census County Subdivision Map portrays census county subdivisions for nonmetropolitan counties and census tracts for Standard Metropolitan Statistical Areas (SMSA) as defined in the 1970 or 1980 Census of Population. Maps compiled prior to the 1980 census use 1970 census data, those compiled after the 1980 census use 1980 data. The political units boundaries from the Political Units Maps form the framework for delineation of the census county subdivisions. The County Subdivisions-Townships and Places map, and the maps from the appropriate Census Tracts: SMSA publications of the Bureau of the Census are used to obtain boundaries for this map. A legend of census county subdivision names and codes is also compiled at this time from the Geographic Identification Code Scheme (U.S. Bureau of the Census, 1972b).

The Federal land ownership map is compiled showing only surface areas of federally owned land occurring in units of 40 acres or more. A two-digit code is used to identify parcels of federally owned land.

The State Land Ownership map is completed only for those States which have a cooperative agreement with the National Mapping Division. Under this type of agreement, the agency must furnish the necessary compilation source information for compiling such maps. The code referencing system is designed separately for each State.

During the compilation process, all maps are checked with adjacent maps to ensure continuity. Map editing consists of an overall review of the manuscript for cartographic errors, such as missing identification numbers, broken lines, improper fittings, and any other obvious cartographic errors. In addition, a comparative review is made with the source

materials to ensure that map compilation meets specified requirements for photographic interpretive accuracy and delineation of polygons.

Quality Control

Quality control consists of an in-depth review of the map manuscript to determine if category definitions and specifications for interpretation and compilation have been consistently followed. A complete cartographic review includes reviewing the accuracy of interpretation, proper placement of identification numbers, adherence to specified minimum sizes for the land use and land cover categories and use of specified line weights. Errors are noted for correction on a stable-base overlay or diazo copy of the manuscript.

Three types of accuracy checks are performed. The first accuracy check is for interpretation. Various field validation techniques and processes are used to establish the accuracy of land use and land cover interpretations. The second accuracy check concerns delineation of polygons compared to boundaries existing on the Earth's surface. Since delineations are taken from photographic source materials, the outline is as precise as the scale of the photograph will allow. The third accuracy check is for positional accuracy. The positional accuracy of the maps must be consistent with that of the published map used as the compilation base.

In addition to quality control of individual sheets which make up the land use and land cover and associated map set, there must be a composite quality control of all sheets in the set. Table 4-1 shows some of the types of correspondence which must be achieved.

Final Reproduction and Release

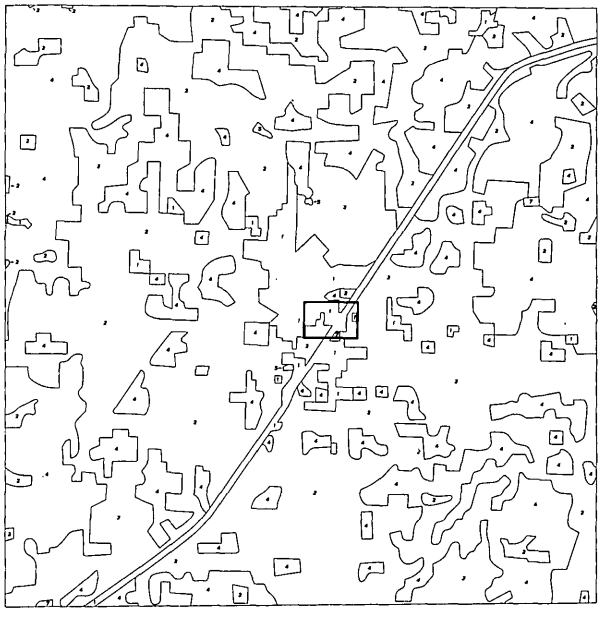
After a final review, reproductions are made and the maps are released to open file in the appropriate regional mapping center along with a copy of the planimetric base. Copies are also sent to the various State cooperators and USGS outlets as required.

Land Use and Land Cover Mapping Specifications at Scales of 1:100,000 and Larger

Regional and local natural-resource managers often require that their land use and land cover maps be more detailed and at a larger scale. For more detailed and larger scale land use maps, the source photographs must be more recent and larger scale and the minimum polygon size and minimum polygon width must be smaller. Table 4-2 illustrates the relations among the levels of land use and land cover classifications, base map scales, photographic scales, minimum polygon sizes and widths, and sources required for delineation of land uses.

To further illustrate these relationships, several land use and land cover maps at various scales and classification levels follow.

Figure 4-3 illustrates the Level I land uses around Lebanon, Mo. Figure 4-4 shows the same geographic area at a Level II land use. Specifications used for both compilations were those detailed in Open-File Report 77-555 for 1:250,000-scale compilations.



Scale 1:250,000

LEVEL I EXPLANATION

1. Urban or Built-up Land
2. Agricultural Land
3. Rangeland
4. Forest Land
5. Water

Figure 4-3.--Level I land use and land cover map, Lebanon, Mo.

Table 4-1.--Composite editing overlay registration checklist

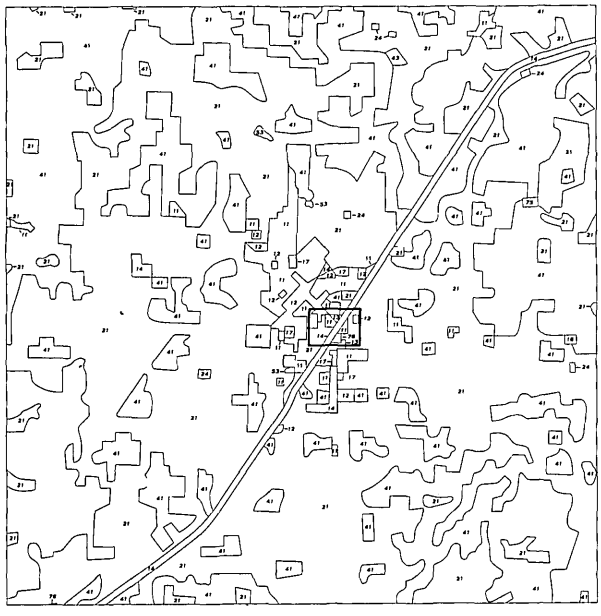
(From Loelkes, 1977, p. 60.)

	LAND USE AND LAND COVER	HYDROLOGIC UNITS	FEDERAL LAND OWNERSHIP	POLITICAL UNITS	CENSUS COUNTY SUBDIVISIONS
LAND USE AND LAND COVER	Check joins with surrounding map compilations.	Map sheets along coastlines must comply with compilation specifications.	Those boundaries for ownership should encompass Category 12. Where delineated boundaries are same, lines must coincide.	Map sheets along coast boundaries must be in compliance with compilation specifications.	Map sheets along coastlines must be in compliance with compilation specifications.
HYDROLOGIC UNITS	No set pattern. Check unit boundaries to ensure lines only cross large rivers. Close units along shorelines.		No set pattern.	Be sure all areas of other than inland water have been properly coded.	No set pattern.
FEDERAL LAND OWNERSHIP	Check Category 12 occurrence within Federal land ownership boundaries	No set pattern.		Many times county & State lines are used for Federal land ownership.	No set pattern.
POLITICAL UNITS	For map sheets along coastline, check compilation for specification compliance.	No set pattern.	Many times, county & State lines are used for Federal land ownership.		All common lines must coincide: county-State CCS-county SMSA-county CCS-State SMSA-State
CENSUS COUNTY SUBDIVISIONS	No set pattern.	No set pattern.	No set pattern, except where political units form boundaries.	All common lines must coincide: county-State CCS-county SMSA-county CCS-State SMSA-State	

Table 4-2. Land use/land cover specifications matrix

Levels of Land Use/Land Cover Classification	Base Map Scale	Effective Photo Source Scale	Minimum Polygon Size[1]	Minimum Polygon Width[1]	Sources Required for Land Use Delineations
I	smaller than 1:250,000	smaller than 1:125,000	greater than 40 acres	greater than 660 feet	100 percent photographic
II	1:250,000 to 1:100,000	1:125,000 to 1:60,000	40 acres and 10 acres	1,320 feet and 660 feet	98 percent photographic 2 percent other source materials
III	1:63,360 to 1:24,000	1:60,000 to 1:20,000	2.5 acres	125 feet	75 percent photographic 25 percent other source materials
IV	1:24,000 to 1:6,000	1:20,000 to 1:6,000	2.5 acres and 1 acre	125 feet and 50 feet	25 percent photographic 50 percent other source materials 25 percent ground truth
V	1:6,000 and larger	1:6,000 and larger	1 acre and smaller	50 feet and smaller	10 percent photographic 40 percent other source material 50 percent ground truth

[1]Since different minimum polygon size and width values are recommended for urban versus rural land use types, two values are listed in these columns.



Scale 1:250,000

LEVEL II EXPLANATION

11 Residential

12 Commercial and Services

13 Industrial

14 Transportation, Communications, and Utilities

17 Other Urban or Built-up Land

21 Cropland and Pasture

24 Other Agricultural Land

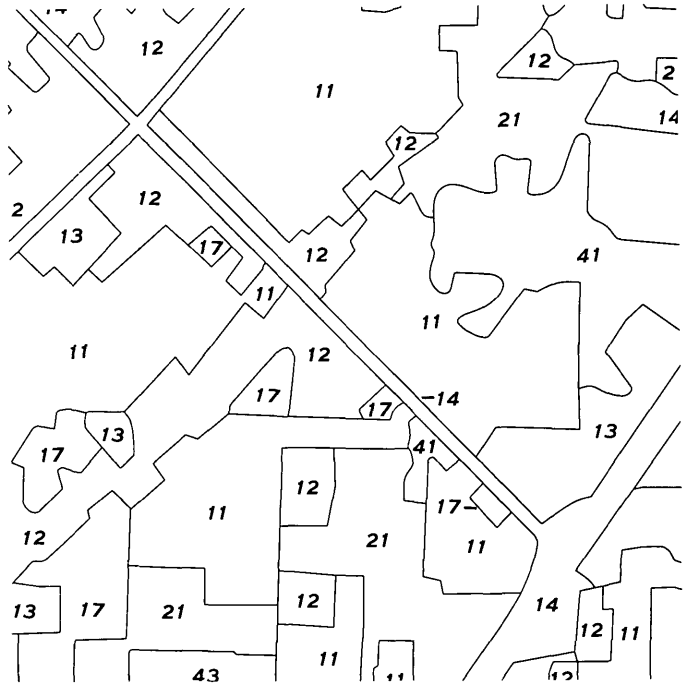
41 Deciduous Forest Land

53 Reservoirs

76 Transitional Areas

Figure 4-4.--Level II land use and land cover map, Lebanon, Mo.

Figure 4-5 depicts a Level II land use and land cover map of Lebanon at the 1:24,000-scale, while figure 4-6 of the same area was compiled at Levels II and III.



Scale 1:24,000

LEVEL II EXPLANATION

11 Residential

12 Commercial and Services

13 Industrial

14 Transportation, Communication, and Utilities

17 Other Urban or Built-up Land

21 Cropland and Pasture

24 Other Agricultural Land

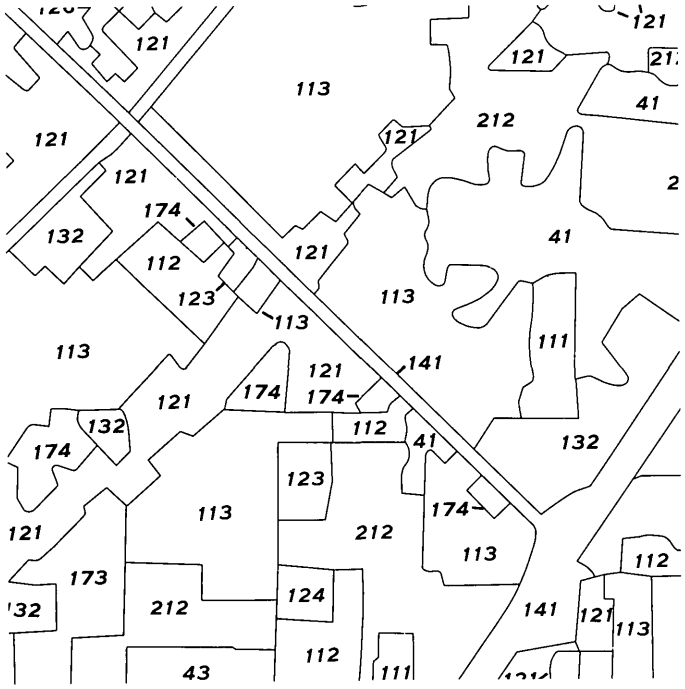
41 Deciduous Forest Land

43 Mixed Forest Land

53 Reservoirs

76 Transitional Areas

Figure 4-5.--Level II land use and land cover map, Lebanon, Mo.



Scale 1:24,000

LEVEL II AND LEVEL III EXPLANATION

111 One and under dwelling units per hectare (DU/hectare)
112 Two to eight DU/hectare
113 Nine and over DU/hectare
121 Retail and wholesale
122 Commercial outdoor recreation
123 Education
124 Hospitals, rehabilitation centers and other public facilities
126 Other public institutions and facilities (other than educational)
132 Light industry
141 Highway
142 Railway
146 Sewage treatment
172 Cemeteries
173 Parks
174 Open space-urban
41 Deciduous forest land
43 Mixed forest land
53 Reservoirs

Figure 4-6.--Level II & III land use/cover map, Lebanon, Mo.

The 1:24,000-scale map compilations are the same areas as those set off by the heavy black rectangles in figures 4-3 and 4-4. The classification system used for the compilation of figure 4-5 followed a multilevel classification system prepared for the Kansas City, Kan., land use test and demonstration project as shown in table 3-3 (Sosinski, 1980). Figure 4-6 followed a classification system used by San Mateo, Calif. The specifications used for compilation were as follows: (1) polygons to be delineated had to have a minimum size of 2.5 acres for Levels II and III, (2) all categories mapped with this mapping unit size had to have a minimum width of 125 ft.

Summary

Compilation procedures and techniques used by the U.S. Geological Survey for land use and land cover mapping at a scale of 1:250,000 or 1:100,000 can be used to compile any scale natural resource thematic map. Specifications to compile mapped data, the level of classifications, and the different types of social and natural resource data input requirements, all fall under these procedures and techniques. The items must, however, be compatible in scale, detail, and specifications. Time spent in project planning to ensure compatibility of the project data will assure successful completion of a mapping project. Table 4-2 showed the relationship of these various aspects of land use mapping. The information contained in this table was prepared primarily for land use and land cover mapping; however, it can be expanded or modified to include other types of natural resource data requirements as well.

SECTION 5: LAND USE AND THE ENVIRONMENT

As the Earth's population has increased and man has become technologically more advanced, his needs for natural resources and space have also increased. These needs, although economically and socially beneficial, have often had an adverse effect on the environment. The shift from an agrarian to an industrialized society has at times changed a pristine environment to an environment of polluted air, water, and soil. Some areas have been polluted to the extent that they are no longer useful.

All uses of land and types of cover either produce or are impacted by some form of pollution. This may range from air quality problems caused by the natural decomposition of organic matter in forested areas, to the illegal disposal of hazardous waste materials. Some forms of pollution have purely aesthetic impact, while others are lethal. Recent episodes, such as the Love Canal area near Buffalo, N. Y., have dramatically shown the far-reaching implications of the improper disposal of chemical wastes. One of the purposes of this guide is to provide the user with some insight to the use of remote sensing and land use and land cover maps and to aid in the understanding of environmental/land use relationships.

Since most types of pollution result from the activities of man, it is easily understood why many of these pollution types are a direct result of man's use of the land. Consequently, an existing land use map, compiled from recent aerial photographs, can be an invaluable tool in attempting to access real or potential environmental problems. The products available through the U.S. Geological Survey's national land use and land cover mapping program can greatly assist environmental specialists and natural-resource planners by narrowing their geographic search area to those land use categories most likely to create pollution problems.

Application of remote sensing for environmental monitoring is well established and documented. Many governmental agencies whose mission involves resource management and mapping have utilized aerial photographs since the mid-1930's. Because of the time-consuming nature of ground investigations, it became readily apparent that only aerial images could provide information in a timely, efficient, and cost-effective manner.

Of the many agencies employing remote sensing, the Environmental Protection Agency (EPA), realized in the late 1960's the benefits which could be derived from imaging sensors. Since that time, a variety of remote sensor studies have been made of regulated pollution sources.

A very basic type of study, an inventory of pollution sources, can be easily carried out using aerial photographs. While the majority of stationary point sources require permits, there are many nonpoint sources which do not. A nonpoint source is an area type source; examples include junkyards, construction sites, landfills, feedlots, and freshly tilled agricultural fields. The major problem associated with nonpoint sources is degradation of water quality caused by surface runoff entering both ground and surface water supplies. Aerial photographs provide an ideal means of analyzing large geographic areas for this type of pollution source.

A new analytical technique developed by EPA for detection of failing septic tank fields uses large-scale color and color-infrared photographs. The technique, used successfully in various regions of the country, is based on the fact that a failing system increases the nutrient levels and available moisture to surface vegetation thereby causing vigorous growth which can be readily observed on color-infrared photographs. It is believed that this technique has saved hundreds of thousands of dollars over conventional field investigations. Data from these studies are used to determine the need for new or expanded waste water treatment facilities.

Aerial images have also been effective in monitoring oil and hazardous materials spills. In such episodes, the images are obtained, processed, and analyzed in the shortest possible time--usually less than 24 hours--to provide information directly to cleanup personnel. A recent development has been installation of a color television camera in the oblique position of the Enviro-pod camera system (see figure 2-8). The aircraft's ground track is recorded on videotape and played back at the spill command post shortly after the plane lands. The vertical Enviro-pod camera photographs are retained for documentation and more detailed analysis at a later time. The television system has also been used to monitor aerial spraying of pesticides. A direct air-to-ground transmission system is presently being developed.

Environmental surveys using aerial imagery have proven invaluable in intensive site analyses of known potential hazardous waste sites. In addition to recent imagery, historical photographic coverage can often be obtained and analyzed, thereby providing a comprehensive site picture. The types of information extracted include areal extent, types of wastes disposed, presence of liquid

storage areas, offsite contamination, vegetation damage or stress, surrounding land use, and onsite or offsite drainage.

Use of imaging systems for environmental monitoring is, as yet, still in its infancy. The vast majority of pertinent data are presently collected using conventional photographic imagery. The Environmental Protection Agency, along with other governmental agencies, is investigating a number of other remote sensing monitoring methods such as laser fluorosensing; light intensification, detection, and ranging systems (LIDAR); and multispectral imaging systems. However, for detection, location, and analysis of pollution sources, the use of conventional photographs has been the most consistent and reliable method.

The basic types of pollution attributable to the Level I land use and land cover categories are discussed in the following paragraphs to facilitate an understanding of the sources of these pollutants and their potential effect on the environment.

Urban Pollution Sources

The main types of pollution in the urban environment are water, air, and noise. The first, water pollution, is caused primarily by improperly treated sewage and waste-water discharges. In residential areas, failing septic tank systems or overloaded sewage disposal plants are sources of water pollution. In commercial areas the large expanse of concrete and asphalt used for street paving and parking areas provide an impervious surface which allows rainfall runoff to convey residual tar, automobile fluids, and litter into streams and rivers. The predominant waste-water problem associated with industrial areas is brought about by the outdoor storage of raw materials and finished products. In addition, improper disposal of waste products can become a major source of pollution. Land used for transportation and utilities contributes to urban pollution primarily from the use of fossil fuels. Both the burning of fossil fuels and the storage and transportation of these fuels are potential pollution sources. Burning coal has also been directly connected to "acid rain." Runoff from highways, railroads, and airports is also among the list of potential water-pollution sources.

The other types of pollution, air and noise pollution, are generally caused by such activities as railroads and airports as well as vehicular operation, industrial plant operations (especially plants burning various types of fossil fuels), and heavy construction operations. Although man's activities in the urban environment do constitute a wide range of potential pollution sources, not all of the Urban or Built-up Land uses are sources of pollution. Public parks, golf courses, lakes, and various other types of greenbelt areas are generally not urban pollution sources.

Agricultural Pollution Sources

The primary source of pollution from agricultural areas are nonpoint, or areal, in nature. Since agricultural practices require large field patterns to be economically efficient, it is of little surprise that these areas are, or at least may become, sources of nonpoint pollution.

Nonpoint pollutants are most often associated with chemical or physical water quality degradation. Following periods of moderate to heavy precipitation, overland runoff passes through agricultural areas, and chemical (such as pesticides and fertilizers) and physical (primarily surface soil particles) contaminants are carried to nearby water bodies.

Accordingly, farmers should be encouraged to use agricultural practices which will lessen the magnitude of nonpoint pollution.

Rangeland Pollution Sources

Rangelands are natural areas by definition and generally are not pollution sources.

Forest Pollution Sources

Forested areas, like agricultural areas, are prime candidates for nonpoint pollution contaminants. These contaminants, primarily loose soil particles and residual herbicides, insecticides, and fertilizers, like nonpoint pollution contaminants from agricultural areas, are transported to nearby water bodies by overland runoff.

Of the above contaminants, soil erosion is by far the greatest nonpoint pollution source resulting from silvicultural practices. Clear cutting activities and use of heavy machinery to construct logging roads are the main offenders.

Water Pollution Sources

Water bodies generally are not pollution sources. However, they serve as the transfer mechanism for chemicals, soil particles, and other organic pollutants that can impact the Earth's ecosystems.

Wetland Pollution Sources

Wetland areas can be subjected to a number of adverse environmental hazards created by human activities. Drainage systems act as transportation routes for distributing pollutants; dumping and filling activities may introduce toxic substances into nearby wetland areas; and adjacent agricultural activities may introduce fertilizers, pesticides, and animal wastes into nearby wetland areas.

Barren Land Pollution Sources

The only Barren Land categories that occur in Missouri are Sandy Areas other than Beaches; Strip Mines, Quarries, and Gravel Pits; and Transitional Areas. Of these categories, the Strip Mines, Quarries, and Gravel Pits category is the most frequent source of pollution. In addition to contributing to air and noise pollution, these areas are often a source of chemical and/or physical contaminants which can enter nearby water bodies.

The above pollution source descriptions are only generalizations. However, as each Level II land use and land cover category is covered in section 6 of this guide, more detailed environmental considerations will be included for that category.

SECTION 6: PHOTOINTERPRETATION KEYS FOR MISSOURI

INTRODUCTION

This section presents the land use and land cover photointerpretation keys and the possible environmental impact of each type of land use or land cover in Missouri. The interpretation keys follow the land use and land cover categories as shown in table 1-1. Each of the Level I land use and land cover categories has a brief general discussion followed by the Level II categories. Each Level II land use and land cover category includes a general description and the possible environmental impact of the category, and is illustrated by a number of sites. Each site is identified by (1) a site number, the general location of which is shown on a map of Missouri (figure 1-1), (2) a short title for the site, (3) the name of the nearest populated place, county, and State name, and (4) the location of each site by latitude and longitude.

In addition to the photographic illustrations, a more complete discussion of the category, and, where appropriate, an environmental statement are included with each of the sites.

In those cases where a second level land use and land cover category can best be represented by the most predominant type, only one site example is presented. In some cases, several examples are provided because of the need for more complete recognition and description of the category. For example, land use categories such as category 41 (Deciduous Forest) may be illustrated well with only one or two examples. However, category 11 (Residential) involves single-family homes, duplexes, garden apartments, trailer parks, high-rise apartments, and inner-city housing. The predominant example of this category, however, is the suburban single-family home. The prime illustration for this category is an area of single-family homes. However, because the category includes the other residential types, they are also illustrated with a very brief description.

Appendix A lists all site information by site number.

LEVEL I, CATEGORY 1 - URBAN OR BUILT-UP LAND

The areas which comprise Urban or Built-up Land are those of intensive use. These areas have a predominance of the land covered with structures. These structures are associated with cities and towns, and other developments such as industrial and commercial areas. It is not necessary that the structures which comprise this category be within, or adjacent to, towns and villages; in fact, they may be completely isolated from urban areas.

As development progresses, land having less intensive or nonconforming use may be located in the midst of Urban or Built-up areas and generally will be included in this category. Agricultural land, forest, wetland, or water areas on the fringe of Urban or Built-up areas will not be included except where they are surrounded and dominated by urban development. The Urban or Built-up category takes precedence over others when the criteria for more than one category are met. For example, residential areas that have sufficient tree cover to meet Forest Land criteria will be placed in the Residential category.

Category 11--Residential

Category Description. Residential land uses range from high-density multiple-unit structures to low-density single-family houses on large suburban lots. Included in this category are single-family residences, apartments, condominiums, mobile homes, recreational homes, and any other building or structure used as a residence. The most common residential type of this category is the single-family home.

Environmental Considerations. The residential category has potential for impacting the environment in several ways. Among these are sewage, waste-water, air, and noise pollution.

Sewage and waste water are a major source of water pollution directly linked to residential development. Direct sewage outfalls and the introduction of untreated sewage effluent into surface and ground-water sources are major pollution problems. Residential areas that are not served by collector sewers must rely on subsurface, on-site, sewage disposal systems (septic tanks) which may malfunction due to soil and geologic problems or adverse seasonal conditions. When septic systems fail towards the ground surface, the runoff of untreated or partially treated sewage effluent can be a major source of surface-water contamination and lake eutrophication, as well as being an immediate health problem to the community. When septic systems are used in areas where the soil is sandy and/or very permeable, ground-water contamination may

occur as the septic effluent moves too rapidly through the soil resulting in inadequate attenuation and filtration of biodegradable particles prior to reaching ground-water level.

Even in residential areas where collector sewer service is available, the waste-water treatment facilities may be inadequate or overloaded and cause the discharge of an effluent that does not meet water quality standards.

Other water pollution sources associated with residential areas include runoff from driveways, parking lots, and solid waste disposal areas (landfills). Surface waters may also be contaminated from runoff containing fertilizers and pesticides used in lawn and garden care.

Additional pollution sources associated with residential areas include air pollution from auto emissions, home heating furnaces, and flourocarbons in aerosol sprays. Changes in microclimates can occur as a result of thermal discharges. Noise pollution can result from construction activity and nearby highways.

Interpretation Keys. Six residential sites are illustrated ranging from high-rise apartments in an urban renewal area to recreational houses on a lake in rural Missouri. The principal example of this category is a recent suburban residential development of single-family homes on the periphery of a large metropolitan area.

Site No. 1 (Single-Family Homes)
Location: Manchester
St. Louis County, Missouri
Geographic Coordinates: 38°36'N
90°31'W

The small-scale vertical mapping photograph, figure 6-1, shows an expanded view of this area of single-family residential homes. Most single-family residences exhibit the same photographic signature of pattern, tone, size, and symmetry. In the upper left portion of the photograph is a subdivision under construction (point A, figure 6-1). Notice how the ground is cleared of vegetation before construction is started.

In the design of subdivisions, there are always areas which cannot be developed because of the topography or hydrologic conditions. These areas are generally left as undisturbed areas of natural vegetation. Two such dark-toned areas, without streets and houses, are shown at A and B in figure 6-2.

Figure 6-1.--Small-scale mapping photograph of suburban residential area in Manchester, Mo.

Figure 6-2.--Low-level oblique photograph of wooded areas left undeveloped.

Streets with circular drives and cul-de-sacs are easily identified by their pattern and light tones.

Ranch-style homes with attached garages of various sizes and shapes can be seen equidistant and symmetrical to the streets (figure 6-3). Upon close examination, sidewalks and driveways are visible. Many of the driveways are probably made of a blacktop material as they are darker in tone than the streets.

In the center foreground of the large-scale vertical photo (figure 6-3, point A) a small park can be identified with its small pool, tennis courts, parking area, and lake.

Figure 6-3.--Large-scale vertical photograph of a subdivision layout and park.

Site No. 2 (Inner-City Residential)
Location: St. Louis
St. Louis County, Missouri
Geographic Coordinates: 38°36'N
90°14'W

The key identification features of inner-city multiple-family residences are the rectangular street patterns, closely spaced buildings with little or no yard space, garages behind the buildings accessable only by the alleys in each block, and the similarity of the shape of the buildings (see figures 6-4 and 6-5).

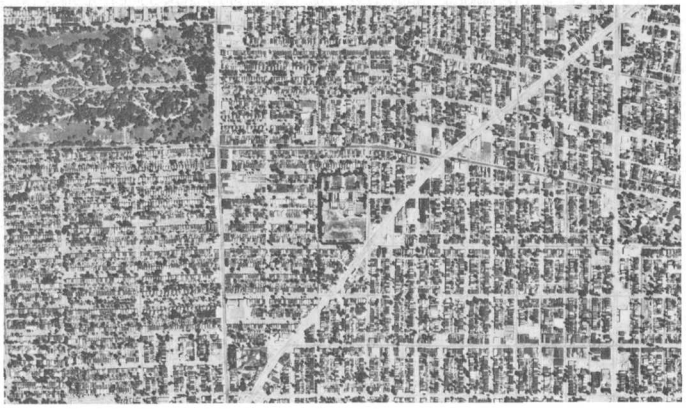


Figure 6-4.--Small-scale photograph of inner-city residential area, St. Louis, Mo.

Figure 6-5.--Large-scale photograph of inner-city residential area, St. Louis.

In most inner-city residential areas, particularly in the older sections of cities, residences are either duplexes or multi-family structures. A typical duplex is shown in figure 6-6.

Figure 6-6.--Ground photograph of multi-family inner-city residential area in St. Louis, Mo.

Many of the older sections of town have local commercial shops and schools intermixed with the residential areas. In figure 6-7, a commercial area is shown at A while a school is located at B.

Figure 6-7.--Low-altitude oblique photograph of inner-city residential area with commercial and school areas.

Site No. 3 (High-Rise Residential)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°31'N
90°13'W

High-rise residential areas may be either apartments or condominiums. These structures are generally 4 to 12 stories in height and may be found within the city limits or in the adjacent suburbs. The buildings, if more than one, are constructed in a geometric pattern (see figure 6-8).

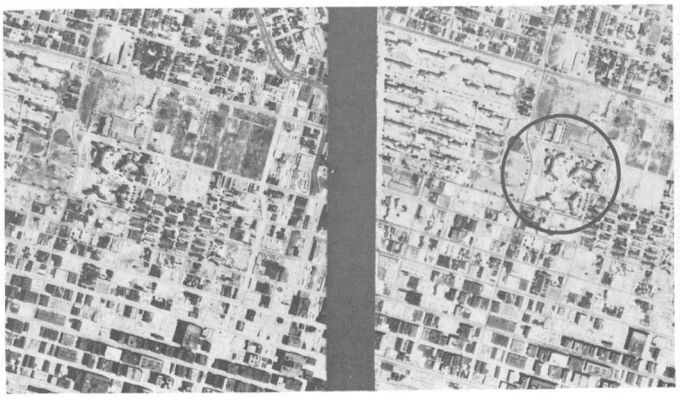


Figure 6-8.--High-rise apartments in an urban renewal area. The stereogram gives an excellent view of the height of the buildings and their similar shapes and sizes.

For convenience of the residents, the parking facilities are located next to the building and around the periphery of the building area (figure 6-9).

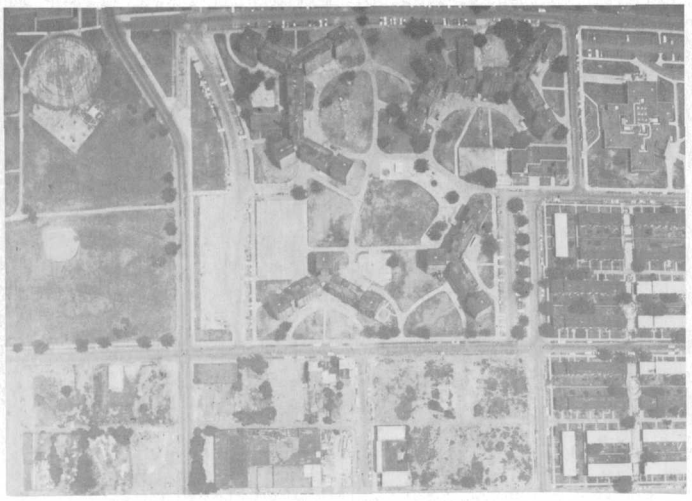


Figure 6-9.--High-rise residential apartments with internal and external parking facilities.

These high-rise residences are located in an area of urban renewal. The area has undergone change since the photograph in figure 6-8 was taken in July 1974. The change is illustrated by the absence of buildings at A in figure 6-10, taken June 1980.

Figure 6-10.--Urban renewal area undergoing change.

The play area for the building tenants is shown in figure 6-11. This figure also illustrates the size of the buildings and the

walkways which connect each of the floors in adjacent sections of the complex.

Figure 6-11.--Ground photograph of high-rise recreational area, St. Louis, Mo.

Site No. 51 (Garden Apartments)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°11'N
93°19'W

Garden apartments are generally found in the suburban area on the outer fringes of larger cities (figure 6-12).

The structures are generally one to three stories in height. They are generally constructed in a rectangular pattern but can be almost of any design, from circular to star shaped. They are referred to as garden apartments because of large grass areas surrounding the buildings and separate entrances (figure 6-13).

Figure 6-13 illustrates garden apartments at A and common-entrance apartments at B. Notice the proximity of parking to the garden apartments as compared to the common parking areas provided for the apartments at the right.

In figure 6-14, which shows garden apartments in midst of single-family homes in Springfield, Missouri, the dark-toned apartments can be identified by their size, shape, and similarity. Parking areas in front of each building make the streets look wider. On the right side of the photo, four separate parking lots are visible at B. Garden apartments usually include recreational facilities within the building complex area.

Figure 6-15 is a ground photograph of typical garden apartments.

Figure 6-12.--Small-scale photograph of garden apartments, Springfield, Mo.

Figure 6-13.--Large-scale photograph of garden apartments in Springfield, Mo.

Figure 6-14.--Low-level oblique photograph of garden apartments in Springfield, Mo.

Figure 6-15.--Garden apartments in Springfield, Mo.

Site No. 52 (Mobile Homes)
Location: Springfield
Green County, Missouri
Geographic Coordinates: 37°11'N
93°22'W

Mobile homes can be found throughout the countryside, however, they are primarily located in suburban areas in courts or parks (figure 6-16).

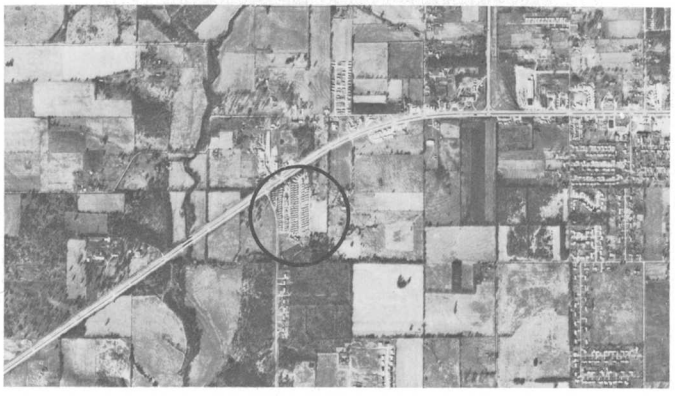


Figure 6-16.--Mapping photograph of mobile home park at Springfield, Mo.

Most mobile homes are secured on a permanent foundation and usually parked in a trailer court or park. Large mobile homes are parked perpendicular to or at an angle to the streets in the court. This practice facilitates the maximum utilization of a limited area. Mobile homes are long and narrow as compared to a house, lighter in tone, and are usually arranged in a regular pattern (figure 6-17).

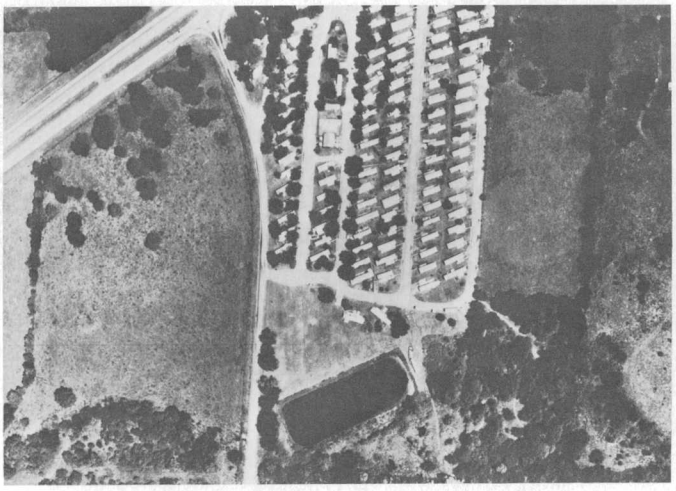


Figure 6-17.--Large-scale vertical photograph of mobile home park, Springfield, Mo.

Utilities are generally run between the backs of the mobile homes, with a gas or oil tank and an electric meter for each home. The water and sewage lines also run between the homes. The general method used for sewage disposal outside the city limits is usually a sewage lagoon (A, figure 6-18). Figure 6-19 presents a ground perspective of a typical mobile home park.

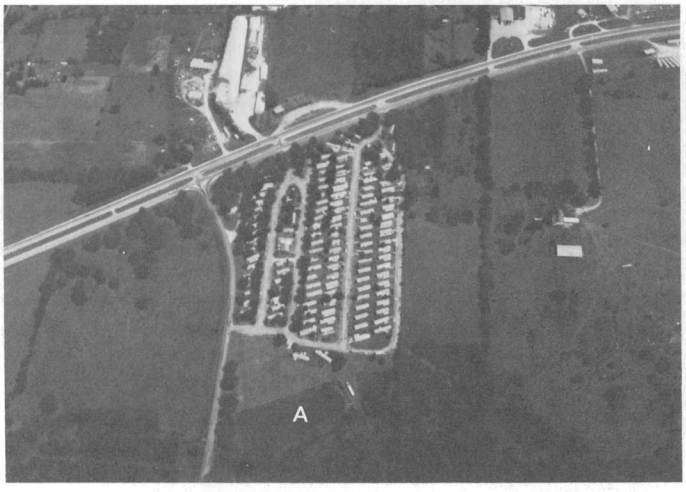


Figure 6-18.--Mobile home park and sewage lagoon near Springfield, Mo.

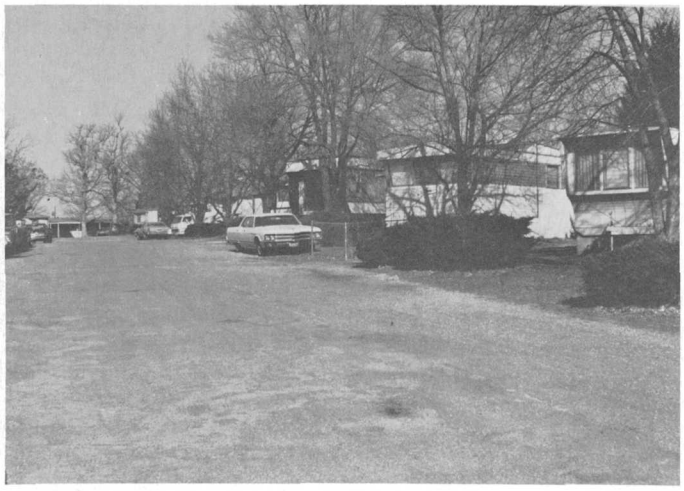


Figure 6-19.--Ground photograph of a typical street in a mobile home park.

Site No. 89 (Recreational Homes)
Location: Trenton
Grundy County, Missouri
Geographic Coordinates: 40°06'N
93°44'W

Recreational homes are frequently very close to water bodies, or in wooded areas, and provide outdoor recreational activities easily accessible to their occupants. This recreation area borders Lake of the Woods. The key identification features of recreational home areas are the road patterns and the different sizes and shapes of the buildings, boathouses, and docks. The general scattering of houses and vacant lots are also common. Figure 6-20 illustrates a rectangular road pattern which gives way to separate access roads to each residence as one approaches the lakeshore.

Figure 6-20.--Small-scale mapping photograph of recreational homes at Lake of the Woods, Mo.

The various shapes and sizes of the buildings are indicative of recreational homes. These homes can be year-round residences or seasonal cabins. Boathouses and boat docks are visible at every lakeshore lot. Wooded areas are considered an asset in recreational developments and therefore are usually not removed during construction (see figure 6-21).

Figure 6-21.--Large-scale vertical photograph of Lake of the Woods residential area.

Figure 6-22 illustrates a recreational home site area with the scattering, almost random, placement of structures.

This particular site is associated with a rather large lake. There are large numbers of recreational areas developed in mountain-type terrain. The lot layout and building type are mainly the same as for lake development. The recreational facilities, however, are in the form of smaller lakes and golf courses which tend to be more centrally located within the development.

These examples illustrate a cross section of the various types of dwelling units which comprise the residential category. There are many other types which are variations of the examples shown, but these examples can be considered typical.

Figure 6-22.--Low-altitude oblique photograph of recreational home area.

Category 12--Commercial and Services

Category Description. Areas which contain structures predominantly used for the sale of products or services are classified as commercial. Included in this category are central business districts, shopping centers, commercial strip developments along highways, and junkyards. The main buildings, secondary structures, and supporting areas--office buildings, parking lots, landscaped areas, and waste-disposal areas--are also included in this category. Institutional land use, such as educational, religious, health, correctional, and military facilities are likewise included in this category. Cultural and recreational areas that can be identified on aerial photos, and included in this category, are commercial sports arenas, drive-in theatres, amusement parks, and commercial campgrounds. At military bases and institutional facilities, areas not specifically related to the purpose of the institution should be placed in the appropriate category.

Environmental Considerations. Commercial and Services land use areas share the following general potential for environmental effects. Extensive concrete and asphalt coverings cause high rates of surface water runoff which can affect water quality and quantity. The runoff is capable of carrying residual tar, oil, automobile fluids, litter, and other solids into storm sewers and eventually into nearby streams. The extent to which water quality is affected depends upon where the water has traveled during its course. Quantity is influenced by the impervious layers blocking the percolation and absorption of water into the Earth to replenish the ground water aquifier supplies. Excessive runoff can cause flooding during heavy rainfalls in commercial areas or in nearby residential communities. Commercial areas in general have high rates of consumption and discharge of water. This results in large sewage volumes and depletion of local water reserves. Specific pollution hazards to water quality from commercial land uses include chemical contamination, thermal contamination, and over nutrification. Of all the commercial establishments in land use category 12, the activity which has one of the largest potentials for pollution is salvage yards. Salvaging of batteries and autos can contaminate soil, water, and air with toxic chemicals, lead, and iron oxides. The burning of auto interiors pollutes the air and can spread noxious odors to nearby communities.

Air quality is also affected by activities of commercial districts. High-volume traffic contributes exhaust emissions, dust levels are higher, and power generators can contribute particulate matter into the air. Airborne lint and debris can also effect air quality in these regions.

A noticeable byproduct from high-density commercial areas is excessive noise. Vehicles, heavy machinery, loudspeakers, and loading areas all contribute to abnormally high noise levels. These noises can be intensified by nonabsorbing building materials which can create echos. Noise levels may also be high at certain times in the neighborhood of concert halls, sports arenas, and fairgrounds.

