Canyon Diablo Watershed

Rapid Watershed Assessment Report June, 2011

Prepared by:

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Arizona Department of Environmental Quality
Arizona Department of Water Resources
Arizona Game & Fish Department
Arizona State Land Department
USDA Forest Service
USDI Bureau of Land Management

NRCS Natural Resources Conservation Service

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Canyon Diablo Watershed
15020015
8-Digit Hydrologic Unit
Rapid Watershed Assessment

Section 1: Introduction

Overview of Rapid Watershed Assessment

A Rapid Watershed Assessment (RWA) is a concise report containing information on natural resource conditions and concerns within a designated watershed. The "rapid" part refers to a relatively short time period to develop the report as compared to a more comprehensive watershed planning effort. The “assessment” part refers to a report containing maps, tables and other information sufficient to give an overview of the watershed including physical characteristics and socioeconomic trends.

The assessments involve the collection of readily available quantitative and qualitative information to develop a watershed profile, and sufficient analysis of that information to generate an appraisal of the conservation needs of the watershed. These assessments are conducted by conservation planners, using Geographic Information System (GIS) technology. Conservation Districts and other local leaders, along with public land management agencies, are involved in the assessment process.

An RWA serves as a communication tool between the Natural Resources Conservation Service (NRCS) and partners for prioritizing conservation work in selected watersheds. RWAs serve as a platform for conservation program delivery; provide useful information for development of NRCS and Conservation District business plans, and lay a foundation for future cooperative watershed planning.

General Description of the Canyon Diablo Watershed

The Canyon Diablo Watershed is located in north-central Arizona in the vicinity of the City of Flagstaff. Total land area is approximately 767,000 acres (Figure 1-1). Land ownership is primarily private, state trust, and federal land administered by the U.S. Forest Service. National Park Service lands include the Sunset Crater and Walnut Canyon National Monuments. A portion of the Navajo Nation is located within the watershed. Major land uses in the watershed include range, forest, and urban. Recreational uses are also important activities.

The Barringer Meteor Carter is private property, leased by the Barringer family who also operates a fine museum at the crater rim.

The City of Flagstaff is the only incorporated city within the watershed. Conservation assistance is provided through the Coconino Natural Resource Conservation District and the Little Colorado River Soil and Water Conservation District. The U.S. Department of Agriculture (USDA) Service Centers that serve the area are located in Flagstaff and Dilkon, Arizona.

Priority resource concerns in the watershed include soil erosion (sheet & rill and concentrated flow), water quantity (runoff and flooding), noxious and invasive plants, wildfire hazard, and inadequate quantities & quality of feed and water for both wildlife and domestic animals.

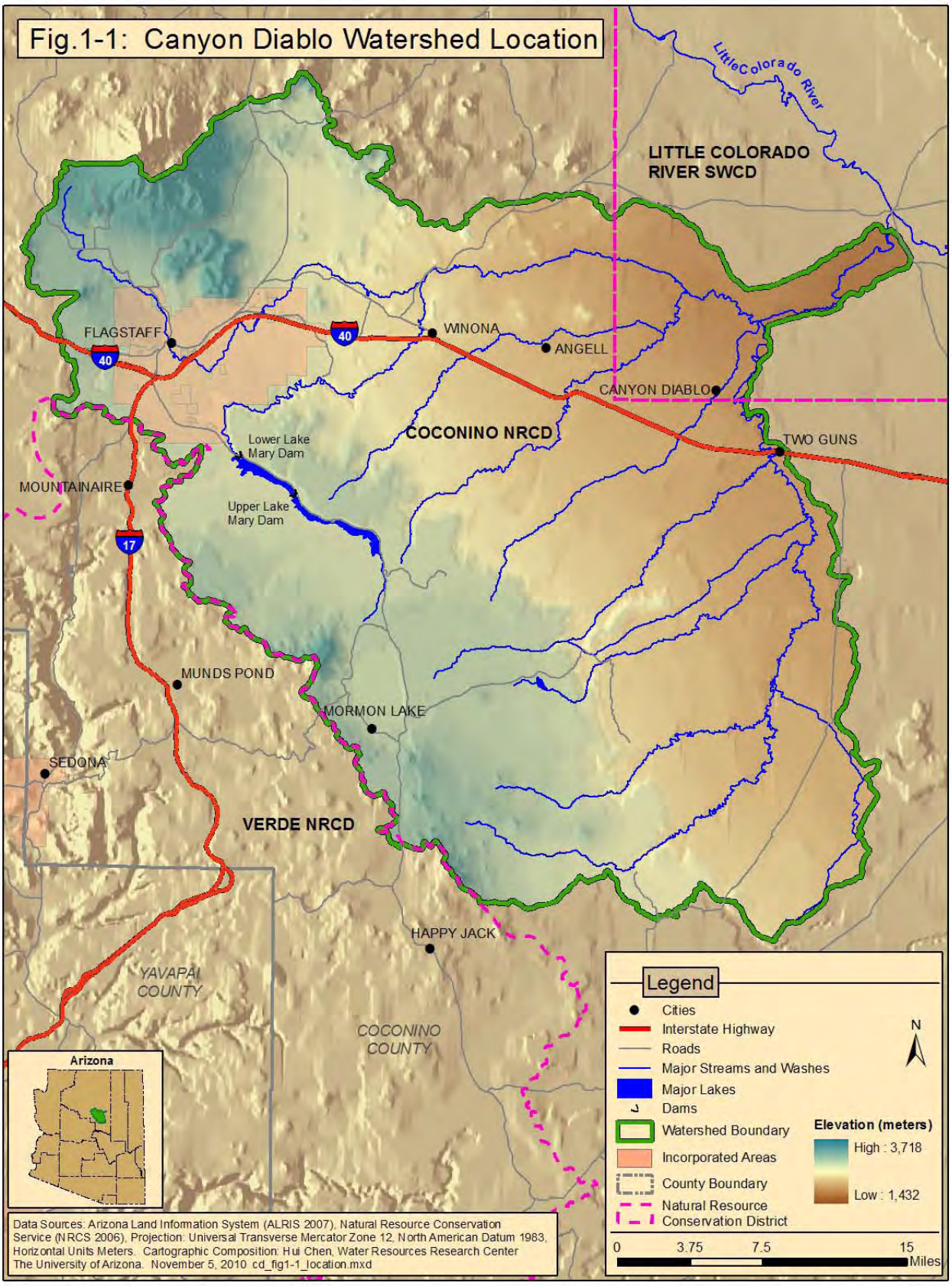
Fig.1-1: Canyon Diablo Watershed Location
Little Colorado River
LITTLE COLORADO RIVER SWCD
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
COCONINO NRCD
TWO GUNS
Lower Lake Mary Dam
Upper Lake Mary Dam
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
VERDE NRCD
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
Incorporated Areas
County Boundary
Natural Resource Conservation District
Elevation (meters)
High : 3,718
Low : 1,432
N
0 3.75 7.5 15 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 5, 2010 cd_fig1-1_location.mxd

Section 2: Physical Description

Watershed Size

The Canyon Diablo Watershed covers approximately 767,000 acres (1,198 square miles), representing about 1% of the state of Arizona. The watershed has a maximum width of about 67 miles east to west, and a maximum length of about 85 miles north to south.

