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Land-Cover Analysis for the Fort Cobb Reservoir Watershed, Southwestern Oklahoma, 2005

Chapter 5 of
Assessment of Conservation Practices in the Fort Cobb Reservoir Watershed, Southwestern Oklahoma

Compiled by the U.S. Geological Survey and the Agricultural Research Service

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Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Area	
hectare (ha)	2.471	acre

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Land-Cover Analysis for the Fort Cobb Reservoir Watershed, Southwestern Oklahoma, 2005

By Patrick J. Starks,[1] Mahesh Rao,[2] and Siewe Siewe[2]

Abstract

The Fort Cobb Reservoir watershed is one of 14 benchmark watersheds studied by Agricultural Research Service to assess the effects of U.S. Department of Agriculture-Natural Resources Conservation Service conservation practices on selected environmental endpoints (for example, water quality, sediment reduction, and wildlife habitat). The Soil and Water Assessment Tool is an efficient and effective hydrologic model that can be used to study these potential effects. One data source necessary to run Soil and Water Assessment Tool simulations is a spatially distributed land-cover dataset. A series of Landsat 5 Thematic Mapper images from 2005 were used in combined unsupervised and supervised classification procedures to produce a seven-category land-cover scene for the Fort Cobb Reservoir watershed. These seven categories (winter wheat, grass/pasture, peanuts/cotton, forests, roads, other summer crops, and water) indicated the predominant land covers of the watershed. Land devoted to the production of winter wheat and grass (grass/pasture) accounts for the largest areas of the watershed at 43 percent and 34 percent, respectively. Total land area devoted to annual crops accounted for about 56 percent of the watershed.

Introduction

The U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS), Grazinglands Research Laboratory has conducted research in the Fort Cobb Reservoir watershed (fig. 1) as part of the USDA Conservation Effects Assessment Project (Steiner and others, 2008). The Fort Cobb Reservoir watershed is one of 14 benchmark watersheds studied by ARS to assess the effects of USDA-Natural Resources Conservation Service conservation practices on selected environmental endpoints (for example, water quality, sediment reduction, and wildlife habitat).

The Soil and Water Assessment Tool (SWAT) is an efficient and effective hydrologic model that can be used to study the potential effects of conservation practices (Arnold and others, 1998; Arnold and Fhorer, 2005; Gassman and others, 2007). Spatially distributed land-cover datasets are necessary to run SWAT simulations. Although some land-cover datasets exist for the Fort Cobb Reservoir watershed, the Grazinglands Research Laboratory determined that a baseline land-cover dataset depicting "current" conditions was necessary. The Grazinglands Research Laboratory, in cooperation with personnel from the Department of Geography at Oklahoma State University (OSU), Stillwater, Oklahoma, created a land-cover dataset for the Fort Cobb Reservoir watershed for 2005.