The most noticeable detrimental environmental effect of a commercial area is its high-density land use. Sparse vegetation is common and "heat islands" are likely in sections devoid of greenery. The alteration of the terrain by heavy urbanization affects hydrology, vegetation, climate, and habitat.

Not all commercial land uses should be considered detrimental. Hospitals, schools, and other institutions provide open areas which, for the most part, are nonpolluting and aesthetically pleasing.

Interpretation Keys. Presented on the following pages are examples of Commercial and Services land uses in Missouri.

Site No. 4 (Shopping Center)
Location: Mehlville
St. Louis County, Missouri
Geographic Coordinates: 38°31'N
90°20'W

Large shopping centers are usually located in the suburbs of urban areas. The key identification features are large or interconnected buildings surrounded by well-paved parking lots and its location near an interchange or a four-lane divided highway for easy access and exit.

The small-scale mapping photograph (figure 6-23) shows the location of a Mehlville shopping center. The intersection of two interstate highways and major arterial streets provide easy and convenient access to the facility. Some of the surrounding residential and commercial development served by this shopping center is also visible. Since the date of the mapping photograph, July 1, 1974, the shopping center has expanded as evidenced in the photograph in figure 6-24, taken in June 1980. The dark rough-textured area to the west of this complex at A, is an area of trees which may eventually be converted to additional parking or other commercial activities. The photograph shows the large retail building completely surrounded by well-marked paved parking facilities.

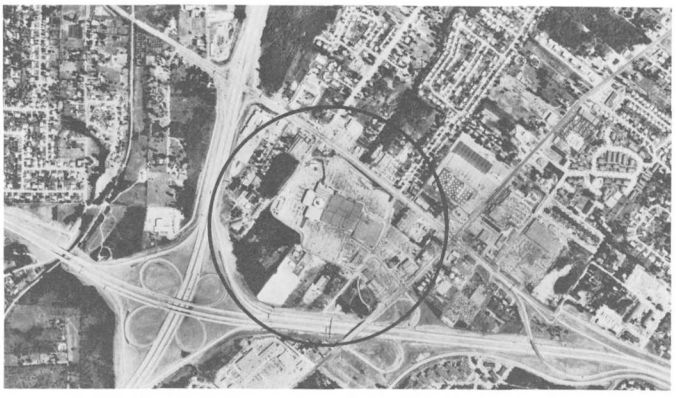


Figure 6-23.--Small-scale mapping photograph of shopping center near St. Louis, Mo.

Figure 6-25 provides a ground perspective of the complex and some of the well-marked paved parking facilities.

Large shopping centers such as this site are built to have large covered malls. The various stores within the building open onto the outside of the building as well as the malls. When major chain stores are involved with the shopping center, they will generally build with a characteristic design which will be evident in all shopping centers the store occupies.

Figure 6-24.--Large-scale vertical photograph of shopping center at Mehlville, Mo.

Figure 6-25.--Ground photograph of shopping center.

Site No. 53 (Shopping Mall)
Location: Springfield
Greene County, Missouri.
Geographic Coordinates: 37°10'N
93°16'W

The small-scale photograph shown in figure 6-26 locates a Springfield shopping mall in relation to major traffic arteries, surrounding residential structures, and other commercial land uses.

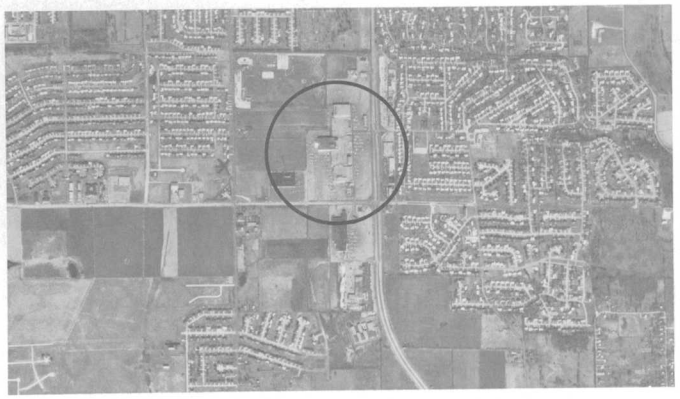


Figure 6-26.--Small-scale mapping photograph of shopping mall at Springfield, Mo.

The mall, Battlefield Mall, is more clearly shown in figure 6-27. In this large-scale photograph the building and parking lot can be easily identified by their lighter tones. The major traffic arteries provide easy access to the mall. Unlike shopping centers, malls have all of the stores under one roof with a walkway (mall) serving all stores.

Figure 6-27.--Low-level oblique photograph of Battlefield Mall, Springfield, Mo.

Figure 6-28.--Battlefield Mall's main entrance and parking lot.

Figure 6-28 shows the main entrance to the mall and associated parking facilities.

Site No. 79 (Central Business District)
Location: Kansas City
Jackson County, Missouri
Geographic Coordinates: 39°06'N
94°35'W

The stereogram presented in figure 6-29 provides an excellent perspective of the height of the buildings and the extent of parking within this central business district (CBD). Metropolitan CBD's have a large number of high-rise buildings. They usually are easily accessed by interstate bypass routes.

Figure 6-30 illustrates the built-up nature of CBD's. The CBD is the heart of the office/commercial activity of the city. The photograph clearly shows the high-rise buildings surrounded by large, lighter tone parking lots. Most of the lots are full; therefore, it's evident that these photographs were taken during business hours.

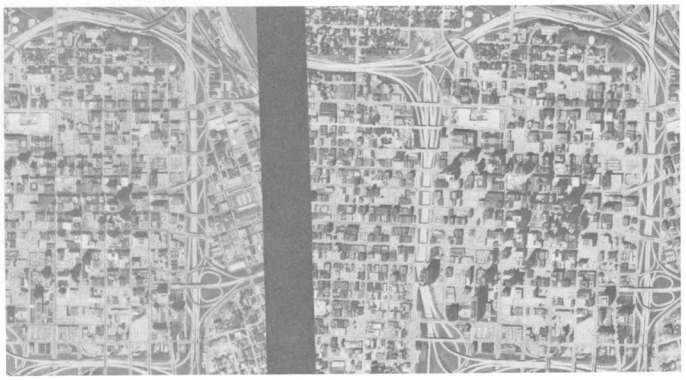


Figure 6-29.--Stereogram of portion of the Kansas City, Mo., central business district.

Figure 6-30.--Forward oblique photograph of Kansas City CBD.

Figure 6-31 presents a more familiar view of the Kansas City CBD.

Figure 6-31.--Ground-level view of central business district, Kansas City, Mo.

Site No. 49 (Medium-Size City CBD)
Location: Lebanon
Laclede County, Missouri.
Geographic Coordinates: 37°41'N
92°40'W

Figure 6-32 shows the central business district's growth away from the city's main traffic intersection. The central business district originally developed along the railroad and is now expanding in all directions.

Figure 6-32.--Medium-size city central business district, Lebanon, Mo.

Figure 6-33, a large-scale vertical photograph, more clearly illustrates some of the recognition features of a medium-size town CBD. Notice the angle parking at A and the dark roofs of the three and four-story buildings at B.

Figure 6-33.--Large-scale vertical photograph of CBD, Lebanon, Mo.

Site No. 40 (Small-Town CBD)
Location: Ironton
Iron County, Missouri
Geographic Coordinates: 37°36'N
90°38'W

The main section of the central business district of Ironton is shown in figure 6-34. Small-town CBD's usually parallel the main traffic artery. Two- or three-story buildings line the street. Also shown in figure 6-34, in the west-central sector of the circle is the Iron County Court House. Notice the proximity of the residential structures to the CBD area. This is common in small-town CBD's.

Figure 6-35 provides a more traditional view of this small-town CBD.

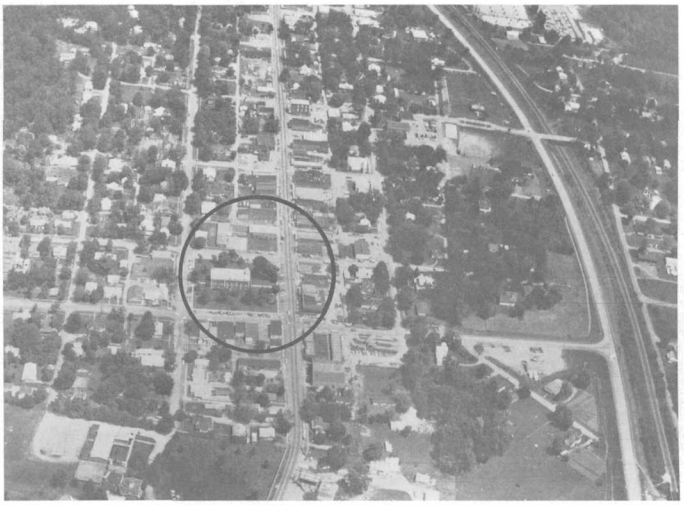


Figure 6-34.--Large-scale oblique photograph of Ironton, Mo.

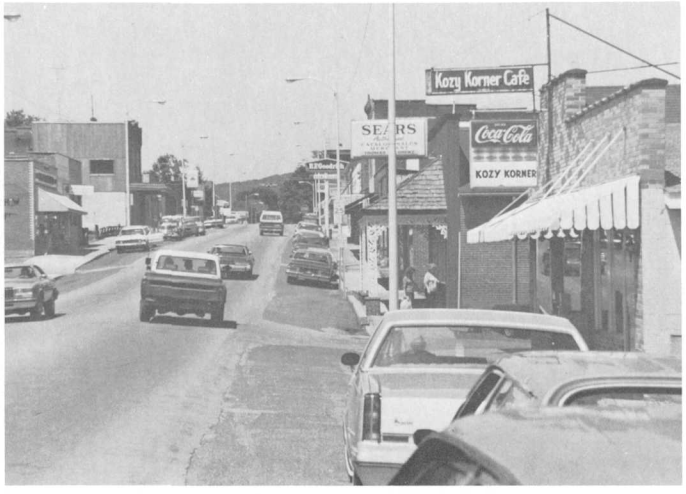


Fig. 6-35.--Ground view of CBD area, Ironton, Mo.

Site No. 46 (Commercial Strip Development)
Location: St. Robert
Pulaski County, Missouri
Geographic Coordinates: 37°49'N
92°10'W

Commercial development along major traffic arteries and access routes is often referred to as "commercial strip development." These areas provide retail goods and services to nearby residents. Figure 6-36 identifies two commercial strip development areas at A and B which serve the residents of St. Robert and military personnel from Fort Leonard Wood. Area A provides motel accommodations, fast food services, a general merchandise store, a car dealer, and other similar goods and services. Area B, particularly near the bottom of the photograph, provides services normally found to exist near military bases--bars, dry cleaners, groceries, general merchandise stores, a bank, and a TV repair shop.

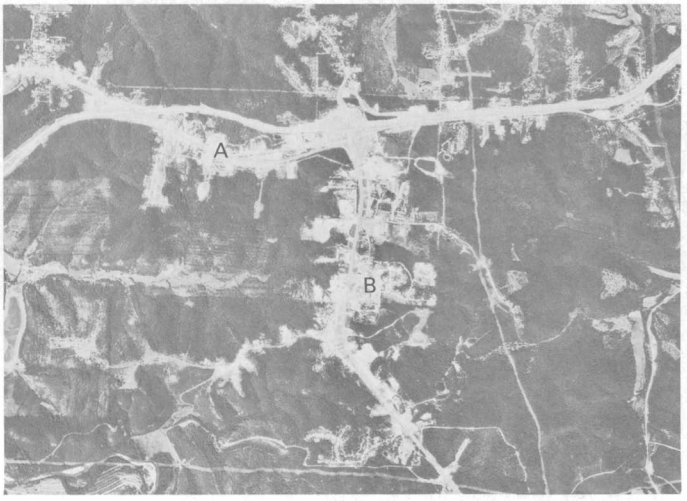


Figure 6-36.--Mapping photograph of commercial strip development, St. Robert, Mo.

Figure 6-37 is a forward oblique photograph of the commercial strip development near the Fort Leonard Wood main gate. Notice the small parking lot facilities associated with the establishments at A, B, and C. In contrast, look at the large shopping center parking lot for the grocery/general merchandise complex at D. This particular example of commercial strip development illustrates how these types of retail goods and services can be provided without adversely affecting the traffic flow of a major traffic artery. Most larger urban examples of commercial strip development are characterized by commercial structures and parking lots abutting the street.

Figure 6-37.--Low-level oblique photograph of commercial strip development near main entrance of the army base at Fort Leonard Wood, Mo.

Site No. 54 (Motels)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°15'N
93°16'W

Figure 6-38 identifies an area of motels paralleling one of Springfield's major arterial streets (Glenstone Avenue). To the north of the area lies Interstate Highway 44. Motels are frequently located along major traffic arteries in proximity to interstate highways.

The key to identifying motels on small-scale photographs such as figure 6-38, in addition to their proximity to major transportation routes, is their linear structure, swimming pools, and individual parking facilities adjacent to the structures.

The large-scale photograph in figure 6-39 identifies swimming pools at A and two areas with swimming pools and tennis courts at B. Individual motel parking facilities are noted at C. Also identified in figure 6-39 is the North Park Mall at D.

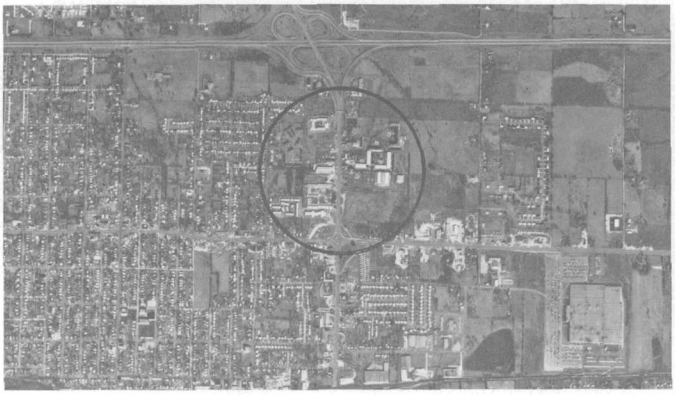


Figure 6-38.--Mapping photograph of motels along Glenstone Avenue in Springfield.

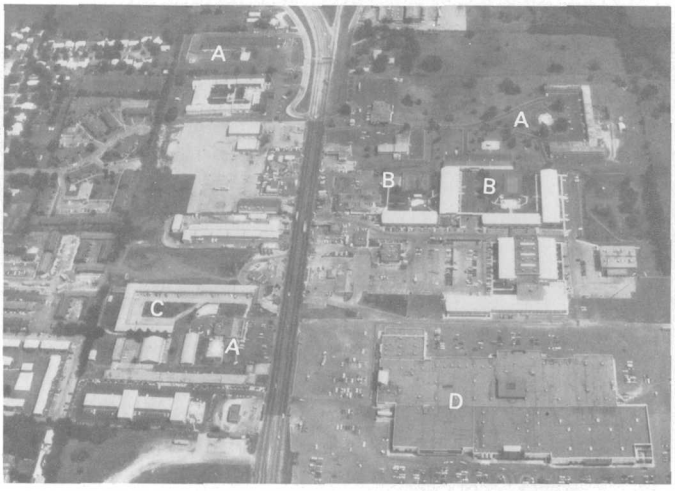


Figure 6-39.--Forward oblique photograph of Springfield motels.

A ground-level photograph of one of the motels is shown in figure 6-40. Note the restaurant facilities nearby.

Figure 6-40.--Motel and restaurant on Glenstone Avenue in Springfield, Mo.

Site No. 55 (Suburban Office Building)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°11'N
93°16'W

Suburban office buildings range from two- to three-story structures to high-rise structures. Firms seeking facilities away from the central business district usually select less-expensive suburban locations with easier traffic access. Site 55 is a suburban office building (figure 6-42) in southeast Springfield which was recently constructed in place of a drive-in theater (figure 6-41). If one were categorizing land use as of the date of the mapping photography (January 1975), the drive-in movie theater would also fall under land use category 12.

Figure 6-41.--Mapping photograph of drive-in theater, January 1975.

Modern office buildings may take on a variety of shapes and designs. Figure 6-42 presents a modern office building nearing final construction phases. The photograph was taken on a weekday in July 1980. Since there are no cars in the parking lot at A, one can assume that the office building was not yet ready for occupancy. Also visible, at B, were several construction trailers. The alternating rows of white and black of the building structure infer that the structure is multi-story. This fact is supported by the ground-level photograph shown in figure 6-43 taken in January 1981. Notice the cars parked in front of the building. Also notice in figure 6-42 at C the well kept grounds at the front of the building, the circular drive, and the area for temporary parking.

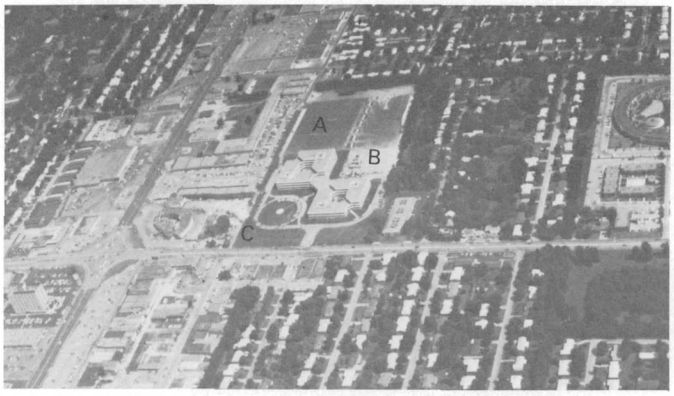


Figure 6-42.--Office building with parking lots.

Figure 6-43.--Ground photograph of office building.

Site No. 69 (State Capitol Building)
Location: Jefferson City
Cole County, Missouri
Geographic Coordinates: 34°50'N
92°10'W

All Federal, State, and local government buildings and adjacent facilities and grounds are placed in land use category 12. Circled in figure 6-44 is the Missouri State Capitol Building and other nearby State office buildings and grounds. Situated adjacent to the Missouri River in Jefferson City, the Capitol and surrounding facilities and grounds are well maintained.

Figure 6-44.--State Capitol Building, Jefferson City, Mo.

As with many State capitol structures, the Missouri State Capitol Building structurally resembles the Nation's Capitol Building. Figure 6-45 more clearly presents the building with its graciously adorned cupola, elevated main entrance and steps, and legislative wings for the Senate and House. Also common among State capitol buildings and grounds is the circular traffic pattern surrounding the structure.

Since parking is always a problem around State capitols, many States construct parking garages nearby. Figure 6-45 shows a multi-level parking garage at A. Also shown in this large-scale photograph at B is just one of many of the State's office buildings.

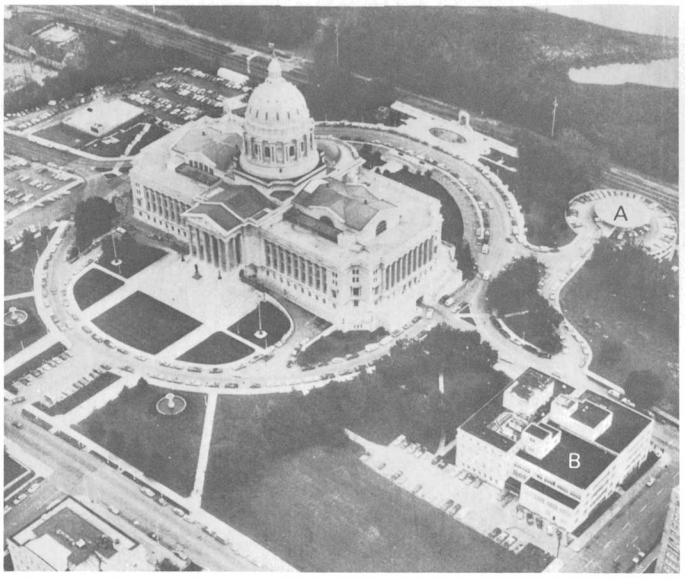


Figure 6-45.--Large-scale oblique photograph of Missouri State Capitol.

Site No. 76 (Warehouses)
Location: Kansas City
Jackson County, Missouri
Geographic Coordinates: 39°06'N
94°32'W

Warehouses are normally large flat-roof buildings located near rail and/or highway transportation facilities. Although seldom located adjacent to major traffic arteries, they usually are located on secondary arterial streets to facilitate access by large semi-trailers. Figure 6-46 is a forward oblique photograph of a major general merchandise warehouse in east Kansas City. Notice the highway at A, the rail facilities at B, and the new warehouse structure at C. Unlike shopping centers which are seldom over two stories, large warehouses such as this one often have more than two stories. Also notice in this photograph the ease of access provided by the surrounding local streets (D).

Figure 6-46.--Low-level oblique photograph of warehouse facility in east Kansas City.

Another recognition factor which can be employed in the identification of warehouses is the amount and location of parking facilities. Unlike shopping centers which have large, well-marked parking facilities adjacent to the retail structure, warehouses have much smaller parking lots located away from the structure (see figure 6-47, point A). Since most of the goods stored in the warehouse are moved by mechanized equipment, few employees are needed to operate a warehouse.

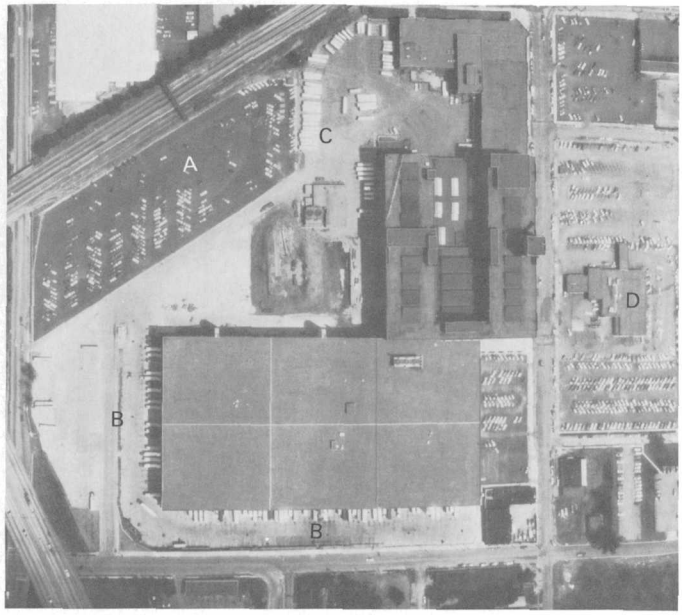


Figure 6-47.--Large-scale photograph of warehouse facility and employee parking area.

Figure 6-47 also shows the areas used to load and unload semitrailers (B). Additional semitrailers not in use are parked at C. A shopping center at D is just east of the warehouse.

A number of semitrailer units are parked at the warehouse loading dock in figure 6-48.

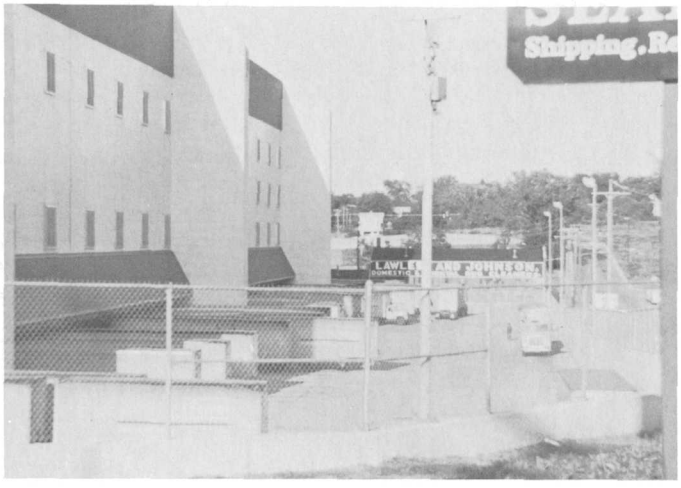


Figure 6-48.--Tractor semitrailers parked at loading dock.

Site No. 77 (Warehouse)
Location: *Kansas City*
Jackson County, Missouri
Geographic Coordinates: 39°07'N
94°34'W

Shown in figure 6-49 are just a few of some of the larger regional distribution warehouses located to the northeast of the Kansas City central business district. Notice the railroad facilities at A and the Missouri River at B.

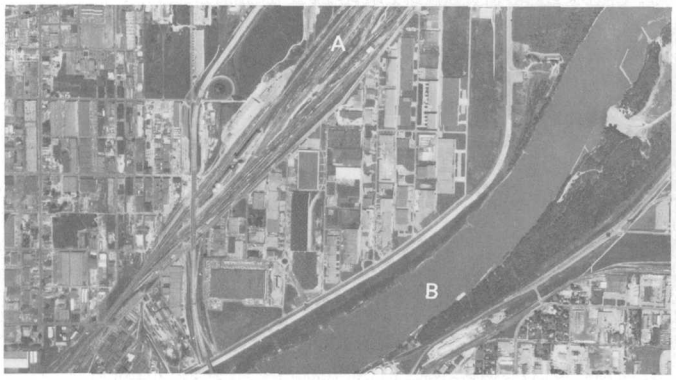


Figure 6-49.--Mapping photograph of warehouse area in Kansas City.

As with the photorecognition characteristics noted earlier for site 76, figure 6-50 shows two other warehouses in which tractor semitrailer units play a major role. The warehouse at A is primarily served by tractor semitrailers, while that at B receives, and possibly ships, goods by *rail as well as* tractor semitrailers. Notice the six railroad boxcars at the loading docks on the east side of warehouse B. Also note the semitrailers parked on the north side of warehouse A and on the west side of warehouse B.

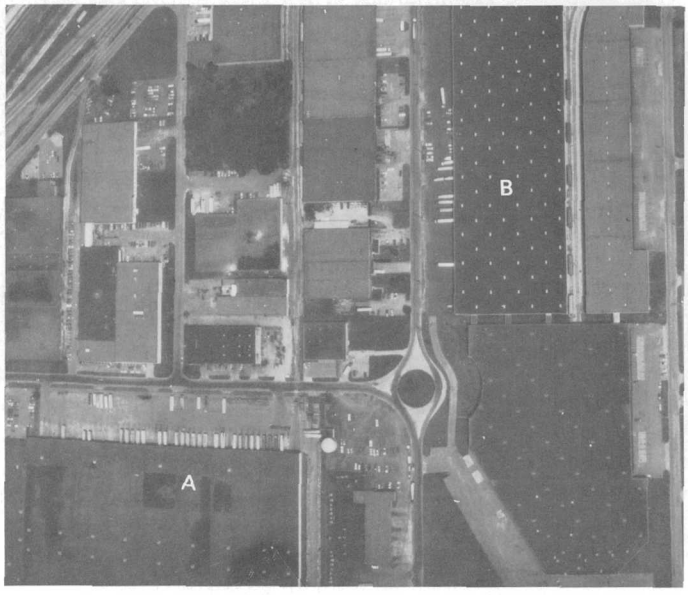


Figure 6-50.--Large-scale photograph of warehouse.

Site No. 72 (Auto Salvage Yard)
Location: Columbia
Boone County, Missouri
Geographic Coordinates: 39°58'N, 92°26'W

Auto salvage yards, such as the one shown in figure 6-51, are included in land use category 12. This particular auto salvage yard is well organized with autos lining both sides of dirt access roads. If not careful, particularly on small-scale mapping photography, a photointerpreter may at first glance believe the area is one of residential development because of the road patterns. However, on closer inspection, one realizes that the roads are too narrow and the rectangular objects (cars) too small and too close together to be houses or mobile homes. At the top of figure 6-51, at A, is the salvage yard office and workshop.

Most communities consider auto salvage yard operations to be eyesores. Therefore, they require auto salvage yard owners to shield their yards from direct view. In urban built-up areas most auto salvage yards are surrounded by high wooden fences. In rural areas, such as site 72, the yards are surrounded by trees. The shielding trees can be seen in figure 6-51 at B and in the ground-level photograph of figure 6-52 at A.

Figure 6-51.--Large-scale vertical photograph of auto salvage yard near Columbia, Mo.

Figure 6-52.--Ground photograph of auto salvage yard.

Site No. 45 (Auto Salvage Yard)
Location: St. Robert
Pulaski County, Missouri
Geographic Coordinates: 37°48'N
92°09'W

Figure 6-53 presents another example of an auto salvage yard. This yard is located near the Fort Leonard Wood U.S. Army base just west of the four-lane access road to the base. As with the previous example, notice how the autos are placed in tightly packed rows with dirt access roads. Also notice the sales office/workshop located at A.

Situated in a heavily wooded area, the yard is obscured from view, particularly from the access road. Notice how the owner/operator of the yard is clearing some of the trees near B to make way for more wrecked or junked autos.

Figure 6-53.--Auto salvage yard at Fort Leonard Wood, Mo.

Site No. 7 (Sports Stadium)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°38'N
90°12'W

Commercial sports complexes such as stadiums, field houses, racetracks, and other recreational complexes such as amusement parks and golf-course clubhouses are included in land use category 12. Such complexes are characterized by well-organized grounds and/or structures with ample parking facilities. Most of the larger complexes, such as sports stadiums, are located near major traffic access routes in metropolitan areas.

Site 7, Busch Memorial Stadium in downtown St. Louis, is typical of sports complexes included in land use category 12. Figure 6-54 shows a sports stadium with parking facilities at A and major traffic access routes at B.

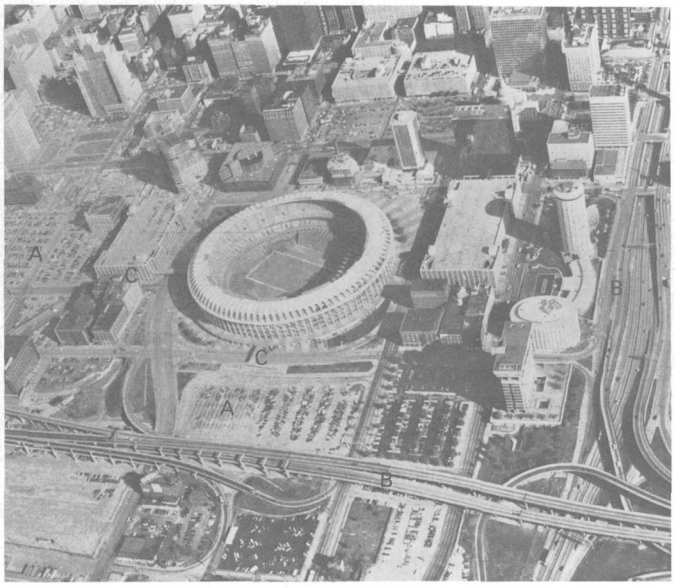


Figure 6-54.--Busch Memorial Stadium in downtown St. Louis, Mo.

Also notice at C the pedestrian walkways extending to the stadium at C from the parking facilities. The stadium, which seats over 50,000, is the home for professional football, baseball, and soccer teams.

This sports facility in the downtown area of St. Louis is surrounded by many open air parking facilities. These facilities are also used by the people employed in the area during the weekdays. Multistoried parking facilities developed in the area, however, they are very difficult to identify on the photography.

Figure 6-55 shows the walkramps to the stadium.

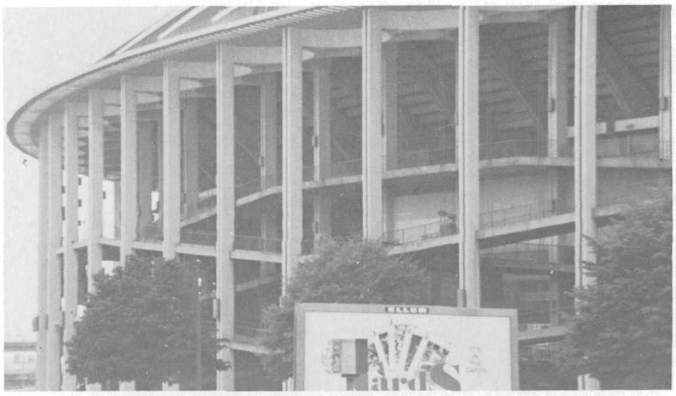


Figure 6-55.--Ground photograph of Busch Memorial Stadium.

Site No. 78 (Sports Stadiums)
Location: Kansas City
Jackson County, Missouri
Geographic Coordinates: 39°03'N
94°29'W

The Harry S. Truman Sports Complex, figure 6-56, is a unique twin sports stadium located on the east side of the Kansas City Metropolitan area at the junction of Interstate 70 and the I-435 bypass. The baseball stadium at A is the home of the Kansas City Royals; the football stadium at B is the home of the Kansas City Chiefs. Notice the extensive area of parking surrounding the stadiums. Also notice the additional parking facilities at C, which have been added since completion of the complex.

As with all major sports complexes, ease of traffic access is very important. Notice the numerous parking access points at D.

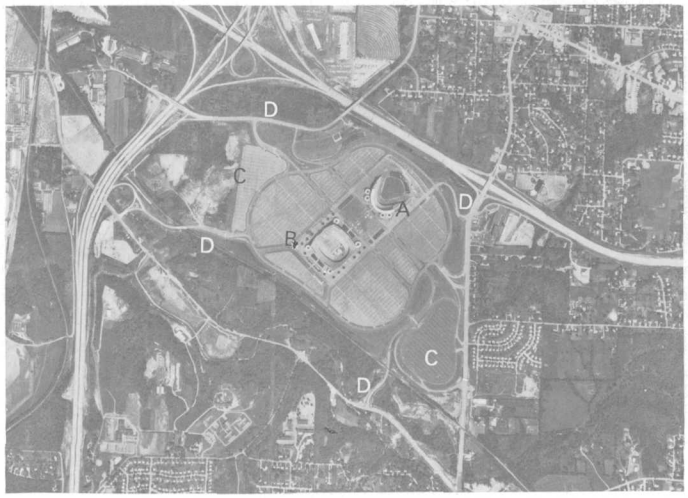


Figure 6-56.--Small-scale photograph of Harry S. Truman Sports Complex, Kansas City.

Figure 6-57 is a large-scale photograph of the sports complex. Notice the walkramps for both the baseball stadium at the top of the photograph and the football stadium in the foreground. The VIP parking area is shown at A. The dark circular areas surrounding the football stadium are shrubbery areas. Also notice the lighter strips on the football field. At the time of this photograph (June 1980) the artificial turf was under repair.

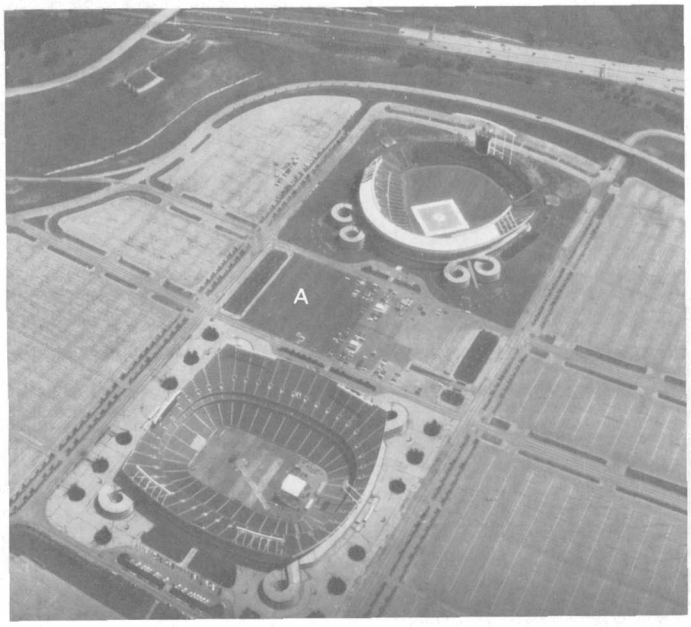


Figure 6-57.--Low-level oblique photograph of sports complex.

Figure 6-58 presents a ground-level view of the sports complex--the football stadium on the left, and the baseball stadium on the right. Notice the spiral walkramp at A.

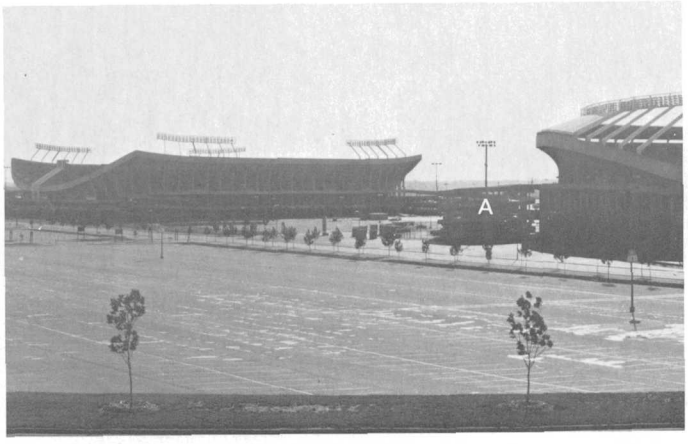


Figure 6-58.--Harry S. Truman Sports Complex.

Site No. 59 (Regional Fairgrounds)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°15'N
93°18'W

Fairgrounds, including associated exhibition buildings, grandstands, racetracks, rodeo arenas, corrals, paddock areas, and midway areas are included in land use category 12. Circled in figure 6-59 is the Ozark Empire Regional Fairgrounds in east Springfield. Originally located away from the Springfield urbanized area, urban encroachment is quite evident in this small-scale photograph. Notice residential structures to the south, Central Bible College to the east, and Hillcrest High School to the north. Figure 6-59 also shows Dickerson Park Zoo, west of the fairgrounds.

Figure 6-59.--Mapping photograph of Ozark Empire Regional Fairgrounds at Springfield.

The facilities associated with this regional fairground area are shown more clearly in figure 6-60. Exhibition buildings are located at A, the racetrack at B, the midway area at C, and the grandstand at D. Notice the lack of parking facilities at the fairgrounds.

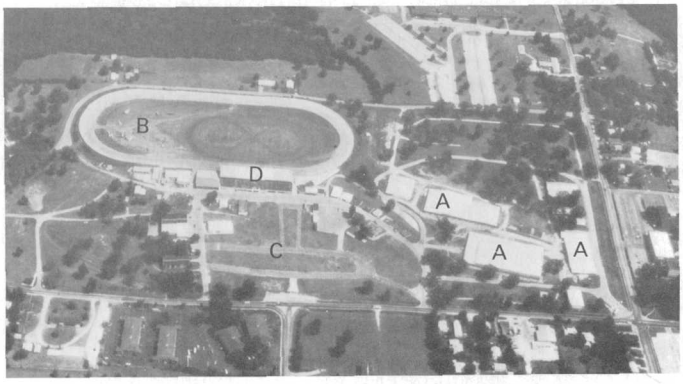


Figure 6-60.--Large-scale photograph of Ozark Empire Fairgrounds.

Figure 6-61 shows one of the exhibition buildings at the fairgrounds.

Figure 6-61.--Exhibition building at Ozark Empire Fairgrounds.

Site No. 5 (Hospital)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°38'N
90°16'W

Medical and health facilities, such as Barnes Hospital in figure 6-62 are included in land use category 12. Since this particular site is adjacent to other Commercial and Services structures it is difficult to identify the site as a medical complex from aerial photographs. One must rely on ancillary data or ground investigations to identify the site as a hospital.

Some features which should be noted in figure 6-62 are the parking facilities at A, the underground parking facilities at B (where the tennis courts are located), and the interconnecting walkways between the buildings such as those at C.

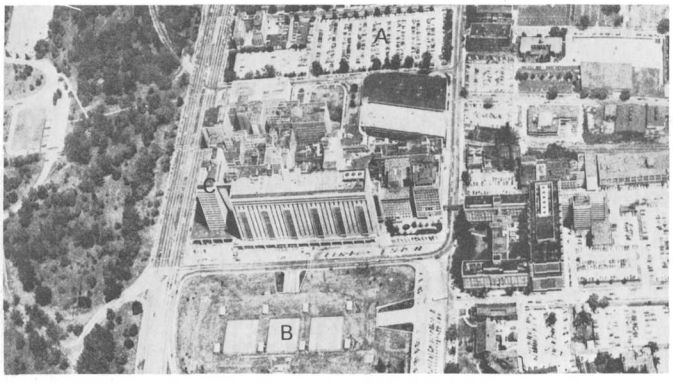


Figure 6-62.--Low-level oblique photograph of Barnes Hospital in St. Louis, Mo.

Pictured in figure 6-63 is a ground-level photograph of the Barnes Hospital complex. Notice the interconnecting walkways at A.

Figure 6-63.--Barnes Hospital, St. Louis, Mo.

Site No. 57 (Hospital)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°11'N
93°17'W

Figure 6-64 depicts another regional medical complex--Springfield's St. John's Hospital serving southwest Missouri. Unlike Barnes Hospital in St. Louis, this medical complex is more easily identified since it is surrounded by residential structures. As with most medical complexes, the multistory buildings and wings are interconnected. Prominent in figure 6-64 is the main entrance to the hospital with the circular drive and covered entrance. A more recent addition to the hospital--an east wing--is shown at A. Ample parking is available at B.

A ground-level view of the hospital is shown in figure 6-65. Notice the cross on top of the complex at A, and the newer wing at B.

Figure 6-64.--Forward oblique photograph of St. John's Hospital in Springfield, Mo.

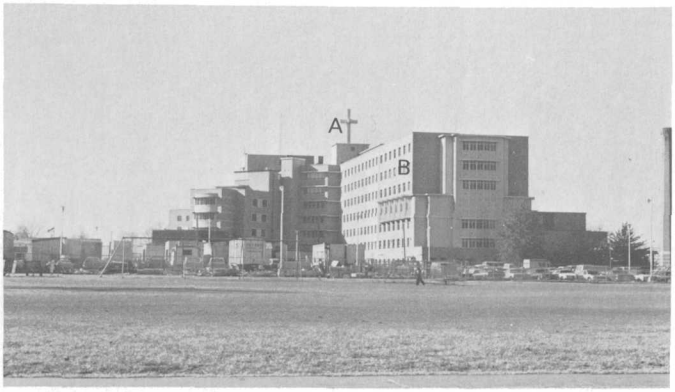


Figure 6-65.--St. John's Hospital, Springfield, Mo.

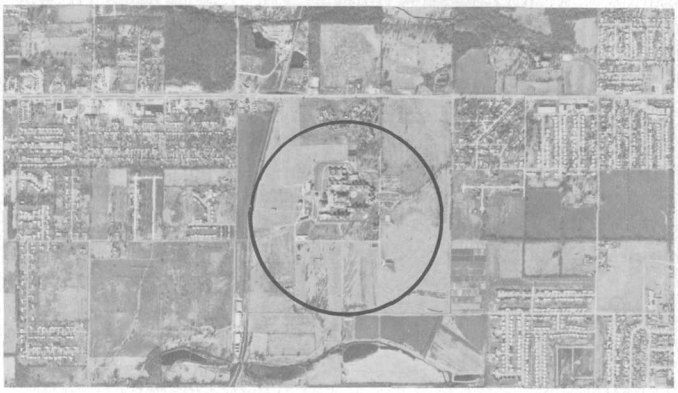


Figure 6-66.--Mapping photograph of Federal Medical Center at Springfield, Mo.