The drainage area for the Canyon Diablo Watershed is approximately 1,200 square miles. Elevations in the drainage area range from over 3,718 ft to about 1,432 ft above sea level. The headwaters are from the Rio de Flag and Walnut Creek watersheds.

The Canyon Diablo Watershed was delineated by the U.S. Geological Survey and has been subdivided by the NRCS into smaller watersheds or drainage areas. Each drainage area has a unique hydrologic unit code number (HUC) and a name based on the primary surface water feature within the HUC. These drainage areas can be further subdivided into even smaller watersheds as needed. The Canyon Diablo Watershed is an 8-digit HUC of 15020015 and contains the following 10-digit HUCs (Figure 2-1):

- 1502001501 Rio de Flag
- 1502001502 Walnut Creek
- 1502001503 San Francisco
- 1502001504 Canyon Diablo (Local Drainage)

Geology

Canyon Diablo Watershed is within the Colorado and Mogollon Plateau region of Arizona. The Geology in this region is Composed of Consolidated sedimentary rock, and predominately Coconino Sandstone, overlaid by the Kaibab Limestone Formation. These Permian age rocks are found across northern Arizona, southern Utah, east central Nevada, and southeast California. They are shown on the map (Figure 2-2) as sedimentary rock with the symbol 'P'. The Colorado and Mogollon Plateaus were deposited in the Early Permian, around 250 million years ago (Chronic, 1983). Due to the nature of the rock, well established drainage on the Colorado Plateau does not exist; therefore, precipitation which easily dissolves Kaibab limestone, sinks down through underground channels and caverns (in the Kaibab Formation), and eventually reaches the surface again as springs at lower elevations. Many springs in the Grand Canyon and at the base of the Mogollon Rim are fed by water falling high atop the Colorado Plateau.

Although the sedimentary rock formations have remained as flat layers across the region, there is some deformation present due to faulting. High angle, nearly vertical faults, striking northeast, southwest, cut across almost all of the various aged rock layers.

Considerable volcanic activity occurred in the San Francisco volcanic field in the Flagstaff area and southwest to the margin of the Colorado Plateau in east central Arizona. This volcanic field includes the San Francisco, with Mt. Humphreys which is the highest point in the state; Sunset Carter the youngest volcano, and approximately 600 other vents in the area that had been identified. Several flows that range from 4 to 6 million years old, cap several elongate, flat-topped mesas in and to the south

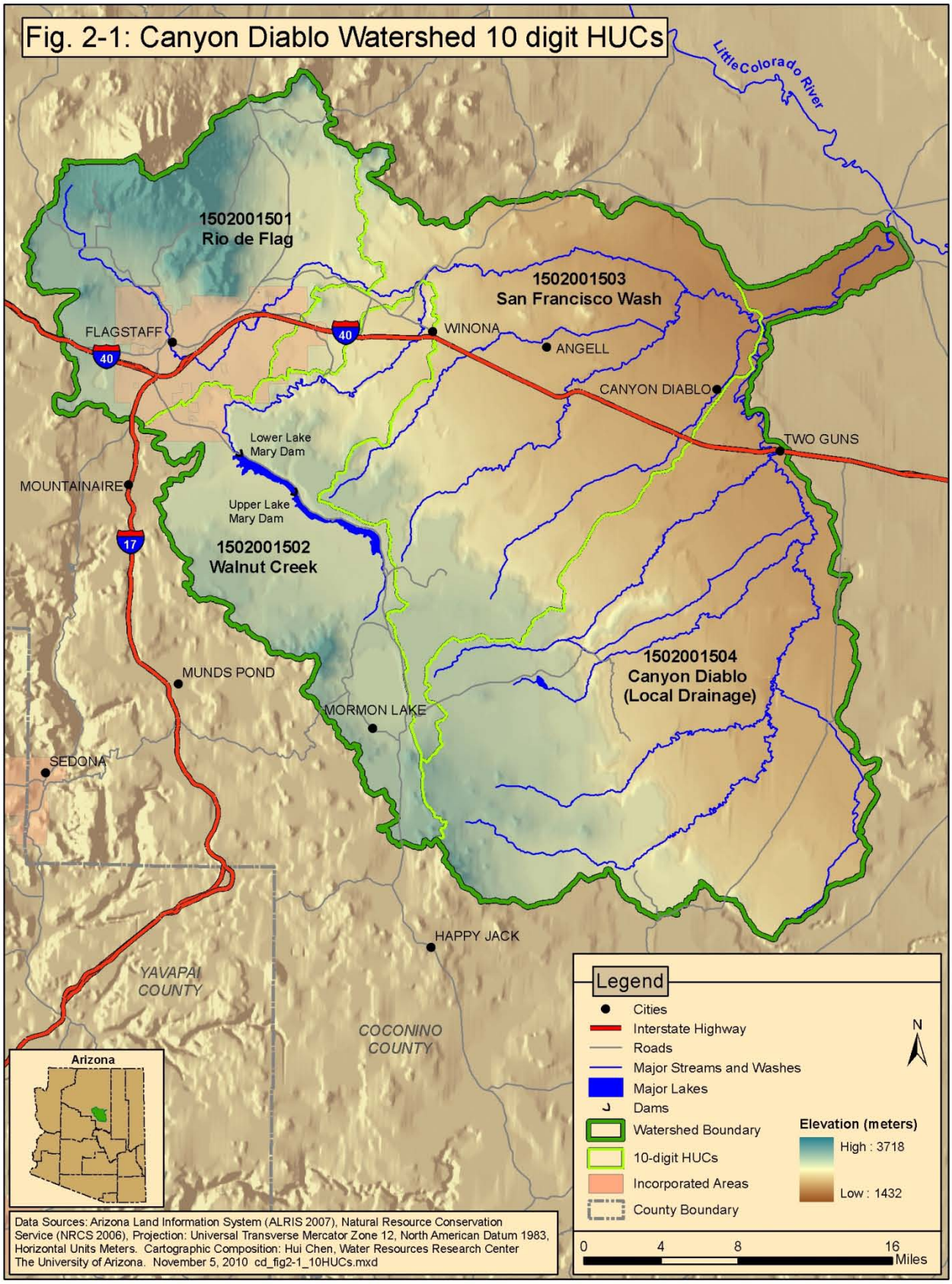
Fig. 2-1: Canyon Diablo Watershed 10 digit HUCs
Little Colorado River
1502001501
Rio de Flag
1502001503
San Francisco Wash
1502001502
Walnut Creek
1502001504
Canyon Diablo
(Local Drainage)
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
Lower Lake
Mary Dam
Upper Lake
Mary Dam
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI
COUNTY
COCONINO
COUNTY
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
Incorporated Areas
County Boundary
Elevation (meters)
High : 3718
Low : 1432
N
0
4
8
16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 5, 2010 cd_fig2-1_10HUCs.mxd

of Flagstaff, including Sweitzer Mesa and Anderson Mesa.