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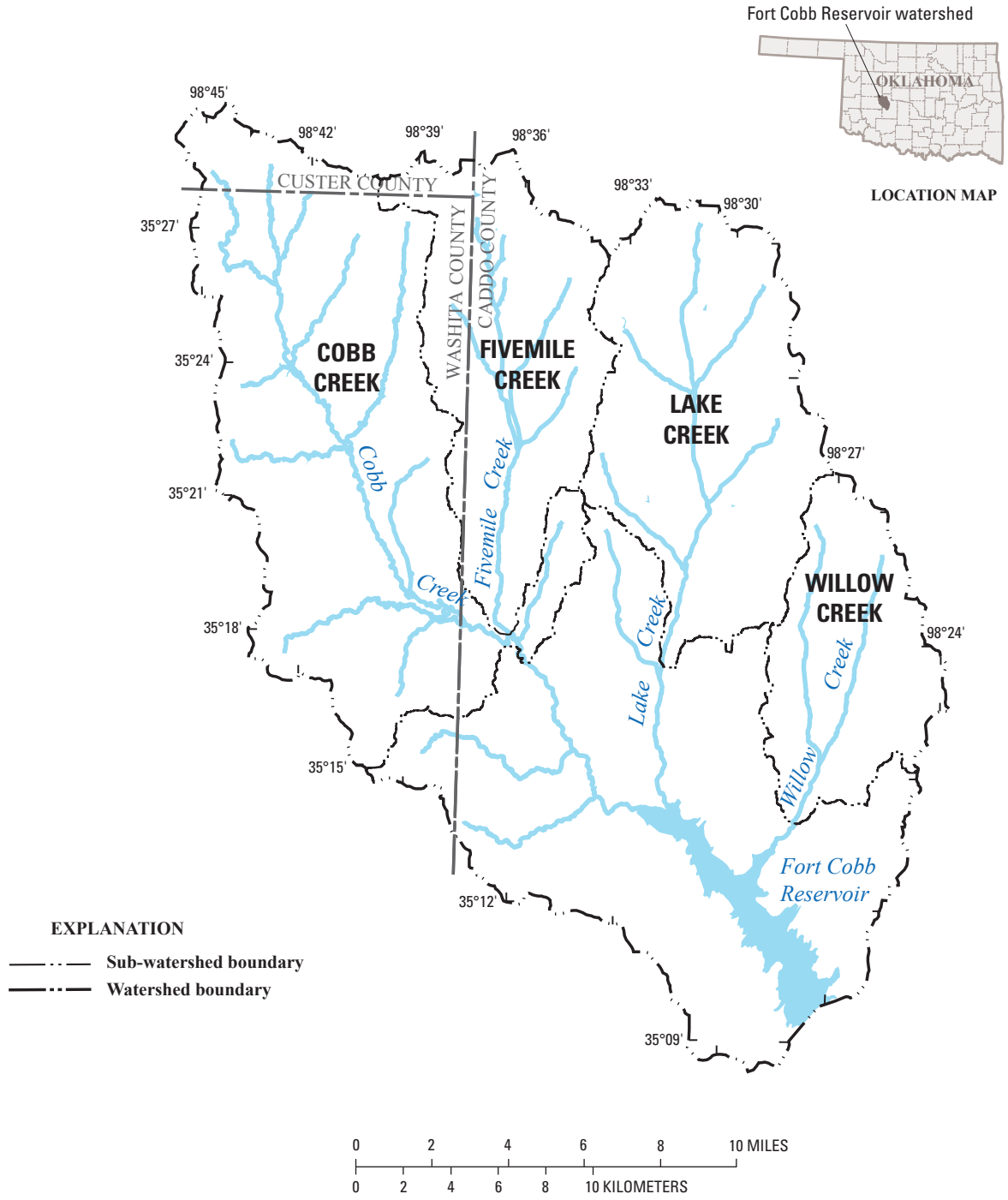

Figure 1. Boundaries of the Fort Cobb Reservoir watershed and of the subwatersheds of the major contributing streams, southwestern Oklahoma. (Data source: Natural Resources Conservation Service, 2008.)