Site No. 56 (Federal Hospital)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°10'N
93°19'W

Federal and State prisons and medical-correctional institutional areas are also included in land use category 12. Figure 6-66 identifies the Federal Medical Center in southwest Springfield. Once located away from the built-up area, urban expansion has produced residential encroachment.

Even though there has been residential encroachment in the area around the institution, there will be maintained a clean buffer zone between the institution and the nearest built-up area.

The Federal Medical Center is a minimum security complex devoted primarily to mental health care and incarceration of individuals convicted of "white-collar" crimes.

Figure 6-67 provides a clearer view of many of the photorecognition characteristics associated with such an institution. Note the double chain link fence at A, the guard towers at B, and the structural similarity of the buildings at C. Also notice the baseball field at D. This particular area is enclosed by yet another wall (point E). A more secure area of the institution is shown at F. Employee and visitor parking facilities are shown at G.

Institutions such as this normally maintain some of their own fuel and water. Behind the double chain link fence to the west is a water tower at H and a storage tank at I. Also visible is a maintenance building at J.

The main entrance to the institution is shown in figure 6-68. Notice the guard tower at A.

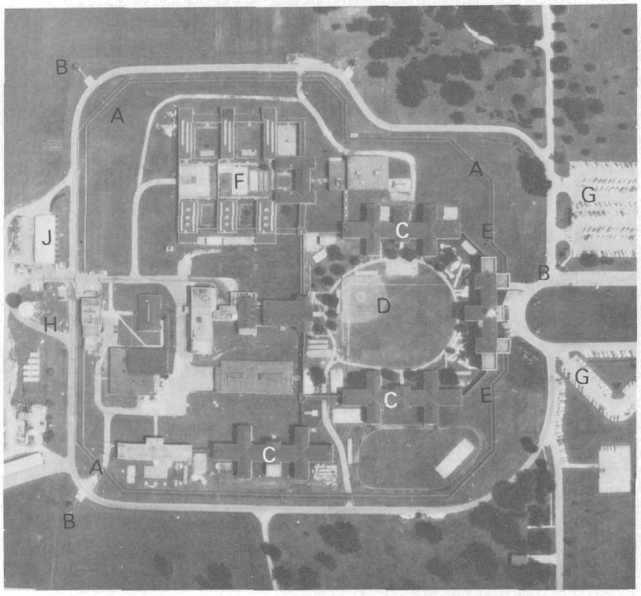


Figure 6-67.--Large-scale vertical photograph of Federal Medical Center.

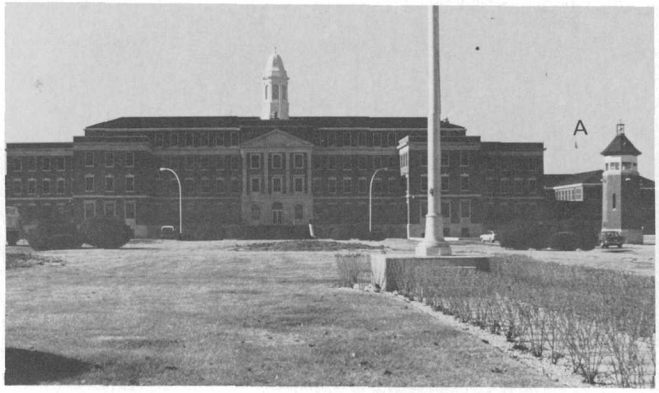


Figure 6-68.--Main entrance to Federal Medical Center at Springfield, Mo.

Site No. 58 (University)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°12'N
93°16'W

All buildings, grounds, and parking lots associated with educational institutions are included in land use category 12. The physical layout of Southwest Missouri State University in Springfield is shown in figure 6-69. Identified in this stereogram are the football stadium at A, tennis courts at B, newer, high-rise dormitories at C, and older classroom buildings at D. Note the relative height differences between the high-rise dormitories at C and the older classroom buildings at D.

Figure 6-69.--Stereogram of Southwest Missouri State University campus in Springfield, Mo. (Note that this photograph is oriented with east at top.)

A large-scale vertical photograph of the campus is shown in figure 6-70. Again, note the football stadium at A, the tennis courts at B, and the high-rise dormitories at C. Also note the availability of parking at D. This photograph was taken in July 1980. Had it been taken during the fall or spring, the parking lots would have been full. Other facilities visible in figure 6-70 include the gymnasium and swimming pool at E, the library at F, the student union at G, and the administration building at H. Finally, note the maze of walkways which link the campus structures.

Also shown in figure 6-70 is a practice field at I. Although it is unlikely, these areas may also fall victim to construction someday.

Figure 6-71 presents a ground-level view of Carrington Hall--the administration building on campus.

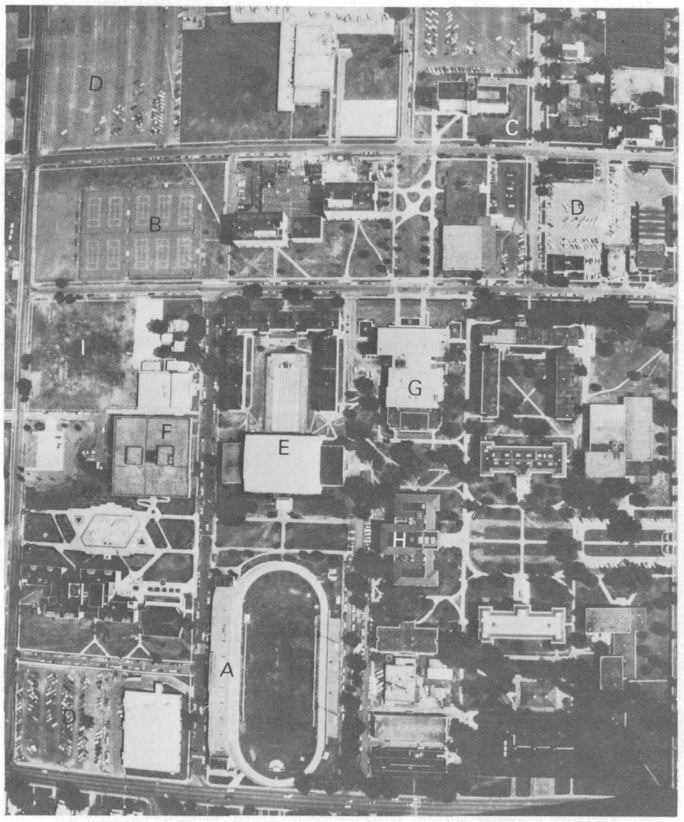


Figure 6-70.--Low-altitude vertical photograph of Southwest Missouri State University campus in Springfield, Mo.

Figure 6-71.--Administration building at Southwest Missouri State University.

Site No. 6 (Intermediate School)
Location: Webster Groves
St. Louis County, Missouri
Geographic Coordinates: 38°34'N
91°22'W

Elementary and secondary schools are most frequently located in residential neighborhoods

away from high traffic-volume areas. As with other institutional land uses, scholastic buildings, grounds, and associated facilities are included in land use category 12.

Elementary schools usually consist of one building with limited recreational facilities. Junior high schools may consist of several buildings and may even have their own football field or stadium. Intermediate and high schools, however, can be characterized as rather large campuses with several separate buildings (normally connected by covered walkways) or with interconnected buildings, large football/athletic fields with viewing stands, and parking facilities for the faculty and staff as well as for the students.

Figure 6-72 is a mapping photograph of Webster Groves Intermediate School southwest of St. Louis. The intermediate school is shown at point A. At point B can be seen a municipal park and recreation area--two ballfields, a swimming pool, and some tennis courts. This latter area should be classified as land use category 17. Also shown in figure 6-72, just north of the school, is Interstate 44.

Figure 6-72.--Small-scale photograph of intermediate school campus and municipal park and recreation area, Webster Groves, Mo.

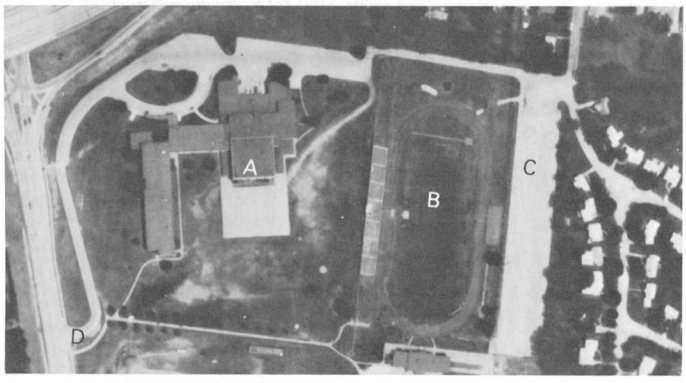


Figure 6-73.--Large-scale vertical photograph of Webster Groves Intermediate School.

Figure 6-73 is a vertical photograph of the intermediate school campus. The school building is shown at A, the football/athletic field at B, and faculty parking facilities at C. Also notice the controlled traffic access at D.

The front entrance to the school and covered passenger loading and unloading area are shown in figure 6-74.

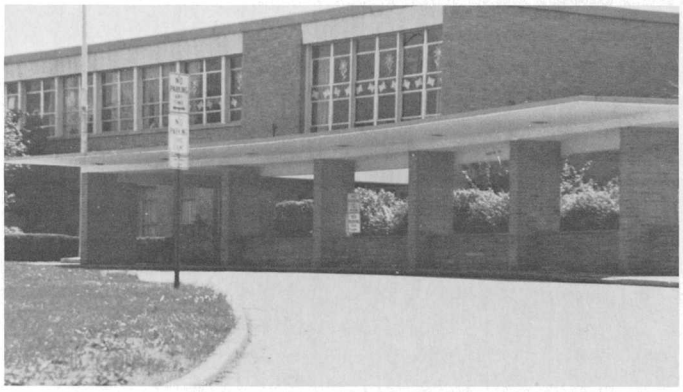


Figure 6-74.--Main entrance and passenger loading area for Webster Groves Intermediate School.

Site No. 48 (Military Installation)
Location: Fort Leonard Wood
Pulaski County, Missouri
Geographic Coordinates: 37°46'N
92°08'W

Figure 6-75 shows several key identification features of most military installations. Point A identifies the main parade ground. Although this particular site is not surrounded by buildings on all sides, most military base parade grounds are surrounded by administrative buildings. Point B, site of the original parade grounds, is now an athletic field. Basic training quarters and instructional buildings are shown at C. On-base, dependent housing facilities are shown at D. A general merchandise warehouse area can be seen at E. Also shown at F is the airfield which serves the base. Point G identifies advanced training barracks and training buildings. Although not shown on this photograph, firing ranges and bivouac areas are located just to the south.

Figure 6-76 presents a large-scale photograph of the main parade grounds at A, the basic training building at B, the base training barracks at C, the base theater at D, and athletic fields at E. Notice the viewing stands on the west side of the parade grounds. Also note the whitish tone of the training area at B where the recruits have denuded the area.

Figure 6-75.--Mapping photograph of Fort Leonard Wood Army base.

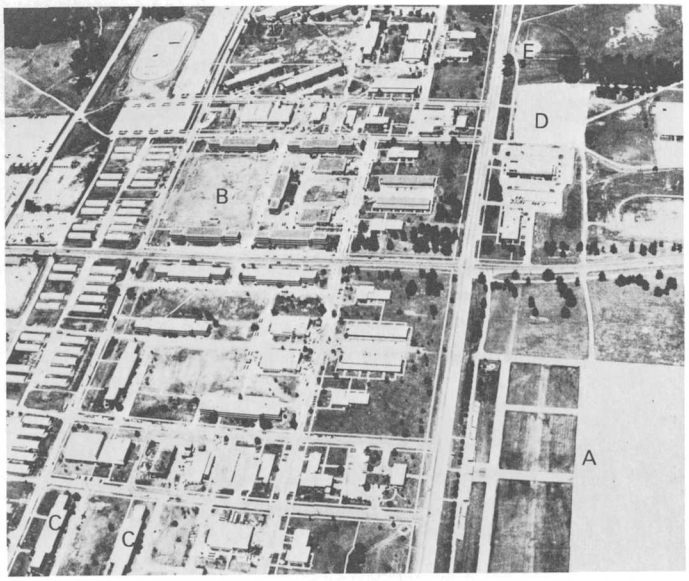


Figure 6-76.--Low-level oblique photograph of main parade grounds and basic training facilities at Fort Leonard Wood, Mo.

Category 13--Industrial

Category Description. Probably no other category in the classification system has such a diversity of structure types as the industrial category. This category covers a wide variety of land uses, from installations involved with product design, assembly, finishing, processing, and packaging to steel mills, cement plants, chemical plants, electric power generators, oil refineries, and mining. In all of these industrial activities, the buildings, parking and shipment areas, and stockpiles of raw materials and waste products are all included in the delineation of the area. For mining, only the surface manifestation of the mining is delineated. That is, the buildings, mine shafts, and spoil material are included. Underground mining activities are not delineated as industrial but rather are shown by the type of surface cover (i.e., agricultural land, forest land).

Different classification systems separate industries into different sub-categories in a variety of ways. The Standard Industrial Classification Manual, for example, describes industrial categories by the generic type of industry as listed below:

Division A - Agriculture, forestry, and fishing
Division B - Mining
Division C - Construction
Division D - Manufacturing

Many metropolitan areas use this classification scheme; however, there are several other schemes used to classify industries (processing industries, manufacturing industries, and fabrication industries). Industries, by whatever classification term is used, have identification features unique to each type. Professional Paper 964 (Anderson and others, 1976) only used the term "industrial;" however, in the descriptive text, it refers to a breakout of light and heavy industries.

To illustrate the difference between light and heavy industries, the following descriptions have been used.

Light Manufacturing. "These light industrial activities are focused on design, assembly, finishing, and packaging of products rather than processing of raw materials. Materials used have generally been processed at least once. Included are facilities for administration and research, assembly, storage and warehousing, shipping, and associated parking lots and grounds. Land held in reserve may also be evident. Among the industries in this category are research laboratories, small textile mills, electronics firms, trucking companies, and even such large industries as automobile assembly plants.

"In comparison with heavy industries, these are relatively 'clean'--contributing considerably less smoke, noise, dust, other effluents, and visual 'pollution.'

"Identification of these industries can be based on type of buildings, parking and shipping arrangements, and location in relation to cities or villages. Unlike shopping centers, large commercial establishments or schools, outdoor storage of materials may be discernible along with trailer trucks parked on the premises. Rail lines may be present. Loading docks and power sources (large transformers, power lines, smokestacks, or large

fuel storage tanks) may suggest a manufacturing process rather than retail sales.

"Occasionally, inactive plants are found. Some have been converted to other uses such as retail sales. Where these uses could be detected, they were mapped accordingly. Otherwise, inactive plants are classified by their apparent former use."[1]

Heavy Manufacturing. These industrial activities may be thought of as dirty, being devoted to heavy fabrication, making and assembling parts which are, in themselves, large and heavy, or to the processing of basic raw materials, including ore dressing operations.

The following description of heavy processing industries is taken from the Manual of Photographic Interpretation.

"Processing industries subject to accumulated raw materials to treatment by mechanical or chemical means or by heat to render them suitable for further processing, or to produce materials from which finished products can be made. Characteristic facilities for storing and handling bulk materials are useful clues to the identity of these industries. Blast furnaces, kilns, chemical processing towers, and large chimneys or stacks are usually visible and serve to indicate the kind of processing being carried on.

"Processing industries usually require large quantities of power; coal piles, fuel tanks, boiler houses, or transformer yards may indicate the source of power. The buildings which house processing equipment are often large and usually complex in outline and roof structure. Since processing usually includes refinement of raw materials, piles and ponds of waste are common; they have to be distinguished from stored raw materials.

"Processing industries can be subdivided according to function into mechanical processing, chemical processing, and heat processing industries. A few industries depart from the functional classification, but this departure does not interfere with the utility of the key.

"Mechanical processing industries are those engaged in sizing, sorting, separating, or otherwise changing the physical form or appearance of the raw materials. They can be identified by the presence of bulk materials stored in piles, ponds, or reservoirs, outdoor equipment such as silos, bins, bunkers, and open tanks, or handling equipment such as conveyors, launders, cranes, and railroad cars. A great deal of power is generally required, and boiler houses or transformer yards are quite common. Buildings are likely to be large and complex. Piles or ponds of waste are also common.

"Mechanical processing industries differ from other processing industries in that they have few pipelines, closed or tall tanks or stacks except those on boiler houses. They do not have kilns.

"Typical mechanical processing industries are ore reducers, sawmills, and grain mills. Plants for hydroelectric power production, water purification, and sewage disposal also fall in this class. Aluminum refining is one of those industries whose images place them in this class although the processes are not mechanical.

"Chemical processing industries separate or rearrange the chemical constituents of the raw materials. Pressure, heat, and catalysts or other chemicals are usually employed. Closed vessels for handling liquids, gases, or suspensions of solids in liquids or gasses are typical of these industries, as is the use of fluid flow in processing. Closed tanks, pipelines, and towers for cracking or distillation are usually visible in photographs of chemical processing industries.

"Heat processing industries refine, separate, or reform the raw materials, or derive energy from them. Large quantities of coal or other fuel, chimneys, stacks, blast furnaces, and kilns are characteristic of these industries. Pipelines and tanks are sometimes used but are never abundant, and their presence, which might be taken to indicate chemical processing, is outweighed by the abundance of objects evidencing the use of heat. Industries typical of this class are thermal electric power plants, iron and copper smelters, cement plants, and clay products plants."[2]

Environmental Considerations. Industrial land use category (13) contains the greatest number of potential sources of pollution. Environmental problems can arise from the open storage of raw materials, the manufacturing of the products, the storage of the finished products and byproducts, and the disposal of waste materials.

The most frequent environmental impact is the deterioration of water quality and soil contamination. These conditions occur because of runoff from the raw materials, improper or careless storage practices for finished products, and improper disposal of harmful waste byproducts.

[1]Description of light industry is taken from the Land Use and Natural Resource Classification Manual (Swanson, 1972), p. 14-15.

[2]The description of heavy processing industries is taken from the Manual of Photographic Interpretation, American Society of Photogrammetry (1960), p. 701-702.

Open storage of raw materials can lead to runoff containing heavy metals, phosphates, and other harmful substances which can find their way into surface and ground-water resources. Contamination from finished products can occur from faulty and leaking storage tanks, unrevetted storage tanks, and careless cleanup practices when a spill or leakage occurs.

The most damaging conditions which occur are the result of improper disposal of waste byproducts. Burying of drums containing toxic chemicals in unsafe landfills; directly discharging toxics into waterways or onto the ground; and unlined, poorly constructed waste lagoons all contribute to the deterioration of both ground and surface water quality.

At the local level, industries also contribute to air and noise pollution. Depending on the type of industry, the air quality in the surrounding area may deteriorate. Some of the air pollution is caused by auto emissions from employee autos and company trucks. Additional air quality problems may arise if the industry uses processes which require the emission of pollutants into the air.

Noise pollution by industry is generally confined to the plant and immediate area, effecting mostly those employed by the industry and nearby residents.

Interpretation Keys. The following examples illustrate various types of industry. These examples by no means cover all the various industrial types, but they do present a good cross section of the Industrial category.

Site No. 8 (Rolling Mills-Steel)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°37'N
90°18'W

This site is an example of a steel rolling mill. The installation would be classified as a heavy or processing industry if compared to the definitions given in the category description. The stereogram, figure 6-77, shows the plant layout, the high-sided buildings, and the raw materials yard.

These types of mills have stacks along the sides of one of the buildings (point A, figure 6-78) which are probably soaking pits where the ingots of metal are heated to the point where the rolling process can form the required steel pieces.

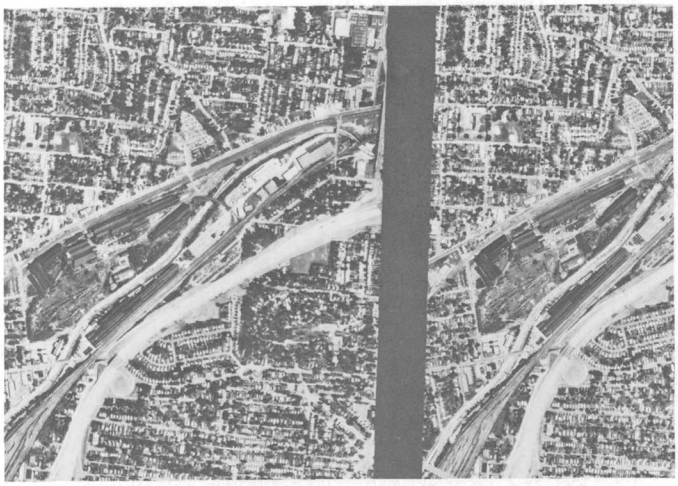


Figure 6-77.--Stereogram of a steel rolling mill, St. Louis, Mo.

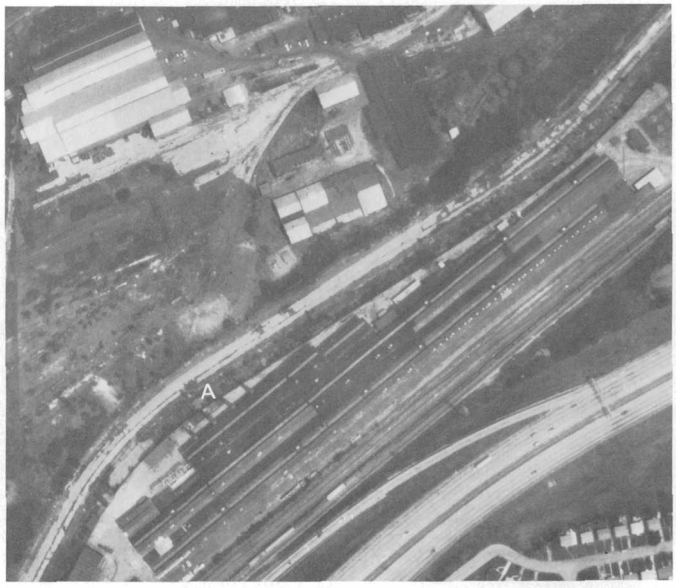


Figure 6-78.--Large-scale vertical photograph of building layout and stacks, St. Louis, Mo.

The identifying features of this type of installation are the long, high-sided buildings with the skylights (figure 6-79). The buildings are constructed in this manner to allow room for the heavy travelling cranes. These cranes move the steel to various processing stations within the buildings.

This installation is serviced by both truck and railroad. There is marked difference in the plant as shown in the small-scale stereogram, dated 1974, (figure 6-77) and the large-scale oblique photograph taken in 1980 (figure 6-80). In figure 6-80, tanks have been removed from A. Lack of raw materials in the

raw materials yard, point B, and absence of finished products would lead one to believe that the mill is no longer active.

Figure 6-79.--Ground photograph of high-sided building with skylights.

Figure 6-80.--Low-altitude oblique photograph of steel mill.

Site No. 9 (Barge Building)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°32'N
90°15'W

This installation is located on the St. Louis waterfront south of mid-town (figure 6-81).

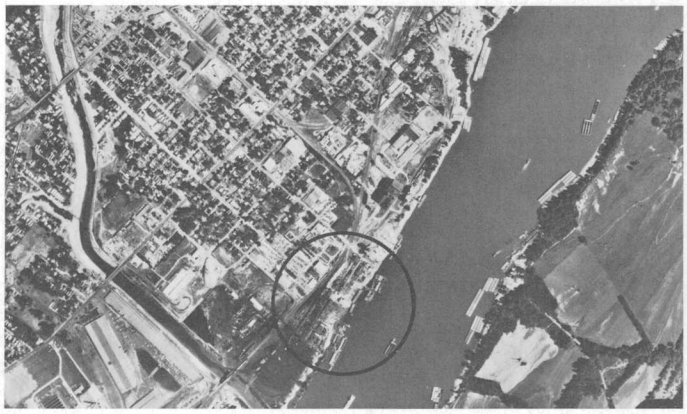


Figure 6-81.--Barge building and repair, St. Louis, Mo.

This installation is a barge-building and barge-repair or refitting operation. There are several identifying features for this installation. Among these are the number of barges in proximity to the installation. The barges are not moored in any systematic manner as they would be if they were being loaded or unloaded.

The primary identifying features of this type installation are shown in figure 6-82. Notice the shipways (marine railings) which are used to launch the vessels at A. The barge is built on the steel tracks, and when the hull is completed, it slides down the ways into the river. After the barge hull is launched, there remains a number of items to be completed, such as the decks and hatches. These jobs are generally completed while the barge is moored in the river. The travelling crane, point B, figure 6-82 and point A, figure 6-83, is used to move steel into position for welding during construction. The raw materials used in barge construction, steel, are shown in the form of rolls at point C, figure 6-82, and at point A, figure 6-84. Directly behind these rolls, at point B, figure 6-84, is a large building where fabrication of pieces of steel for the barges takes place.

In addition to the barges and tugboats moored next to the installation, there are two drydocks which are used to raise the vessel out of the water so that the hull is exposed for repair. At D, figure 6-82, is a tugboat in one drydock, being repaired or refitted.

This installation, although small in comparison to the large shipbuilding yards found in the major port cities, has the same identifying features. The size and length of the shipways will be larger in proportion to the size of the ship being constructed. The crane will be larger as will be the storage and fabrication areas. All of these identifying features will be recognized as a boat or shipbuilding area.

Figure 6-82.--Low-altitude oblique photograph showing plant components.

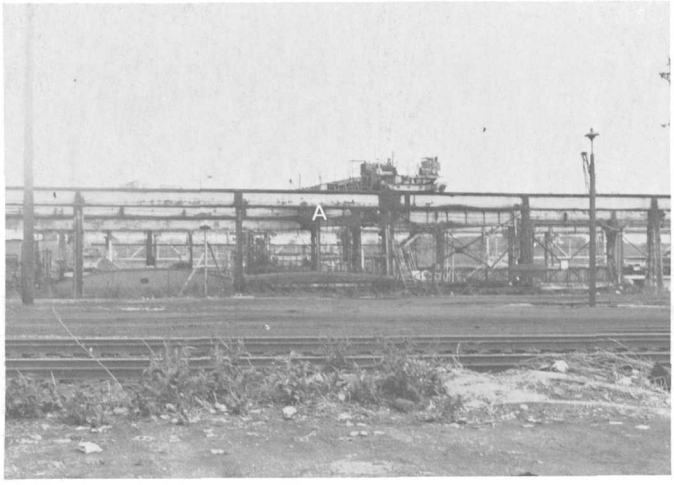


Figure 6-83.--Travelling crane.

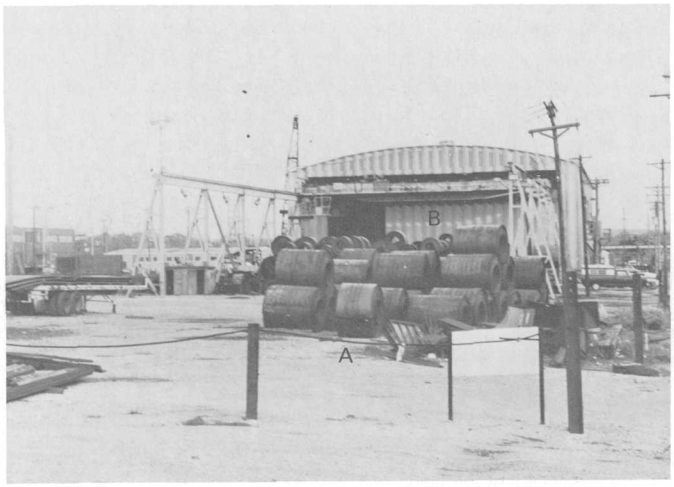


Figure 6-84.--Storage yard and fabrication building.

Site No. 21 (Cement Plant and Quarry)
Location: Cape Girardeau
Cape Girardeau County, Missouri
Geographic Coordinates: 37°16'N
89°32'W

Located near the southern city limits of Cape Girardeau, very near the Mississippi River, the plant shown in figures 6-85 through 6-89 has all of the recognition characteristics of a cement plant. Raw materials for the plant are obtained from the adjacent quarry shown in figure 6-85.

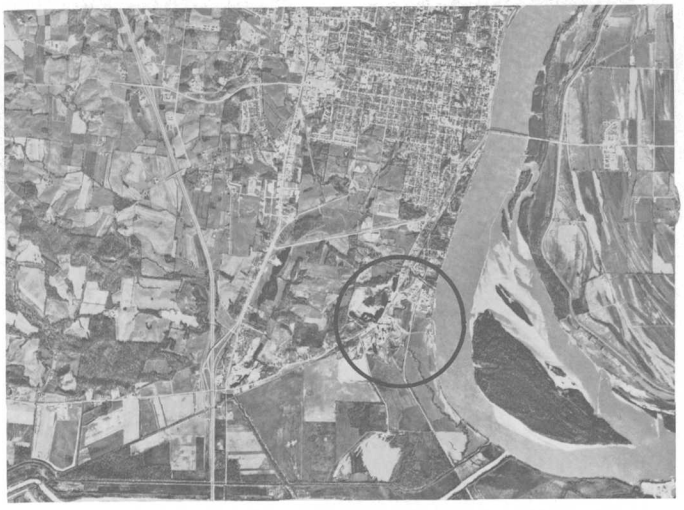


Figure 6-85.--Cement plant with quarry, Cape Girardeau, Mo.

Since the quarry meets minimum size parameters (10 acres), it should be classified as category 75. The raw materials are transported from the quarry to a cement plant by means of a complex conveyor-belt system (figure 6-86).

Additional features associated with cement plants are identified in figures 6-87 and 6-88. Roasting kilns are shown at A in figure 6-87. Actually there are two kilns; however, one is obscured by the construction activity at C. Also shown at B in figure 6-87 are 10 large silos. Several silos are shown in figure 6-88, as well as several cement trucks at A.

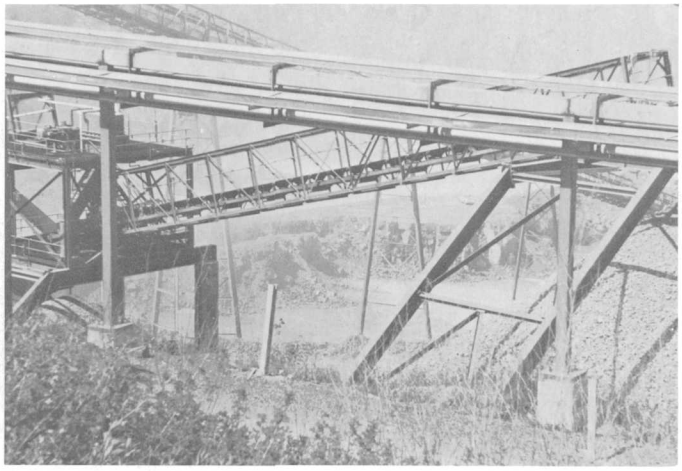


Figure 6-86.--Conveyor belts used for transporting materials to the plant area.

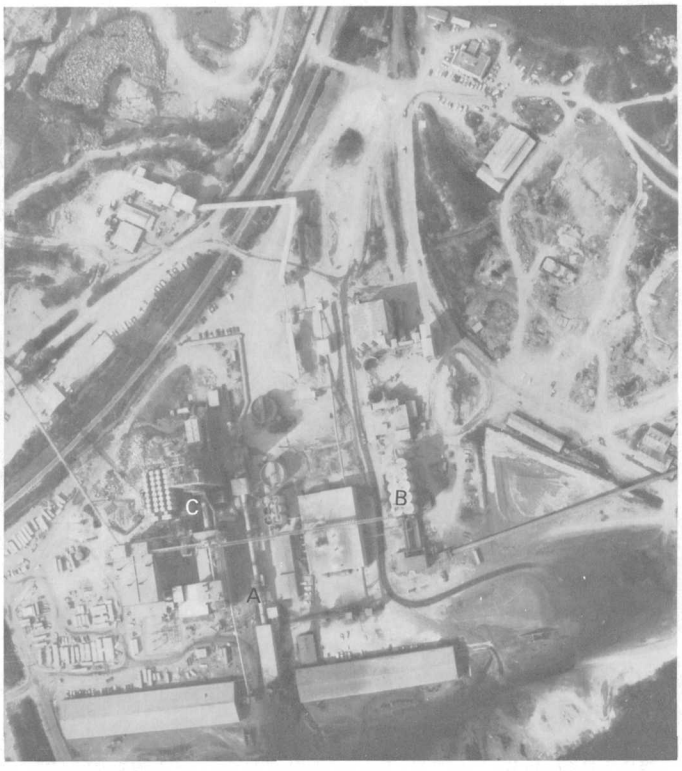


Figure 6-87.--Low-level photograph of cement plant.

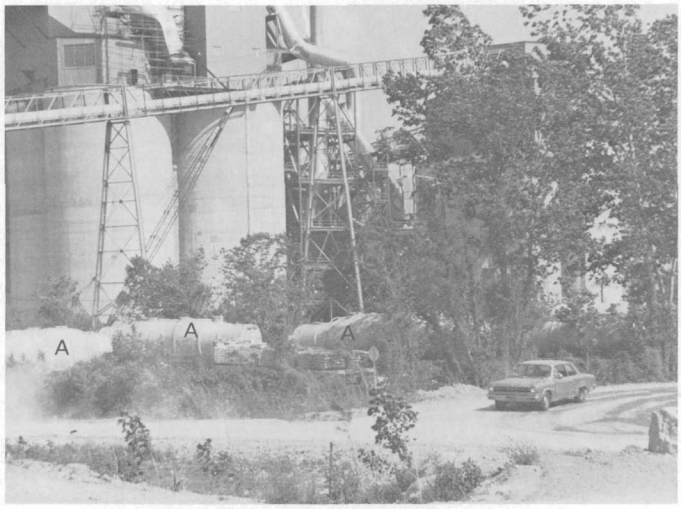


Figure 6-88.--Ground photograph of silos and cement trucks.

Figure 6-89, presents a good view of the entire layout of the cement plant. Notice the quarry at A, the conveyor belts at B, storage silos at C, and the railroad at D. Although not shown on this photograph, port facilities are located just east of the plant area.

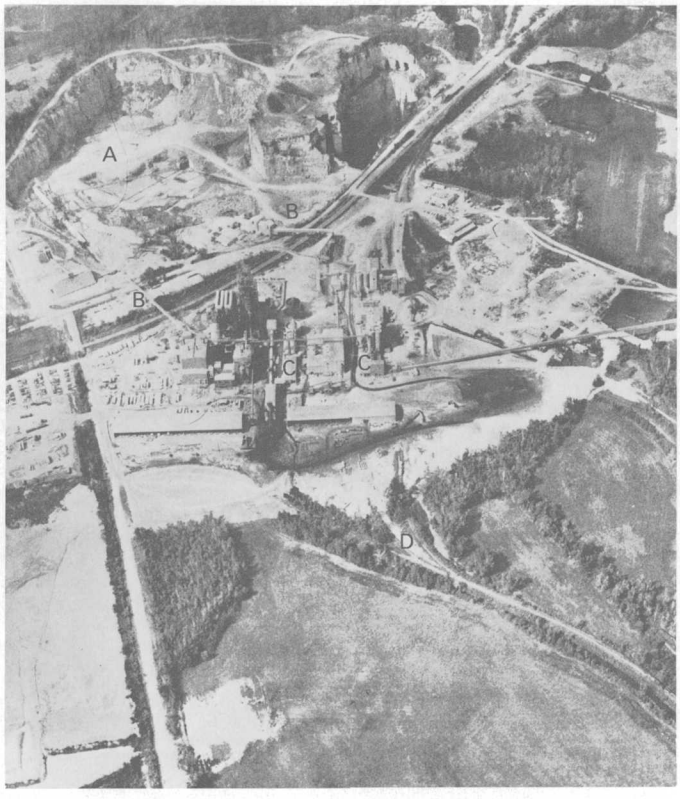


Figure 6-89.--Low-level oblique photograph of cement plant with associated features.

Site No. 35 (Mine)
Location: Bunker
Reynolds County, Missouri
Geographic Coordinates: 37°32'N
91°09'W

The primary purpose of the installation in figure 6-90 is to mine lead ore, process it, and concentrate it for smelting. This mining and the concentration processes that the ore is subjected to are generally the same for other mines in this area. Building arrangement and style of structures may be different; however, the identifying features will be the same. Identifying features of the mine are shown in figure 6-91: one or more shafts at A, an ore crusher building at B, and the concentration building at C. Since the mine uses water floatation, it has its own reservoir.

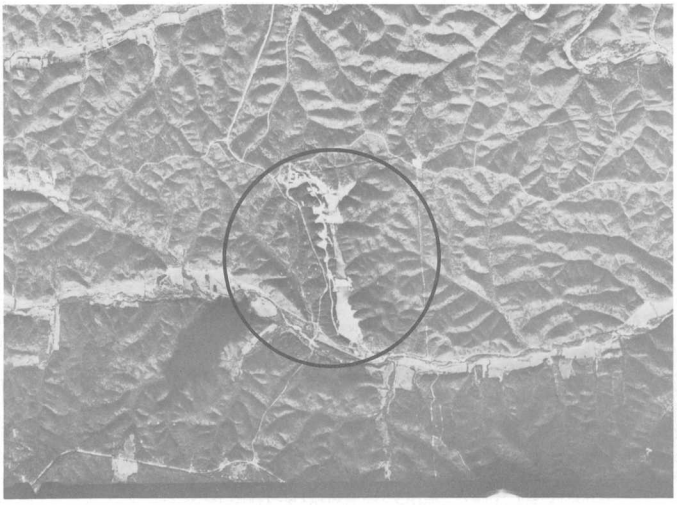


Figure 6-90.--Mapping photograph of a mining installation at Bunker, Mo.

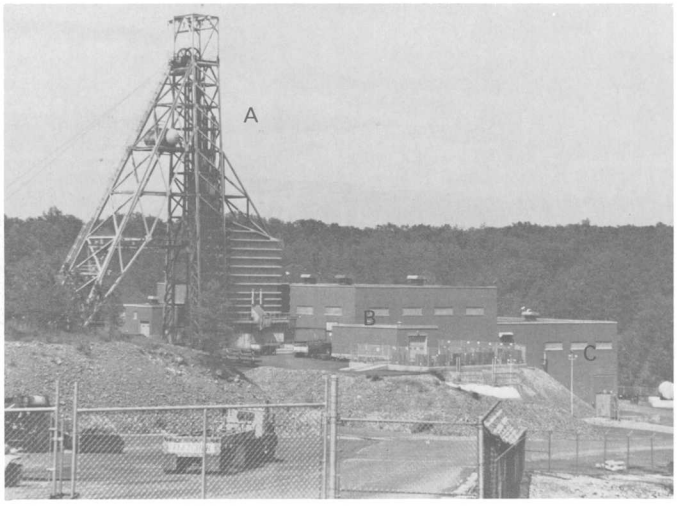


Figure 6-91.--Mine shaft and processing building.

Figure 6-92 shows the plant layout. The reservoir is at A, the mine shafts at B, the crusher and concentrating buildings at D, and dewatering tanks at C. The processing buildings, built on a hillside, allow for gravity flow throughout the processing system.

All above-ground structures and features associated with mining activity, such as the reservoir, shafts, processing buildings, and tailings pond, should be included in category 13. Figure 6-93 shows the spatial relationship of these characteristics: point A--the reservoir, point B--the mine shafts and processing buildings, and point C, the tailings pond.

Figure 6-92.--The mine area, Bunker, Mo.

Figure 6-93.--Mine layout, Bunker, Mo.

Site No. 36 (Metal Processing)
Location: Buick
Reynolds County, Missouri
Geographic Coordinates: 37°34'N
91°08'W

This is a mine and ore concentration site. The final product from this mine is the same as that at site 35. This installation is larger than site 35 and the individual operations are separated. The tailings pond is rather far removed from the mine itself, as can be seen in figure 6-94, where point A is the mine and point B is the tailings pond.

The various components of the installation are connected by conveyors. The layout of the site is shown in figure 6-95. The mine shafts (A) at this mine do not look like the shafts at site 35, however, they serve the same purpose. The primary crusher (B) has a conveyor to the secondary grinder and screener (C) also shown at this operation. Also, there is a feed back to the primary crusher from the secondary grinder. The conveyor then moves the material to the silos (D) for storage awaiting the concentration process (E). The dewatering tanks are shown at F. Since this type of mining operation requires considerable electric power, a transformer yard was constructed at G. Point H indicates the location of piles of ore concentrate.

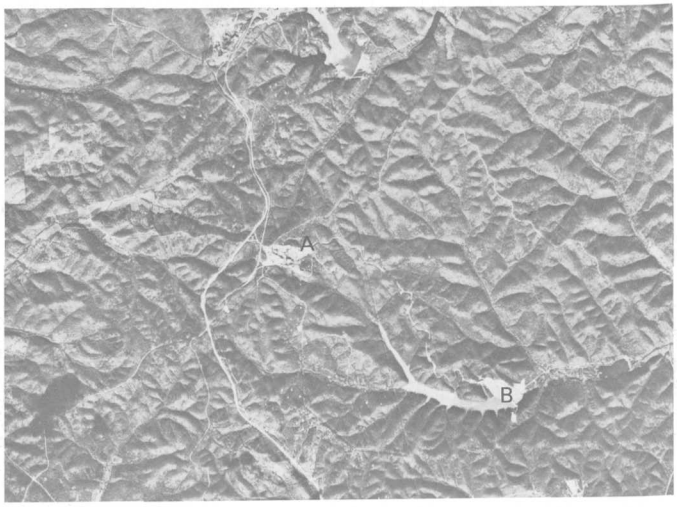


Figure 6-94.--Small-scale photograph of mine area.

Figure 6-95.--Mine layout indicating component points.

The ground photograph (figure 6-96) shows a close view of one of the mine shafts (A), the secondary grinder and screens (B), the storage silos (C), the concentrator and processing building (D), and the transformer yard (E). This mine, like site 35, is serviced by truck and railroad.

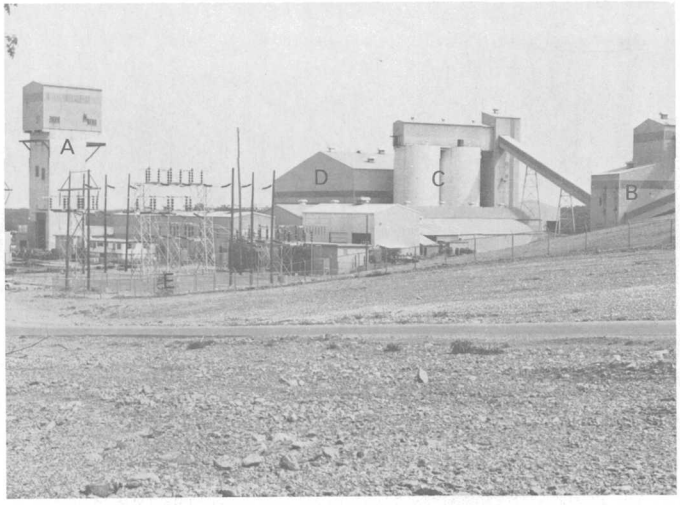


Figure 6-96.--Ground photograph of mine area, Buick, Mo.