The volcanic rocks, basalt flows and cinder cones form the watershed's boundaries to the northwest and southwest. Pumice and cinders are light weight, and are quarried as aggregate for construction across the watershed. Basaltic rock is represented on the map by QTb, Tby and the volcanic rock by QTv.

The Mogollon Rim's limestones and sandstones were formed from sediments deposited in the Triassic and Permian Period. Several of the Rim's rock formations are also seen on the walls of the Grand Canyon. In many places, the Rim is capped or even buried by the extensive basaltic lava flows. This sedimentary rock is represented on the map by TrM and P.

The Barringer Meteor Crater is located on the eastern boundary of the Canyon Diablo Watershed. The impact probably occurred before the coming of humans to the Western Hemisphere, some 50,000 years ago (Phillips 1991). The crater is approximately 1.2 kilometers (0.75 mile) in diameter and 180 meters (594 feet) deep with an upturned rim which rises 30-60 meters (99-198 feet) above the surrounding plateau.

Soils

Soils within the Canyon Diablo Watershed are diverse and formed as the result of differences in climate, vegetation, geology, and physiographic. Detailed soils information for the watershed is available from the Natural Resources Conservation Service (NRCS) within the following Soil Surveys:

"Soil Survey of Oak Creek-San Francisco Peaks Area, AZ, Part of Coconino County" and "Soil Survey of Little Colorado River Area, AZ, Parts of Coconino and Navajo Counties." Soils data and maps from these Soil Surveys can be accessed through the NRCS Web Soil Survey website: http://websoilsurvey.nrcs.usda.gov.

Common Resource Areas

The USDA, Natural Resources Conservation Service (NRCS) defines a Common Resource Area (CRA) as a geographical area where resource concerns, problems, or treatment needs are similar (NRCS 2006). It is considered a subdivision of an existing Major Land Resource Area (MLRA). Landscape conditions, soil, climate, human considerations, and other natural resource information are used to determine the geographic boundaries of a Common Resource Area.

The Canyon Diablo Watershed is comprised of four Common Resource Areas (Figure 2-3 and Table 2-1).

The uppermost portion of the watershed in the vicinity of the City of Flagstaff is comprised of CRA 39.1 "Mogollon Plateau Coniferous Forests." Elevations range from 7,000 to 12,500 feet and precipitation averages 20 to 35 inches per year. Vegetation includes ponderosa pine, Gambel oak, Arizona walnut, sycamore, Douglas fir, blue spruce, Arizona fescue, mountain muhly, muttongrass, pine dropseed, and dryland sedges.

The soils in CRA 39.1 have a mesic to cryic soil temperature regime and a typic ustic to udic ustic soil moisture regime.

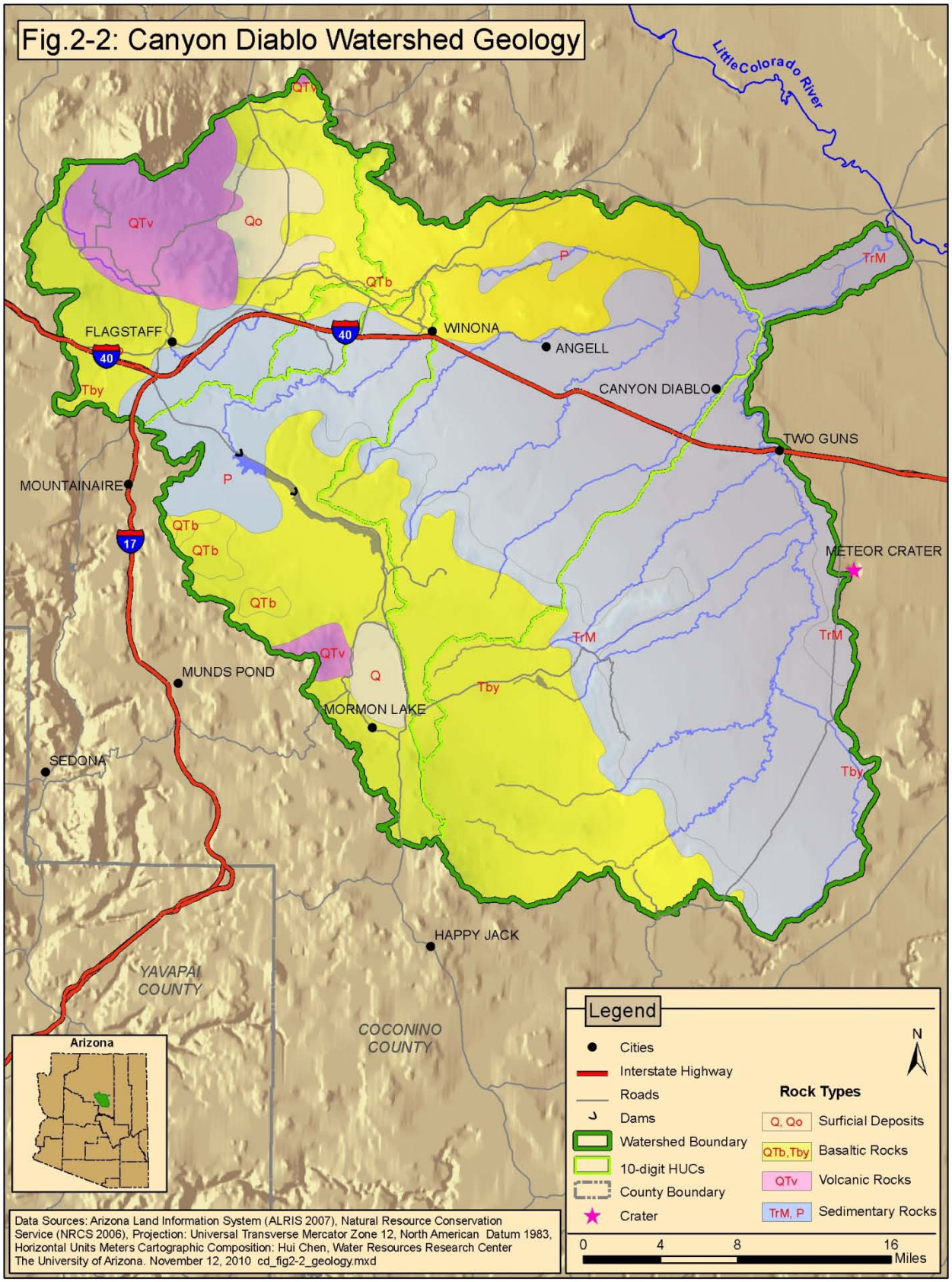
Fig.2-2: Canyon Diablo Watershed Geology
Little Colorado River
QTv
Qo
P
TrM
QTb
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
Tby
MOUNTAINAIRE
METEOR CRATER
MUNDS POND
Q
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
Arizona
Legend
Cities
Interstate Highway
Roads
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Crater
N
Rock Types
Q, Qo Surficial Deposits
QTb, Tby Basaltic Rocks
QTv Volcanic Rocks
TrM, P Sedimentary Rocks
0 4 8 16 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 12, 2010 cd_fig2-2_geology.mxd

The dominant soil orders are Alfisols, Mollisols, and Inceptisols. Moderately deep and deep, medium and moderately fine-textured, soils occur on mountains. Deep and moderately deep, gravelly, medium to fine-textured soils occur in mountain meadows. Shallow, gravelly, cobbly and stony, medium and fine-textured soils occur on plains, mesa tops and cinder cones.