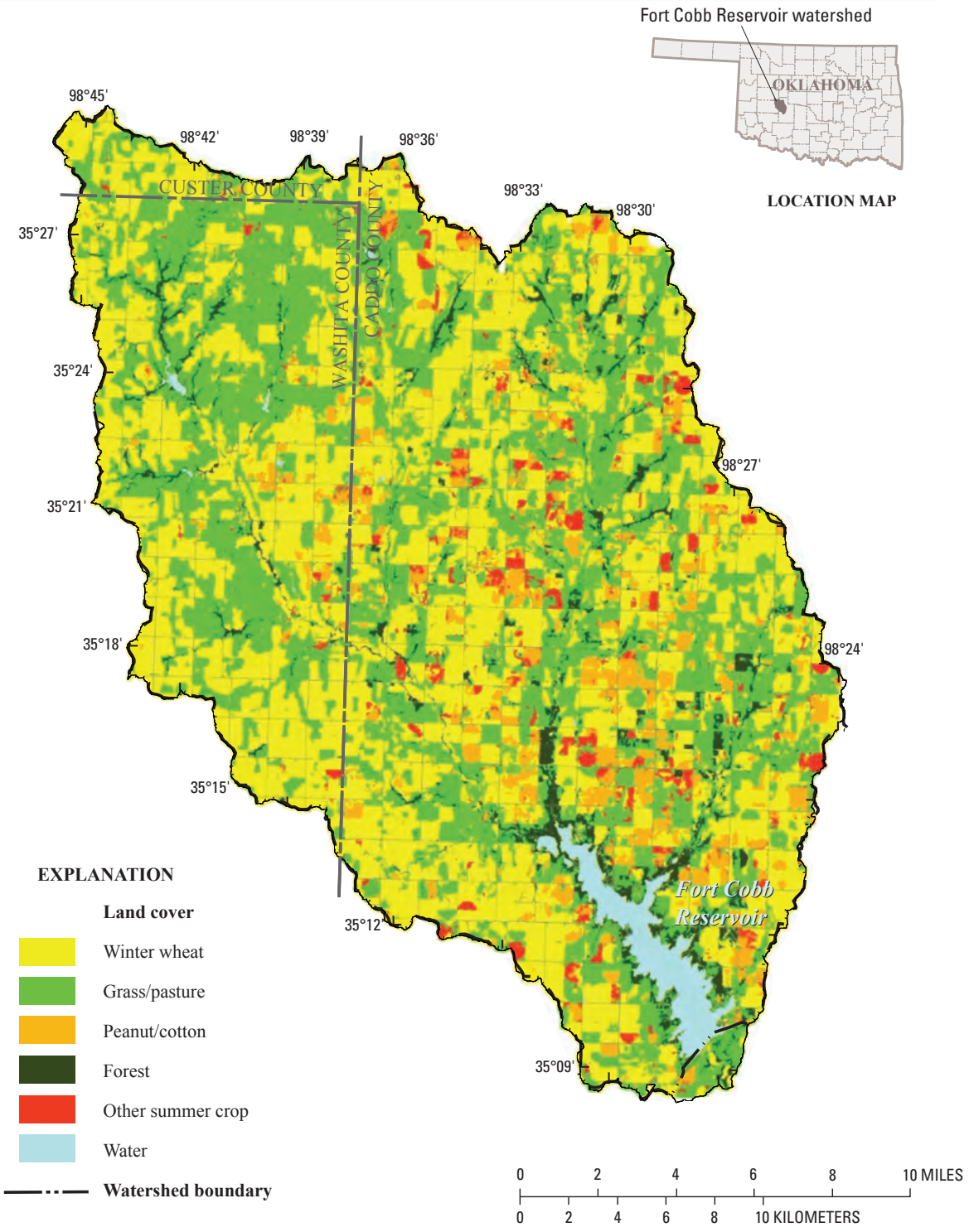

Figure 2. Land cover in the Fort Cobb Reservoir watershed, 2005, southwestern Oklahoma.

Methods

Data Collection

Ground-truth data were collected by the Grazinglands Research Laboratory to coincide as closely as possible with remotely sensed data acquisitions from the Landsat 5 Thematic Mapper (TM) (table 1). Ground-truth data were collected at 38 preselected sites (road intersections) scattered across the watershed on the March 24 and 29 sampling dates, and consisted of manually recorded observations of land cover in the northeast, southeast, southwest, and northwest directions radiating from the observation locations. Digital photographs of each quadrant were taken, and the geographic location of each sampling site was recorded by using a hand-held Global Positioning System unit. Some of the original sampling sites were revisited on subsequent sampling dates to assess any changes to the sites. Copies of all TM imagery, ground-truth data, and sampling-site coordinates were supplied to OSU for use in creating the 2005 land-cover map.

Table 1. Landsat 5 Thematic Mapper data acquisition dates and dates when ground-truth data were collected at the Fort Cobb Reservoir watershed.

[TM, thematic mapper]

Landsat 5 TM overpass dates	Ground-truth collection dates
March 29, 2005	March 24 and 29, 2005
June 29, 2005	June 29 and 30, 2005
September 1, 2005	August 1, 2005
November 4, 2005	November 3, 2005

Image Processing

Image processing and related analysis were done at the OSU Center for Applications of Remote Sensing laboratory housed in the Department of Geography. After receiving the TM images from Grazinglands Research Laboratory, the data were preprocessed by reprojecting the images to Universal Transverse Mercator Zone 14 by using the Geodetic Reference System (GRS) 1980 spheroid and the 1983 North American Datum (NAD 83). Two images per date were required to fully represent the watershed. Before spatially joining these two rows, an atmospheric correction was applied to each image by using the methods of Chavez (1996). The two rows were joined after atmospheric correction and reprojection and the resulting image created a subset of the watershed boundary.