Site No. 37 (Mine and Smelter)
Location: Buick
Reynolds County, Missouri
Geographic Coordinates: 37°34'N
91°08'W

Shown in figure 6-97 is the area covered by the mine, smelter, and tailings pond of a large new installation near Buick, Missouri.

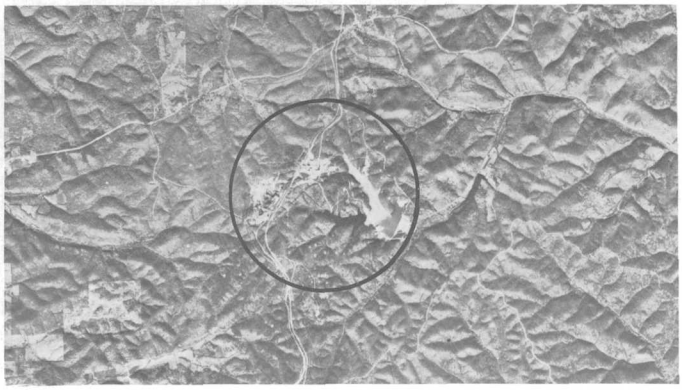


Figure 6-97.--Mapping photograph of mining and lead smelting plant at Buick, Mo.

Figure 6-98 shows a low-level oblique photograph of the mining and concentrator area at A and the smelter area at B. The mining and concentration of lead ore were previously illustrated in sites 35 and 36. Therefore, the description given here is for the smelting area only.

The smelting areas are labeled in figure 6-99. The concentrate and flux begins the smelting process at A where the ingredients for smelting are mixed together. Then, by conveyor, they are transported to B, the sintering building. Sintered material is transported to C, the blast furnace. From the blast furnace the material moves into the refinery building at D. The lead bullion awaits shipment at E. Sulfuric acid is a byproduct of the smelting process. The fumes from the smelting process are piped through the bag house (F) to the acid plant (G) where they are converted to sulfuric acid.

Figure 6-98.--Low-level photograph of the mining and smelter areas.

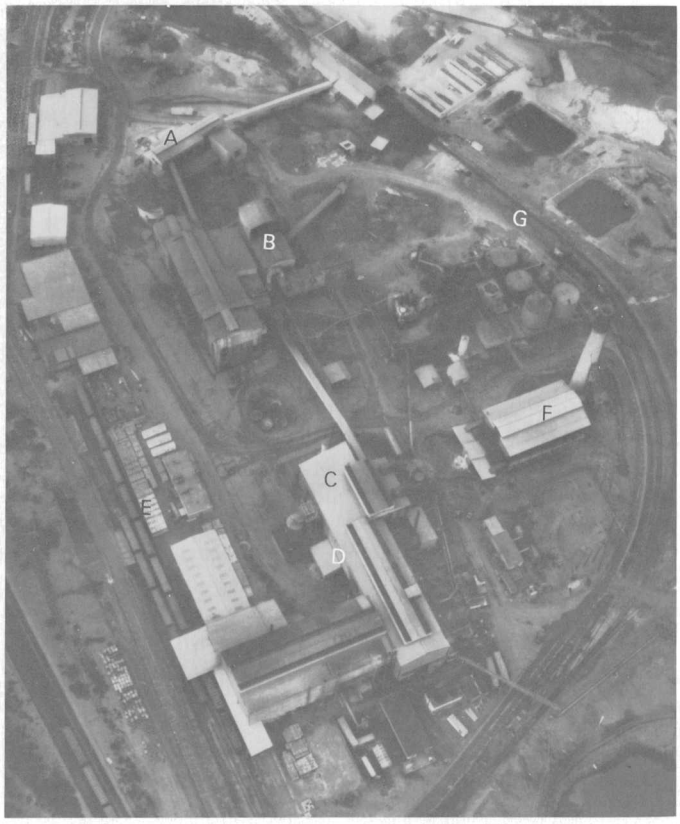


Figure 6-99.--Low-level photograph of lead smelter.

Figure 6-100 shows a ground-level photograph of the mixing building (A), the smelting building (B), the blast furnace building (C), the refinery (D), and the stack for the bag house (E).

Figure 6-100.--Ground photograph of the smelter area at Buick, Mo.

Site No. 50 (Stave Company)
Location: Lebanon
Laclede County, Missouri
Geographic Coordinates: 37°40'N
92°40'W

Site No. 85 (Sawmill)
Location: Potosi
Washington County, Missouri
Geographic Coordinates: 37°55'N
90°51'W

These two sites are lumber-related industries and therefore will be considered together. Site 50 is a stave mill which, in addition to producing barrel staves, also produces walnut fixtures. The stave mill is located in the town of Lebanon (figure 6-101). The sawmill (site 85) is located in a heavily forested area (see figure 6-102) and also produces pallets.

Figure 6-101.--Mapping photograph of the stave company, Lebanon, Mo.

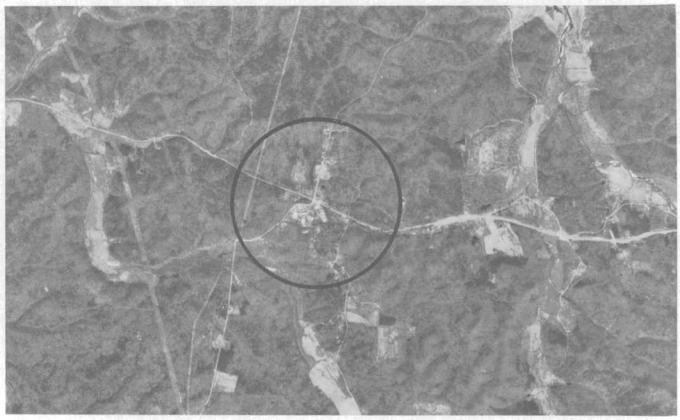


Figure 6-102.--Mapping photograph of the lumber mill near Potosi, Mo.

Raw materials for both plants are wood. However, the sawmill uses logs while the stave company uses processed lumber. Figure 6-103 shows lumber piles stacked at A and stave processing at B. Figure 6-104 identifies the location of the storage area for logs (B) to be processed at the sawmill (A).

The logs, before processing, are shown in the ground shot at A in figure 6-105, while the finished pallets are shown at B.

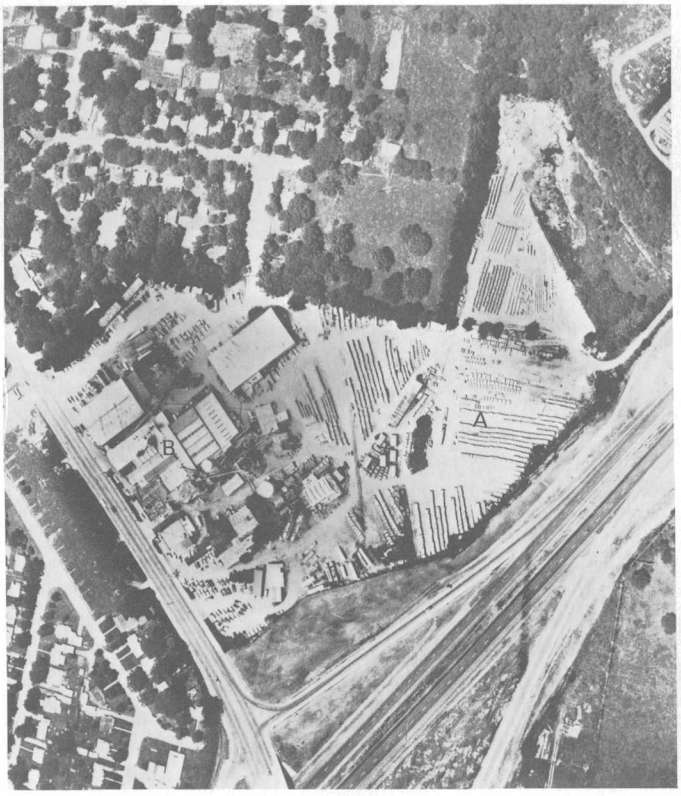


Figure 6-103.--Stave factory, Lebanon, Mo.

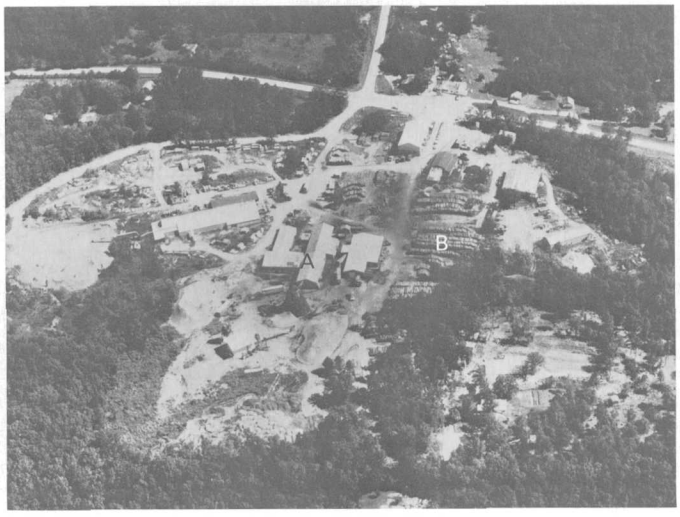


Figure 6-104.--Sawmill, Potosi, Mo.

Figure 6-105.--Sawmill and raw materials.

The one identifying feature which is identical for both of these industries is the sawdust burner. The sawdust burners for the stave factory can be seen in figure 6-106, while the sawdust burner for the sawmill is shown in figure 6-107.

Figure 6-106.--Sawdust burners at the stave factory, Lebanon, Mo.

Figure 6-107.--Sawdust burner at the lumber mill, Potosi, Mo.

Site No. 60 (Light Industry)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°15'N
93°12'W

This plant is located just east of Springfield, Mo., an area surrounded by cropland and pasture (figure 6-108). The features which identify light processing industries are large expansive flat top buildings with low profiles, ventilation outlets on the roof, and silos, at C, for storage of raw materials (figure 6-109). This installation is serviced by rail (A) and by truck (B). Truck loading docks are shown at E and F. The largest concrete apron and truck loading dock (E) is probably the shipping dock, while the railroad and truck loading docks at F are most likely used for delivery of raw materials. Also note the employee parking at D.

Figure 6-108.--Mapping photograph of light processing industry east of Springfield, Mo.

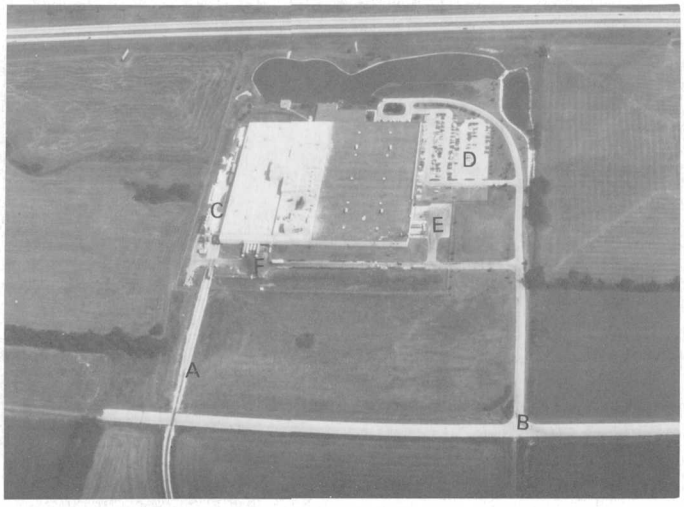


Figure 6-109.--Low-level oblique photograph of light industry.

Also notice in figure 6-110 the rail tank car at A. With light industry, the silos may not always be present, but the remaining identifying features will be.

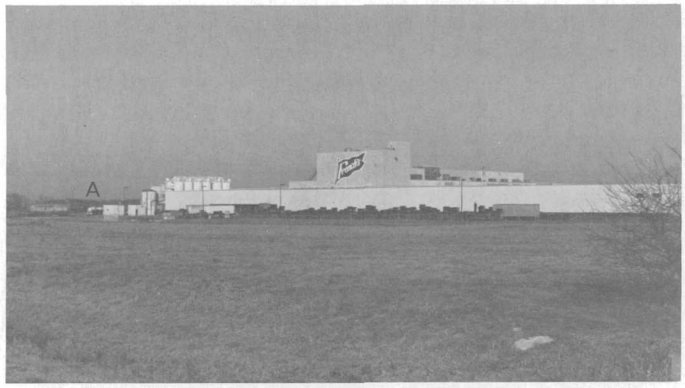


Figure 6-110.--Ground shot of light industry building shows low profile, loading docks, and storage silos.

Site No. 66 (Dam-Hydroelectric)
Location: Table Rock Reservoir
Taney County, Missouri
Geographic Coordinates: 36°36'N
93°19'W

Site No. 71 (Nuclear Power Plant)
Location: Reform
Callaway County, Missouri
Geographic Coordinates: 38°45'N
91°45'W

Site No. 96 (Thomas Hill Power Plant-Thermal)
Location: Thomas Hill Reservoir
Randolph County, Missouri
Geographic Coordinates: 39°33'N
92°38'W

Sites 66, 71, and 96 are power plants. These sites represent the three major types of power generation plants: hydroelectric, nuclear, and thermal. Some of the identifying features are the same for all (transformer yards and transmission lines), while other identification features are unique.

Site No. 66 is a hydroelectric plant. Although there is machinery and equipment associated with this plant, it is housed within the dam. The identifying features associated with this industry are shown on figure 6-111, particularly the dam (A). The electrical generator area is identified by tailraces at B. The water in the reservoir is funneled past

a set of turbines which are rotated by water pressure. The turbines are in turn attached to generators for developing electric current. The transformer yard, at C, is a starting point for transmitting the electric current. In addition to using the dam as a means of generating electric power, the reservoir provides recreational activities. At D, a fish hatchery uses cold water from a reservoir.

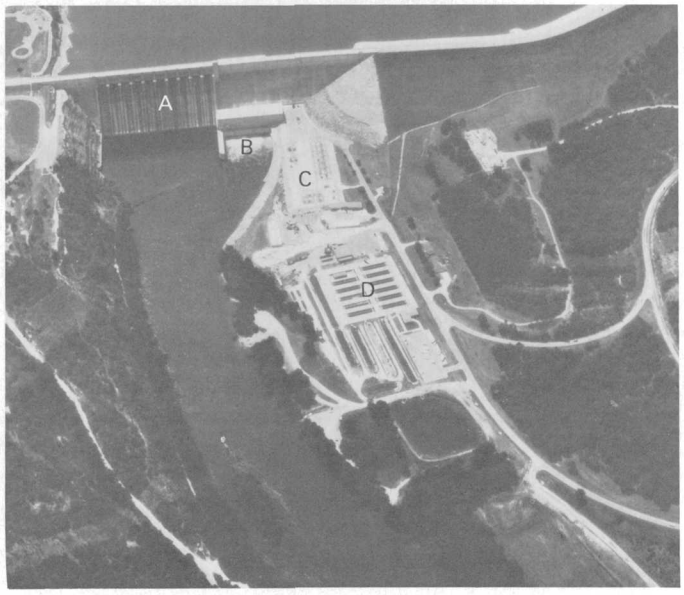


Figure 6-111.--Table Rock hydroelectric power generation dam.

Site No. 71 is a nuclear power plant under construction. Figure 6-112, photographed in July 1980, shows the plant under construction. There are many features which can be used to identify a nuclear plant. Among these features are the cooling tower (A) and the nuclear reactor building (B). In this particular photograph, because these items are under construction, they are difficult to identify. Nuclear power plants require a source of cooling water (C) as do thermal power plants (site 96). In the nuclear plant, the nuclear reactor creates the heat to convert the water to superheated steam which drives the turbines which turn the generators. Prior to discharge, water must be cooled and purified for further use. The ground photograph (figure 6-113), taken in June 1981, clearly shows the cooling tower (A) and the nuclear reactor building (B).

Site 96 is a thermal power plant. Figure 6-114, taken on Apri1 11, 1977, shows the plant prior to recent expansion. The plant is located next to a reservoir so that water needed for cooling is readily available. Also, note that it is located in an area where there is a great deal of surface mineable coal for fuel. Features which identify the installation

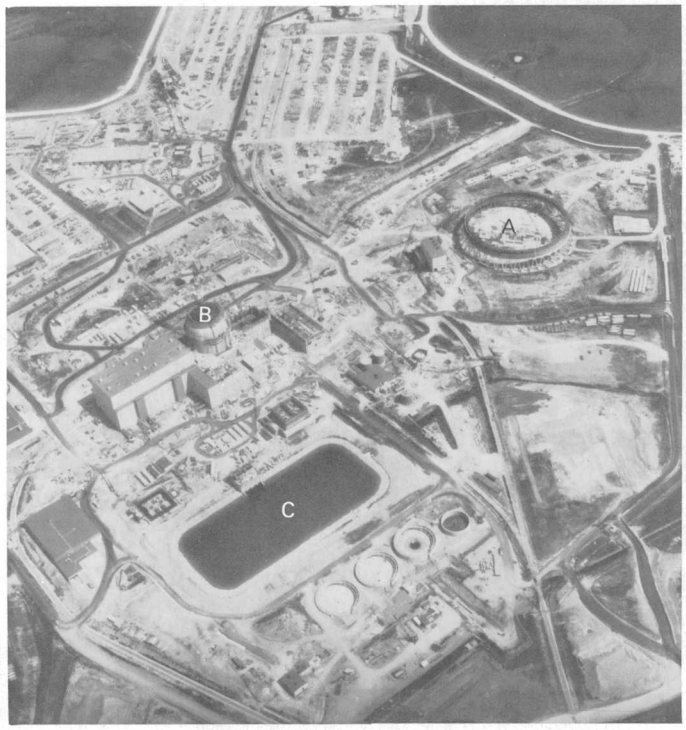


Figure 6-112.--Nuclear plant under construction near Reform, Mo., July 1980.

are shown in figure 6-115: the coal pile (A) to be used for fuel and the conveyor belt which transports the coal to the main plant (B and C). In the plant, the coal is put through tube or ball mills to grind it into a fine powder. This coal powder is used to fire the boiler which heats the water and converts it to steam to turn turbines that run the generators. The water is then cooled (D). Another identifiable feature is the transformer yard (E).

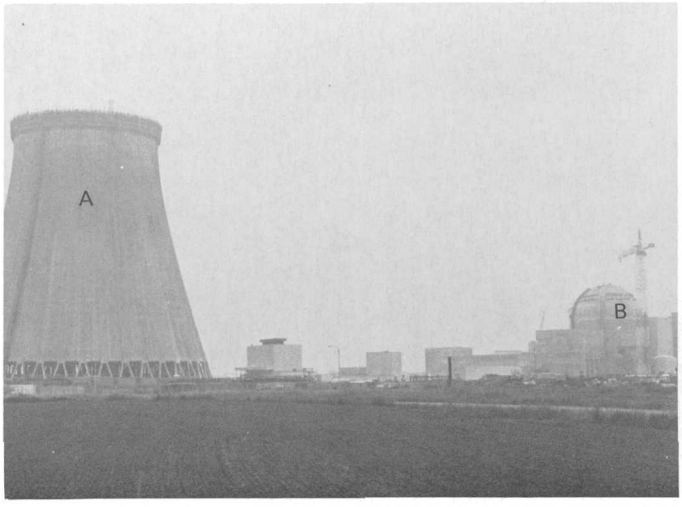


Figure 6-113.--Ground photograph of the same nuclear power plant, June 1981.

Figure 6-114.--Mapping photograph of thermal power plant at Thomas Hill Reservoir, April 1977.

The photograph in figure 6-115 was taken in 1981. Construction has produced a great deal of change since the time the photograph was acquired for figure 6-114.

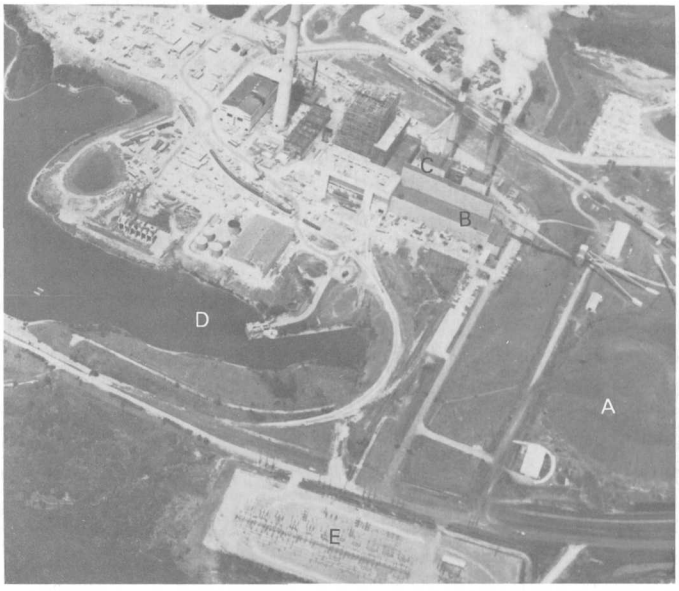


Figure 6-115.--Low-level oblique photograph of the thermal power plant, 1981.

Site No. 81 (Stockyards)
Location: Kansas City
Jackson County, Missouri
Geographic Coordinates: 39°06'N,
94°37'W

This land use type (figure 6-116) is a unique type of industrial installation which does not exist to the extent of the others previously illustrated. If the installation was in the countryside, it probably would be confused with confined feeding category 23.

The installation is served by both railroad and highway. The rectangular pattern of stock pens at A, figure 6-117, is one of its identifying features. The buildings at B are also divided into pens; this can be clearly seen only from the ground (figure 6-118).

Figure 6-116.--Mapping photograph of the stockyards in Kansas City, Mo.

Figure 6-117.--Low-altitude oblique photograph of the stockyards in Kansas City.

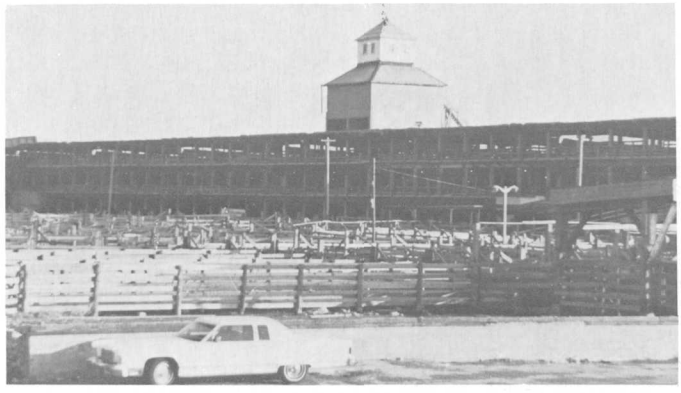


Figure 6-118.--Ground photograph of stockyards.

Site No. 90 (Coal Processing Plant)
Location: Hartford
Putnam County, Missouri
Geographic Coordinates: 40°29'N
92°52'W

This coal processing plant, figure 6-119, is located in the coal surface mining area of northern Missouri. Its function is to receive the coal, crush it, and grade it into specific sizes. The coal is either mined nearby or trucked in from more distant areas for processing. At this installation, the coal is primarily obtained from the surface mine area at point A. At the plant, the coal is moved to the crusher house (figure 6-120), and transported by conveyors to various areas of the yard where it awaits shipment (figure 6-121) to truck loading chutes (B, figure 6-120).

Figure 6-119.--Low-altitude oblique photograph of a coal processing plant near Hartford, Mo.

Figure 6-120.--Low-altitude vertical photograph of processing plant, Hartford, Mo.

Figure 6-121.--Coal in bin awaiting transshipment.

Site No. 100 (Chemical Plant)
Location: Louisiana
Pike County, Missouri
Geographic Coordinates: 39°41'N
91°19'W

This chemical plant, figure 6-122, is divided into various sections which constitute different types of processing. The features which identify this installation as a chemical plant are visible on both the large-scale photograph and the ground photograph. The fractionating towers may be seen in several areas of the plant (A, figures 6-122, 6-123, and 6-124). There are also cooling towers in each area of chemical processing (B, figures 6-122, 6-123, and 6-124). The various types of storage tanks, spherical and cylindrical, are seen throughout the plant (C, figure 6-122 and 6-123). Also visible is numerous piping used for specific processing, as well as for connecting the various parts of the plant. A coal-fueled power plant is located at D, figure 6-122. The plant is served by river, truck, and railroad, as shown at E in figure 6-122.

These Industrial category illustrations are but a few of the land use classification types in the State of Missouri, and represent the categories of light and heavy industry described in U.S. Geological Survey Professional Paper 964 (Anderson and others, 1976).

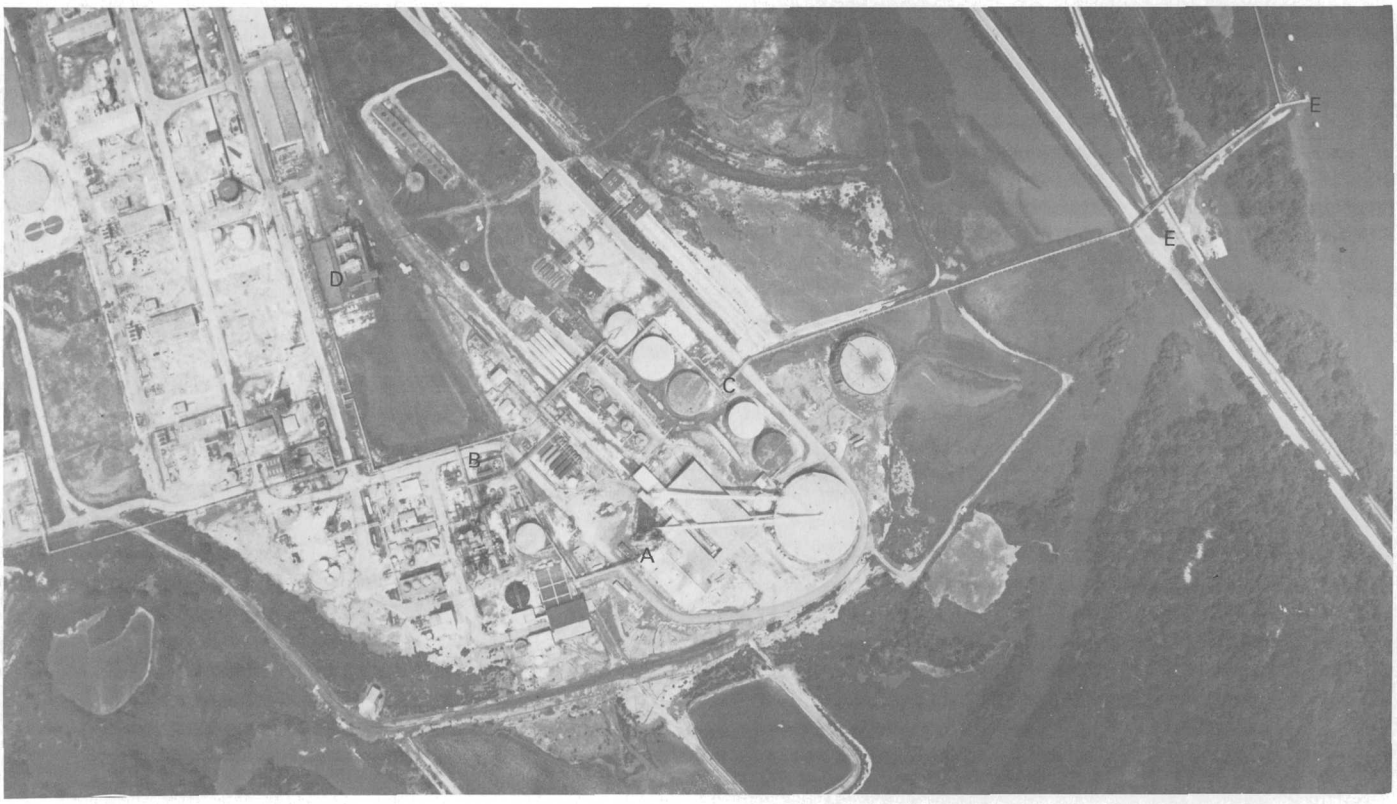


Figure 6-122.--Vertical photograph of the chemical plant at Louisiana, Mo.

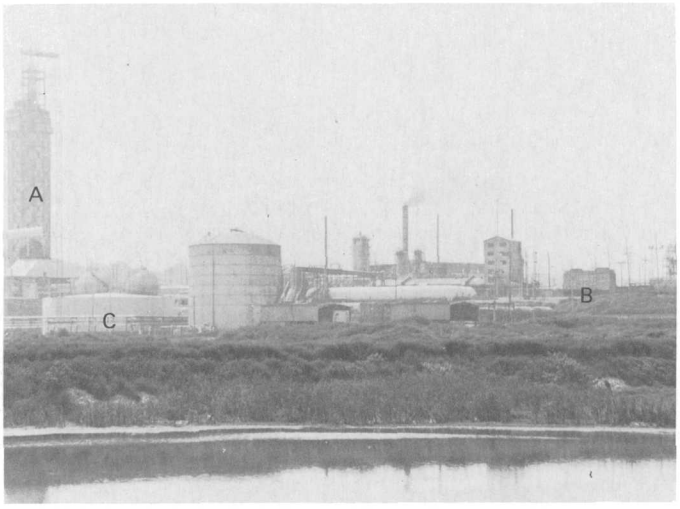


Figure 6-123.--Fractionating columns and tanks.

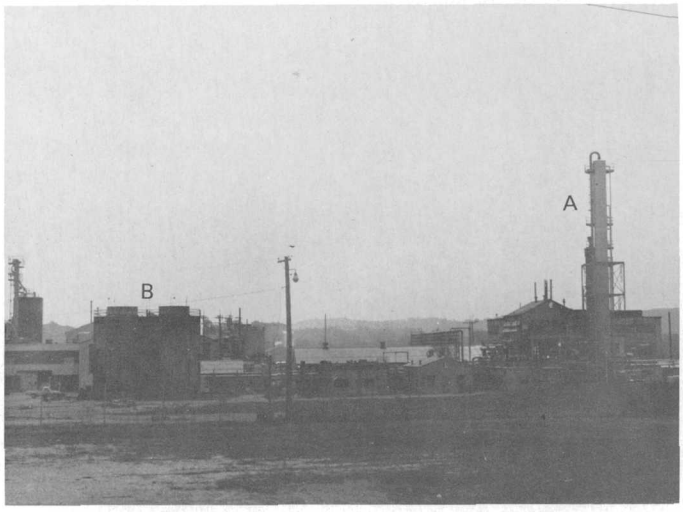


Figure 6-124.--Fractionating columns and cooling towers.

Category 14--Transportation, Communications, and Utilities

Category Description. Major transportation routes and areas greatly influence other land uses. The types and extent of routes determine the degree of access and thus affect the present and potential use of an area.

Linear areas of highways and railroads are among the land use types included in this category. The highways include rights-of-way, interchanges, and service and terminal facilities. Rail facilities include stations, parking lots, roundhouses, repair and switching yards, and related areas. Also included are overland track and spur connections of sufficient width for delineation at mapping scale.

Airports, seaports, and major lake and river ports are also included in this category.

Airport facilities include all the runways, intervening land, terminals, service buildings, navigation aids, fuel storage, parking lots, and limited buffer zones. Port facilities include docks, shipyards, drydocks, locks, and waterway control structures.

Finally, communications and utilities areas are included in this category. Communications and utilities areas are those involved with the processing, treatment, and transportation of water, gas, oil, electricity, and areas used for airwave communications. Included are pumping stations, electric substations, and areas used for radio, radar, or television antennas.

Environmental Considerations. Transportation facilities such as highways, railroads, airports, and riverports are potential water pollution sources. The pollution occurs as a result of runoff and leakage of fossil fuels associated with these facilities. River and lake ports have a high potential for pollution. Leakage and spillage of raw chemicals, petroleum products, coal, and other cargo handled and distributed in ports can be detrimental to water quality and aquatic life, and cause health problems for adjacent communities. Toxic substances such as polychlorinated biphenyl (PCB), used in diesel locomotive transformers and motors, are often stored at railroad yards and repair shops. The land around airport facilities is often used for solid waste disposal, creating a potential for soil and water contamination. Accidental discharge of toxic chemicals in transport via highways and railways can release these poisons to the soil, water, and air. The toxin can sterilize the soil, reduce air quality, and contaminate ground water. Almost all major transportation facilities, especially those with heavy traffic, are generally associated with unacceptable levels of noise and inferior air quality.

Waste-water treatment plants can be a major source of water pollution. Obsolete, inadequate, and overloaded facilities result in the discharge of effluents that do not meet water quality standards, and at times raw sewage may be discharged into the natural drainage system.

When ecologically sensitive areas such as wetlands and forestlands are altered, the whole ecosystem may be changed. Facilities associated with the distant transport of communications and electricity have rights-of-way clearing through forest and other natural areas which can also have adverse impacts on the environment. Rights-of-way are usually sprayed with pesticides and herbicides which can have a detrimental effect on wildlife and contribute to water pollution by surface runoff.

Interpretation Keys. The following nine sites illustrate the land use types associated with the Transportation, Communications, and Utilities category.

Site No. 10 (Highway Intersection)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°38'N
90°17'W

Figure 6-125 shows the intersection of U.S. Highway 40 and Hampton Avenue in St. Louis, Missouri. It is an excellent example of a major urban arterial road and a controlled-access highway. The cloverleaf-type intersections, dividing medians, and the right-of-way, are all included when delineating highways. However, they must meet the minimum width requirements of the land use and land cover specifications (300 feet wide for controlled-access highways). On the aerial photograph, the highway is easily recognizable by its lighter, smooth texture and ribbonlike appearance. The dividing medians between lanes are identified by their darker tone and position. The rectangular images on the road surfaces are cars and trucks.

Figure 6-125.--A low-level photograph of a highway cloverleaf, St. Louis, Mo.

Site No. 11 (Truck Terminal)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°31'N
90°12'W

Truck terminals generally provide maintenance and serve as a transfer point for shifting loads between trucks. They are classified as category 14 whenever they meet minimum mapping size requirements. Such a truck terminal has been circled in figure 6-126. Notice its proximity to a major transportation route--Interstate 55--to its left. The transfer building is the long, narrow, white structure in the circle on the photograph. Near the top center of the circle at A is a smaller square maintenance and repair building.

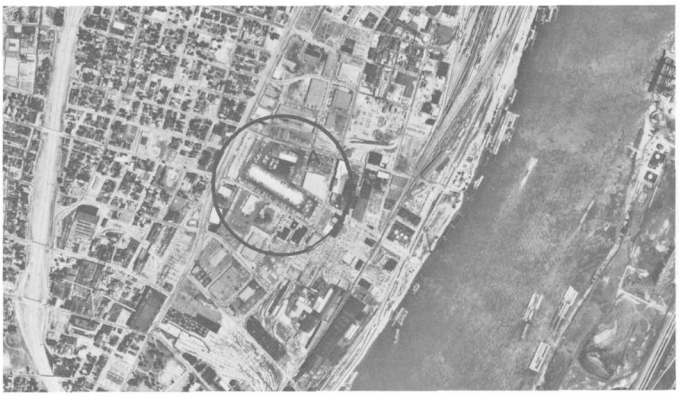


Figure 6-126.--Mapping photograph of a truck terminal, St. Louis, Mo.

Truck terminal facilities can be seen more clearly in the vertical photograph shown in figure 6-127. Notice the transfer building at A, the maintenance and repair shop at B, and parking facilities at C. The volume of business activity at this terminal is reflected by the size of its parking space and the number of trailers parked at the transfer building.

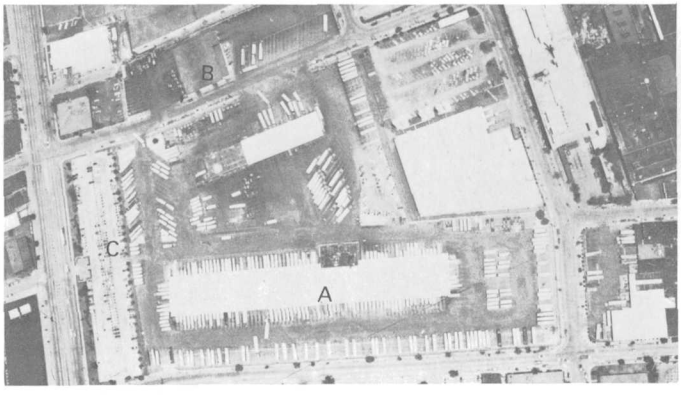


Figure 6-127.--Truck terminal, St. Louis, Mo.

Site No. 12 (Railroad Yards)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°35'N
90°12'W

Rail facilities in this land use category include stations, roundhouses, repair shops, switching and storage yards, and related areas, as well as surface track and spur connections of sufficient width for map delineation.

Rail facilities circled in figure 6-128 are representative of those in land use category 14. Often single- and double-track railroad beds are too narrow for delineation on small-scale land use maps.

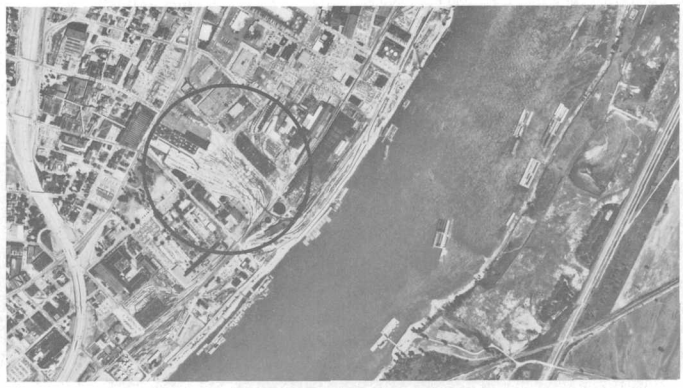


Figure 6-128.--Mapping photograph of rail facilities, St. Louis, Mo.

The southern choke-point for these yards is shown at point A in figure 6-129. The choke-point is that point in the yards where the main line branches out into the rail yards. Figure 6-129 also shows related rail facilities (switching and storage yards at B, repair shops at C, and a warehouse at D). Notice the tracks entering the repair shops. At D, notice the truck trailers backed up to the warehouse loading docks (docks not visible).

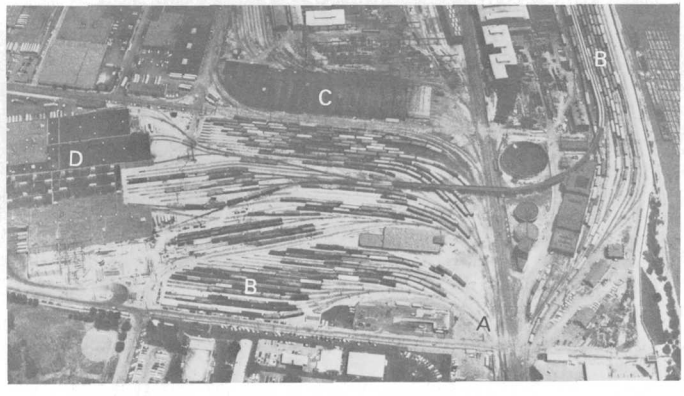


Figure 6-129.--Low-level oblique photograph of rail facilities on St. Louis waterfront.

Railroads, with their yards, tracks, and repair facilities, are easily recognized by their linear pattern. The yards all emanate from a choke-point on the main tracks, the

spurs usually parallel storage buildings, and repair shops have tracks entering or running through them.

Site No. 61 (Railroad Yards and Repair Shops)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°13'N
93°20'W

Figure 6-130 presents another view of a railroad yard with repair shops. As with site 12, this railroad facility exhibits the common photorecognition characteristics--a widening area of parallel tracks emanating from a choke-point on the main tracks, large repair buildings with tracks entering the structures, and an irregular track pattern in the repair area of the railroad yard.

Figure 6-130.--Mapping photograph of the railroad yard at Springfield, Mo.

Figure 6-131.--Low-altitude oblique photograph of the switching yard and repair shops.

Site details are seen in figure 6-131. Located at Springfield, the site is part of the Burlington Northern railroad line. Repair shops are located at A, while the main switching and car storage area is at B. Notice the irregular track pattern of the repair area. The repair shop and employee parking lot are shown from ground level in figure 6-132.

Figure 6-132.--Burlington Northern diesel repair shop.

Site No. 42 (Airport)
Location: Vichy
Maries County, Missouri
Geographic Coordinates: 38°08'N
91°46'W

Airports, with their runways, hangars, shops, and associated facilities, are included in land use category 14. Airports vary in size from grass landing strips to vast complexes in urban areas. The key identifying photographic feature of an airport is an area cleared of vegetation and other obstructions and with long, linear runway surfaces. If the airport is more than just a grass landing strip (which are not shown on 1:250,000-scale U.S. Geological Survey land use and land cover maps), it will normally have smaller parallel taxi strips, aircraft parking aprons, hangars, and passenger terminals. The primary runways are normally oriented into the prevailing wind.

Figure 6-133 is a stereogram of the Rolla National Airport at Vichy. This stereoscopic image illustrates level terrain of the airport.

The airport's primary function is to provide maintenance and storage facilities for general aviation aircraft. Charter flights are also common; however, at the time of this writing, there were no scheduled commercial flights. This accounts for the lack of large terminal buildings and other built-up facilities in figure 6-134. The main runways are located at A and B, the main hangars at C, and taxi strips at D.

Figure 6-135 shows three DC-3 aircraft parked in front of one of the main hangars.

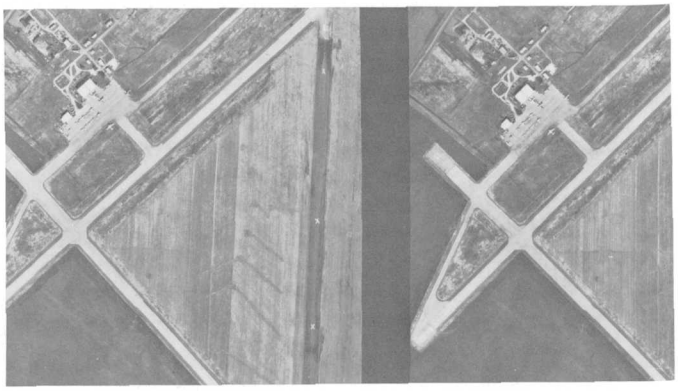


Figure 6-133.--Stereogram of airport at Vichy, Mo.

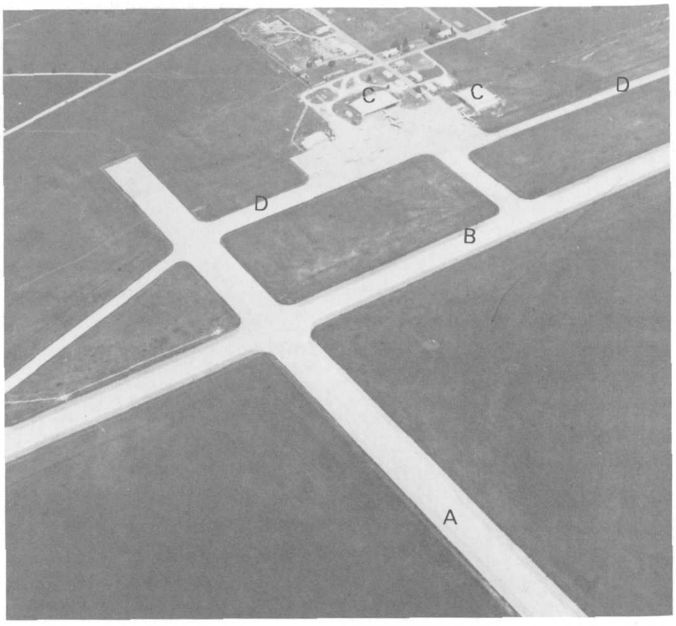


Figure 6-134.--Low-level oblique of Rolla National Airport at Vichy, Mo.