Below the coniferous forest occurs CRA 35.7 “Colorado Plateau Woodland – Grassland” with elevations ranging from 5,000 to 7,000 feet and precipitation averaging 14 to 18 inches per year. Vegetation includes one-seed juniper, Colorado pinyon, Stansbury cliffrose, Apache plume, four-wing saltbush, Mormon tea, sideoats grama, blue grama, black grama, galleta, bottlebrush squirreltail, and muttongrass.

The soils in CRA 35.7 have a mesic soil temperature regime and an aridic ustic soil moisture regime. The dominant soil orders are Vertisols and Mollisols. Shallow to moderately deep, gravelly and cobbly, medium to fine-textured, soils occur on hills and mountains. Shallow, medium and fine-textured, soils and rock outcrop occur on plateaus and plains. Shallow, gravelly, cobbly and stony, medium and fine-textured, soils occur on plains and mesa tops and on cinder cones.

Most of the lower portion of the watershed is comprised of CRA 35.1 “Colorado Plateau Mixed Grass Plains” with elevations ranging from 5100 to 6000 feet and precipitation averaging 10 to 14 inches per year.

Vegetation includes Stipa species, Indian ricegrass, galleta, blue grama, fourwing saltbush, winterfat, and cliffrose.

The soils in CRA 35.1 have a mesic soil temperature regime and an ustic aridic soil moisture regime. The dominant soil orders are Aridisols and Entisols. Shallow, gravelly, cobbly and stony, medium and fine-textured soils occur on plains, mesa tops and cinder cones. Shallow to deep, medium and fine-textured, soils and rock outcrop occur on plateaus and plains.

The lowest portion of the watershed draining to the Little Colorado River is comprised of CRA 35.2 “Colorado Plateau Shrub – Grasslands” with elevations ranging from 3,500 to 5,500 feet and precipitation averaging 6 to 10 inches per year. Vegetation includes shadscale, fourwing saltbush, mormon tea, blackbrush, Indian ricegrass, galleta, blue grama, and black grama.

The soils in CRA 35.2 have a mesic soil temperature regime and an aridic soil moisture regime. The dominant soil orders are Aridisols and Entisols. Sandy, shallow to deep, wind-deposited soils occur on plains and plateaus. Shallow and deep, moderately coarse to moderately fine-textured, soils occur on sandstone and shale plateaus. Rocky outcrop is common.

All of the above Common Resource Areas occur within the Colorado Plateau Physiographic Province which is characterized by a sequence of flat to gently dipping sedimentary rocks eroded into plateaus, valleys and deep canyons. Sedimentary rock classes dominate the plateau with volcanic fields occurring for the most part near its margin.

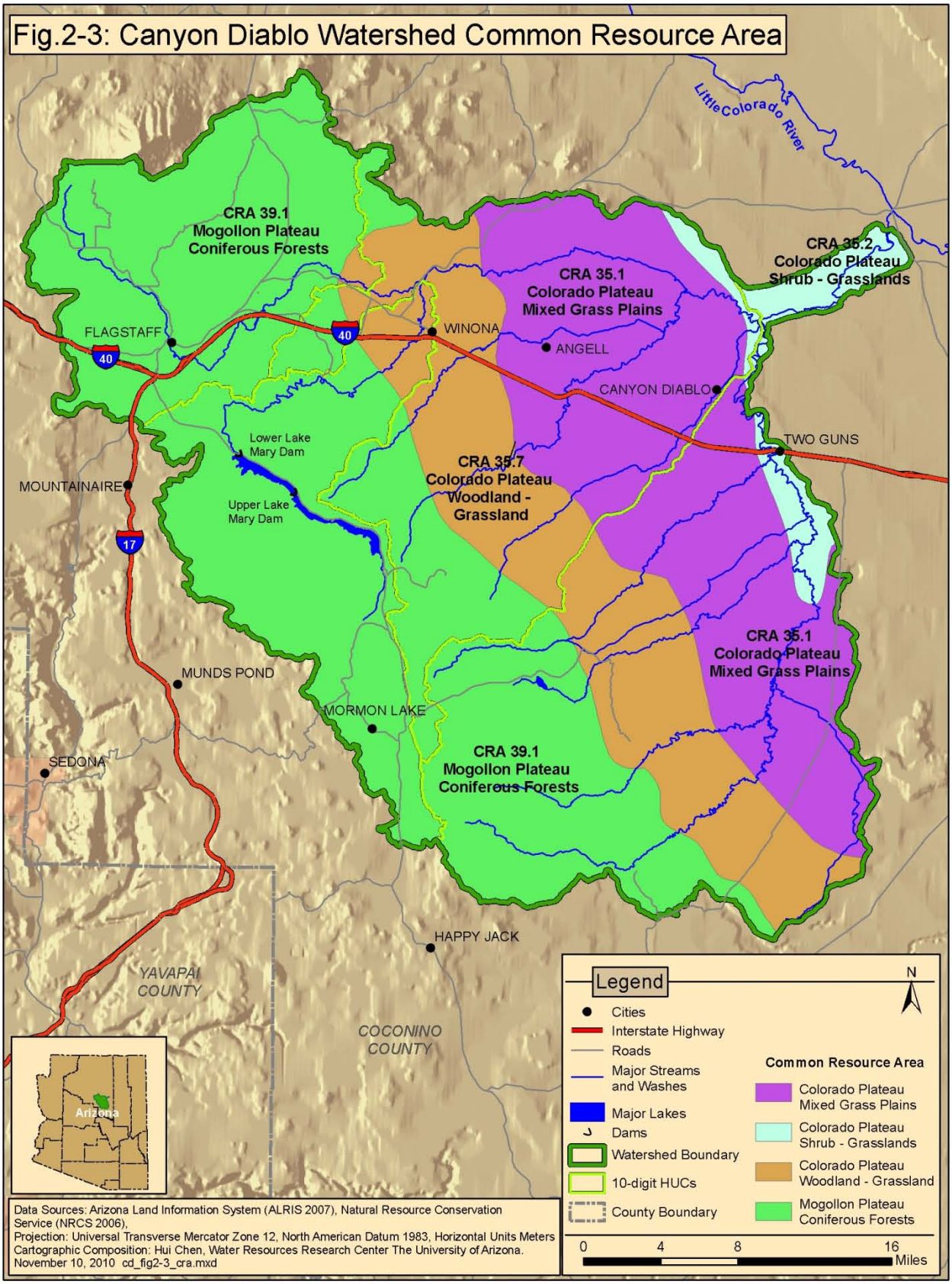
Fig.2-3: Canyon Diablo Watershed Common Resource Area
Little Colorado River
CRA 39.1
Mogollon Plateau
Coniferous Forests
CRA 35.1
Colorado Plateau
Mixed Grass Plains
CRA 35.2
Colorado Plateau
Shrub - Grasslands
CRA 35.7
Colorado Plateau
Woodland -
Grassland
CRA 35.1
Colorado Plateau
Mixed Grass Plains
CRA 39.1
Mogollon Plateau
Coniferous Forests
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
Lower Lake
Mary Dam
Upper Lake
Mary Dam
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI
COUNTY
COCONINO
COUNTY
40
40
17
Arizona
Legend
N
Cities
Interstate Highway
Roads
Major Streams
and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Common Resource Area
Colorado Plateau
Mixed Grass Plains
Colorado Plateau
Shrub - Grasslands
Colorado Plateau
Woodland - Grassland
Mogollon Plateau
Coniferous Forests
0
4
8
16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006),
Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters
Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona.
November 10, 2010 cd_fig2-3_cra.mxd