The March, June, September, and November watershed images were classified individually to determine the land cover of each pixel (table 1). Assessment of the individual land covers for each month, in addition to the ground-truth data and Oklahoma crop calendar (Oklahoma State University, 2010), were used to create the final land-cover map for 2005. More specifically, a hybrid approach involving unsupervised and supervised classification procedures were done on each image separately. A series of "static" land-cover layers were created in order to eliminate chances of classifying a pixel into multiple categories. For example, roads, water, and forests were not expected to change during the study period. These pixels were easily identified in the images and pixels associated with these land covers were assigned a unique code, and individual images constructed for each of these land-cover categories. These static land covers were then masked out of the images prior to classification. Subsequent to separate classification of the images, the outputs were combined by using a multicriterion modeling rule set.

According to the Oklahoma Agricultural Statistics for crop year 2005, winter wheat is the dominant crop in the Fort Cobb watershed (U.S. Department of Agriculture, 2006). Observational surveys of the watershed revealed that most of the winter wheat is grown in upland areas and that much of the watershed is in grass (native range, improved pastures, and sod farms). Field observation indicates that uplands planted in winter wheat are seldom used for other agricultural crops and that areas devoted to grass/pasture are not likely to change during a growing season; thus, pixels associated with upland wheat and grass/pasture were considered to be static. The static winter wheat layer was constructed by using an image combination rule set for the individually classified images. If a pixel was classified as winter wheat in March or November, harvested/plowed in June, and plowed in September, the land cover associated with that pixel was considered to be winter wheat. Similarly, rules were established to create a static grass/pasture layer. The remaining areas/pixels of the watershed not in a static land-cover category were then classified into either peanut/cotton or other summer crop category by using a rule set based on the Oklahoma crop calendar in conjunction with the individual monthly classified images.

Land Covers in the Fort Cobb Reservoir Watershed

The supervised classification resulted in a final land-cover map (fig. 2) with seven categories: winter wheat, grass/pasture, peanut/cotton, forest, roads, other summer crops, and water. Land-cover statistics are given in table 2. The ground-truth datasets used in this study did not allow for differentiation of summer crops beyond what is shown. The road category also includes urban, built-up areas, and quarries.

About 20 percent of the watershed is irrigated, mostly in the Willow Creek and Lake Creek subwatersheds. Most of the summer crops are grown in these two subwatersheds. Field trips revealed that two or more crops are commonly grown under one pivot irrigation system. These crops are often cotton and peanuts, which may have been planted after winter wheat. Field peas, watermelons, peppers and other specialty crops are grown in the watershed, but when combined, these crops account for a small percentage of the watershed land area.

For comparison, table 3 lists 2001 land-cover statistics for the Fort Cobb watershed as reported by Storm and others (2003). Storm and others (2003) estimated that 40 percent of the watershed was in pasture (pasture, native grass, and rangeland). The 40 percent is a little larger than the estimate of 34 percent obtained by using the 2005 land-cover dataset.

Table 2. Land-cover statistics from the 2005 land-cover analysis for the Fort Cobb Reservoir watershed.

[Percentages do not add to 100 because of rounding]

Land-cover category	Watershed area (percent)
Winter wheat	43
Grass/pasture	34
Peanut/cotton	9
Forest	5
Roads	5
Other summer crops	<4
Water	<2

Table 3. Land-cover statistics for the Fort Cobb Reservoir watershed for 2001 (Storm and others, 2003).