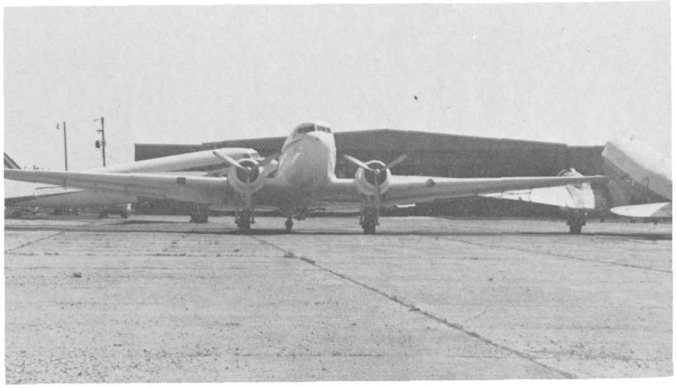


Figure 6-135.--DC-3 aircraft parked on apron at Rolla National Airport, Vichy, Mo.

Site No. 62 (Downtown Airport)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°13'N
93°15'W

Figure 6-136 shows the Springfield Downtown Airport. Like most downtown airports, open areas which once surrounded the facility are now occupied by residential (A) or commercial structures (B). Frequently, these airport facilities are abutted by other land use categories. As residents become more and more concerned about potential aircraft accidents, more attempts are made to close the facilities.

Figure 6-136.--Mapping photograph of Downtown Airport, Springfield, Mo.

Figure 6-137, depicts the single paved runway at A, taxi strip at B, parking aprons (grass rather than hard surface), and hangar facilities at C.

Figure 6-137.--Downtown airport, Springfield, Mo.

Site No. 14 (Municipal Water Treatment Plant)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°45'N
90°11'W

One of the two municipal water treatment plants in St. Louis, Missouri, is pictured in figure 6-138. This plant, the Chain of Rocks Waterworks, uses the Mississippi River for its water source. The water is pumped into settling tanks where, after a period of time, heavier particulate materials and impurities settle out. Later the water is filtered, chlorinated, and then distributed to the city's water mains. The settling tanks and water treatment areas are more clearly shown in figure 6-139. The settling tanks appear as the larger rectangular tanks at A, the water treatment tanks are square tanks at B, and the treatment plant is shown at C.

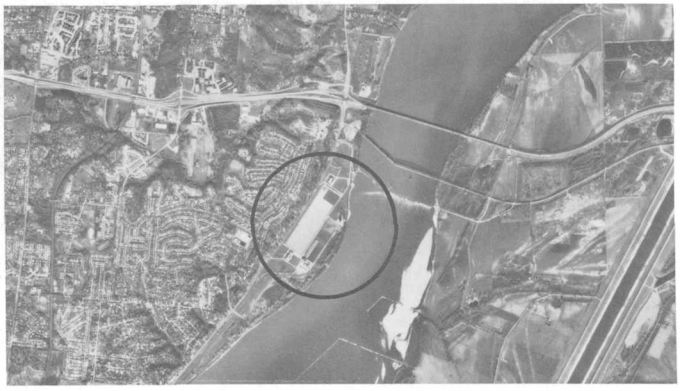


Figure 6-138.--Mapping photograph of Chain of Rocks Waterworks in St. Louis, Mo.

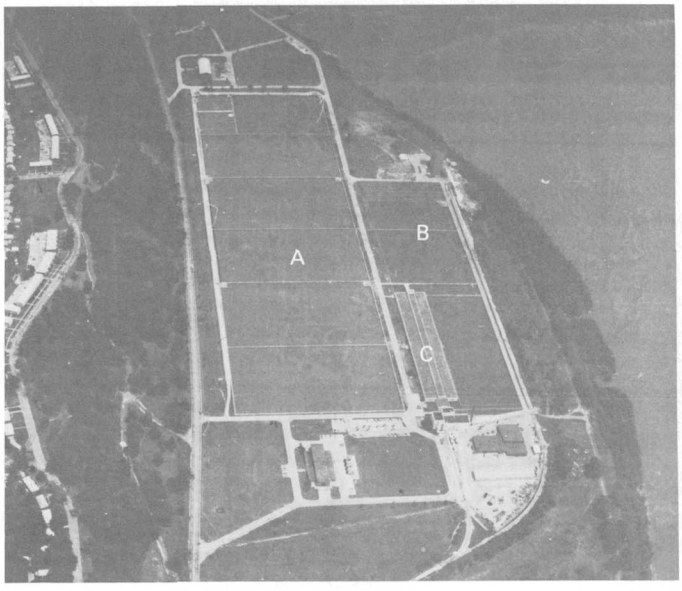


Figure 6-139.--Oblique photograph of Chain of Rocks Waterworks.

Figure 6-140 presents a ground-level photograph of the settling tanks in the foreground with the treatment plant in the background.

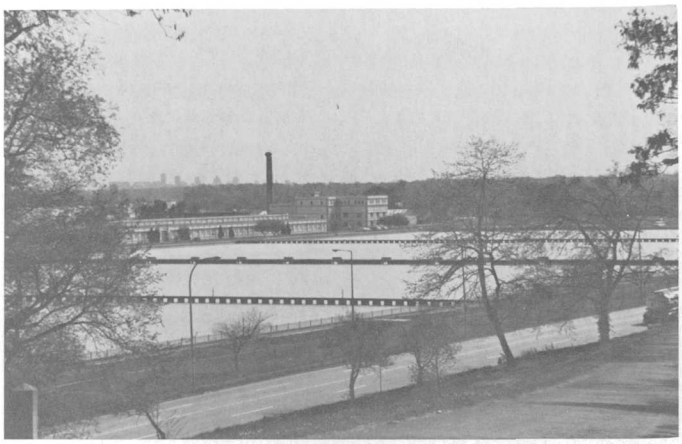


Figure 6-140.--Ground-level photograph of Chain of Rocks Waterworks.

Site No. 63. (Water Treatment Plant)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°10'N
93°13'W

This plant, just newly constructed, supplements the supply of water provided by the plant at Fullbright Spring. The water for the plant is pumped from the James River, treated, then pumped into the city's water mains. The low-level vertical photograph shown in figure 6-141 was taken in July 1980, near the final phases of construction. Notice the rectangular shape of the treatment tanks.

A visit to the site in January 1981 revealed that the plant had been placed in operation (see figure 6-142).

Figure 6-141.--Water treatment plant under construction, July 1980, Springfield Mo.

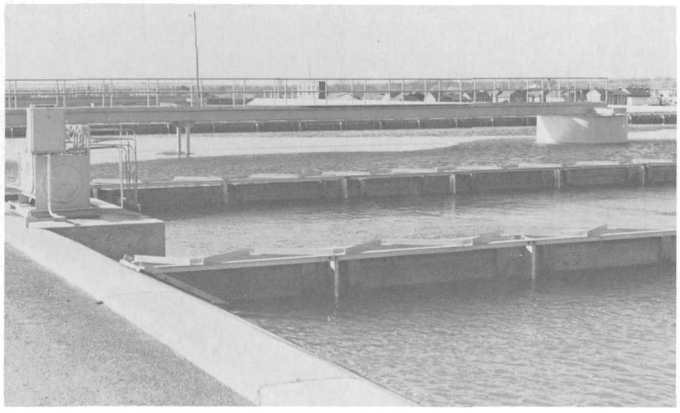


Figure 6-142.--Water treatment plant in operation, January 1981, Springfield, Mo.

Site No. 13 (Sewage Treatment Plant)
Location: Lemay
St. Louis County, Missouri
Geographic Coordinates: 38°32'N
90°17'W

Site No. 91 (Sewage Treatment Plant)
Location: Kirksville
Adair County, Missouri
Geographic Coordinates: 40°09'N
92°34'W

Sewage treatment plants are found in or around most medium or large cities. There are many different processes by which sewage can be treated, however, the identifiable features are nearly the same for all plants.

Site 13, figure 6-143, shows a sewage treatment plant for St. Louis City prior to expansion. The array of rectangular tanks is a typical identifying feature. The large-scale oblique photograph (figure 6-144), taken June 1980, shows the expanded plant. There are two types of tanks visible in this photograph; initial processing tanks are shown at A and secondary tanks are shown at B. The tanks at C are newly constructed and were not in operation at the time of the photograph (June 1981).

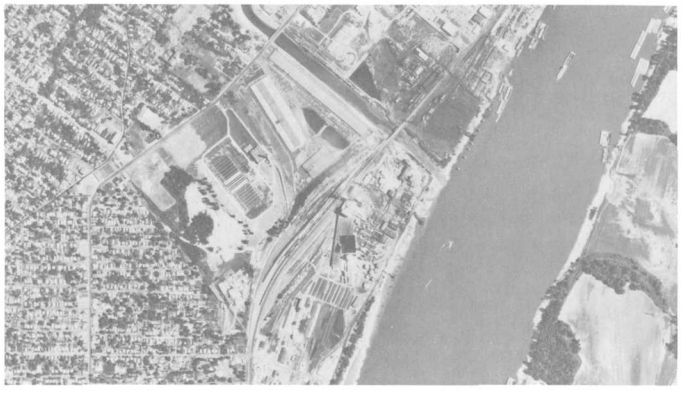


Figure 6-143.--Small-scale photograph of St. Louis sewage treatment plant, 1974.

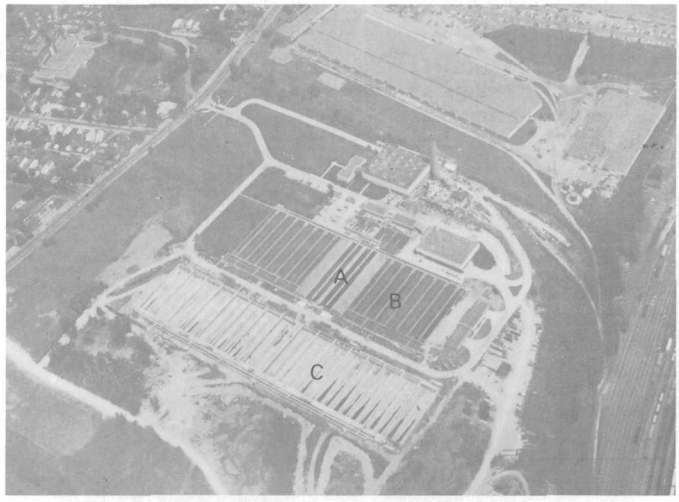


Figure 6-144.--Low-altitude oblique photograph (1980) of sewage treatment plant undergoing additional construction, St. Louis, Mo.

Site 91 is a small sewage treatment plant just south of Kirksville, Missouri. The plant has circular tanks, as opposed to the rectangular tanks at site 13. Figure 6-145 shows the plant layout and several identifying features. Point A is the area of initial processing where the screening and grinding of raw sewage occurs. At B are two primary settling tanks. The tone of the liquid in the tanks is a clue to the process flow. The darker tanks at C contain water which has been treated, while the lighter tanks at B hold raw sewage. The two circular white tanks at D are probably digester tanks where the material that settles out by the settling process is converted to sludge. Point E is the outlet where the treated effluent flows into a nearby stream.

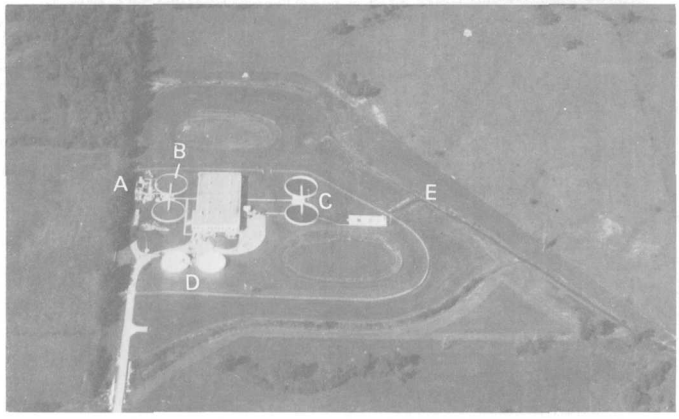


Figure 6-145.--Low-altitude oblique photograph of sewage treatment plant, Kirksville, Mo.

Category 15--Industrial and Commercial Complexes

Category Description. The Industrial and Commercial Complexes category includes those industrial and commercial land uses that typically occur together or in close functional proximity. These areas are commonly referred to as "Industrial Parks." The major types of business establishments located in these planned industrial parks are light manufacturing, printing, distributing, research and development facilities, and computer systems companies, in addition to warehousing, wholesaling, and retailing.

Environmental Considerations. Industrial and Commercial Complexes are a minimum source of pollutants. The clean industries and commercial establishments in these "parks" generally are nonpolluting types. However, improper disposal of wastes and spillage of working materials will produce adverse environmental effects. Excessive surface water runoff from buildings and hard-surfaced parking areas creates the potential for flash flooding.

Interpretation Keys. Areas which meet specifications for Industrial and Commercial Complexes are not widespread. The following example, however, is representative of land use category 15.

Site No. 15 (Industrial and Commercial Complexes)
Location: Robertson
St. Louis County, Missouri.
Geographic Coordinates: 38°46'N
90°23'W

The photograph at figure 6-146 shows an industrial/commercial area just north of Lambert-St. Louis Airport. The buildings are modern in design with ample parking for employees. The warehouse and manufacturing buildings are serviced by railroad for transportation of raw materials and finished products. The ground photograph, figure 6-147, provides a closeup of one of the buildings and the well-kept grounds.

Industrial and Commercial Complexes are usually located in suburban or rural areas. The key identifying feature is the planned layout of buildings exhibiting the same or very similar construction. The lack of smokestacks, storage tanks, raw materials or finished products, and wastes signifies that no heavy industries are present.

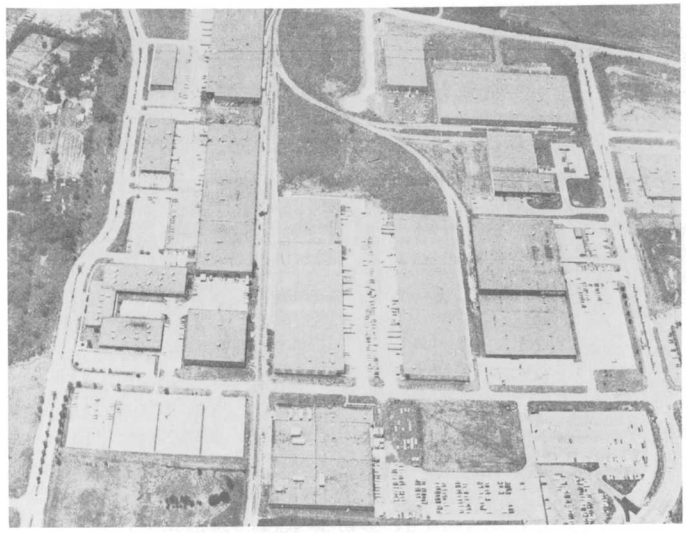


Figure 6-146.--Low-altitude oblique photograph of an Industrial and Commercial Complex, St. Louis County, Mo.

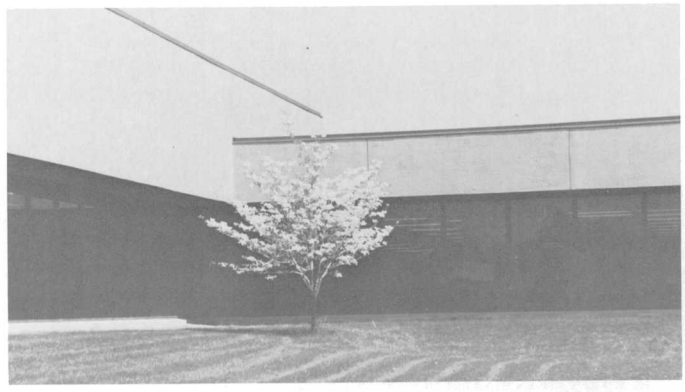


Figure 6-147.--Ground photograph of Industrial and Commercial Complex.

Category 16--Mixed Urban or Built-up Land

Category Description. The Mixed Urban or Built-up Land category is used when a mixture of urban uses cannot be separated into individual categories at mapping scales. Where more than one-third intermixture of another use or uses occurs in a specific area, it is classified as Mixed Urban or Built-up Land. This category includes developments along transportation routes and in cities, towns, and built-up areas where separate land uses cannot be mapped individually at map scale.

Environmental Considerations. This category, a mixture of urban land uses, such as residential, industrial, and commercial has the same potential for pollution as the land use categories which comprise it. Excessive runoff can affect water quality and produce a potential for flooding during heavy rainfalls.

Air quality and noise levels can be affected by this land use category as well.

Interpretation Keys. The following are examples of Mixed Urban or Built-up Land category 16.

Site No. 16 (Mixed Urban or Built-up Land)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°38'N
90°15'W

Figure 6-148, an urban area east of Forest Park is an excellent example of Mixed Urban or Built-up Land. This site has several hotels and motels, apartments, duplexes, hospitals, schools, churches, office buildings, and other commercial activities. The main land uses are commercial and residential, but in areas where more than one-third is mixed, it is classified as Mixed Urban or Built-up Land.

The oblique photograph in figure 6-149 shows height of the buildings, irregular building pattern, rectangular streets, and various sizes and shapes of the buildings. The key identifying feature of Mixed Urban or Built-up Land is its combination of both residential and commercial structures.

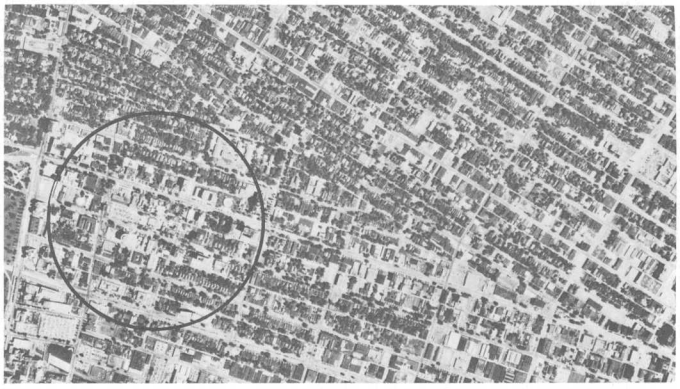


Figure 6-148.--Mapping photograph of Mixed Urban or Built-up Land area, St Louis, Mo.

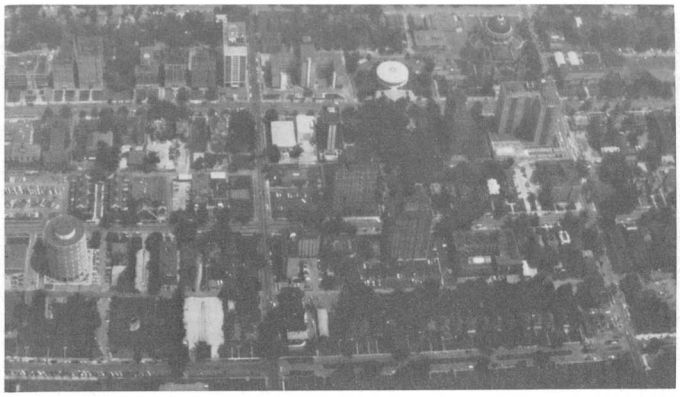


Figure 6-149.--Low-altitude oblique photograph of Mixed Urban or Built-up Land area.

Site No. 64 (Mixed Urban or Built-up Land)
Location: Springfield
Greene County, Missouri
Geographic Coordinates: 37°12'N
93°17'W

Figure 6-150 shows an example of the Mixed Urban or Built-up Land in Springfield. This area is adjacent to the central business district; the small lighter tones and images are single-family residences or duplexes. The residential and commercial categories are too small to separate at the mapping scale; therefore, the area should be classified as a "mixed" category. On the small-scale mapping photograph (figure 6-150) it is evident that the "mixed" category is a transitional category between residential and commercial.

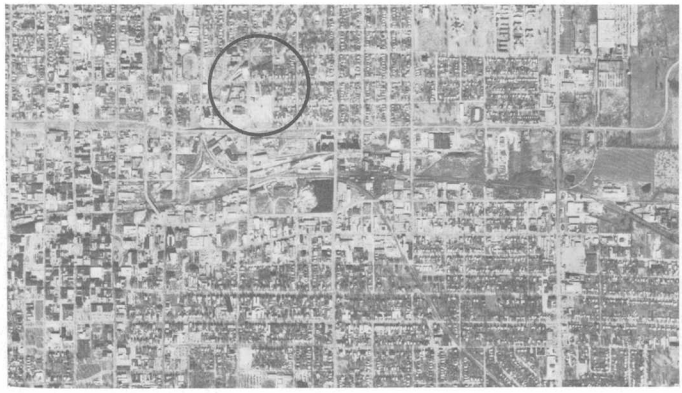


Figure 6-150.--Mapping photograph of a Mixed Urban and Built-up Land area, Springfield, Mo.

The large-scale photograph (figure 6-151) shows the complex intermixture of the various sizes and shapes of the buildings which make up this category.

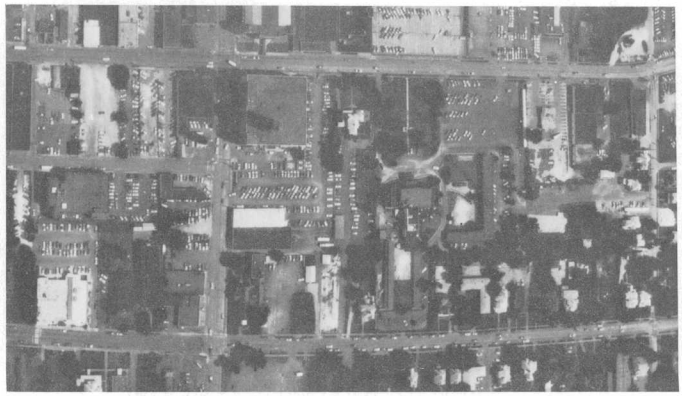


Figure 6-151.--Large-scale photograph of Mixed Urban and Built-up Land area.

Category 17--Other Urban or Built-up Land

Category Description. Other Urban or Built-up Land consists of such land uses as parks, cemeteries, waste dumps, water control structures and spillways, golf courses and driving ranges, and undeveloped land within the urban area.

Environmental Considerations. Landfills are the main potential pollution sources in this category. Uncontrolled waste dumps are becoming obsolete since most communities dispose of waste in sanitary landfills or recycle it. (Note that sanitary landfills are classified as land use category 76 rather than 17.) Parks, public lands, golf courses, zoos, and undeveloped land all provide open areas which for the most part are nonpolluting.

Interpretation Keys. The next four sites are land use examples included in category 17.

Site No. 17 (Forest Park)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°38'N
90°17'W

Key recognition features of parks are irregular road patterns, the coarse photographic texture which results from tree cover, and various athletic fields. Larger parks usually have a pond or lake, while others have museums and bandstands. Urban parks are usually surrounded by residential or commercial areas.

Figure 6-152, Forest Park in St. Louis, illustrates a large urban park in a metropolitan area. It is a good example of this category. There is a diversity of activity visible within the confines of the park. In this photograph are parking lots (A), ball diamonds (B), tennis courts (C), golf courses (D), a zoo (E), and the Muny Opera (F) with its separate parking lot and seating area.

This site is indicative of the larger metropolitan parks. There are, however, smaller parks throughout the State in the medium and small towns which do not have all of the activities associated with them that the larger parks have. Many times without auxiliary source material, the park area may appear as a grove of trees and not be decernible as a park. Since most parks are generally surrounded by built-up area, by definition, they will generally fall in this category.

Figure 6-152.--Mapping photograph of Forest Park in St. Louis, Mo.

In the vertical photograph of figure 6-153 can be seen the zoo with its animal shelters, enclosures, aquatic animal ponds, and walkways between the different exhibits.

Figure 6-153.--Large-scale photograph of the St. Louis Zoo.

Site No. 47 (Golf Course)
Location: Fort Leonard Wood
Pulaski County, Missouri
Geographic Coordinates: 37°44'N
92°05'W

Golf courses are also included in the Other Urban or Built-up Land category. Often they are located within urban areas, in parks, and on outskirts of suburban residential areas.

If the golf course is part of an athletic complex, the built-up area consists of the clubhouse, swimming pool, and parking lots, and if these facilities meet minimum size requirements, they are mapped as category 12. If they are not large enough, they are included in category 17.

Figure 6-154, a small-scale photograph, shows the layout of the Fort Leonard Wood golf course. With proper magnification, the fairways, bunkers, and greens can be identified. However, in this photograph, all that can be detected is the general cleared fairways and white spots--sand traps.

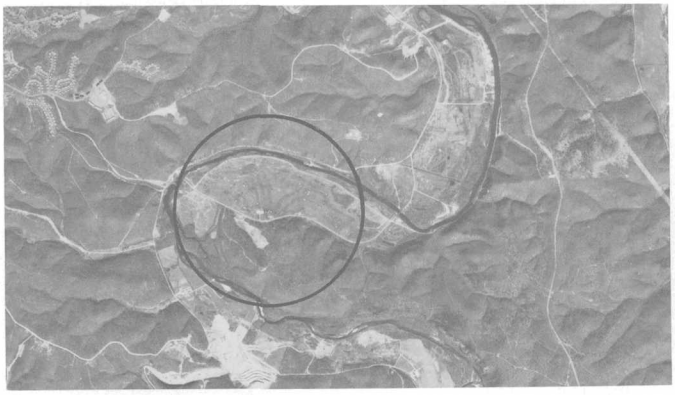


Figure 6-154.--Mapping photograph of the golf course at Fort Leonard Wood, Mo.

The fairways, darker in tone and smoother in texture than the "rough", are clearly visible on the large-scale photograph (figure 6-155). At the end of each fairway, the greens, with their associated light-toned sand traps, are easily identified. The fairways are cleared of trees or when retained, line the fairways on one or both sides.

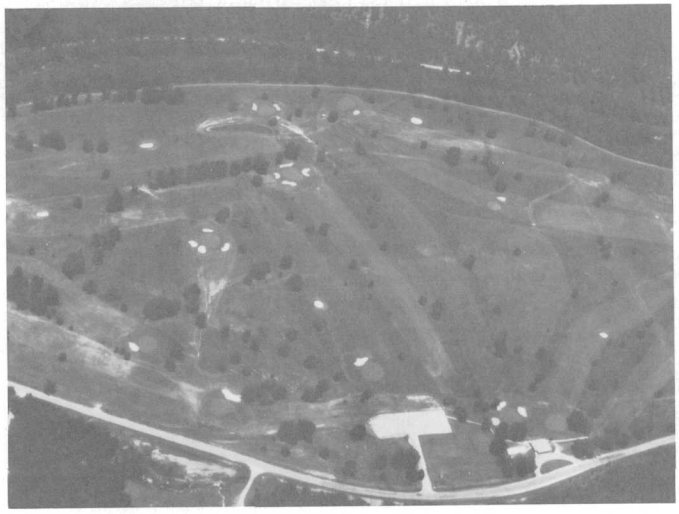


Figure 6-155.--Large-scale photograph of Fort Leonard Wood golf course.

Site No. 18 (Cemetery)
Location: Mehlville
St. Louis County, Missouri
Geographic Coordinates: 38°30'N
90°17'W

Cemeteries are likewise included in category 17. Most larger cemeteries are within or close to an urban area. Many of the smaller rural cemeteries are too small to delineate at land use mapping scales. Cemeteries may have regular or irregular road patterns with the area generally open with shade trees bordering the roads. Figure 6-156 is a mapping photograph of the National Cemetery at Jefferson Barracks in south St. Louis County.

Figure 6-156.--Mapping photograph of National Cemetery near Mehlville, Mo.

Under magnification, figure 6-157 illustrates symmetrical patterns of the gravestones.

Figure 6-157.--Large-scale photograph of road pattern and gravestones.

Site No. 92 (Cemetery)
Location: Kirksville
Adair County, Missouri
Geographic Coordinates: 40°10'N
92°34'W

Figure 6-158 is a smaller cemetery near Kirksville, Missouri, located in the northern part of the State. The light-toned road pattern, the scattered shade trees, and lack of buildings help identify this site as a cemetery. In the vertical photograph, figure 6-158, the light-toned dot-shaped images are gravestones. Notice the linear arrangement of the graves.

The ground photograph, figure 6-159, shows the well-kept grounds and regular spacing of the grave markers.

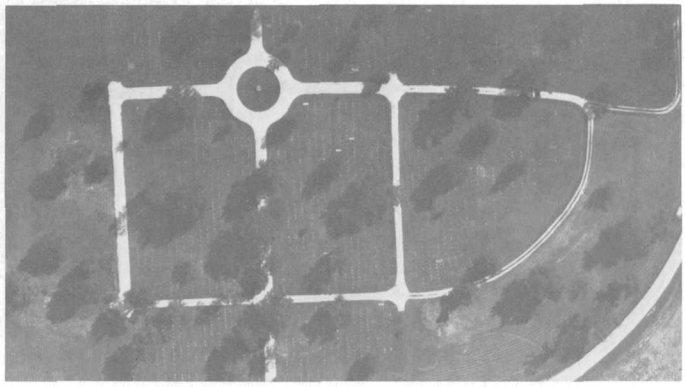


Figure 6-158.--Large-scale photograph of the cemetery layout at Kirksville, Mo.

Figure 6-159.--Ground photograph of cemetery.

LEVEL I, CATEGORY 2 - AGRICULTURAL LAND

Agricultural Land may be defined broadly as land used primarily for production of food and fiber, or, as in the case of farmsteads, built-up service areas associated with agricultural practices. In Missouri, approximately 63 percent of the land is used for agriculture--most of which is either cropland or pasture.

On aerial photographs, particularly high-altitude photographs, the primary recognition characteristics of agricultural activity are the distinctive geometric field and road patterns on the landscape, the traces produced by livestock or mechanized equipment, and the variations in photographic tones (gray levels) of the adjacent land parcels. Compared with the Urban or Built-up Land categories previously discussed, the number of building complexes is less and the density of the road and highway network is much lower in Agricultural Land areas. Finally, there is a marked deficiency of woodland vegetation.

The Level II categories of Agricultural Land are: Cropland and Pasture; Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas; Confined Feeding Operations; and Other Agricultural Land.

Category 21--Cropland and Pasture

Category Description. The Cropland and Pasture category includes harvested croplands, summer-fallow and idle croplands, croplands in soil-improvement grasses and legumes, croplands used for pasture in rotating crops, and improved as well as idle pasture. Approximately 62 percent (28 million acres) of Missouri is used as cropland or pasture. Of this amount, roughly two-thirds is cropland. The majority of Missouri's croplands are located in northern Missouri--north of the Missouri River. The remaining croplands are located in the bootheel area of the State and along alluvial flood plains.

It is also important to note that the U.S. Geological Survey's classification system does not separate cropland from pasture in the Level II land use and land cover mapping. Even at Level III, it is difficult to separate the two categories. Generally, a Level III differentiation between cropland and pasture areas required excessive field validation.

Concerning the separation of cropland from pasture, most croplands exist where the slopes are less than 10 percent. However, with certain conservation management practices, such as terracing, croplands may occur on slopes slightly greater than 10 percent. In the latter case, the terracing practices help to identify the areas as croplands. Accordingly, as the slope of the land increases beyond 10 percent, one finds less cropland and more pasture.

Environmental Considerations. Cropland and Pasture areas are most frequently associated with nonpoint pollution. Since the farmer must first prepare the land for planting, fertilize it, and then use pesticides to protect the crops, there are many pollution possiblities.

If tillage farming is used, loosened soil particles become prime candidates for transport to nearby water bodies. If medium to heavy precipitation follows shortly after a field has been plowed, numerous particles of soil can be transported to nearby water bodies as part of the surface runoff. The term used to refer to the condition of soil particles suspended in water is "sediment load." When a farmer does not take precautions to lessen the amount of surface soil loss which can occur with surface runoff, the number of soil particles entering nearby water bodies may increase significantly. When the sediment load becomes 1,000 parts per million or higher, there is a greater probability that aquatic plant and animal life may be adversely affected. The increase in sediment load reduces sunlight penetration, thereby reducing plant growth. Reduced plant growth reduces the level of oxygen plant production which affects the ability of certain fish species to survive in these waters.

In addition to soil erosion from plowed areas, pasture areas may also become a source for transportable soil particles, particularly where livestock overgrazing has denuded the landscape. However, the extent of soil particle contribution from overgrazing is much less than that which occurs from plowing.

In Missouri, soil loss and the subsequent increase of sediment load is by far the greatest surface water quality contaminant.

Besides the potential for increased sediment loads in nearby streams, cropland areas are also a source for such chemical pollutants as fertilizers and pesticides. As with loose soil particles, any residues from fertilizer or pesticide applications may be carried to nearby streams with surface runoff. Accordingly, the farmer must exercise care in the application of such materials to reduce the potential for water quality degradation.

Interpretation Keys. Cropland and Pasture areas are depicted in several examples which follow.

Figure 6-160 illustrates the characteristic checkerboard pattern of cropland areas in northwestern Missouri near Plymouth. The checkerboard pattern results from different crop stages (exhibited by varying gray tones) and differences in tillage directions. Cropland areas, generally devoid of trees, possess a smoother texture than pasture land areas. A small pasture area lies just south of the east-west road to the west of a small farmstead in figure 6-160 at point A. Note the mottled texture of this area. The oblique photograph (figure 6-161) shows more clearly the characteristic checkerboard cropland pattern and the general lack of trees in cropland areas.

Figure 6-160.--Mapping photograph of cropland near Plymouth, Mo.

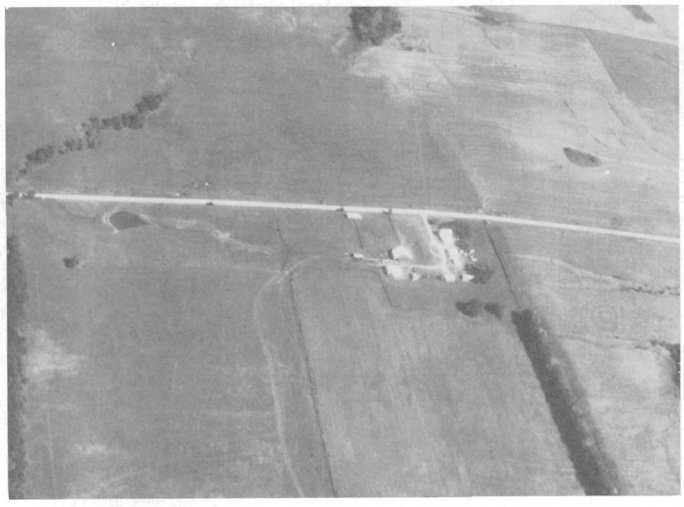


Figure 6-161.--Low-level photograph of cropland near Plymouth, Mo.

Site No. 93 (Cropland)
Location: Plymouth
Livingston County, Missouri
Geographic Coordinates: 39°37'N
93°43'W

Site No. 44 (Pasture)
Location: Jerome
Phelps County, Missouri
Geographic Coordinates: 37°58'N
91°59'W

Figure 6-162, along the Gasconade River, presents an interesting pasture land photographic image. The white dots (or small circles) identify former locations of hay bales. Figure 6-163, of the same area but taken in winter, does not exhibit the dot pattern. Notice also the differences in gray values for the two figures. The winter scene in figure 6-163, shows the pasture area as a much lighter gray than in figure 6-162. Although the area may be in pasture at the time of figure 6-162 (June 1980), chances are that it will revert to cropland in the near future. This highlights another important point--using aerial photography, one must delineate the land use of an area according to its use at time of photographic acquisition.

Figure 6-162.--Low-level photograph of pasture land near Jerome, Mo., June 1980.

Figure 6-163.--Mapping photograph of pasture land near Jerome, January 1976.

Site No. 68 (Cropland)
Location: Chamois
Osage County, Missouri
Geographic Coordinates: 38°40'N
91°45'W

Figure 6-164 shows another cropland area near Chamois along the Missouri River. The linear pattern of cropping techniques is easily recognized and the fact that the area is devoid of trees supports classification as cropland. Figure 6-165 provides a better illustration.

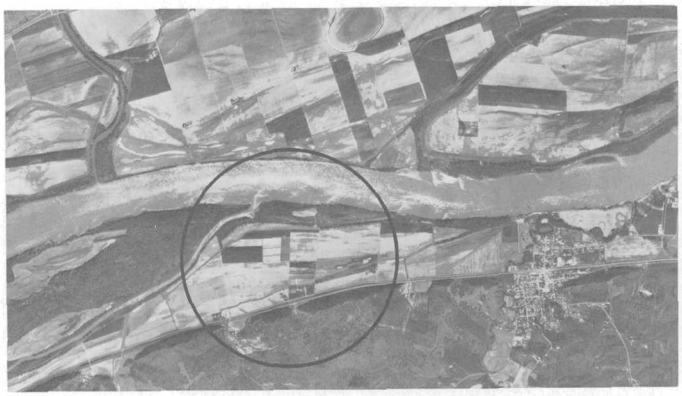


Figure 6-164.--Mapping photograph of cropland near Chamois, Mo.

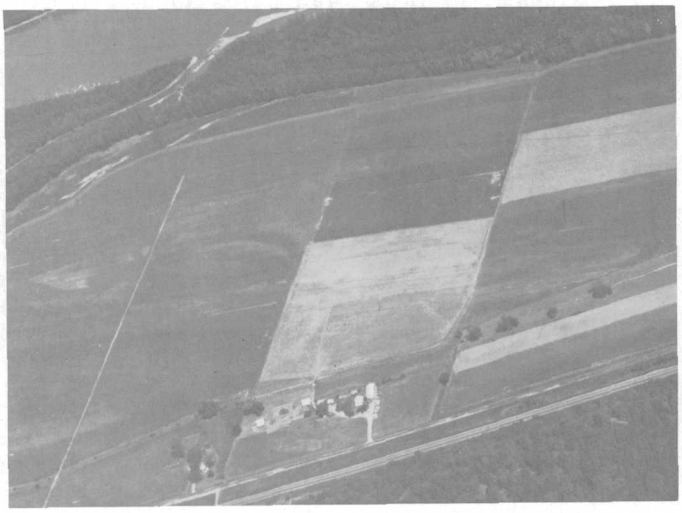


Figure 6-165.--Oblique photograph of cropland near Chamois, Mo.

Category 22--Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas

Category Description. Category 22 includes orchards, groves, vineyards, nurseries, and ornamental horticultural areas which produce various fruit and nut crops; nurseries and horticultural areas are used permanently for such purposes. Included in these land use categories are floricultural and seed-and-sod areas, and some greenhouses. Tree nurseries, which provide seedlings for plantation forestry, are also included in category 22 when they meet the minimum acreage requirements.

Orchards and groves are some of the more easily recognized land use types on aerial photographs, particularly during the growing season. The primary recognition feature is the grid pattern exhibited by the equally spaced rows of trees or bushes. Although the grid pattern is more easily identified on large-scale photographs, it is also discernible on high-altitude aerial photographs when they are appropriately magnified.

Environmental Considerations. Potential environment impacts from orchards, groves, and vineyards are very similar to those associated with cropland areas. Surface runoff can transport loose soil particles and various residual fertilizers, pesticides, and herbicides to nearby water bodies. To a lesser extent, nursery areas may also yield the same type of pollutants. Except for a possibility of pollution contaminants associated with the improper disposal of waste, ornamental horticultural areas are seldom a source of pollution.

Interpretation Keys. Presented below are three examples of orchards and a vineyard.

Site No. 23 (Orchard)
Location: Kelso
Scott County, Missouri
Geographic Coordinates: 37°11'N
89°33'W

Circled in figure 6-166, just south of Kelso, is an apple orchard. Because of the small scale of the photograph, one would have to view the area under magnification to clearly discern the orchard grid pattern. The orchard is seen more clearly in the oblique photograph (figure 6-167). Note the open spaces in the orchard. Apparently, the owner has lost some of the trees to disease or severe weather.

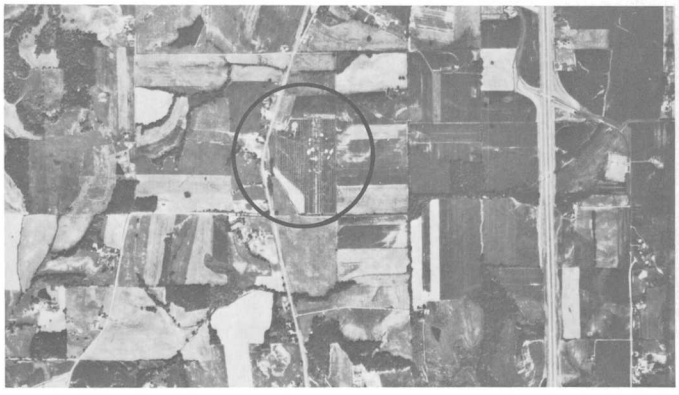


Figure 6-166.--Mapping photograph of an apple orchard south of Kelso, Mo.

Figure 6-167.--Low-level photograph of an apple orchard south of Kelso, Mo.

Site No. 41 (Orchard)
Location: Bonne Terre
St. Francois County, Missouri
Geographic Coordinates: 37°55'N
90°32'W

Another orchard is shown in figure 6-168 near Bonne Terre. This oblique photograph illustrates well the equally spaced rows common to orchards. Notice the various tones exhibited by the orchard. This is caused by growth stage differences and by differences in the crop types. The area just to the right of the pond (A) is an area of more mature apple trees. Just to the west of the pond are younger apple trees (B). The four rows just above the younger apple trees, the lighter gray area, are peach trees. The next four rows are vineyards.

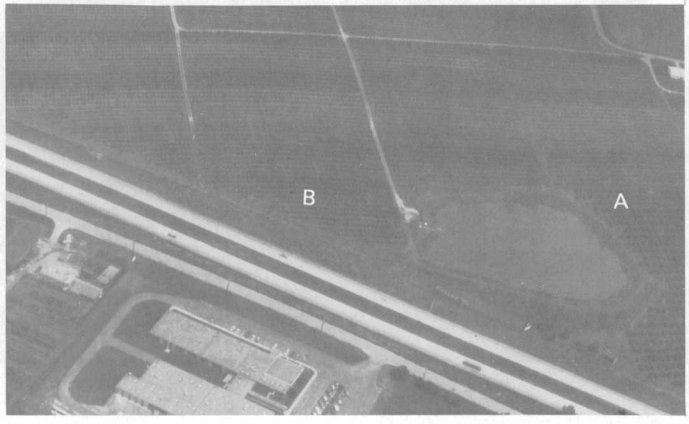


Figure 6-168.--Low-level photograph of orchard at Bonne Terre, Mo.