Table 2-1: Canyon Diablo Watershed –
Common Resource Areas

Common Resource Area Type	Area (sq. mi.)	Percent of Watershed
35.1 Colorado Plateau Mixed Grass Plains	314	26%
35.2 Colorado Plateau Shrub - Grasslands	45	4%
35.7 Colorado Plateau Woodland - Grassland	232	19%
39.1 Mogollon Plateau Coniferous Forests	607	51%

Data Sources: GIS map layer "cra_a_az".
Arizona Land Information System (ALRIS 2004).
Natural Resource Conservation Service (NRCS 2006)

Slope Classifications

Slope, as well as soil characteristics and topography, are important when assessing the vulnerability of a watershed to erosion. About 7% of the Canyon Diablo Watershed has a slope greater than 15%, while about 78% of the watershed has a slope less than 5%.

Canyon Diablo (Local Drainage) - 1502001504 has the least amount of slope, with 86% of its area less than 5% slope. Rio de Flag - 1502001501Watershed has the greatest amount of slope, with 20% of the area greater than 15% slope (Table 2-2 and Figure 2-4).

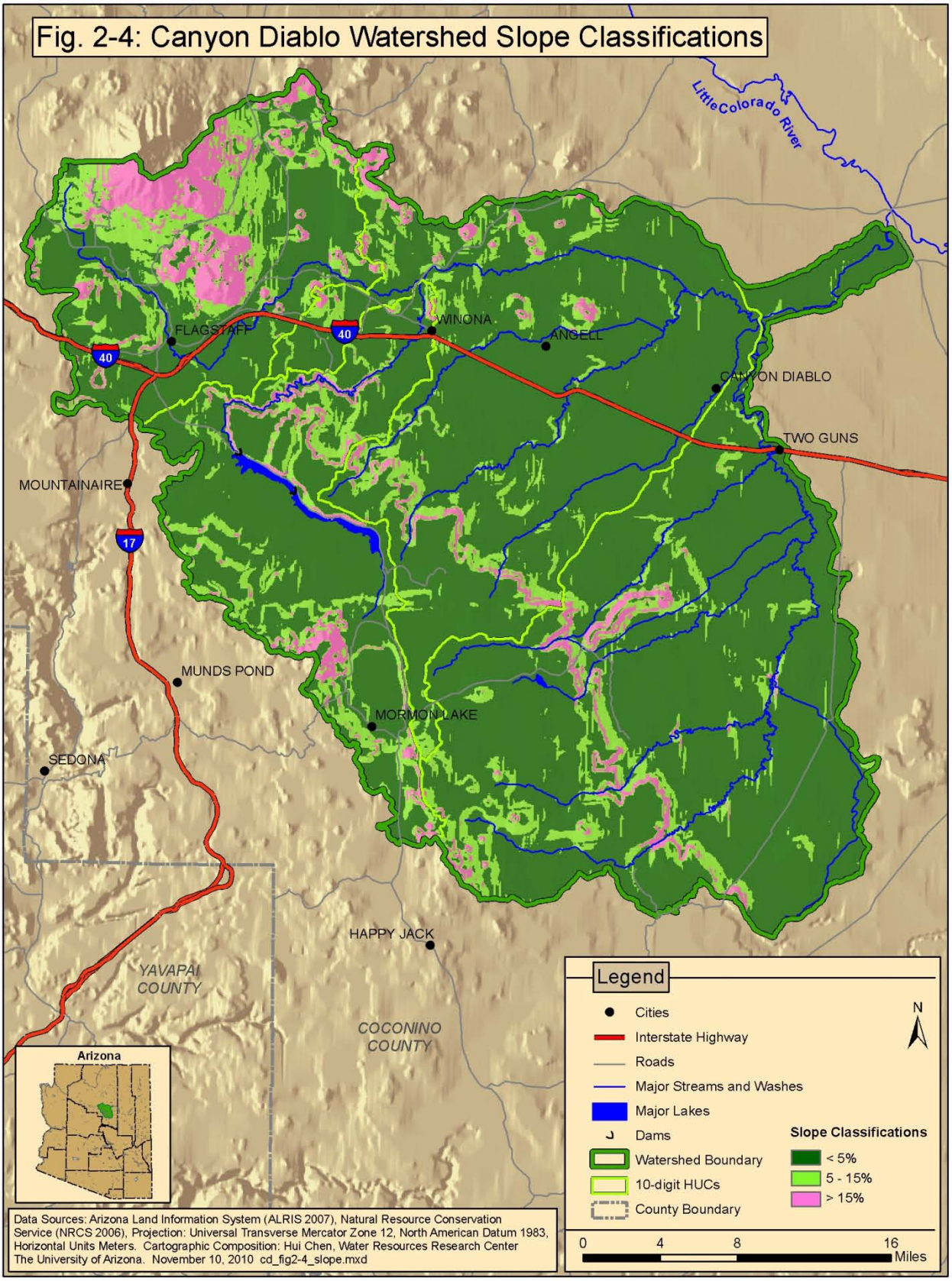
Fig. 2-4: Canyon Diablo Watershed Slope Classifications
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Slope Classifications
< 5%
5 - 15%
> 15%
N
0 4 8 16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 10, 2010 cd_fig2-4_slope.mxd

Table 2-2: Canyon Diablo Watershed Slope Classifications.

10-digit Watershed Name	**Area (sq. mi.)**	**Percent Slope**		
		< 5%	**5-15%**	**>15%**
Rio de Flag-1502001501	201	53%	27%	20%
Walnut Creek-1502001502	194	73%	20%	7%
San Francisco Wash-1502001503	356	85%	12%	3%
Canyon Diablo (Local Drainage)-1502001504	446	86%	12%	3%
Canyon Diablo Watershed	1197	78%	16%	7%

Data Sources: Derived from DEM, obtained from U.S. Geological Survey, October, 2008 http://seamless.usgs.gov/

Gage Stations, Streams, Canals and Lakes

There is one listed active gage station in the Canyon Diablo Watershed (Table 2-3.1). The gage is at the Flagstaff Precipitation USGS ID 350802111403400 is shown in Figure 2-5, located just outside the watershed boundary.