Land-cover category	Watershed area (percent)
Planted/cultivated 1	46
Pasture	40
Forest	7
Planted/cultivated 2	5
Water	2
Urban	<1
Barren	<1

Forest land (trees and shrubs) accounted for about 5 percent of the watershed area from the 2005 land-cover analysis, whereas Storm and others (2003) estimated about 7 percent in 2001. Combined Planted/Cultivated 1 and Planted/Cultivated 2 land-cover categories (table 3) indicated that cropland occupied about 51 percent of the watershed area in 2001. This percentage compares favorably with the (about) 56 percent for the 2005 land-cover dataset when the winter wheat, peanuts/cotton, and other summer crops categories are combined.

The Fort Cobb Reservoir watershed occupies about 17 percent of Caddo County, and 9 and 1 percent of Washita and Custer Counties, respectively. Agricultural statistics for 2005 show that 97,124 hectares (240,000 acres) of wheat were planted in Caddo County, 111,289 hectares (275,000 acres) in Washita County, and 89,840 hectares (222,000 acres) in Custer County (U.S. Department of Agriculture, 2006). Adjusting the county level statistics by the area of each county occupied by the watershed indicates that a total of 29,368 hectares (72,570 acres) of wheat were planted in the watershed – about 37 percent of the watershed area. Considering that the 2005 winter wheat category (fig. 1) also may include other winter crops that may be spectrally similar to wheat (rye, barely, and oats), it was concluded that the total area estimated as winter wheat in the 2005 land-cover image is reasonable.

Summary

A series of Landsat 5 TM images from 2005 were used in combined unsupervised and supervised classification procedures to produce a seven-category land-cover scene for the Fort Cobb Reservoir watershed. These seven categories (winter wheat, grass/pasture, peanuts/cotton, forests, roads, other summer crops, and water) indicated the predominant land covers of the watershed. Land devoted to the production of winter wheat and grass (grass/pasture) accounts for the largest areas of the watershed at 43 percent and 34 percent, respectively. Total land area devoted to annual crops accounted for about 56 percent of the watershed. County level agricultural statistics for 2005 and the 2001 land-cover estimates generated by previous investigators support the results of the 2005 land-cover map reported.

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Appendix 1. Location of sampling sites where ground-truth data were collected on March 24 and March 29, 2005 across the Fort Cobb Reservoir watershed to coincide with remotely sensed data from the Landsat 5 Thematic Mapper.

Appendix 1. Location of sampling sites where ground-truth data were collected on March 24 and March 29, 2005 across the Fort Cobb Reservoir watershed to coincide with remotely sensed data from the Landsat 5 Thematic Mapper.

[ID, identifier; latitude and longitude in decimal degrees]

Sample site ID	Latitude	Longitude
FC1-01	35.40617	-98.5884
FC1-02	35.40643	-98.6234
FC1-03	35.40634	-98.6412
FC1-04	35.40661	-98.6763
FC1-05	35.43565	-98.6941
FC1-06	35.43542	-98.6234
FC1-07	35.37736	-98.6234
FC1-08	35.36352	-98.5881
FC1-09	35.36303	-98.6589
FC1-10	35.33410	-98.6587
FC1-11	35.27651	-98.659
FC1-12	35.24749	-98.6592
FC1-13	35.23317	-98.5884
FC1-14	35.26186	-98.5885
FC1-15	35.30533	-98.5883
FC1-16	35.33417	-98.5886
FC1-17	35.34843	-98.6235
FC1-18	35.31953	-98.6235
FC1-19	35.29092	-98.6236
FC2-1	35.20420	-98.4295
FC2-2	35.23179	-98.4297
FC2-3	35.26182	-98.4297
FC24	35.29062	-98.4298
FC2-5	35.30533	-98.4474
FC2-6	35.33431	-98.4298
FC2-7	35.33423	-98.4419
FC2-8	35.33410	-98.4648
FC2-10	35.37720	-98.5004
FC2-11	35.33416	-98.5003
FC2-12	35.33411	-98.4822
FC2-13	35.30514	-98.4827
FC2-14	35.26208	-98.4827
FC2-15	35.26191	-98.5177
FC2-16	35.27641	-98.5529
FC2-17	35.33397	-98.5528
FC2-18	35.36300	-98.5354
FC2-19	35.39173	-98.5353
FC2-20	35.42098	-98.5554