Figure 6-169, a ground photograph of the orchard, shows three rows of apple trees to the right of the pickup (with camper), and four rows each of peach trees and grapevines.

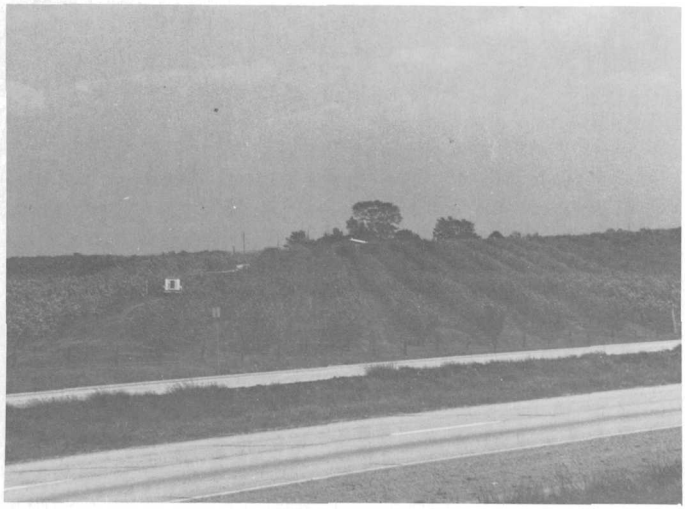


Figure 6-169.--Orchards at Bonne Terre, Mo.

Site No. 73 (Orchard)
Location: New Franklin
Howard County, Missouri
Geographic Coordinates: 39°02'N
92°43'W

The equal spacing of orchard rows is also illustrated by this orchard near New Franklin. However, notice in this low-level photograph (figure 6-170) the gentle curved pattern of the rows. These patterns result when orchards are planted in hilly areas as opposed to the linear pattern exhibited by orchards planted on flatter terrain (see figure 6-168).

Figure 6-170.--Oblique photograph of an orchard northeast of New Franklin, Mo.

Site No. 43 (Vineyard)
Location: St. James
Phelps County, Missouri
Geographic Coordinates: 38°02'N
91°34'W

Finally, just east of St. James, large vineyards are shown in figure 6-171. It is difficult to identify vineyards on small-scale aerial photography after the frost season. Even with large-scale imagery, positive identification is difficult. The photointerpreter must be aware of the existence of vineyards in an area, and even then, must take advantage of ancillary data such as topographic maps to identify these areas.

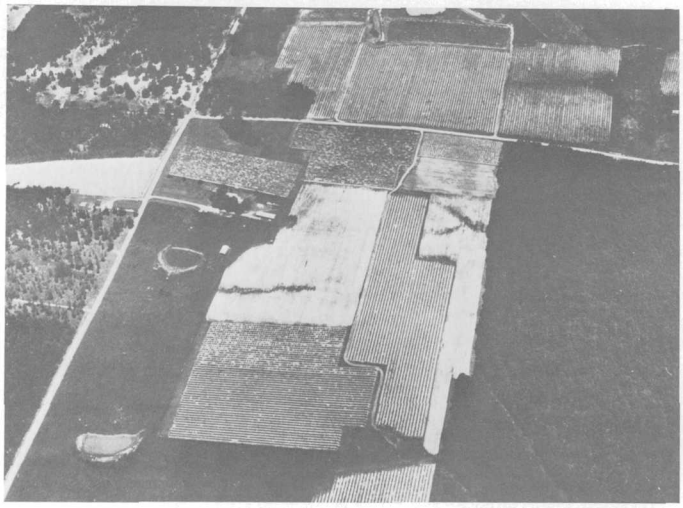


Figure 6-171.--Oblique photograph of vineyard northeast of St. James, Mo., June 1980.

Category 23--Confined Feeding Operations

Category Description. Confined Feeding Operations are large, specialized livestock production enterprises; chiefly beef cattle feedlots, dairy operations with confined feeding, large poultry farms, and hog feedlots. Confined Feeding operations have large animal populations restricted to relatively small areas. Confined Feeding Operations exhibit a built-up appearance, chiefly composed of animal shelter buildings, fencing, access paths, and waste-disposal areas.

Environmental Considerations. Confined Feeding Operations, as noted above, tend toward large animal populations restricted to relatively small areas. If not properly maintained they can become a source for air and/or

water pollution. If animal waste is allowed to accumulate beyond acceptable levels, foul odors and various insects can become windborne. Areas downwind, such as urban residential, are subjected to high levels of air pollution.

In addition to the potential for air pollution, Confined Feeding Operations are often a source of water pollution. Since the ground surface is often denuded, periods of moderate to heavy precipitation can produce intense surface runoff which can transport such organic nutrients as phosphates and nitrates and/or loose soil particles to nearby water bodies. If the magnitude of the nutrients reaching nearby water bodies, particularly lakes or reservoirs, is significant, eutrophication can be greatly accelerated.

In some cases the trophic state of some of these water bodies is enhanced so much that they are overtaken by decaying aquatic plants to the extent that they fill up and become Nonforested Wetland areas.

In those instances where significant amounts of soil particles are transported to nearby water bodies, the increase in sediment load will often lessen the amount of sunlight penetration and thereby reduce aquatic plant production. A reduction in plant production results in a reduction in dissolved oxygen levels which may then cause these water bodies to become less suited as habitats for certain fish species.

Interpretation Keys. A cattle Confined Feeding Operation, a combination hog/cattle operation, a chicken operation, and a turkey farm are shown in the following illustrations.

Site No. 29 (Chicken Houses)
Location: Bloomfield
Stoddard County, Missouri
Geographic Coordinates: 36°53'N
89°55'W

Perhaps one of the more easily recognized types of confined feeding operations are chicken houses. Chicken houses are long, narrow wood or metal structures and most frequently occur in groups of three. Even on high-altitude photographs (figure 6-172), this characteristic pattern can be easily detected. The pattern is even more easily discerned from the oblique photograph shown in figure 6-173. Whitish tones of the chicken house roofs result from use of corrugated metal roofs which reflect a great deal of the Sun's rays.

Figure 6-174 provides a ground-level photograph of two of the three chicken houses shown in the center portion of figure 6-173.

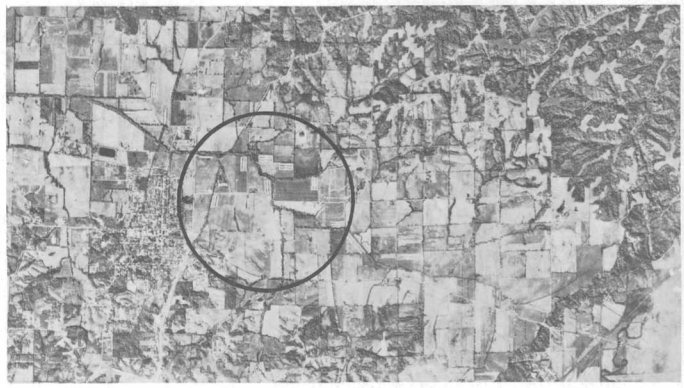


Figure 6-172.--Mapping photograph of chicken houses east of Bloomfield, Mo.

Figure 6-173.--Low-level photograph of chicken houses east of Bloomfield, Mo.

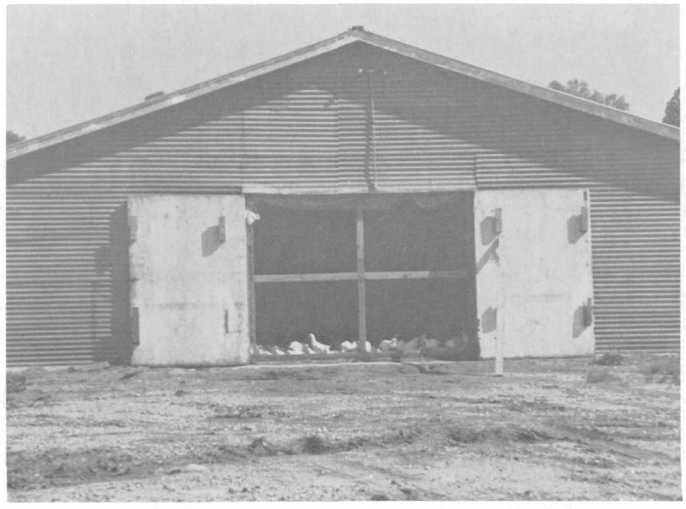


Figure 6-174.--Chicken house east of Bloomfield, Mo.

Site No. 87 (Confined Cattle Feeding)
Location: Spickard
Grundy County, Missouri
Geographic Coordinates: 40°15'N
93°13'W

Another type of confined feeding which is easily recognized is that of confined cattle feeding. Circled in figure 6-175 is a confined cattle feeding operation at Spickard, Missouri. Lack of vegetation is shown clearly on the vertical photograph of figure 6-176. Note the whitish areas near the animal shelter buildings. These areas are devoid of vegetation. Also notice the rectangular shape of the fenced feedlots. Just to the northwest of the larger animal shelter buildings are a series of smaller buildings and narrower feedlots. The feedlots at A are not presently in use. Examination of the smaller feedlots reveals that a distinct texture difference exists. The smooth-textured area lots are used more frequently. The less frequently used lots (A) have grown up with vegetation and therefore, exhibit a coarser texture.

Figure 6-175.--Mapping photograph of confined cattle feeding near Spickard, Mo.

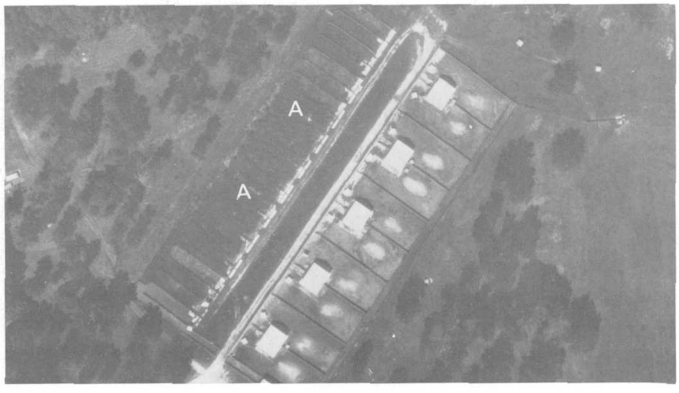


Figure 6-176.--Low-level photograph of confined cattle feeding operation near Spickard, Mo.

Site No. 86 (Confined Hog and Cattle Feeding)
Location Ravenwood
Nodaway County, Missouri
Geographic Coordinates: 40°25'N
94°40'W

Another example of confined feeding is illustrated in the oblique and vertical photographs shown in figures 6-177 and 6-178. Two types of confined feeding operations are apparent. In figure 6-178, eight rather large rectangular feedlots are shown in the middle of the photograph. They are very similar in appearance to the feedlots shown earlier in figure 6-176; therefore, one would expect to find cattle here. However, when the imagery was enlarged, it appeared as though the eastern feedlots were also being used for hogs. To the west of these feedlots, just north of a small pond, are located 12 smaller hog feedlots. The whitish area leading away from the feedlots to the pond is used during cleanup operations. The pond serves as a settling pond.

The differences in tone and texture can be used to identify the various stages of use for the larger feedlots. The fourth feedlot from the north at A in figure 6-178, as shown by its courser texture and spotted tone, has not been used recently. However, note that the second feedlot from the north has a smoother texture and more even gray tones. Under appropriate magnification, more than a dozen hogs are visible in the second feedlot. Another item commonly associated with confined feeding operations, in addition to the animal shelter buildings, are feed storage tanks. Located at the extreme top of figure 6-178, at B, can be seen five feed storage tanks.

Figure 6-177.--Low-level oblique photograph of confined feeding operation north of Ravenwood.

Figure 6-178.--Low-level vertical photograph of confined feeding operation north of Ravenwood.

Site No. 95 (Turkey Farm)
Location: Winigan
Sullivan County, Missouri
Geographic Coordinates: 40°02'N
92°56'W

Also included in land use category 23 are turkey farms. Turkey farms are rather difficult to identify on high-altitude aerial photographs. Therefore, prior knowledge of their existence in an area is normally required to increase the probability of correct photographic identification. Four turkey farm areas are shown in the oblique photograph of figure 6-179. The turkey farms are located just west of Winigan, Missouri. Two of the areas are active (A and B), two are inactive (C and D). The inactive areas appear whitish in tone with small, darker squares indicating the former locations of portable range shelters now located at A and B.

Although open range feeding of turkeys is an identification feature of this category, the areas in which the birds feed would not be delineated as confined feeding. The brooder houses themselves and auxillary structures would be the only area to be delineated.

Figure 6-179.--Low-level oblique photograph of a turkey farm near Winigan, Mo.

The vertical photograph of figure 6-180 clearly illustrates the practice of relocating turkey farm areas once an area has been denuded of vegetation. Note the small darker gray rectangular spots paralleling the road (A). These spots mark the former positions of the range shelters. The range shelters, as well as most of the turkey feeders, have been moved to a new position just to the south of their old location (B). The range shelters, without sides, are constructed to allow the turkeys to get out of the sun during the hot summer months. During winter, the turkeys are housed in large, long poultry houses such as those seen in the ground-level photograph of figure 6-181 just east of the area shown in figure 6-180.

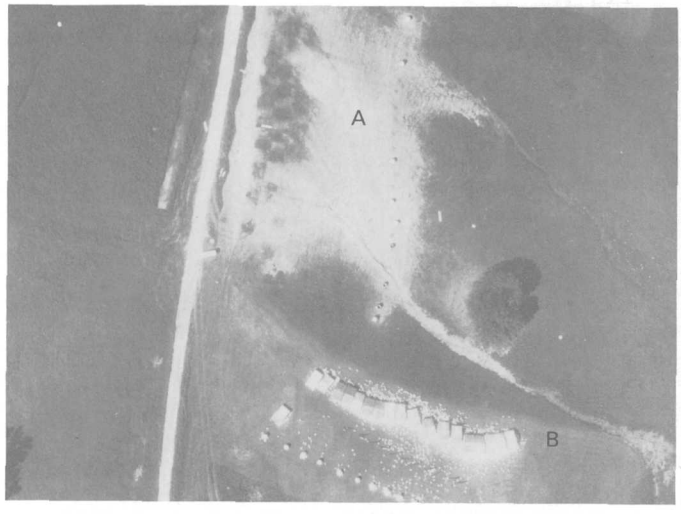


Figure 6-180.--Low-level photograph of turkey farm area near Winigan, Mo.

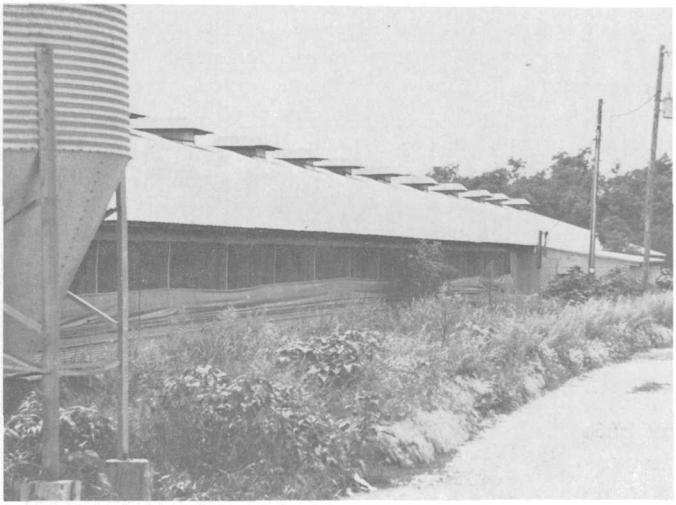


Figure 6-181.--Turkey brooder house near Winigan, Mo.

Category 24--Other Agricultural Land

Category Description. The Other Agricultural Land category includes farmsteads, holding areas for livestock such as corrals, farm lanes and roads, ditches and canals, small farm ponds, fish farms and hatcheries, horse farms, and other similar associated built-up features adjacent to and closely associated with agricultural resource management.

Environmental Considerations. The pollution potential from Other Agricultural Land areas is very similar to the other Level II categories of Agricultural land previously discussed; that is, Other Agricultural Land areas may become sources for nonpoint water pollution. However, primarily because of their relatively small areal extent, the pollution potential from these areas is less than that from the more extensive Agricultural Land Level II categories.

Also included in the Other Agricultural Land category are fish hatchery operations. After a period of time, fish hatchery ponds may become saturated with waste (such as phosphates and nitrates) and various disease organisms. If there is a discharge of fish pond waters due to flooding, breaching, leaching, or a deliberate release, several conditions may ensue: eutrophication of nearby water bodies may occur; disease organisms may spread; or the escape of non-native fish species into nearby water bodies may lead to the depletion of natural stocks by predation or competitive exclusion.

Fish hatchery operations may also generate foul odors, particularly from a fish kill which will attract insects and cause diseases to spread. Abandoned fish ponds, left filled with water, are also possible insect breeding areas.

Interpretation Keys. The Other Agricultural Land category is illustrated by a fish farm and farmstead.

Site No. 38 (Fish Farm)
Location: Montreal
Camden County, Missouri
Geographic Coordinates: 37°53'N
92°31'W

Fish farms are shallow manmade water bodies maintained for the purpose of raising fish for wholesale trade. Quite often, due to differences in water depths or sediment loads and algae concentrations, the adjourning irregularly shaped water bodies exhibit a variety of shades from gray to black. Figure 6-182 illustrates this well. The differences in the shades of gray are illustrated even more clearly in the oblique photograph (figure 6-183) of the southernmost fish farm ponds shown in figure 6-182. A ground-level photograph (figure 6-184) further illustrates the shape of the individual fish farm ponds and provides the reader with an appreciation for the widths of the holding levees separating the ponds. The levees provide the owners access to the ponds for maintenance and harvesting.

Figure 6-182.--Mapping photograph of a fish farm southeast of Montreal, Mo.

Most fish farms will be found in stream valleys. The stream water will flow directly through or be directed into the ponding areas. In southeast Missouri in rice production areas, reservoirs used to store water for the fields are used part of the year for fish production. These types of fish ponds are impossible to delineate without ground observation.

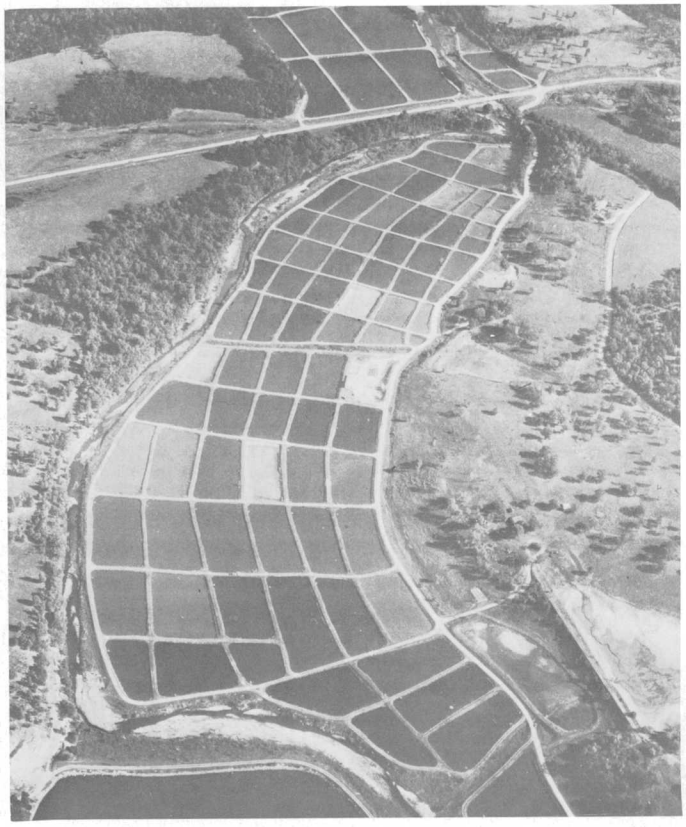


Figure 6-183.--Low-level photograph of fish farm ponds southeast of Montreal, Mo.

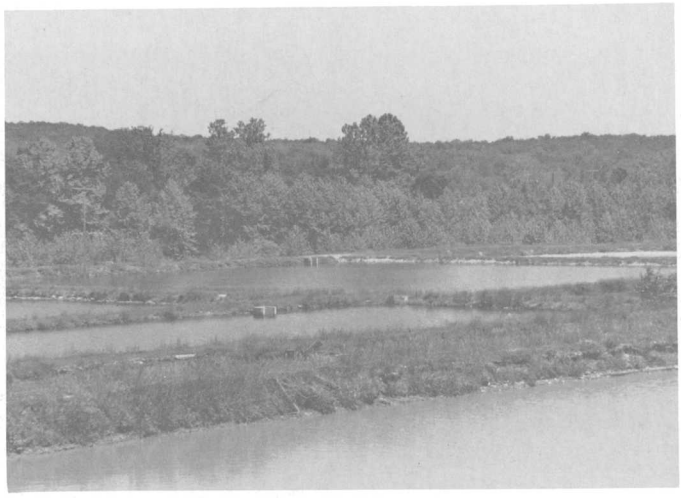


Figure 6-184.--Fish farm ponds near Montreal, Mo.

Site No. 99 (Farmstead)
Location: Maitland
Holt County, Missouri
Geographic Coordinates: 40°07'N
95°04'W

Farmsteads are built-up service areas associated with agricultural practices. In order for farmsteads to be shown on a land use map, they must meet the minimum mapping size requirements for the scale of the map. On land use maps at a publication scale of 1:250,000, farmsteads must be at least 10 acres in size to be shown. Circled in figure 6-185 is a farmstead approximately 6 miles south of Maitland, Missouri. The built-up photographic signature of the farmstead, surrounded by cropland and pasture, is easily identified. The oblique photograph (figure 6-186) further illustrates the extent of the built-up features associated with this farmstead. Noted on the photograph are residential structures at A, B, and C; feed storage tanks at D; tractors at E; and several rectangular shelter/storage buildings at F. In addition to the built-up signature displayed by the farmstead, the lighter gray tone of the farmstead draws the attention to the site.

Figure 6-185.--Mapping photograph of a farmstead south of Maitland, Mo.

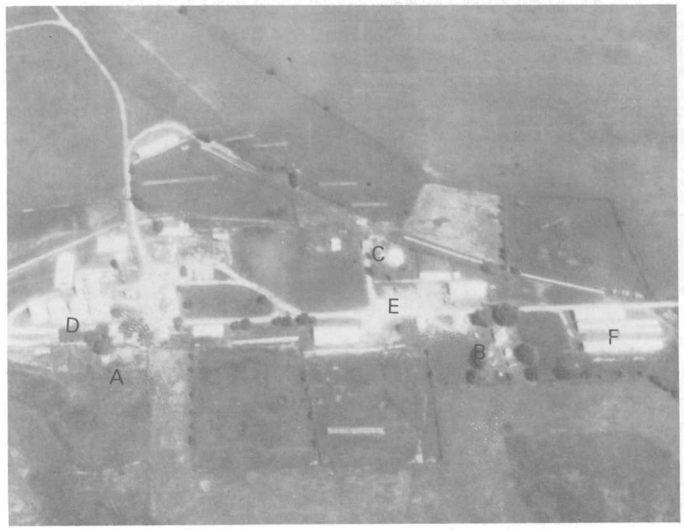


Figure 6-186.--Low-level oblique photograph of the farmstead near Maitland, Mo.

LEVEL I, CATEGORY 3 - RANGELAND

Historically, Rangeland has been defined as land on which the potential natural vegetation is predominately grasses, grasslike plants, forbs, or shrubs and where natural herbivory was an important influence in its precivilization state. Generally, management practices do not include fertilization, cultivation, or irrigation. Instead, Rangeland management practices follow ecological principles of resource management.

In Missouri, what little Herbaceous Rangeland there is, primarily is located in the west-central and southwest portions of the State. Shrub and Brush Rangeland, specifically eastern brushland vegetation, is found in the same areas as Cropland and Pasture; namely, north of the Missouri River and along the Mississippi River floodplain.

Category 31--Herbaceous Rangeland

Category Description. Herbaceous Rangeland encompasses lands dominated by naturally occurring grasses and forbs as well as those areas of natural rangeland which have been modified to include grasses and forbs as their principal cover, when managed for rangeland purposes and not managed using typical pastureland practices.

As noted earlier, the Herbaceous Rangeland areas of Missouri occur in the west-central and southwestern portions of the State. Unlike the more expansive Herbaceous Rangeland areas found from the Texas Panhandle northward to the Dakotas, Missouri Herbaceous Rangeland areas are boxed in by Cropland and Pasture; Therefore, it is difficult to accurately identify Herbaceous Rangeland areas on high-altitude photographs. The boxed-in shape of these areas robs the photointerpreter of one of the most important photorecognition characteristics of the more expansive Herbaceous Rangeland areas--the irregularly shaped natural landscape. Not only are there so few areas of Herbaceous Rangeland in Missouri, but add to this the fact that these areas are difficult to identify on high-altitude aerial photographs, and it can be realized why there is a high potential for an understatement of the total Herbaceous Rangeland acres in the State.

Environmental Considerations. Herbaceous Rangeland areas are, by definition, areas which are managed by ecological resource management principles rather than by fertilizing, cultivating, or irrigation. Therefore, such areas are not a potential pollution source.

Interpretation Keys. Since Herbaceous Rangeland areas are of limited extent in Missouri, there are few good examples of this land use category. However, the forb prairie just west of Kingdom City, Missouri, provides an excellent example.

Site No. 102 (Forb Prairie)
Location: Kingdom City
Callaway County, Missouri
Geographic Coordinates: 39°57'N
92°00'W

Most of the Herbaceous Rangeland that exists in Missouri is owned and/or protected by the Missouri Department of Conservation. As of 1978, the State had 23 public prairies totaling over 6,000 acres. These prairies were owned by either the Missouri Department of Conservation, the Missouri Prairie Foundation, the Nature Conservancy, the University of Missouri, or a combination of the above. One of these sites, Tucker Prairie, is circled in figure 6-187. Under appropriate magnification, one can discern a difference in the Cropland fields surrounding the prairie and the prairie itself. The Cropland fields retain signs of tillage, while the prairie areas do not. Had the surrounding areas been Pasture rather than Cropland, it would have been more difficult to identify prairie areas.

Even the use of low-level imagery adds little to assisting the photointerpreter in identifying the area as Herbaceous Rangeland (see figure 6-188). Only when verified by ground observations can one be confident of an accurate classification of Herbaceous Rangeland in Missouri (see figure 6-189). This photograph illustrates a field of black-eyed Susans, a typical forb vegetation.

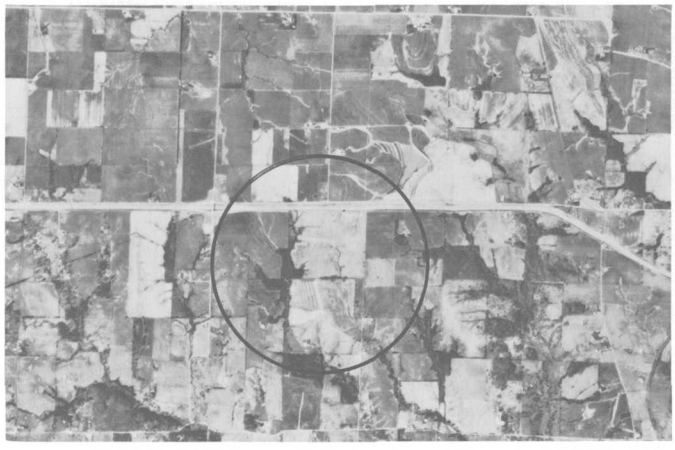


Figure 6-187.--Mapping photograph of forb prairie west of Kingdom City, Mo.

Figure 6-188.--Oblique photograph of forb prairie west of Kingdom City, Mo.

Figure 6-189.--Tucker (forb) Prairie west of Kingdom City--ground observation.

Category 32--Shrub and Brush Rangeland

Category Description. Shrub or scrub vegetation, characteristic of arid or semiarid regions, is not found in Missouri. Eastern brushland areas, however, do occur primarily north of the Missouri River and adjacent to the Mississippi River north of Cape Girardeau.

Eastern brushlands are typically former croplands or pasture lands (cleared from original forest lands) which are being allowed to revert to their natural state. Accordingly, these areas, grown up in brush, are in transition back to forest land to the extent that they are no longer identifiable as cropland or pasture. Many of these areas are extensively grazed by livestock and provide wildlife habitat. More often, they are retained as part of the farm, but are not used at their former levels of intensity. Traditionally, botanists have not included eastern brushland areas in the Rangeland category because of their original forested state prior to clearing for cropland or pasture; therefore, they have been summarized statistically with pasture land. However, since they primarily function as grazing land, they are included in the U.S. Geological Survey's classification system's Rangeland category. Following sufficient reforestation, these areas should be classified as Forest Land.

Environmental Considerations. Eastern brushland areas, particularly in their early stages of development, may reduce water quality as surface runoff transports loose soil particles to nearby water bodies. However, as these areas mature and are retained in Rangeland, there are few, if any, contaminant sources associated with eastern brushland areas.

Interpretation Keys. Examples of eastern brushland can be found in many areas of the State. The following example, near New Hampton, is illustrative of this land use category.

Site No. 84 (Eastern Brushland)
Location: New Hampton
Harrison County, Missouri
Geographic Coordinates: 40°16'N
94°10'W

Circled in figure 6-190, just east of New Hampton, is an example of eastern brushland as it appears on mapping photographs. Notice the slightly darker gray tone and coarser texture exhibited by the presence of the brushland

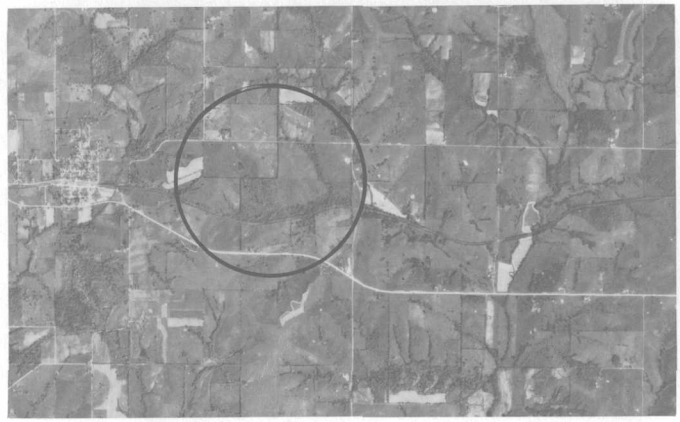


Figure 6-190.--Mapping photograph of eastern brushland area near New Hampton, Mo.

vegetation. Vegetation nearest the railroad (the southern boundary of the area) is actually too dense to be classified as eastern brushland. However, because the strip does not meet minimum mapping width criteria at the 1:250,000 scale, this more heavily vegetated strip should be combined with the eastern brushland to the north and shown as eastern brushland.

Figure 6-191 illustrates more clearly the characteristic vegetation pattern of eastern brushland. Notice the denser strip of trees near the bottom of the photograph.

Figure 6-191.--Oblique photograph of eastern brushland area near New Hampton, Mo.

LEVEL I, CATEGORY 4 - FOREST LAND

Areas of trees capable of producing timber and other wood products, which exhibit a tree-crown areal density (crown closure percentage) of 10 percent or more, and exert an influence on the climate or water regime, are classified as Forest Land. Although the precise boundary between Forest Land and other categories of land use may be difficult to delineate, generally Forest Land areas can be identified rather easily on high-altitude aerial photographs. The majority of the Forest Land in Missouri is located south of a line extending from Joplin in the southwest through Columbia to Hannibal in the northeast. Statewide, over 15 million acres of Forest Land cover Missouri.

Also included in the Forest Land category are lands from which trees have been removed to less than 10 percent crown closure but which have not been developed for other uses. These areas often have been clear cut and are scheduled for blockplanting. This practice is commonplace in our national forest lands.

Not included in the Forest Land category are those areas which would otherwise be classified as Forest land if it were not for the fact that the water table was at or near the ground surface. Since the wetland condition is of much interest to land managers and planning groups, such lands are classified as Forested Wetland.

At Level II, Forest Land is separated into three categories: Deciduous, Evergreen, and Mixed. From small-scale aerial photographs, the photointerpreter must rely on site association knowledge, tone, and texture analysis to differentiate these cover categories. In addition, the availability of photographs obtained during the period when deciduous trees are bare can be very helpful in separating Deciduous and Evergreen Forest cover types.

Prior to initiating Forest Land photointerpretation, the photointerpreter should be familiar with the various tree species known to exist in the area. This task can be facilitated by consulting silviculture handbooks normally available from State or Federal service agencies for the area.

Photographic tone can also be used to help identify forest cover types. Generally, evergreen trees exhibit a darker tone (dark green) than deciduous trees. On color-infrared winter photographs, evergreen trees are generally magenta in color.

Concerning photographic texture, even-aged coniferous trees generally exhibit a smooth, carpetlike texture. Deciduous trees, on the other hand, exhibit a rougher texture as a result of their varying heights and rounded crowns, particularly when the stands are of an uneven-aged nature.

Category 41--Deciduous Forest Land

Category Description. Deciduous Forest Lands include all forested areas with a predominance of trees that lose their leaves at the end of the frost-free season or at the beginning of the dry season. Nearly 94 percent of Missouri's 15 million acres of Forest Land is of the deciduous cover type--mostly oak.

The geographic extent of the Deciduous Forest Land parallels that of Missouri's Forest Land; that is, the majority of the Deciduous Forest Land occurs south of a line extending from Joplin to Columbia to Hannibal.

Environmental Considerations. Deciduous Forest Land areas exert a strong influence on local water supplies and microclimatic conditions. Silvicultural management practices may effect both the quantity and quality of nearby water bodies. Since the types of pollution which may occur from Deciduous Forest Lands

would be the same for Evergreen Forest Lands and Mixed Forest Lands, a detailed description of environmental considerations is presented only for the Deciduous Forest Land category rather than each Level II Forest Land category.

Thinning and harvesting operations may increase water quantity by reducing existing transpirational surface areas and decrease water quality as a consequence of the transport of chemical (primarily herbicides, insecticides, and fertilizers) and physical (loose soil particles) contaminants to nearby water bodies with surface runoff.

The use of herbicides for plantation clearing, site preparation, right-of-way maintenance, and other uses may contaminate the soil, wildlife, and surface or ground-water supplies. Insecticides, used to check the spread of harmful pests, can cause both air and water pollution--not to mention the possibility of adversely affecting certain beneficial species such as honey bees.

Forest fertilization, if improperly administered, can increase the nutrient load of nearby water bodies and thereby increase existing trophic states. Logging road construction and maintenance activities can lead to erosion and increase nearby water course sediment loads. Repeated passes of logging equipment over the area can result in soil compaction, reduce percolation rates, and as a consequence, intensify surface runoff rates--even to the extent that it may cause minor flooding and the loss of tree vigor.

Interpretation Keys. The Deciduous Forest Land areas at Windsor (west-central Missouri) and Kirksville (northeast Missouri) illustrate land use category 41.

Site No. 74 (Reforested Strip Mine)
Location: Windsor
Henry County, Missouri
Geographic Coordinates: 38°34'N
93°35'W

A number of areas in the State which have been strip mined have been allowed to return to Forest Land vegetation. One such area, approximately 6 miles west of Windsor, is circled in figure 6-192. Notice the alternating rows of white (ridges) and dark (forested troughs) in the upper left portion of the circle. Figure 6-193, an oblique photograph of the same area, reveals the extent to which additional deciduous tree growth has occurred between 1972 and 1980. Just to the southwest of the strip mines shown in figure 6-192 is an excellent example of a larger strip mined area

Figure 6-192.--Mapping photograph of strip mine area west of Windsor, Mo., undergoing natural reforestation, 1972.

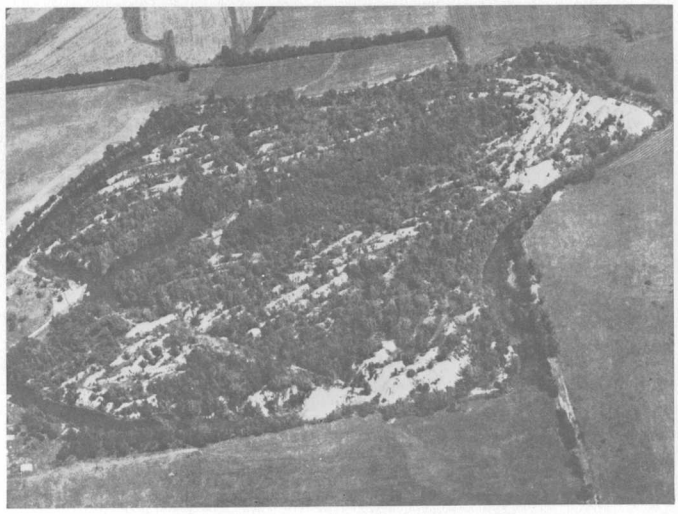


Figure 6-193.--Low-level oblique photograph of reforested strip mine area, 1980.

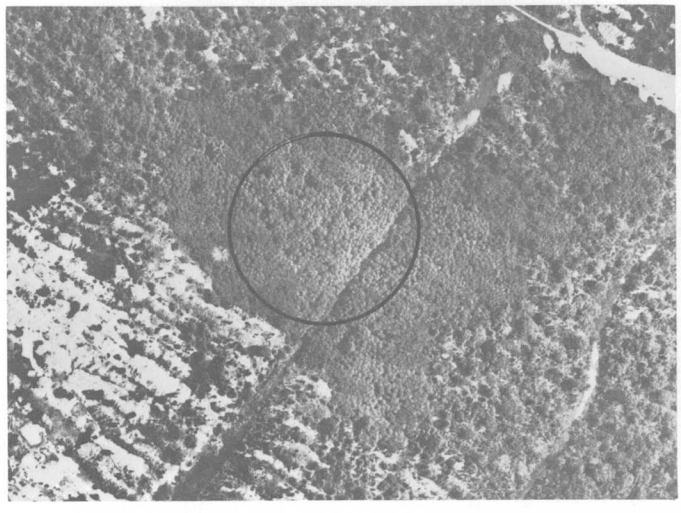


Figure 6-194.--Low-level vertical photograph of mature, natural reforestation of former strip mine area southwest of Windsor.

after more than 30 years of natural reforestation. Notice the two types of forest cover shown in figure 6-194. The smoother textured, area, circled, is an area of coniferous forest cover. The remaining area is covered by deciduous trees.

Site No. 94 (Deciduous Trees)
Location: Kirksville
Adair County, Missouri
Geographic Coordinates: 40°11'N
92°38'W

Another example of Deciduous Forest is shown in figure 6-195. This site, at Thousand Hills State Park just west of Kirksville, Missouri, also provides an excellent example of coniferous evergreen trees adjacent to deciduous trees. Although coniferous trees are not native to the area, Boy Scouts voluntarily planted some scotch pines in several places in the park about 25 years ago. The coniferous trees stand out as the darker tone areas in figure 6-195.

Figure 6-196, an oblique photograph taken 6 years later, shows an area of defoliated trees at A. A recent forest fire has destroyed some of the scotch pines. To the east of the defoliated area are the deciduous trees with their characteristic, more rounded tree crowns (B). Notice that the deciduous trees generally have a lighter tone on black-and-white photographs. Had frost-season photography been available, it would have also been helpful in separating the deciduous from the evergreen trees.

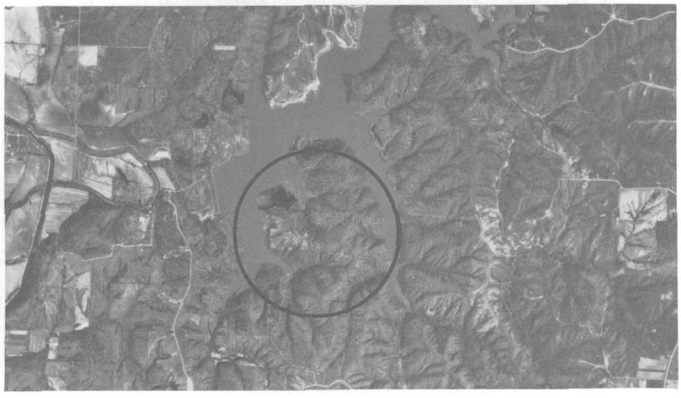


Figure 6-195.--Mapping photograph of deciduous and evergreen forest cover in Thousand Hills State Park, 1974.

Figure 6-196.--Low-level 1980 oblique photograph of a portion of the area shown in figure 6-195.

Category 42--Evergreen Forest Land

Category Description. Forest areas in which the trees are predominately those which remain green throughout the year are classified as Evergreen Forest Lands. Included in this category are both coniferous and broadleaved evergreens. Evergreen species commonly associated with Wetland areas are not included in this category.

The two most common species of evergreens occurring in Missouri are the shortleaf pine (pinus echinata) and the eastern redcedar (juniperus virginiana). The former is found primarily in the southeastern part of the State while the latter can be found in extreme east-central Missouri and in some east-central counties.

Environmental Considerations. The environmental description presented earlier for land use category 41, Deciduous Forest Land, applies to Evergreen Forest Land areas as well; therefore, refer to land use category 41 for information on the potential pollution contaminants most likely to be associated with Evergreen Forest Land.

Interpretation Keys. Presented below are examples of planted pine at New Madrid and eastern redcedar near Bradleyville (south-central Missouri).

Site No. 25 (Plantation Pine)
Location: New Madrid
New Madrid County, Missouri
Geographic Coordinates: 36°32'N
89°26'W

Located about 3 miles southeast of New Madrid is a rectangular area of planted shortleaf pine. Photographed in 1974, notice the height differences between the planted pine and the adjacent deciduous trees in figure 6-197. Figure 6-198, an oblique photograph of the same area in 1980, illustrates both the rapid rate of tree growth exhibited by this species in southeast Missouri and the characteristic carpetlike texture common to even-aged coniferous tree cover. Although not the case with this particular pine plantation, many pine plantations are actually planted in rows. When viewed from the air, or on an aerial photographs, row pine plantations are easily identified.

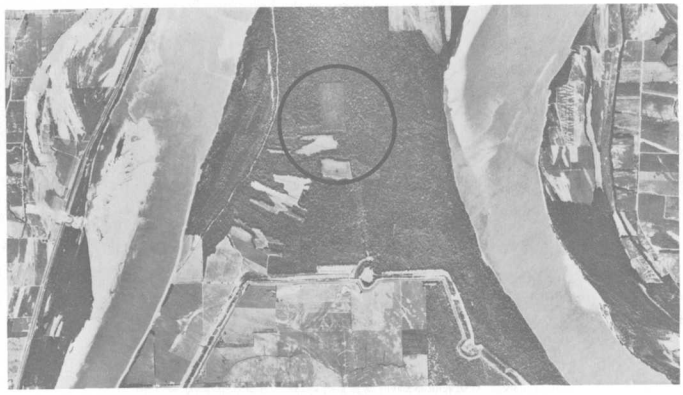


Figure 6-197.--Mapping photograph of planted pine near New Madrid, Mo., 1974.