Table 2-3.2 lists major lakes and reservoirs in Canyon Diablo Watershed, as well as their watershed position, surface area, elevation and dam name. Upper lake Mary is the largest surface water body in the watershed with a surface area of 861 acres.

Table 2 -3.3 lists the major streams and their lengths. Stream lengths range from 80 miles for Canyon Diablo to 16 miles for Wallace Canyon.

Table 2-3.1: Canyon Diablo Watershed USGS Stream Gages and Annual Mean Stream Flow

USGS Gage ID	Site Name	Begin Date	End Date	Annual Mean Stream Flow (cfs)
350802111403400	FLAGSTAFF PRECIP	No available USGS data	No available USGS data	No available USGS data

Data Sources: USGS website, National Water Information System http://waterdata.usgs.gov/nwis/

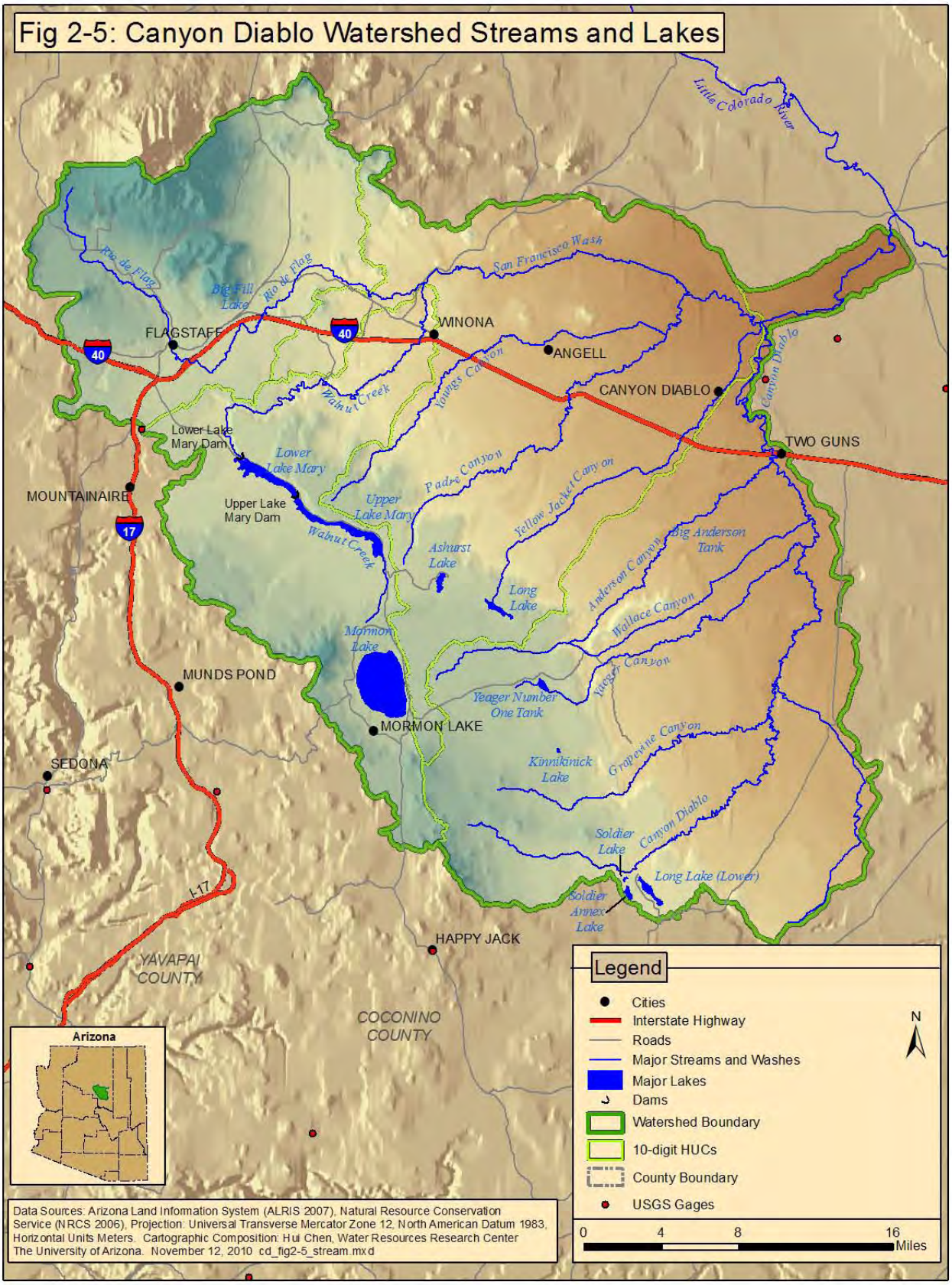
Fig 2-5: Canyon Diablo Watershed Streams and Lakes
Little Colorado River
Rio de Flag
Big Fill Lake
Rio de Flag
San Francisco Wash
FLAGSTAFF
40
40
WINONA
ANGELL
CANYON DIABLO
Canyon Diablo
Walnut Creek
Towns Canyon
Lower Lake Mary Dam
Lower Lake Mary
TWO GUNS
Padre Canyon
Yellow Jacket Canyon
MOUNTAINAIRE
Upper Lake Mary Dam
Upper Lake Mary
17
Walnut Creek
Ashurst Lake
Big Anderson Tank
Anderson Canyon
Long Lake
Wallace Canyon
Mormon Lake
MUNDS POND
Yeager Canyon
Yeager Number One Tank
MORMON LAKE
Grapevine Canyon
SEDONA
Kinnikinick Lake
Canyon Diablo
Soldier Lake
Long Lake (Lower)
I-17
Soldier Annex Lake
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
USGS Gages
N
0
4
8
16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 12, 2010 cd_fig2-5_stream.mxd

Table 2-3.2: Canyon Diablo Watershed Major Lakes and Reservoirs

Lake Name (if known)	Watershed	Surface Area (acres)	Elevation (feet above mean sea level)	Dam Name (if known)
Ashurst	San Francisco Wash	230	7123	
Big Anderson Tank	Canyon Diablo (Local Drainage)	5	1791	
Big Fill Lake	Rio de Flag	16	2082	
Kinnikinick	Canyon Diablo (Local Drainage)	126	7046	
Long	Canyon Diablo (Local Drainage)	268	6740	
Lower lake Mary	Walnut Creek	764	2088	Lower Lake Mary Dam
Soldier Lake	Canyon Diablo (Local Drainage)	30	6782	
Upper lake Mary	Walnut Creek	861	2120	Upper Lake Mary Dam
Yeager Number One Tank	Canyon Diablo (Local Drainage)	97	2147	

Data Sources: GIS data layer "Lakes", Arizona State Land Department, Arizona Land Resource Information System (ALRIS), February 7, 2003
http://www.land.state.az.us/alris/index.html

Table 2-3.3: Canyon Diablo Watershed Major Streams and Lengths.