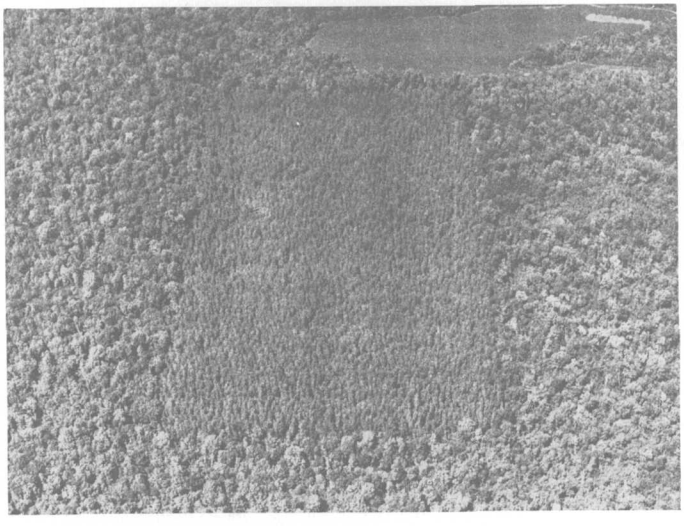


Figure 6-198.--Low-level oblique photograph of planted pine near New Madrid, 1980.

Site No. 65 (Eastern Redcedar)
Location: Bradleyville
Taney County, Missouri
Geographic Coordinates: 36°46'N
92°57'W

The second most prevalent type of Evergreen Forest Land, eastern redcedar, is shown in figure 6-199 at A. This area barely meets the minimum mapping size of 40 acres required for 1:250,000-scale land use and land cover mapping. The photograph, taken on January 23, 1976, allows the photointerpreter to easily separate deciduous and evergreen trees. The darker tone areas are eastern redcedars (evergreens) while the lighter tone areas, particularly on the right side of figure 6-199 at B, are deciduous trees which have lost their leaves. In the upper-left portion of figure 6-199 is an area of Mixed Forest Land; that is, an area of evergreen and deciduous trees where neither predominates. Figure 6-200, an oblique photograph, illustrates the darker tone of the cedar trees. Notice how the cedar trees parallel the limestone bedding plains as they curve around the hillsides. The areas devoid of tree cover have been cleared for pasture. A comparison between figure 6-199 and figure 6-200 reveals the extent of additional clearing that occurred at A between 1976 and 1980.

Figure 6-199.--Mapping photograph of eastern redcedar forest cover southwest of Bradleyville, January 1976.

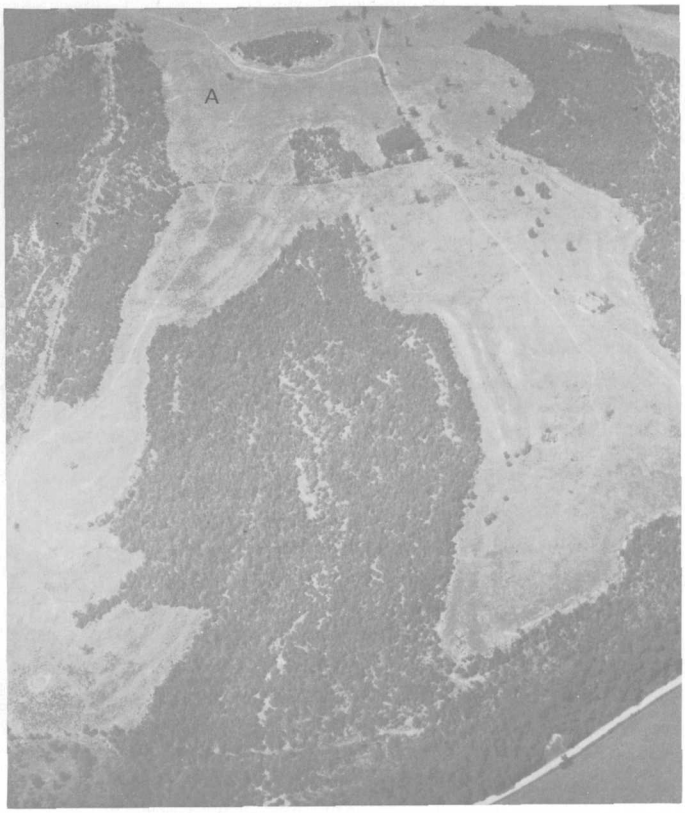


Figure 6-200.--Low-level oblique photograph of eastern redcedar forest cover near Bradleyville, July 1980.

Category 43--Mixed Forest Land

Category Description. A Forest Land area is classified as Mixed Forest when more than one-third intermixture of either evergreen or deciduous tree species occurs in a specific area. In actuality, this division of the Forest Land category is a function of the land use and land cover mapping specifications and, therefore, will be less often used at some mapping scales than others, particularly at larger mapping scales.

Environmental Considerations. The environmental description presented earlier for land use category 41, Deciduous Forest Land, applies to Mixed Forest Land areas as well; therefore refer to land use category 41 for information on the potential pollution contaminants most likely to be associated with Mixed Forest Land.

Interpretation Keys. Site 39, near Edgehill, presents an example of Mixed Forest Land.

Site No. 39 (Mixed Deciduous and Evergreen Forest Cover)
Location: Edgehill
Iron County, Missouri
Geographic Coordinates: 37°37'N
90°54'W

An example of Mixed Forest Land is illustrated by figure 6-201. This area, approximately 3 miles north-northeast of Edgehill, has varying degrees of deciduous (lighter tone areas) and evergreen (darker tone areas) trees. Notice the small, but more homogeneous, stands of darker tone evergreen trees (circled on the photograph) surrounded by deciduous trees. Because this photograph was taken during the frost season (photo date March 9, 1980), the deciduous trees exhibit an even lighter tone than had the photo been taken during the frost-free season. Quite often, frost season (leaf-off) photographs are not available. In such cases, if color-infrared photographs are available, the task of separating deciduous and evergreen trees or delineating Mixed Forest Land areas is facilitated. Figure 6-202, a black-and-white reproduction of a high-altitude color-infrared (CIR) photograph taken in September 1974, illustrates the benefits to be gained from the use of CIR photographs--even when they are reproduced in black-and-white. The evergreen trees appear as darker tones on the photograph. Notice the dark tone of the purer stands of evergreen trees at A. The deciduous trees are lighter in tone. Also notice, particularly along stream segments, the lighter tone of the deciduous trees which have begun to lose their leaves. In such cases these linear areas appear whitish to gray in tone. The lighter, almost white, areas in the photograph are rock outcroppings.

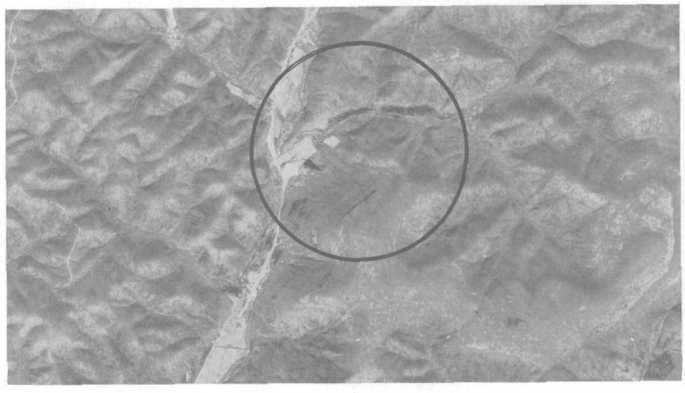


Figure 6-201.--Black-and-white reproduction of a mapping photograph of mixed forest cover near Edgehill, March 1980.

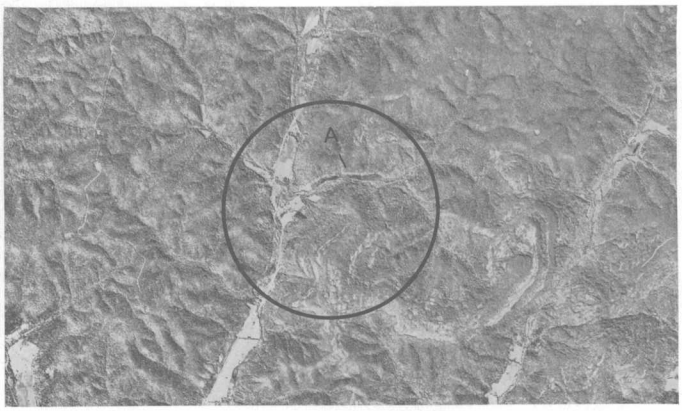


Figure 6-202.--Black-and-white reproduction of a color-infrared mapping photograph of mixed forest cover near Edgehill, September 1974.

LEVEL I, CATEGORY 5--WATER

Water areas, as defined by the Bureau of the Census, include all areas within the land mass of the United States that are persistently covered by water, at least 40 acres in size, and if linear, are at least 1/8 mile wide. However, for most purposes, agencies require the identification of water bodies smaller than 40 acres. The U.S. Geological Survey land use and land cover maps include all water bodies greater than 10 acres which are at least 300 feet wide and shown as double-line streams on the 1:250,000-scale base map. Water included in this category are streams and canals, lakes, reservoirs, and bays and estuaries.

At the 1:250,000-scale land use and land cover mapping for Missouri, only major rivers, such as the Mississippi, Missouri, and Osage, and major canals, such as those near Kennett in southeast Missouri, are shown. Natural lakes are rare with less than 17 square miles of this land use type in the State. More common are the State's many reservoirs. Reservoirs such as Clearwater, Pomme de Terre, Stockton, and Table Rock account for over 232,000 acres of State's reservoirs. Bays and estuaries are not found in Missouri.

The above acreage figures reflect water area totals based on Level II land use and land cover mapping at the 1:250,000 scale. At a larger mapping scale and a greater level of land use detail, these acreage totals increase somewhat.

It is important to note that all water bodies should be delineated as they exist at the date (time) of the photography, except areas in an obvious state of flood.

Category 51--Streams and Canals

Category Description. Included in the Streams and Canals category are rivers, creeks, canals, and other linear water bodies. Where the water course is interrupted by a control structure, the impounded area is placed in the Reservoir category.

Environmental Considerations. Streams and canals are not in themselves pollution sources. Instead, it is the discharge from point sources and surface runoff from nonpoint pollution sources, such as agricultural and silvicultural areas, which reduce stream and canal water quality. Perhaps flooding is the most serious detrimental effect which can occur from streams. When streams overflow their banks they can, and have, caused significant damage to manmade structures and crops.

Interpretation Keys. Two sites, site 70 and 26, follow which depict rivers and canals.

Site No. 70 (Missouri River)
Location: Jefferson City
Cole County, Missouri
Geographic Coordinates: 38°35'N
92°11'W

Rivers and streams are easily recognized on aerial photographs. As shown in figure 6-203, natural water courses consist of somewhat parallel land/water interface boundaries which quite often vary in width as a function of normal fluvial processes. Water bodies are most often characterized by medium gray tones on aerial photographs. Figure 6-204 is an oblique photograph of the same section of the Missouri River at Jefferson City. Notice the bridge over the river and the barges docked on the northern shore.

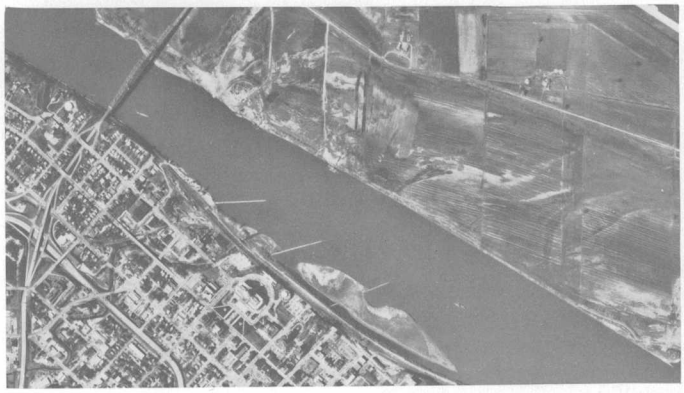


Figure 6-203.--Mapping photograph of Missouri River at Jefferson City, Mo.

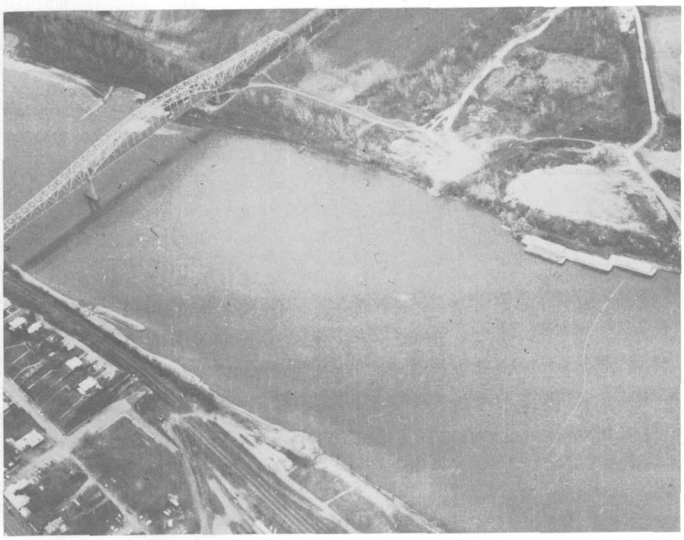


Figure 6-204.--Oblique photograph of Missouri River at Jefferson City, Mo.

Site No. 26 (Canals)
Location: Kennett
Dunklin County, Missouri
Geographic Coordinates: 36°10'N
90°01'W

Canals, or ditches, are constructed for one of two purposes: to drain or to irrigate an area. Around the turn of the century, a number of drainage ditches were constructed in southeast Missouri extending from south of Cape Girardeau to across the Missouri/Arkansas State line. This area, once swampy and marshy, is now very productive cropland. From a weblike network of ditches north of Gideon, many of the smaller ditches finally enter one of five main ditches about 3 miles southeast of Gideon where the five ditches extend southwest for almost 35 miles. Pictured in figure 6-205 is a segment of the five main drainage ditches about 4.5 miles southeast of Kennett. Unlike natural linear water courses (streams and rivers), canals and ditches have parallel land/water interface boundaries of nearly constant separation. Three of the ditches in the photograph appear medium gray in tone--the two westernmost ditches and the easternmost one. The two other ditches are lighter gray, almost white. The difference in tone can be explained by slight differences in water levels, camera angles, and subsequent Sun reflections. The lighter gray tone ditches are reflecting more sunlight and therefore show up as light gray in the photograph.

Figure 6-206, an oblique photograph of the same area, also shows differences in gray tone values for the ditches; however, in this case, only one ditch reflects more sunlight.

Figure 6-205.--Mapping photograph of canals near Kennett, Mo.

Figure 6-206.--Oblique photograph of canals near Kennett, Mo.

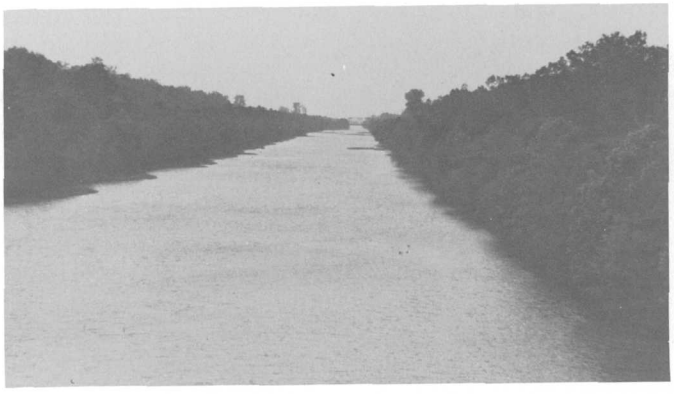


Figure 6-207.--Ground shot of drainage canal near Kennett, Mo.

Figure 6-207 is a ground-level photograph of one of the ditches taken from a bridge 6 miles northwest of the location shown in figures 6-205 and 6-206. Notice how straight the water course is and its constant width.

Category 52--Lakes

Category Description. Lakes are naturally enclosed standing water bodies, including regulated natural lakes but excluding reservoirs. Only lakes 10 acres or greater at the time of photoacquisition are delineated on the U.S. Geological Survey 1:250,000-scale land use and land cover maps. If the photointerpreter has source material which provides the name of a water body, he should not necessarily classify the water body from this information because many reservoirs in Missouri have lake names. Accordingly, the majority of Missouri's nonlinear water bodies are reservoirs and not lakes. It is important to remember that lake water levels are maintained by the seepage of ground water and the direct surface runoff of precipitation, whereas reservoir water levels are the result of manmade impoundments and the subsequent accumulation of surface runoff, primarily by contributing linear water courses.

For the most part, Missouri lakes are found in the flood plains of the State's two largest rivers--the Mississippi and the Missouri. These lakes, called oxbow lakes, are formed by sealing off the meanders of alluvial streams. As alluvial streams mature, their meanders (snake-like patterns) grow until the channels bend to meet themselves, causing the meander loops to be pinched (sealed) off and abandoned--therefore, oxbow lakes can be found all along the Missouri and Mississippi Rivers.

Environmental Considerations. Like streams and canals, lakes are not in themselves pollution sources. The same types of point and nonpoint pollution sources which affect linear water bodies also affect lakes. However, unlike linear water bodies, lakes do not possess the same flood hazard potential. Therefore, one is more likely to find manmade construction, namely houses and businesses, closer to the land/water interface boundaries of lakes than streams or rivers.

Interpretation Keys. Site 83, an oxbow lake west of Fortescue, Missouri, characterizes Missouri lakes.

Site No. 83 (Oxbow Lake)
Location: Fortescue
Holt County, Missouri
Geographic Coordinates: 40°05'N
95°21'W

Located west of Fortescue, Big Lake is one of Missouri's many oxbow lakes. In figure 6-208, it appears as a crescent shape with the cresent ends pointing west toward the Missouri River. Close inspection of the photograph reveals a series of meander scars to the east. Figure 6-209, an oblique photograph of the northern half of the lake, shows the extent to which resort-type residential structures rim the land/water interface boundary.

Figure 6-208.--Mapping photograph of an oxbow lake west of Fortescue, Mo.

Figure 6-209.--Oblique photograph of a portion of Big Lake west of Fortescue.

Category 53--Reservoirs

Category Description. Manmade impoundments of water used for such purposes as irrigation, flood control, municipal water supplies, recreation, and hydroelectric power generation are classified as reservoirs. On aerial photographs, reservoirs are identified by their overall nonlinear shape and associated manmade water-control structures--such as dams or levees. It is the manmade water-control structures which key the photointerpreter to classify a nonlinear water body as a reservoir. As with land use category 52 (Lakes), only reservoirs 10 acres or greater at the time of photoacquisition are delineated on 1:250,000-scale land use and land cover maps. Accordingly, many farm ponds in Missouri are not included in the acreage figures for reservoirs presented in Section 7. Of the State's 377,022 acres of water, 232,559 acres (61 percent) are represented by the Reservoir category. This category includes reservoirs such as Table Rock Lake, Stockton Lake, Lake of the Ozarks, Clearwater Lake, Clarence Cannon Lake, and many more smaller reservoirs around the State.

Environmental Considerations. Comments previously presented as environmental considerations for lakes hold true for reservoirs. Concerning flood hazard potential, the most dreaded occurrence would be a dam break. Fortunately however, such occurrences are rare.

Interpretation Keys. The Clearwater Lake Reservoir exemplifies many Missouri reservoirs.

Site No. 33 (Clearwater Lake Reservoir)
Location: Piedmont
Wayne County, Missouri
Geographic Coordinates: 37°08'N
90°46'W

Located approximately 4 miles west of Piedmont, Clearwater Lake Reservoir is one of Missouri's excellent recreational areas. Around the reservoir's perimeter are a number of public access points and use areas. Some of these areas are identified in figure 6-210 at A, B, and C; also shown is the dam at D. Note the straight land/water interface formed by the dam and the water.

Figure 6-211 shows more clearly the back side of the dam and some of the recreational/camping facilities. In figure 6-212, several campers and trailers can be seen parked at the site. Also shown in figure 6-211, at A, is a boat ramp. Figure 6-213 shows a ground photograph of the boat ramp area.

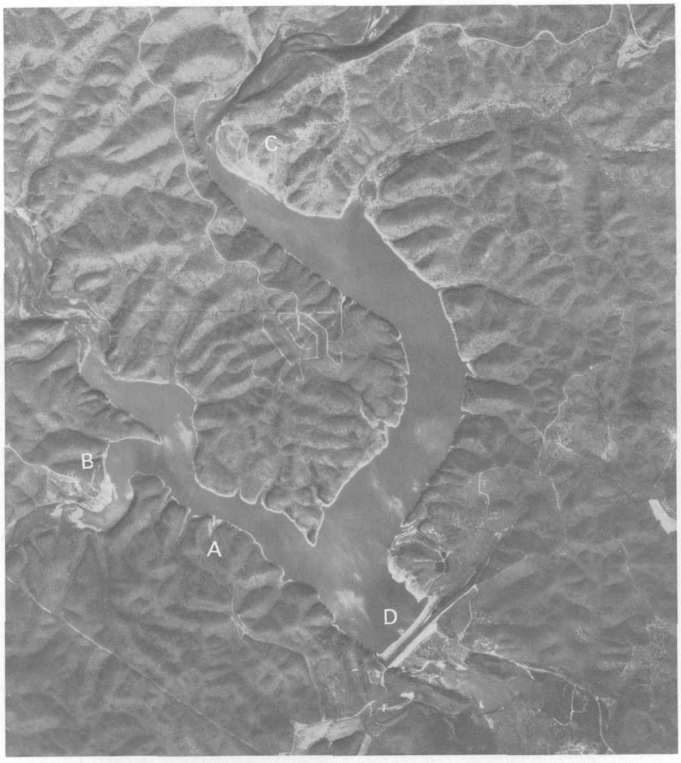


Figure 6-210.--Mapping photograph of Clearwater Lake Reservoir near Piedmont, Mo.

Figure 6-211.--Oblique photograph of Clearwater Dam near Piedmont, Mo.

Figure 6-212.--Camping area at Clearwater Dam near Piedmont, Mo.

Figure 6-213.--Public use area and boat ramp at Clearwater Lake Reservoir near Piedmont, Mo.

LEVEL I, CATEGORY 6--WETLAND

Wetland areas are areas where the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydrophytic vegetation is established, however, alluvial and tidal flats may be nonvegetated. Examples of wetlands include swamps, marshes, mudflats, and portions of streams, lakes, reservoirs, and bays which exhibit surface aquatic or hydrophytic vegetation. Shallow water areas where aquatic vegetation is submerged are classified as open water and not included in the Wetland category.

Extensive parts of some river flood plains qualify as Wetland, as do regularly flooded irrigation overflow areas. Not included in the Wetland category are agricultural lands where seasonal wetness or short-term flooding provides an important component of the total annual soil moisture necessary for crop production; for example, flooded fields associated with rice production or developed cranberry bogs.

Uncultivated Wetland, from which wild rice, cattails, or wood products, and other crops are harvested, or Wetland grazed by livestock, are placed in the Wetland category.

Wetland areas drained for any purpose belong to the land use and land cover category for which they are being used. If, however, drainage is discontinued and such use ceases, classification may revert to the Wetland category. Wetland managed for wildlife purposes may exhibit short-term land use changes as different management practices are used; however, such areas should be classified as Wetland.

With regard to the delineation of Wetland areas, two separate boundaries are important: the upper wetland boundary above which almost any non-wetland category of land use or land cover may exist, and the boundary between wetland and open water beyond which the appropriate Water category should be utilized.

Wetland areas in Missouri occur primarily along the Mississippi and Missouri River flood plains, the upper reaches of reservoirs, and in the Missouri bootheel counties of Wayne, Stoddard, Bollinger, Mississippi, and Dunklin. These five counties account for slightly more than one-third of all of Missouri's 66,862 acres of Wetland.

The Level II categories of Wetland are Forested Wetland and Nonforested Wetland. Approximately two-thirds (46,585 acres) of Missouri's Wetland areas are Forested Wetland.

Category 61--Forested Wetland

Category Description. Wetlands dominated by woody vegetation are classified as Forested Wetland. In Missouri, the Forested Wetland category is primarily represented by bottomland oaks such as pine; swamp, white, and shingle oaks; and tupelo, blackgum, sweetgum, and cypress species.

Extensive Forested Wetland areas are usually more easily identified on color-infrared (CIR) photography than on color or black-and-white photography. These areas exhibit a bluish cast on CIR imagery as opposed to the red colors of deciduous trees and magenta colors of the evergreens.

If available, ground surveys of soil types or the duration of flooding can provide supplemental information to assist the photointerpreter in delineating Forested Wetland areas. Many times photographs acquired with low Sun angles will aid in detecting standing water areas where tree crown closure values are not too great.

Environmental Considerations. Like water, Forested Wetland areas do not cause pollution. These areas, however, can become victims of a range of man's activities which can ruin an otherwise balanced ecosystem. In Missouri, the greatest potential pollution source for Forested Wetland areas is nonpoint pollution, primarily runoff from adjacent agricultural areas. If proper precautions are not taken, agricultural areas may introduce such pollutants as livestock manure, fertilizers, and pesticides.

Interpretation Keys. Two sites, both in southeast Missouri, are described below to illustrate Forested Wetland areas.

Site No. 31 (Swamp)
Location: Puxico
Stoddard County, Missouri
Geographic Coordinates: 37°01'N
90°10'W

Figure 6-214, a black-and-white reproduction of a color-infrared photograph of a portion of the Mingo National Wildlife Refuge (approximately 3 miles north of Puxico), depicts both land use categories 61 (Forested Wetland), at A, and 62 (Nonforested Wetland), at B. Notice the dark areas as opposed to the lighter area just above A. The dark areas are wetter areas of woody vegetation, while the lighter areas are higher, drier areas of forest land. The lighter area at B, Nonforested Wetland, is discussed later.

On color-infrared photography, the Forested Wetland areas appear bluish in color while the drier deciduous forest areas appear red in summer. During the frost season, deciduous trees appear as blue-green when the leaves are brown, yellow when the leaves are red, and white when the leaves are yellow. The photograph shown in figure 6-214 was taken in November 1974, when the leaves had already turned brown; therefore, on the color-infrared photography, the trees at C appeared blue-green.

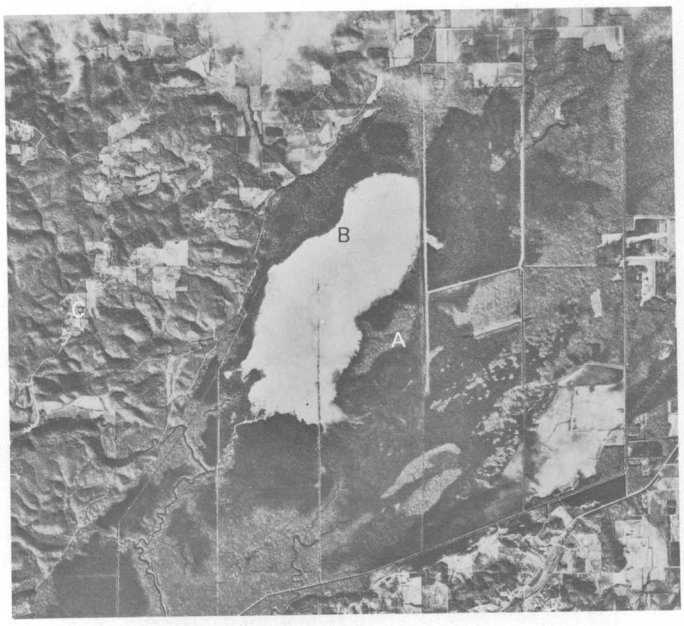


Figure 6-214.--A black-and-white reproduction of a color-infrared mapping photograph of swamp and marsh areas in Mingo National Wildlife Refuge near Puxico, Mo.

Figure 6-215, a forward oblique photograph of the same area, also suggests slight differences in moisture levels. Notice the slightly lighter tone exhibited in the area just to the right of A. Apparently there has been an increase in water levels since 1974 when the photograph shown in figure 6-214 was obtained. The increased water levels have increased the size of the wetland area which existed in 1974.

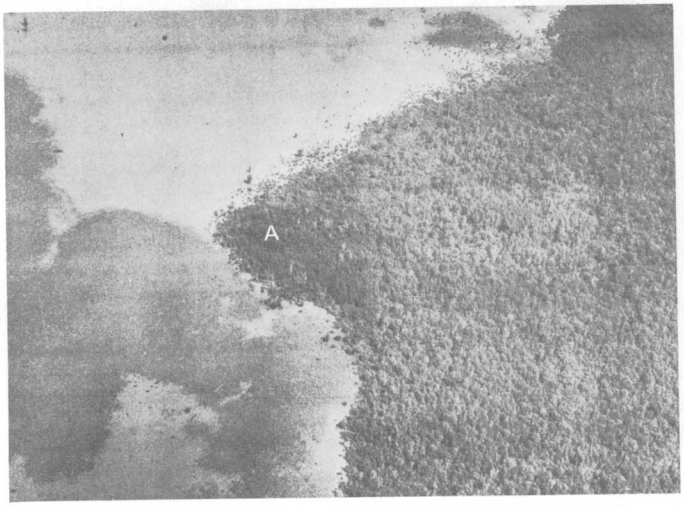


Figure 6-215.--Low-level photograph of swamp area in Mingo National Wildlife Refuge near Puxico, Mo.

Site No. 32 (Swamp and Marsh)
Location: Wappapello
Wayne County, Missouri
Geographic Coordinates: 36°58'N
90°23'W

Located approximately 6 miles west of the Mingo National Wildlife Refuge lies Wappapello Lake--actually it is a reservoir since this water body was formed following the construction of a dam on the St. Francis River near Wappapello in 1941. Many of the upper reaches of the reservoir now exist as Forested and Nonforested Wetland areas. Site 32, noted by the circle on figure 6-216, illustrates the wetland nature of just one of these areas. Notice the dark gray tone of the Forested Wetlands area in the southwest quadrant of the circle. Also notice the lighter gray tones of adjacent deciduous trees.

Figure 6-217 provides a closer view of the area. Note the difference between the Forested Wetland vegetation at A and B as compared to the Nonforested Wetland area at C.

At the time of this photograph, September 1980, water level of the reservoir was down somewhat. Accordingly, some of the areas, such as just above the B and below the A in the photograph, were not water covered. Although they can be seen more clearly on the original large-scale color photograph, these areas can be identified as the lighter gray areas on this photograph. Marsh areas, at C, appear as even lighter gray areas on the photograph.

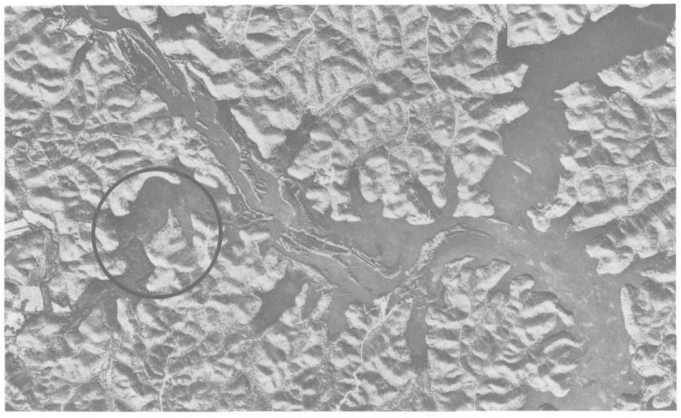


Figure 6-216.--Forested Wetlands on upper reaches of Lake Wappapello reservoir west of Wappapello.

Figure 6-217.--Oblique photograph of forested wetlands near Wappapello.

Category 62--Nonforested Wetland

Category Description. Nonforested Wetlands are areas dominated by herbaceous wetland vegetation or are nonvegetated. In Missouri, these areas include fresh marshes and nonvegetated flats. As suggested in the introductory comments, the Nonforested Wetland category accounts for only one-third of the State's 66,862 acres of wetland. Of this amount, approximately 20,000 acres, almost half is situated in numerous reservoir hollows. The remainder occurs mostly in alluvial flood plains of the Mississippi and Missouri Rivers.

Environmental Considerations. As with Forested Wetlands, Nonforested Wetland areas are not pollution sources. Likewise, since Nonforested Wetland areas are often situated adjacent to Forested Wetland areas, the environmental consideration comments presented earlier for Forested Wetlands hold for Nonforested Wetlands as well. Therefore, no further comments are presented here.

Interpretation Keys. Site 31, in southeast Missouri, and site 82, in northwest Missouri, illustrate the types of Nonforested Wetland areas found in the State.

Site 31 (Marsh)
Location: Puxico
Stoddard County, Missouri
Geographic Coordinates: 36°59'N
90°10'W

Figure 6-214, presented earlier in the descriptions for Forested Wetland, identifies the area of the Mingo National Wildlife Refuge to be described here. Water levels have increased since 1974 and, consequently, the area immediately below point A in figure 6-214 now exists as Nonforested Wetland. Figure 6-218, a 1980 photograph of the same area, illustrates the surface appearance of a Nonforested Wetland area. Note the overall mottled tone of the area. The lighter areas at A and B are small water areas, the darker areas at C and D are Forested Wetlands. The remaining nonvegetated area is Nonforested Wetland.

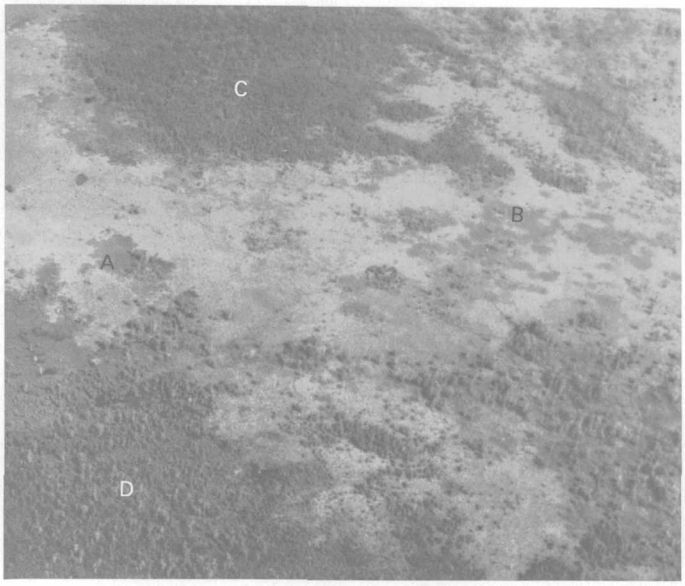


Figure 6-218.--Oblique photograph of Nonforested Wetland in Mingo National Wildlife Refuge near Puxico, Mo.

Site No. 82 (Nonforested Wetland)
Location: Mound City
Holt County, Missouri
Geographic Coordinates: 40°04'N
95°15'W

Site 82, located approximately 4 miles south of Mound City, is located near the southern end of the Squaw Creek National Wildlife Refuge. Figure 6-219, taken in 1975, shows the area at a time of relatively high water levels. Notice the light gray tone of the water area. In contrast, figure 6-220, taken in September 1980, was obtained near the end of a prolonged drought. Notice how aquatic vegetation has replaced much of the water area that existed in 1975. Also note the overall mottled appearance of the area. The mottled appearance results from differences in algal growth and herbaceous vegetation. The complete lack of woody vegetation in the area should also be noted since this rarely occurs in Missouri.

Figure 6-219.--Mapping photograph of Nonforested Wetland area near Mound City, Mo.

Figure 6-220.--1980 Oblique photograph of Nonforested Wetland area near Mound City, Mo.

LEVEL I, CATEGORY 7--BARREN LAND

Barren Land is land with limited ability to support plant life with less than one-third of the area in vegetation or other cover. In general, it is an area of thin soil, sand,

or rocks. Vegetation, if present, is widely spaced and scrubby. Barren Land is more often found in nature; however, land also may become barren because of man's activities. The Level II categories of Barren Land are: Dry Salt Flats; Beaches; Sandy Areas Other Than Beaches; Bare Exposed Rock; Strip Mines; Quarries and Gravel Pits; Transitional Areas; and Mixed Barren Land. Barren Land categories found in Missouri are Sandy Areas Other Than Beaches (mostly islands and sand bars created by the currents in the larger rivers of the State), Strip Mines, Quarries and Gravel Pits, and Transitional Areas.

The geologic structure of Missouri allows mining of coal in the northern portion of the State, while Quarries and Gravel Pits occur throughout the State.

When land clearing occurs, either in rural or urban areas of the State, and the former or future use of the land cannot be discerned, the area is said to be in transition. Accordingly, in order to avoid inferential errors in classification, it is considered to be a Transitional Area. This transitional classification is also used when forest land is cleared for agriculture, wetland is drained for development, or where areas become temporarily bare, such as construction for highways, residences, shopping centers, industrial sites, or suburban and rural residential subdivisions. Land areas altered by filling, such as sanitary landfills, are also included in the Transitional Area category. These areas in Missouri are mostly forest lands converted for agriculture purposes and areas cleared for new construction.

Category 73--Sandy Areas Other Than Beaches

Category Description. There are approximately 4,000 acres of Sandy Areas Other Than Beaches in Missouri. Most of these sandy areas occur in the channels and banks of the Missouri and Mississippi Rivers, and are formed by sand deposited by their currents. These sandbar islands and tow heads are in a constant state of change--every time the current increases, they are subject to being washed away, and the sand deposited in another location. Because of this instability, vegetation does not have a chance to become established.

Environmental Considerations. Sandy Areas Other Than Beaches, formed by natural process, are not a source of pollution.

Interpretation Keys. The following site indicates the types of areas to be delineated under this category.

Site No. 24 (Sandbar)
Location: 10 miles northeast of Hayti
Pemiscot County, Missouri
Geographic Coordinates: 36°20'N
89°36'W

Figure 6-221, a mapping photograph taken in 1974, shows an area in the Mississippi River channel which would be delineated under this category. Because of their inherent instability, the size and shape of the islands, sandbars, and tow heads are in a constant state of change. Since vegetation hasn't had a chance

Figure 6-221.--Sandy area along the Mississippi River.

Figure 6-222.--Low-altitude oblique photograph of unstable sandy area in Mississippi River.

to become established, these areas are much lighter in tone than the surrounding areas. The instability of this feature is shown in figure 6-222, a low-altitude oblique photograph taken in 1980 of the same area shown in figure 6-221. The photograph shows the light-toned sandy areas in the river and adjacent to the dark-toned shoreline.

Category 75--Strip Mines, Quarries, and Gravel Pits

Category Description. Surface mining activities that have significant surface expressions are included in this category. Vegetative cover and overburden are removed to expose deposits of extractive material such as coal, limestone, iron ore, or copper. Quarrying of stone and the recovery of sand and gravel also result in large open pits. All surface expressions of this type of mining, including active, inactive, and unreclaimed quarries and gravel pits, are included in this category. When other land use or land cover types have been established, these areas are no longer included in this category. Missouri contains approximately 75,177 acres of land in category 75.

Environmental Considerations. Strip mines, quarries, and gravel pits are often a source of significant pollution. Extraction of minerals is often accompanied by careless disposal of spoil materials containing heavy metals and toxic chemicals. Runoff from these waste products may sterilize local soils and contaminate surface and ground water. Surface runoff can collect large concentrations of sulfur and iron resulting in "acid drainage."

Strip mining activities and their associated removal of topsoil increase the erosional potential of an area and may result in increased sediment loads in nearby streams.

Quarries and gravel extraction activities can create excessive noise levels and lower air quality. The use of heavy machinery, vehicles, and intermittent blasting results in increased local noise levels. Dust and debris, caused by heavy machinery and crushing operations, affect local air quality and can create health hazards to nearby residents.

Improper reclamation methods, or the lack of them, can create a site which continually affects the environment. These sites, especially quarries, have been used as landfill sites for both residential and industrial wastes, which if not properly controlled may lead to ground-water contamination. Land collapse, subsidence, and increased erosion result in increased loss of land. The drainage pattern and hydrology of large regions may also be altered, as well as water quality. Removal or burying of topsoil under spoil material also affects the future productivity of extraction sites.

Interpretation Keys. Presented below are examples of a strip mine, quarry, and gravel pit.

Site No. 97 (Coal Strip Mine)
Location: Thomas Hill Reservoir
Randolph County, Missouri
Geographic Coordinates: 39°32'N
92°38'W

Identification features for strip mining are the spoil banks of overburden, the lack of vegetation on active mines, and deep trenches. The last trench in a sequence of strips is usually water filled. The outer edge of the mining area is called the highwall or headwall. Active strip mines use power shovels for stripping overburden or mining.

This strip mine is just south of the Thomas Hill Reservoir in Randolph County, Missouri. The mapping photograph, figure 6-223, shows the layout of the mined area. New mining is occuring at A, a newly reclaimed mine is at B, and an older reclaimed area at C.

Figure 6-223.--Mined area near Thomas Hill Reservoir, Mo.

Figure 6-224 shows mounds of overburden, newly mined coal, and a power shovel removing overburden. The overburden is removed, the coal removed, and the trench where the coal

was extracted then filled with overburden. This process is repeated until the coal deposits are depleted. The ground photograph, figure 6-225, shows a mining shovel in the process of stripping coal. This photograph provides insight into the size of the shovel and the depth of the trenches and excavation.

Figure 6-224.--Strip mining in progress.

Figure 6-225.--Ground photograph of stripping process.

Site No. 22 (Quarries)
Location: Cape Girardeau
Cape Girardeau County, Missouri
Geographic Coordinates: 37°16'N
89°34'W

The key identifying photographic features of quarries is the large open pits, usually lighter in tone than adjacent areas, with steep walls. An active quarry will have roads to the pit and loading and crushing facilities.

Quarries are open pits where building stone such as slate, granite, marble, and limestone are extracted. The mapping photograph in figure 6-226, shows two quarries used in producing cement at points A and B. These limestone quarries, south of Cape Girardeau, are owned and operated by a cement company. The limestone is removed and transported to a cement plant nearby. The oblique photograph in figure 6-227 shows the layout of the quarry and the roads leading into the quarry area. The ground photograph, figure 6-228, shows the nearly vertical walls and provides an appreciation for the depth of the quarry.

Figure 6-226.--Mapping photograph of two limestone quarries south of Cape Girardeau, Mo.

Figure 6-227.--Low-altitude oblique photograph of quarry area.

Figure 6-228.--Ground photograph of quarry.

Site No. 30 (Gravel Pit)
Location: Dexter
Stoddard County, Missouri
Geographic Coordinates: 36°49'N
89°58'W

Key identifying features of gravel pits are the light tones and rough-textured areas where gravel is being excavated, lack of vegetation in the areas being worked, and the presence of access roads leading to the area.

The gravel pit shown in figure 6-229 is a mile and a half northwest of Dexter, in southeast Missouri. Topsoil and overburden are removed and the gravel scooped up by shovels and loaded on trucks for hauling to its destination. Many times, gravel pits are only operated during road construction. The absence of vegetation and the rough texture of the excavation area is exhibited on the photograph shown in figure 6-230. This ground photograph also shows the active gravel pit and the depth of the excavation.

Figure 6-229.--Low-altitude oblique photograph of a gravel pit near Dexter, Mo.

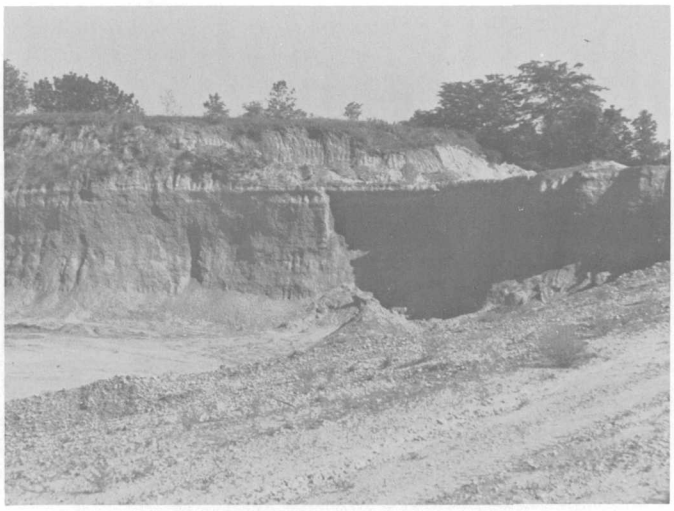


Figure 6-230.--Ground photograph of gravel pit near Dexter, Mo.

Category 76--Transitional Areas

Category Description. The Transitional Area category is used for those areas which are in transition from one land use activity to another. This transitional phase occurs when forest lands are cleared for agriculture, wetlands are drained for development, or when any type of land use ceases as areas become temporarily bare preceding construction for future uses such as residences, shopping centers, industrial sites, or suburban residential subdivisions. Land altered by filling, such as sanitary landfills, is also included in the Transitional category.

Environmental Considerations. The Transitional land use and land cover category in urban areas has the same potential pollution sources as the category to which it belongs. Urban, suburban, and rural areas undergoing conversion to residential and commercial uses exhibit the potential pollution sources associated with construction--excessive noise, dust, and debris, and runoff and erosional possibilities. Following completion of construction, the main environmental concern will be surface runoff and possible localized flooding.

A forested area being cleared for agriculture will exhibit pollution potentials similar to a forested area being harvested or a right-of-way being cleared.

Forested areas undergoing conversion to agriculture are usually sprayed with herbicides to kill trees and brush. Effects of these herbicides on wildlife are controversial, and immediately after spraying, runoff can carry these herbicides into nearby streams and other surface water bodies.

Landfills and spoil dumps are also potentially dangerous sources of water pollution. Landfills are often situated in abandoned pits or quarries. If the geologic structure is unfavorable, or the bedrock permeable, ground water can be contaminated by the disposed wastes. Dust, debris, and noxious fumes from decaying waste can lower air quality in these areas and in adjacent communities.

Interpretation Keys. Two sites, one urban and one rural, are presented to illustrate Transitional Areas.

Site No. 20 (Urban Renewal)
Location: St. Louis
St. Louis City, Missouri
Geographic Coordinates: 38°39'N
90°12'W

The oblique photograph in figure 6-231 shows an urban renewal area in "inner city" St. Louis. Buildings have been removed and future use is unknown, so the area is classified as a Transitional Area. In many urban renewal projects, deteriorating buildings are torn down and modern apartments or civic buildings constructed.

Figure 6-231.--Urban renewal in St. Louis, Mo.

Figure 6-232, a ground photograph, shows some of the buildings in an urban renewal area. These buildings will be removed, and until another land use can be identified, the area is considered Transitional.

Figure 6-232.--Buildings slated for removal in a urban renewal area, St. Louis, Mo.

Site No. 28 (Rural Transition)
Location: Piedmont
Wayne County, Missouri
Geographic Coordinates: 37°13'N
90°30'W

Site No. 28, four and a half miles northeast of Piedmont, is a Rural Transition area. The trees were sprayed with a herbicide and bulldozed into windrows. The larger trees were used for firewood and the remaining debris either burned or left to rot. The cleared areas are then tilled, fertilized, planted in grass, and used for pasture.

Figure 6-233 illustrates various phases of the transition: forested area at A, cleared area at B, and land already in pasture at C.

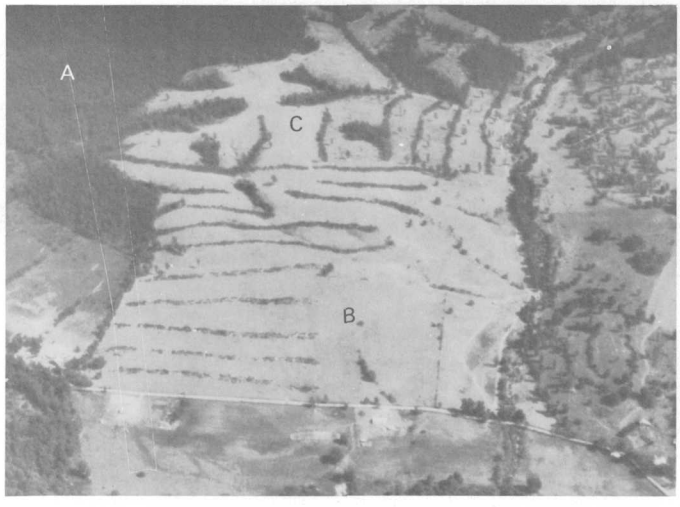


Figure 6-233.--Low-level photograph of forest clearing near Piedmont, Mo.

The ground photograph in figure 6-234 shows the pasture, the windrows, and a few scattered trees in the background.

Figure 6-234.--Ground photograph of forest clearing process.

Site No. 19 (Sanitary Landfill)
Location: Peerless Park
St. Louis County, Missouri
Geographic Coordinates: 38°32'N
90°36'W

Landfills are usually located on the periphery of urban areas in abandoned pits, in low-lying areas, or in other areas of low economic importance. The photographic signatures of landfills can be as varied as the landscape itself. A key identifier of landfills is the lack of trees. The landfills are lighter in tone than the adjacent landscape and tend to have a rough texture (because of the constant repositioning of the waste materials and overburden).

Landfills are included in category 76, Transitional. The mapping photograph, figure 6-235, shows a landfill area at A with lighter tones exhibited in the area of disturbed earth. Also shown, at B, is a drive-in theater which should be placed in land use category 12.

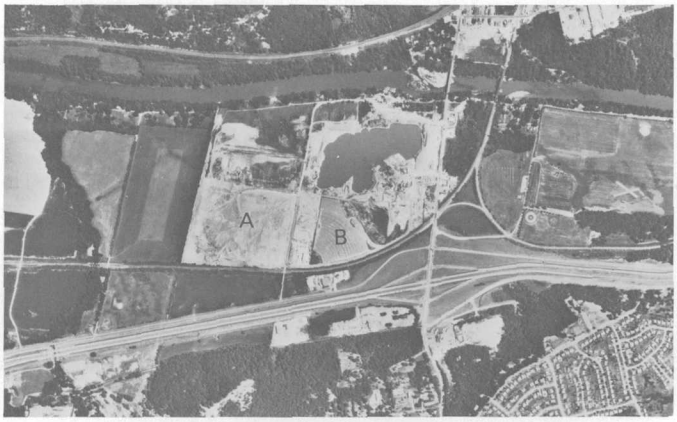


Figure 6-235.--Landfill area, St. Louis County, Mo.

Figure 6-236 shows the inverted "L-shaped" landfill area with its various gray tones and rough texture. When the area is filled to capacity, it will be leveled and developed for another land use such as commercial or residential.

Figure 6-236.--Low-altitude photograph of landfill area near Peerless Park, Mo.

SECTION 7: LAND USE AND LAND COVER TABULATIONS FOR MISSOURI

The graphic maps of land use and land cover, and associated maps, can be used to tabulate the distribution of land use and land cover categories for various regions of concern (e.g., land use by county). Manual methods of computing acreage statistics from maps (e.g., random dot grid counting) are often effective for small project areas, but cannot be used economically over large regions.

In order to meet the need for acreage statistics of large regions, computer methods are used to calculate and cross-tabulate map data. To do this, lines from the maps representing boundaries which separate adjacent polygons must be converted into a computer-readable or digital form. Specialized computer equipment, referred to collectively as digitizers, have been developed to facilitate the conversion of data from graphic to digital form.

There are many varieties of digitizers and methods of representing the map data in a computer. Very often, lines on the map are approximated by line segments defined as a series of x,y coordinates. A group of line segments, or vectors, define closed polygon areas corresponding to poylgons on the maps. While polygons on the political units outline counties, polygons on the land use and land cover map outline areas with homogenous land use or cover characteristics. Associated with each polygon is an attribute code. For example, the land use and land cover attribute code "11" describes a homogeneous area of residential land use. Together, the x,y coordinates and associated attributes form a basic unit for computer processing. Once the map information is digitized, the data are processed and edited by a computer system developed by the U.S. Geological Survey. The system, the Geographic Information Retrieval and Analysis System (GIRAS), is utilized to convert and edit the digital x,y-coordinate data (Mitchell, 1977). To compare digital data between maps, the x,y-coordinate data defining the polygon boundaries are converted into uniform sized grid cells. Once gridded, the maps are registered for orientation and alinement (Guptil, 1978).

The land use and land cover maps use a square grid size of 200 meters. This size (4 hectares, approximately 10 acres) is the same as the minimum-sized polygon portrayed on the land use and land cover maps at a scale of 1:250,000.

After the data are converted from x,y coordinates to a regular matrix of grid cells, subsequent programs merge the grid cells of the individual maps into a single computer file, then count and cross-tabulate the coincidence of attribute codes from two of the maps for each grid cell. In this manner, acreage statistics of land use by county or land use by hydrologic units (or any other associated maps) can be obtained.

The land use and land cover and associated maps for the State of Missouri have been processed through the GIRAS programs and statistical tabulations generated. A listing of the preliminary land use and land cover acreage data by county cross-tabulations follows. The county codes are standard FIPS (Federal Information Processing Standards) codes which are utilized by all Federal agencies. The five digits in these codes consists of a State code (i.e., the leftmost two digits) and a county code (odd numbers only such as 001, 003, 005, etc.). The complete list of codes in ascending order correspond to an alphabetized list of county names for the State (e.g., 29001=Adair county, 29229=Wright county).

Care should be taken in comparing figures from the land use and land cover inventories with other inventories of resources or areal statistical figures. The classification system and methods employed in land use and land cover mapping are explained in this and other documents and it is essential that users understand and critically evaluate the methodologies and data sources used in the various inventories being compared. For example, often-quoted areas of counties may or may not include internal water bodies less than 40 acres, while the land use and land cover maps provide a complete enumeration of all land and water surfaces 10 acres or larger. Estimated areas may be based on manual computations or by more accurate methods employing digitizing. Methodologically, some inventories are based on sampling methods utilizing air photos supplemented with selected field-checks. The land use and land cover maps, by comparison, are based upon precompilation field-checks and interpretation of high-altitude aerial photographs. Basically, differences in inventory results are usually attributable to definable differences for map categories and criteria used in classifying and/or mapping the land surface. Other frequently contributing factors are the dates, scales, and types of photographs used in resource inventory and the scale, methods, and specifications employed in mapping the data. A major objective of this publication has been to aid users in their understanding of the land use and land cover mapping compiled by the U.S. Geological Survey. A better

understanding of land use classification schemes and compilation methods should help users better understand land use and land cover maps and products derived from these maps, such as the areal statistics. Statistical acreage data for the counties and the State of Missouri follow.

State of Missouri Statistical Data-- Land Use By Counties

The following pages present land use acreage values by land use type for each of Missouri's 114 counties and St. Louis City. The number shown beneath each county and St. Louis City is the Bureau of the Census' geographic identification code.

Presented below are the land use codes and their respective explanations. Please note that categories for tundra and perennial ice and snow have been omitted from this list since they do not occur in Missouri. For a more complete listing of the Anderson classification system, refer to table 1-1 in this publication.

10 Urban or Built-up Land
- 11 Residential
- 12 Commercial and Services
- 13 Industrial
- 14 Transportation, Communications, and Utilities
- 15 Industrial and Commercial Complexes
- 16 Mixed Urban or Built-up Land
- 17 Other Urban or Built-up Land

20 Agricultural Land
- 21 Cropland and Pasture
- 22 Orchards, Groves, etc.
- 23 Confined Feeding Operations
- 24 Other Agricultural Land

30 Rangeland
- 31 Herbaceous Rangeland
- 32 Shrub and Brush Rangeland
- 33 Mixed Rangeland

40 Forest Land
- 41 Deciduous Forest Land
- 42 Evergreen Forest Land
- 43 Mixed Forest Land

50 Water
- 51 Streams and Canals
- 52 Lakes
- 53 Reservoirs
- 54 Bays and Estuaries

60 Wetland
- 61 Forested Wetland
- 62 Nonforested Wetland

70 Barren Land
- 71 Dry Salt Flats
- 72 Beaches
- 73 Sandy Areas Other Than Beaches
- 74 Bare Exposed Rock
- 75 Strip Mines, Quarries, and Gravel Pits
- 76 Transitional Areas
- 77 Mixed Barren Land

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Adair 29001	Andrew 29003	Atchison 29005	Audrain 29007	Barry 29009	Barton 29011	Bates 29013	Benton 29015
10	3814	3518	2581	5506	4389	2707	6059	2769
11	2471	1275	998	3074	2768	1364	2165	2501
12	771	366	297	959	583	366	672	198
13	59	0	40	850	208	138	0	0
14	385	1087	1107	119	158	49	2165	40
15	0	0	0	0	0	0	0	0
16	0	316	109	79	504	573	830	10
17	128	474	30	425	168	217	227	20
20	243339	257236	336171	413337	263562	340155	494962	201479
21	243319	256732	335855	412744	262899	340076	494645	201262
22	0	316	0	0	386	0	40	0
23	0	10	128	148	70	49	119	0
24	20	178	188	445	207	30	158	217
30	0	0	306	801	415	0	3034	603
31	0	0	0	0	0	0	1670	0
32	0	0	306	801	415	0	1364	603
33	0	0	0	0	0	0	0	0
40	115606	18918	11614	24009	22870	27112	33388	267101
41	115606	18918	11614	24009	190083	26964	32222	256999
42	0	0	0	0	583	0	0	79
43	0	0	0	0	38104	148	1166	10023
50	731	257	1414	1136	6909	899	712	7709
51	0	148	1305	0	0	0	0	0
52	0	10	0	0	0	0	168	405
53	731	99	109	1136	6909	899	544	7304
54	0	0	0	0	0	0	0	0
60	208	0	267	0	0	0	1681	247
61	0	0	267	0	0	0	880	0
62	208	0	0	0	0	0	801	247
70	168	485	30	909	1483	10892	5328	732
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	109	485	0	850	89	10032	5308	99
76	59	0	30	59	1394	860	20	633
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Bollinger 29017	Boone 29019	Buchanan 29021	Butler 29023	Caldwell 29025	Callaway 29027	Camden 29029	Cape Girardeau 29031
10	979	14975	19363	7294	1781	6137	4516	10348
11	484	7581	11149	5258	1008	2224	2817	5446
12	129	3874	2026	1305	178	781	543	1334
13	109	178	1819	0	0	217	49	563
14	30	1938	2945	198	70	1987	198	2135
15	0	0	0	69	0	10	0	0
16	217	297	20	217	475	543	277	89
17	10	1107	1404	247	50	375	632	781
20	194393	311333	219153	282816	258806	323441	75416	286800
21	194264	311135	218866	282599	258471	323174	74645	286316
22	0	0	158	0	49	0	0	306
23	30	128	20	49	59	59	0	30
24	99	70	109	168	227	208	771	148
30	128	0	0	0	119	227	0	198
31	0	0	0	0	0	0	0	0
32	128	0	0	0	119	227	0	198
33	0	0	0	0	0	0	0	0
40	195125	104545	23979	155715	14066	202954	340432	73677
41	194600	103132	23979	137993	14066	193217	339077	73677
42	30	49	0	7907	0	1246	366	0
43	495	1364	0	9815	0	8491	989	0
50	603	3361	3391	1008	149	4092	31284	3894
51	0	2303	1908	346	0	3064	0	3400
52	10	0	0	0	20	0	0	0
53	593	1058	1483	662	129	1028	31284	494
54	0	0	0	0	0	0	0	0
60	2906	0	1236	247	0	0	0	59
61	2501	0	257	247	0	0	0	59
62	405	0	979	0	0	0	0	0
70	0	5604	257	712	276	2106	1116	563
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	0	5209	178	178	276	1750	69	405
76	0	395	79	534	0	356	1047	158
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Carroll 29033	Carter 29035	Cass 29037	Cedar 29039	Chariton 29041	Christian 29043	Clark 29045	Clay 29047
10	2649	771	12513	4044	2560	3054	960	30068
11	1720	435	6474	1196	1334	2036	811	19630
12	237	59	1473	287	336	494	109	1799
13	336	0	316	139	168	20	10	1670
14	0	69	2916	208	119	49	0	4211
15	0	0	59	0	0	0	0	0
16	287	208	544	168	484	158	0	1048
17	69	0	731	2046	119	297	30	1710
20	416036	21784	413455	201311	437415	192712	258235	208724
21	415611	21784	413080	201252	437257	192594	258136	208655
22	0	0	128	0	0	59	0	49
23	0	0	0	0	30	0	10	0
24	425	0	247	59	128	59	89	20
30	198	0	1680	0	346	0	0	0
31	0	0	0	0	0	0	0	0
32	198	0	1680	0	346	0	0	0
33	0	0	0	0	0	0	0	0
40	24552	303444	20411	99000	42443	163770	66343	18197
41	24552	292572	20411	97300	42443	157603	65661	18197
42	0	5229	0	356	0	593	247	0
43	0	5643	0	1344	0	5574	435	0
50	4675	70	1206	13403	6099	20	1729	3183
51	4181	0	0	0	1700	0	316	2412
52	336	0	10	0	1216	0	0	30
53	158	70	1196	13403	3183	20	1413	741
54	0	0	0	0	0	0	0	0
60	1028	0	79	59	1957	0	0	0
61	929	0	79	59	593	0	0	0
62	99	0	0	0	1364	0	0	0
70	128	0	1463	464	623	356	306	1403
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	128	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	0	0	662	158	0	119	148	227
76	0	0	801	306	623	237	158	1176
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Clinton 29049	Cole 29051	Cooper 29053	Crawford 29055	Dade 29057	Dallas 29059	Daviess 29061	De Kalb 29063
10	3844	7532	4260	3530	3569	2264	3717	3173
11	2115	4616	1097	2343	1295	1127	1819	1166
12	494	1423	415	119	188	356	148	99
13	0	79	20	89	0	0	0	0
14	1166	119	2115	415	59	198	731	1443
15	0	0	0	0	0	0	0	0
16	0	771	435	495	208	455	307	287
17	69	524	178	69	1819	128	712	178
20	256060	158453	312587	111919	249369	176383	322166	258433
21	255912	158394	312034	111751	249309	176097	322027	258383
22	0	0	415	0	0	59	0	20
23	79	0	0	30	20	59	0	0
24	69	59	138	138	40	168	139	30
30	0	0	0	356	0	0	168	0
31	0	0	0	0	0	0	0	0
32	0	0	0	356	0	0	168	0
33	0	0	0	0	0	0	0	0
40	9469	83580	43649	359766	62122	168891	35158	10685
41	9469	67568	40318	351186	60313	166124	35158	10685
42	0	1285	0	1058	59	148	0	0
43	0	14727	3331	7522	1750	2619	0	0
50	425	4221	2589	583	8006	30	663	731
51	0	3855	2342	0	0	0	0	0
52	0	20	10	0	0	0	69	0
53	425	346	237	583	8006	30	594	731
54	0	0	0	0	0	0	0	0
60	138	0	0	0	79	0	40	0
61	0	0	0	0	79	0	0	0
62	138	0	0	0	0	0	40	0
70	880	989	50	514	424	99	781	129
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	267	99	40	0	365	30	346	119
76	613	890	10	514	59	69	435	10
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Dent 29065	Douglas 29067	Dunklin 29069	Franklin 29071	Gasconade 29073	Gentry 29075	Greene 29077	Grundy 29079
10	2184	1383	8571	11298	2085	1720	37125	2539
11	1344	692	5140	5911	1394	1354	22002	1522
12	109	158	1433	2125	148	168	6247	366
13	326	49	248	465	49	0	761	49
14	69	89	732	484	0	40	4942	316
15	0	0	0	0	0	0	0	0
16	198	267	563	1285	425	109	336	158
17	138	128	455	1028	69	49	2837	128
20	141304	169544	317293	280574	116535	290556	305570	251109
21	140879	169317	314900	280168	116535	290487	304344	250871
22	0	0	2234	89	0	0	109	0
23	0	10	40	40	0	0	168	30
24	425	217	119	277	0	69	949	208
30	0	0	0	178	109	1858	0	237
31	0	0	0	0	0	0	0	0
32	0	0	0	178	109	1858	0	237
33	0	0	0	0	0	0	0	0
40	334620	349141	15410	293175	213222	20342	87406	24453
41	321622	344781	15281	265855	205819	20233	81179	24453
42	2303	80	20	1117	395	0	504	0
43	10695	4280	109	26203	7008	109	5723	0
50	2699	40	3311	5189	1750	168	1245	386
51	0	0	3054	3983	1315	0	0	0
52	10	0	0	0	0	0	0	10
53	2689	40	257	1206	435	168	1245	376
54	0	0	0	0	0	0	0	0
60	0	0	1344	820	0	0	30	69
61	0	0	1255	820	0	0	0	0
62	0	0	89	0	0	0	30	69
70	1097	316	248	3529	425	208	1720	297
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	59
74	0	0	0	0	0	0	0	0
75	49	79	109	801	119	208	633	208
76	1048	237	139	2728	306	0	1087	30
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Harrison 29081	Henry 29083	Hickory 29085	Holt 29087	Howard 29089	Howell 29091	Iron 29093	Jackson 29095
10	3756	4342	4152	1957	1780	4212	1819	108222
11	1789	3272	2689	1008	1127	2462	801	62784
12	355	485	247	178	178	1009	306	14589
13	0	99	0	0	30	109	395	5110
14	1463	40	109	653	138	227	10	10161
15	0	0	0	0	0	0	0	751
16	60	248	178	49	198	257	287	1176
17	89	198	929	69	109	148	20	13651
20	417074	383903	107847	272636	239326	258995	48097	234531
21	416787	383774	107758	272497	238397	258916	48047	233553
22	30	0	0	0	613	0	0	810
23	20	40	0	20	267	0	20	0
24	237	89	89	119	49	79	30	168
30	1631	188	0	69	356	59	0	128
31	0	30	0	0	0	59	0	0
32	1631	158	0	69	356	0	0	0
33	0	0	0	0	0	0	0	128
40	40792	60363	145002	18206	57556	332090	304048	40841
41	40792	60056	133427	18206	57556	323313	298167	40841
42	0	208	1483	0	0	4636	1443	0
43	0	99	10092	0	0	4141	4438	0
50	415	3025	5852	4666	2719	425	801	5396
51	0	0	0	2204	2274	0	0	2323
52	0	633	0	2175	0	0	0	69
53	415	2392	5852	287	445	425	801	3004
54	0	0	0	0	0	0	0	0
60	0	287	0	3044	287	0	0	198
61	0	0	0	0	287	0	0	158
62	0	287	0	3044	0	0	0	40
70	1147	14480	346	385	59	286	217	3361
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	40	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	237	14391	79	237	59	138	128	949
76	870	89	267	148	0	148	89	2412
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Jasper 29097	Jefferson 29099	Johnson 29101	Knox 29103	Laclede 29105	Lafayette 29107	Lawrence 29109	Lewis 29111
10	22011	23851	8412	1375	7423	6543	7255	2116
11	12256	14945	3954	959	2916	2896	3637	1256
12	2787	2352	3459	138	890	909	741	237
13	1888	1097	20	0	79	109	80	49
14	1779	1631	702	30	3262	2155	2332	386
15	474	0	0	0	0	0	0	0
16	890	2768	99	159	128	158	297	99
17	1937	1058	178	89	148	316	168	89
20	320298	98723	484534	278072	216316	378931	329294	266963
21	320189	98466	484148	277924	215693	377319	328482	266824
22	0	0	109	0	0	1305	376	0
23	89	0	30	0	0	40	60	30
24	20	257	247	148	623	267	376	109
30	0	0	267	0	0	0	79	0
31	0	0	0	0	0	0	0	0
32	0	0	267	0	0	0	79	0
33	0	0	0	0	0	0	0	0
40	56834	294223	38242	41099	267022	13837	54234	53939
41	56834	244110	37797	41099	260281	13679	54185	53682
42	0	959	0	0	1364	99	0	0
43	0	49154	445	0	5377	59	49	257
50	880	6237	652	326	49	5180	89	2480
51	0	4557	0	0	0	3657	0	0
52	0	89	0	0	0	198	0	59
53	880	1591	652	326	49	1325	89	2421
54	0	0	0	0	0	0	0	0
60	0	218	0	0	0	197	20	0
61	0	208	0	0	0	49	20	0
62	0	0	0	0	0	148	0	0
70	7986	2649	988	267	149	761	297	1018
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	20
74	0	0	0	0	0	0	0	0
75	7393	741	870	267	30	227	277	227
76	593	1908	118	0	119	534	20	771
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Lincoln 29113	Linn 29115	Livingston 29117	McDonald 29119	Macon 29121	Madison 29123	Maries 29125	Marion 29127
10	4982	3252	3084	2392	3066	1642	1306	5575
11	2639	2116	2016	1067	1967	969	327	3687
12	1631	306	346	524	376	188	0	860
13	80	0	59	208	99	148	0	376
14	20	158	148	30	40	109	682	405
15	0	0	109	0	0	0	0	0
16	484	623	198	484	287	119	297	158
17	128	49	208	79	297	109	0	89
20	284962	369145	301636	147897	419397	80062	124719	232665
21	283341	369135	301349	147225	419367	80062	124699	232358
22	722	0	188	49	0	0	0	119
23	316	0	0	366	0	0	0	40
24	583	10	99	257	30	0	20	148
30	524	0	514	0	119	0	0	0
31	0	0	0	0	0	0	0	0
32	524	0	514	0	119	0	0	0
33	0	0	0	0	0	0	0	0
40	107856	24562	34456	195213	91113	237458	213628	42670
41	107698	24562	34456	194363	91113	233336	205829	42670
42	79	0	0	593	0	494	702	0
43	79	0	0	257	0	3628	7097	0
50	6632	455	504	89	2452	415	80	2590
51	0	0	0	0	0	0	0	0
52	731	119	267	0	0	0	0	0
53	5901	336	237	89	2452	415	80	2590
54	0	0	0	0	0	0	0	0
60	2659	830	2600	0	0	0	0	0
61	2659	0	267	0	0	0	0	0
62	0	830	2333	0	0	0	0	0
70	534	148	435	188	3568	791	0	286
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	158	0	336	20	3568	603	0	59
76	376	148	99	168	0	188	0	257
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Mercer 29129	Miller 29131	Mississippi 29133	Moniteau 29135	Monroe 29137	Montgomery 29139	Morgan 29141	New Madrid 29143
10	989	2718	3103	2134	1662	3804	1791	7611
11	791	1631	1759	1186	999	1611	1147	2639
12	49	494	445	415	267	197	297	820
13	0	0	109	79	0	138	0	771
14	40	198	543	0	10	1275	40	2857
15	0	0	0	0	0	0	0	0
16	69	217	79	306	326	465	267	326
17	40	178	168	148	60	118	40	198
20	249833	147699	248924	217394	363521	228621	162427	407151
21	249754	147472	248785	217186	363442	228196	161231	407012
22	0	0	0	0	0	59	227	0
23	0	0	20	0	20	109	99	40
24	79	227	119	208	59	257	870	99
30	336	0	0	0	306	89	89	336
31	0	0	0	0	0	0	0	0
32	336	0	0	0	306	89	89	336
33	0	0	0	0	0	0	0	0
40	38113	230766	7433	47938	61914	110743	218144	16754
41	38113	224470	7433	46011	61914	107441	216009	16744
42	0	820	0	59	0	297	138	0
43	0	5476	0	1868	0	3005	1997	10
50	524	4458	9755	1196	139	1909	8708	13048
51	0	2333	9676	1147	0	1147	0	12474
52	0	0	0	0	0	30	0	534
53	524	2125	79	49	139	732	8708	40
54	0	0	0	0	0	0	0	0
60	0	0	4903	0	0	30	0	0
61	0	0	4903	0	0	30	0	0
62	0	0	0	0	0	0	0	0
70	415	69	810	50	228	633	336	1404
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	69	0	751	0	0	0	0	1315
74	0	0	0	0	0	0	0	0
75	237	59	0	20	119	406	20	20
76	109	10	59	30	109	227	316	69
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Newton 29145	Nodaway 29147	Oregon 29149	Osage 29151	Ozark 29153	Pemiscot 29155	Perry 29157	Pettis 29159
10	9578	3459	1167	1246	1315	7454	4141	5891
11	5871	2283	820	573	534	2718	2006	4003
12	1404	890	267	109	178	890	257	870
13	603	0	0	20	20	198	89	148
14	830	59	30	0	79	3104	1542	208
15	20	0	0	0	0	0	0	0
16	386	128	10	544	455	267	168	227
17	464	99	40	0	49	277	79	435
20	284152	544975	162487	144666	148174	301014	207944	400171
21	282678	544609	162457	144626	148075	300895	207667	399865
22	198	0	0	0	0	10	40	69
23	158	158	0	0	20	0	59	10
24	1018	208	30	40	79	109	178	227
30	0	870	0	40	0	0	148	138
31	0	0	0	0	0	0	0	0
32	0	870	0	40	0	0	148	138
33	0	0	0	0	0	0	0	0
40	106157	10349	342478	242044	327483	4438	90232	31995
41	106127	10349	324538	219854	273199	2876	85023	23969
42	30	0	4161	2283	12266	0	0	0
43	0	0	13779	19907	42018	1562	5209	8026
50	79	406	69	2917	5199	13976	4458	445
51	0	0	0	2857	30	13660	3766	0
52	0	40	0	0	0	0	109	10
53	79	366	69	60	5169	316	583	435
54	0	0	0	0	0	0	0	0
60	0	139	0	0	277	188	386	0
61	0	119	0	0	0	188	99	0
62	0	20	0	0	277	0	287	0
70	1819	287	59	69	1898	1196	1077	257
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	1196	385	0
74	0	0	0	0	0	0	0	0
75	643	287	59	0	40	0	49	257
76	1176	0	0	69	1858	0	643	0
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Phelps 29161	Pike 29163	Platte 29165	Polk 29167	Pulaski 29169	Putnam 29171	Ralis 29173	Randolph 29175
10	7068	3567	12770	3776	20046	1057	2284	4832
11	3074	2194	7136	2580	5427	890	890	2777
12	771	613	563	712	11100	59	277	939
13	148	257	297	20	0	49	524	89
14	2066	148	4161	128	2679	0	79	346
15	0	0	0	0	0	0	0	158
16	495	217	356	69	316	10	297	306
17	514	138	257	267	524	49	217	217
20	142461	320672	220625	284912	85162	246334	239790	235255
21	142372	310101	220358	284467	84945	246304	239494	235195
22	0	731	188	0	0	0	148	0
23	20	356	30	20	0	0	89	20
24	69	484	49	425	217	30	59	40
30	0	89	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	0	89	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
40	278972	106651	32361	120380	247332	83077	65454	64386
41	273407	106651	32361	110772	242291	83077	64564	64386
42	2718	0	0	534	534	0	79	0
43	2847	0	0	9074	4507	0	811	0
50	593	5199	2975	2471	168	1097	1275	3331
51	267	0	1730	0	0	0	0	0
52	0	198	128	0	0	0	0	0
53	326	5001	1117	2471	168	1097	1275	3331
54	0	0	0	0	0	0	0	0
60	0	722	455	0	0	0	0	0
61	0	633	257	0	0	0	0	0
62	0	89	198	0	0	0	0	0
70	790	811	1848	247	840	1641	1087	4043
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	178	811	751	158	89	1028	1087	4043
76	612	0	1097	89	751	613	0	0
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Ray 29177	Reynolds 20179	Ripley 20181	St. Charles 20183	St. Clair 29185	St. Francois 29187	St. Louis 29189	St. Genevieve 29193
10	4557	989	1721	19937	1938	7372	158572	3320
11	3005	306	1315	10151	1473	5268	101530	1097
12	306	30	267	4596	227	820	20243	267
13	40	99	0	554	20	247	6563	188
14	217	109	20	2204	109	237	7542	1571
15	0	0	0	0	0	0	2184	0
16	445	445	20	1127	89	454	3875	148
17	544	0	99	1305	20	346	16635	49
20	303307	48887	109557	244417	254814	117750	76870	126182
21	302457	48828	109557	244071	254745	117602	76840	126043
22	0	0	20	0	0	0	0	0
23	0	0	0	0	10	10	0	30
24	850	59	10	346	59	138	30	109
30	247	0	277	0	158	79	0	0
31	0	0	277	0	0	0	0	0
32	247	0	0	0	158	79	0	0
33	0	0	0	0	0	0	0	0
40	54225	468215	291950	80567	186742	157387	83275	189273
41	54176	456838	279120	79825	185319	150438	81110	164632
42	49	1661	4992	188	267	2412	0	1285
43	0	9716	7838	554	1156	4537	2165	23356
50	1957	2225	109	20667	316	1493	7888	5200
51	978	0	0	9014	0	0	6761	4270
52	544	0	0	850	99	30	109	69
53	435	2224	109	10803	217	1463	1018	861
54	0	0	0	0	0	0	0	0
60	741	0	0	12791	1631	0	2738	870
61	642	0	0	8916	1295	0	2530	870
62	99	0	0	3875	336	0	208	0
70	1136	722	0	1315	2304	7285	5861	1177
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	20	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	415	79	0	366	2304	2313	2194	386
76	721	623	0	949	0	4972	3667	791
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Saline 20195	Schuyler 29197	Scotland 29199	Scott 29201	Shannon 29203	Shelby 20295	Stoddard 29207	Stone 20209
10	6207	970	1305	8787	1068	1770	4922	4102
11	2758	890	880	4498	761	1098	3114	2857
12	415	40	227	1196	99	326	800	484
13	79	0	0	326	30	30	109	20
14	2184	0	59	2303	0	0	415	79
15	0	0	0	0	0	0	0	0
16	741	20	99	89	119	227	187	474
17	30	20	40	375	59	89	297	188
20	450403	163514	248035	246393	75506	280869	486292	117286
21	449662	163504	247837	246186	75298	280810	485610	117266
22	178	0	0	49	0	0	99	0
23	49	0	0	30	0	0	168	0
24	514	10	198	128	208	59	415	20
30	198	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	198	0	0	0	0	0	0	49
33	0	0	0	0	0	0	0	0
40	25492	32885	30700	14470	563429	37293	28220	174081
41	23900	32885	30700	14470	534241	37293	27162	143143
42	30	0	0	0	682	0	544	722
43	1562	0	0	0	28506	0	514	30216
50	5317	89	188	2501	109	534	1373	28862
51	4754	0	0	2244	0	0	158	0
52	99	0	0	119	0	0	89	0
53	464	89	188	138	109	534	1126	28862
54	0	0	0	0	0	0	0	0
60	484	0	0	347	128	0	9558	0
61	257	0	0	139	128	0	8362	0
62	227	0	0	208	0	0	1196	0
70	277	49	89	267	367	128	633	2412
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	20	0	0	0
74	0	0	0	0	0	0	0	0
75	277	0	89	257	60	128	445	40
76	0	49	0	10	287	0	188	2372
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Sullivan 29211	Taney 29213	Texas 29215	Vernon 29217	Warren 29219	Washington 29221	Wayne 29223	Webster 29225
10	1156	4499	3104	5476	3094	1818	2452	4714
11	840	2748	1601	1789	1008	1018	1394	1838
12	49	633	504	1117	178	69	119	573
13	0	40	228	346	109	168	99	59
14	30	208	168	732	1147	69	99	2036
15	0	0	0	0	79	0	0	40
16	217	534	425	1334	524	494	306	0
17	20	336	178	158	49	0	435	168
20	348042	75505	276828	437228	122465	79361	94967	218036
21	347963	75505	276531	437139	122386	79301	94947	217650
22	0	0	0	0	0	0	0	178
23	0	0	20	0	0	20	0	99
24	79	0	277	89	79	40	20	109
30	376	198	158	237	0	0	0	0
31	0	0	0	237	0	0	0	0
32	376	198	158	0	0	0	0	0
33	0	0	0	0	0	0	0	0
40	64435	320585	471733	83383	151159	394320	383023	156200
41	64435	176364	427956	83343	142520	311036	363433	147393
42	0	16922	1967	0	524	6513	5683	376
43	0	127299	41810	40	8115	76771	13907	8431
50	316	11901	109	978	3083	2422	9430	49
51	0	0	0	0	2352	0	0	0
52	0	0	0	197	0	20	1374	0
53	316	11901	109	781	731	2402	8056	49
54	0	0	0	0	0	0	0	0
60	0	0	0	2432	316	0	4902	0
61	0	0	0	356	316	0	4872	0
62	0	0	0	2076	0	0	30	0
70	257	3222	266	3380	721	10003	790	554
71	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0
75	89	138	79	3380	138	9963	217	89
76	168	3084	187	0	583	40	573	465
77	0	0	0	0	0	0	0	0

State of Missouri Statistical Data--Land Use By Counties in Acres

LUCODE	Worth 29227	Wright 29229	St. Louis City 29510
10	652	2659	38756
11	455	1720	8629
12	128	494	10724
13	0	30	3746
14	0	99	2402
15	0	0	0
16	59	237	9242
17	10	79	4013
20	160331	203011	257
21	160272	202606	257
22	0	69	0
23	0	217	0
24	59	119	0
30	672	0	0
31	0	0	0
32	672	0	0
33	0	0	0
40	9667	230588	0
41	9667	217541	0
42	0	840	0
43	0	12207	0
50	109	69	2955
51	0	0	2886
52	0	0	0
53	109	69	69
54	0	0	0
60	0	0	0
61	0	0	0
62	0	0	0
70	148	119	415
71	0	0	0
72	0	0	0
73	0	0	0
74	0	0	0
75	148	99	306
76	0	20	109
77	0	0	0

Total Area, in Acres, by Land Use
For Missouri

Land Use Code	Area (Acres)
11	494275
12	134077
13	35748
14	106232
15	3953
16	51690
17	70079
21	27990118
22	11001
23	4634
24	20573
31	2273
32	17584
33	128
41	14143510
42	105290
43	771635
51	133151
52	11312
53	232559
54	0
61	46585
62	20277
71	0
72	0
73	4003
74	0
75	95177
76	54087
77	0
Level I Totals	
10	896054
20	28026326
30	19985
40	15020435
50	37702
60	66862
70	153267
Nonresidential	280010
Agriculture	28001119
Forest Land	15067020
TOTAL	44559951

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APPENDIXES

APPENDIX A
SITES IN NUMERICAL ORDER

Site No. 82 (Nonforested Wetlands) 62 103
Location: Mound City
Holt County, Missouri
Geographic Coordinates: 40°04'N, 95°15'W

Site No. 83 (Oxbow Lake) 52 98
Location: Fortescue
Holt County, Missouri
Geographic Coordinates: 40°05'N, 95°21'W

Site No. 84 (Eastern Brushland) 32 90
Location: New Hampton
Harrison County, Missouri
Geographic Coordinates: 40°16'N, 94°10'W

Site No. 85 (Sawmill) 13 62
Location: Potosi
Washington County, Missouri
Geographic Coordinates: 37°55'N, 90°51'W

Site No. 86 (Confined Hog and Cattle Feeding) 23 85
Location: Ravenwood
Nodaway County, Missouri
Geographic Coordinates: 40°25'N, 94°40'W

Site No. 87 (Confined Cattle Feeding) 23 85
Location: Spickard
Grundy County, Missouri
Geographic Coordinates: 40°15'N, 93°13'W

Site No. 88 (Not Used)

Site No. 89 (Recreational Homes) 11 36
Location: Trenton
Grundy County, Missouri
Geographic Coordinates: 40°06'N, 93°44'W

Site No. 90 (Coal Processing Plant) 13 67
Location: Hartford
Putnam County, Missouri
Geographic Coordinates: 40°29'N, 92°52'W

Site No. 91 (Sewage Treatment Plant) 14 74
Location: Kirksville
Adair County, Missouri
Geographic Coordinates: 40°09'N, 92°34'W

Site No. 92 (Cemetery) 17 79
Location: Kirksville
Adair County, Missouri
Geographic Coordinates: 40°10'N, 92°34'W

Site No. 93 (Cropland) 21 80
Location: Plymouth
Livingston County, Missouri
Geographic Coordinates: 39°37'N, 93°43'W

APPENDIX B
LIST OF SITES BY CITIES

City	Land Use Category	Site No.	Page
Bloomfield	23	29	84
Bonne Terre	22	41	82
Bradleyville	42	65	94
Buick	13	36	60
	13	37	61
Bunker	13	35	59
Cape Girardeau	13	21	57
	75	22	106
Chamois	21	68	81
Columbia	12	72	46
Dexter	75	30	107
Edgehill	43	39	95
Ft. Leonard Wood	12	48	52
	17	47	77
Fortescue	52	83	98
Hartford	13	90	67
Hayti	73	24	104
Ironton	12	40	41
Jefferson City	12	69	43
	51	70	96
Jerome	21	44	80
Kansas City	12	76	44
	12	77	45
	12	78	47
	12	79	39
	13	81	66
Kelso	22	23	82
Kennett	51	26	97
Kingdom City	31	102	89
Kirksville	14	91	74
	17	92	79
	41	94	93
Lebanon	12	49	40
	13	50	62
Lemay	14	13	74
Louisiana	13	100	67
Maitland	24	99	88
Manchester	11	1	31
Mehlville	11	4	38
	17	18	78
Montreal	24	38	87
Mound City	62	82	103
New Franklin	22	73	83

City	Land Use Category	Site No.	Page
New Hampton	32	84	90
New Madrid	42	25	94
Peerless Park	76	19	109
Piedmont	53	33	99
	76	28	108
Plymouth	21	93	80
Potosi	13	85	62
Puxico	61	31	101
	62	31	102
Ravenwood	23	86	85
Reform	13	71	64
Robertson	15	15	75
St. James	22	43	83
St. Louis City	11	2	32
	11	3	33
	12	5	49
	12	7	47
	13	8	55
	13	9	56
	14	10	69
	14	11	69
	14	12	70
	14	14	72
	16	16	76
	17	17	77
	76	20	108
St. Robert	12	45	46
	12	46	41
Spickard	23	87	85
Springfield	11	51	34
	11	52	35
	12	53	39
	12	54	42
	12	55	43
	12	56	50
	12	57	49
	12	58	51
	12	59	48
	13	60	64
	14	61	71
	14	62	72
	14	63	73
	16	64	76
Table Rock Reservoir	13	66	64
Thomas Hill Reservoir	13	96	64
	75	97	105
Trenton	11	89	36
Vichy	14	42	71
Wappapello	61	32	102
Webster Groves	12	6	51
Windsor	41	74	92
Winigan	23	95	86

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