Stream Name	Watershed	Stream Length (miles)
Anderson Canyon	Canyon Diablo (Local Drainage)	26
Canyon Diablo	Canyon Diablo (Local Drainage)	80
Grapevine Canyon	Canyon Diablo (Local Drainage)	21
Padre Canyon	San Francisco Wash	29
Rio de Flag	Rio de Flag	31
San Francisco Wash	San Francisco Wash	28
Wallace Canyon	Canyon Diablo (Local Drainage)	16
Walnut Creek	Walnut Creek	52
Yaeger Canyon	Canyon Diablo (Local Drainage)	23
Yellow Jacket Canyon	San Francisco Wash	24
Youngs Canyon	San Francisco Wash	24

Data Sources: GIS data layer "Streams", Arizona State Land Department, Arizona Land Resource Information System (ALRIS), October, 10, 2002, ESRI data layer "dtl_streams", 2007 *http://www.land.state.az.us/alris/index.html*

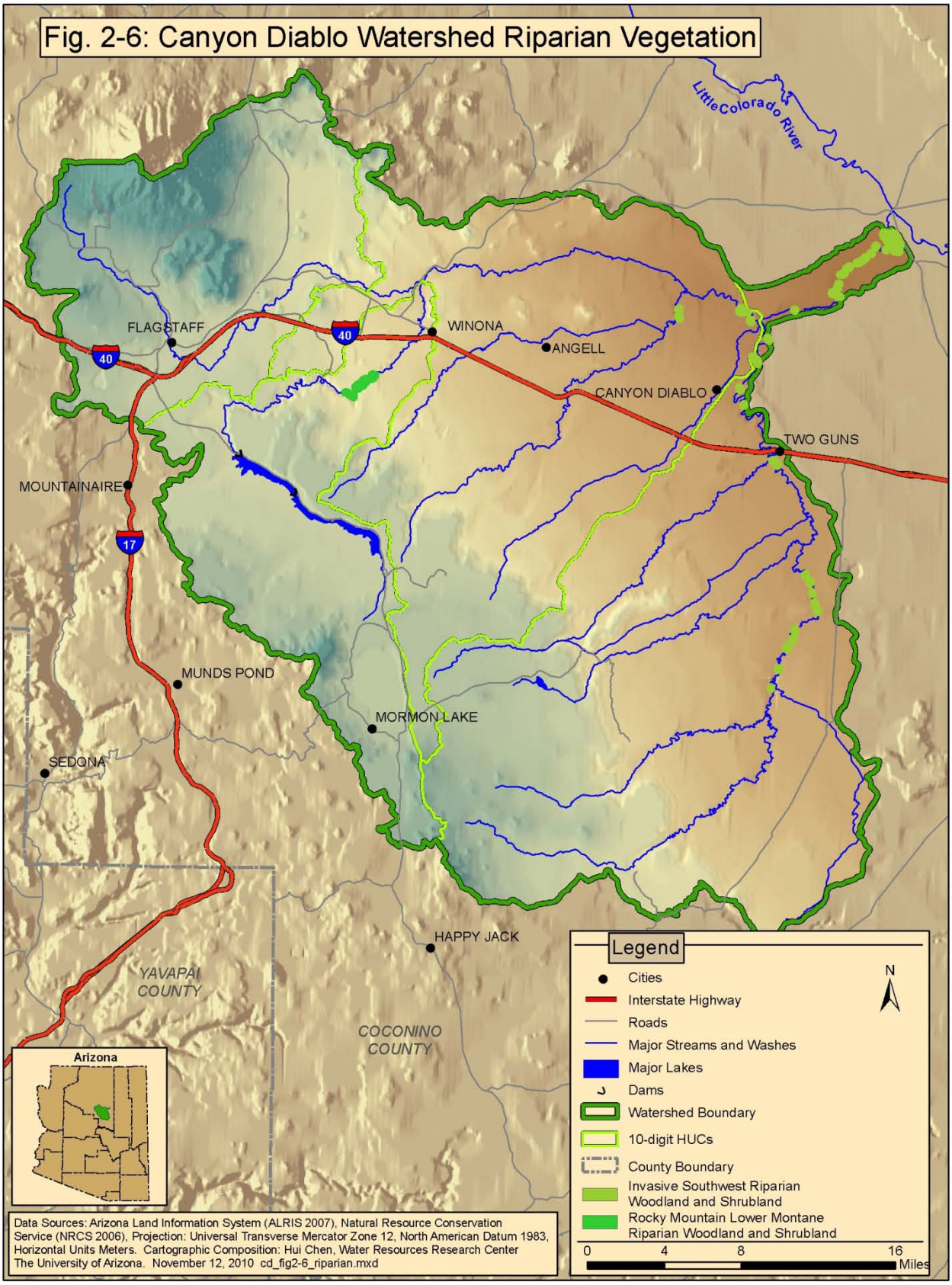
Fig. 2-6: Canyon Diablo Watershed Riparian Vegetation
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Invasive Southwest Riparian Woodland and Shrubland
Rocky Mountain Lower Montane Riparian Woodland and Shrubland
N
0 4 8 16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 12, 2010 cd_fig2-6_riparian.mxd

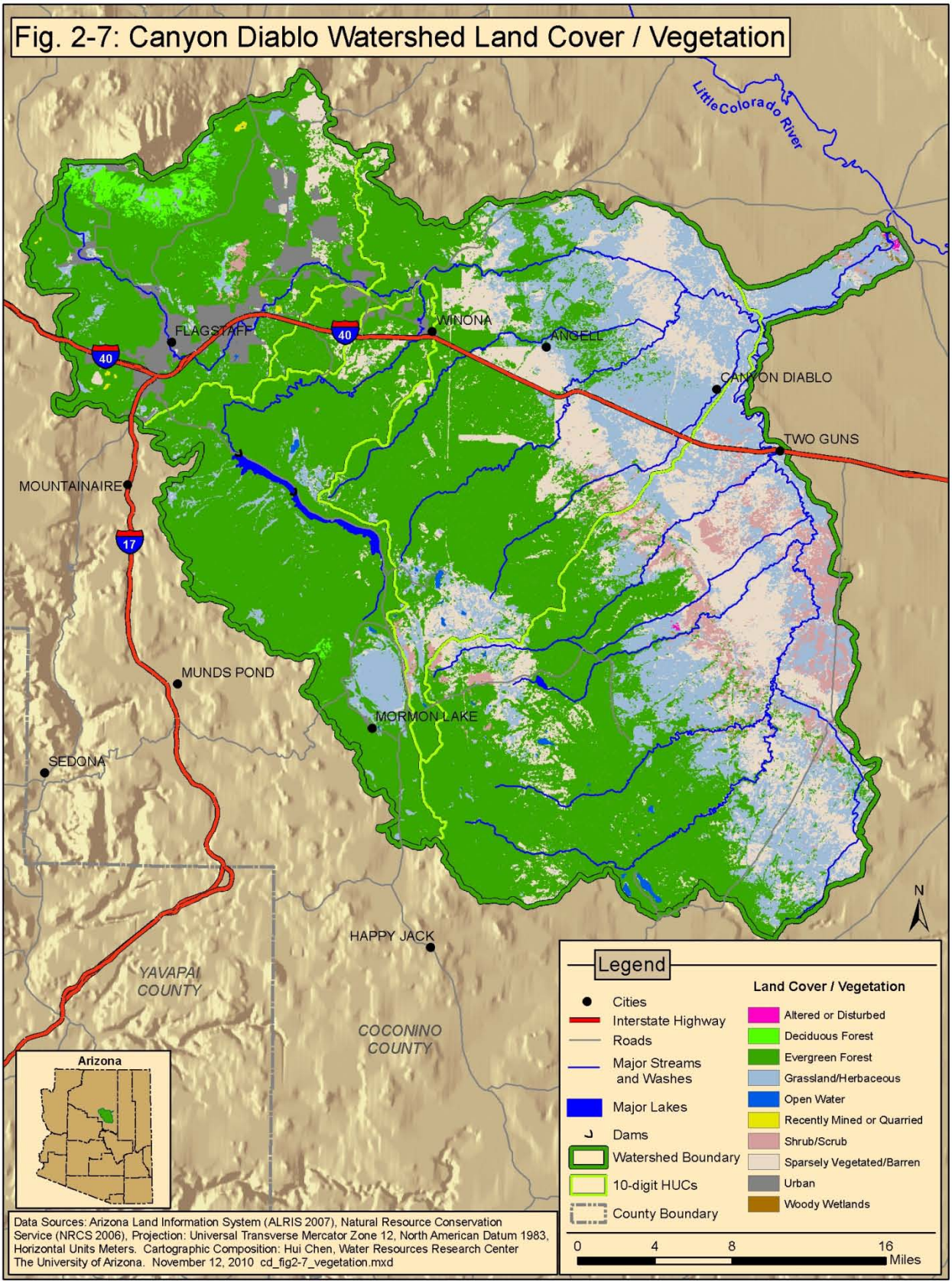
Fig. 2-7: Canyon Diablo Watershed Land Cover / Vegetation
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
N
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Land Cover / Vegetation
Altered or Disturbed
Deciduous Forest
Evergreen Forest
Grassland/Herbaceous
Open Water
Recently Mined or Quarried
Shrub/Scrub
Sparsely Vegetated/Barren
Urban
Woody Wetlands
0 4 8 16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 12, 2010 cd_fig2-7_vegetation.mxd

Land Cover

The Riparian Vegetation map (Figure 2-6) and Land Cover map (Figure 2-7) were created from the Southwest Regional GAP (GAP Analysis Project) land cover map (Lowry et. al, 2005). According to the GAP Analysis Project, only two of the ten types of riparian areas occur within the Canyon Diablo Watershed. Invasive Southwest Riparian Woodland and Shrubland areas encompass approximately 253 acres, and are found in the San Francisco Watershed and Canyon Diablo Local Drainage (Table 2-4).

Rocky Mountain Lower Montane Riparian Woodland and Shrubland are found in the Walnut Creek area on approximately 36 acres. Professional knowledge of the watershed, however, identifies the correct community as "North American Warm Desert Riparian Woodland and Shrubland" (Lowry et. al, 2005).

Within the Canyon Diablo Watershed, Table 2-5 identifies the "evergreen forest" and "Grassland/Herbaceous" as the most common land cover types over the entire watershed, encompassing 57% and 19% of the watershed, respectively. The next most common type of land cover is Sparsely Vegetated/Barren encompassing 17% of the watershed.

Note: There are a total of 26 GAP vegetation categories present within the Canyon Diablo Watershed boundary. Some of these categories occur only in small concentrations, and are not visible at the small scale in which the maps are displayed. Some of the vegetation categories were re-grouped in order to increase the legibility of the map. In collaboration with NRCS, staff was able to create a total of 10 grouped GAP vegetation categories, as shown on Table 2-5.

Table 2-4: Canyon Diablo Watershed Riparian Vegetation (acres) by 10 Digit Watershed.

Riparian Vegetation Community	Invasive Southwest Riparian Woodland and Shrubland	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Rio de Flag-1502001501	-	-
Walnut Creek-1502001502	-	36
San Francisco Wash-1502001503	18	-
Canyon Diablo (Local Drainage)-1502001504	235	-

Data Sources: GIS data layer "newgapveg", Southwest Regional GAP Vegetation (SWGAP), 2005 http://earth.gis.usu.edu/swgap/

Table 2-5: Canyon Diablo Watershed Southwest Regional GAP Analysis Project Land Cover, Percent of 10-digit Watershed.

Land Cover/Vegetation	Rio de Flag-1502001501	Walnut Creek-1502001502	San Francisco Wash-1502001503	Canyon Diablo (Local Drainage)-1502001504	Canyon Diablo Watershed
Altered or Disturbed	-	-	<1%	<1%	<1%
Deciduous Forest	5%	<1%	-	<1%	1
Evergreen Forest	70%	87%	51%	43%	57
Grassland/Herbaceous	4%	8%	24%	26%	19
Open Water	<1%	1%	<1%	<1%	<1%
Recently Mined or Quarried	<1%	<1%	<1%	-	<1%
Shrub/Scrub	1%	<1%	1%	8%	3
Sparsely Vegetated/Barren	6%	3%	23%	23%	17
Urban High Intensity	13%	1%	1%	<1%	3
Urban Low Intensity	1%	-	-	-	<1%
Woody Wetlands	-	<1%	<1%	<1%	<1%
Area (sqmi)	201	194	356	447	1199

Data Sources: GIS data layer "Southwest Regional GAP Program", originated by Southwest Regional GAP program, 2005. http://ftp.nr.usu.edu/swgap/

Meteorological Stations, Precipitation and Temperature

For the years 1961-1990, the average annual precipitation for the Canyon Diablo Watershed was about 23inches (WRCC, 2004) (Table 2-6). Rio de Flag Watershed receives the most rainfall with about 28 inches of annual rain on average, while San Francisco and Canyon Diablo Local Drainage Watersheds receive the least rainfall with an average of 20 inches annually.

The temperature data available for the watershed show Walnut Creek with an average annual high of 50.3°F as the highest in the watershed. Active meteorological stations in the watershed are located in Figure 2-8.

Floods in the region are can result from localized thunderstorm activity and/or the result of more generalized rainfall from regional storms. In both cases, precipitation may vary significantly within relatively small distances. Flash floods may occur on one small watershed while adjacent watersheds receive virtually no precipitation.

Rainfall on an existing snowpack can greatly increase runoff. Due to the drainage area's extreme relief, sparse vegetation, and dynamic weather patterns, floods along Canyon Diablo Creek typically occur with little or no warning.

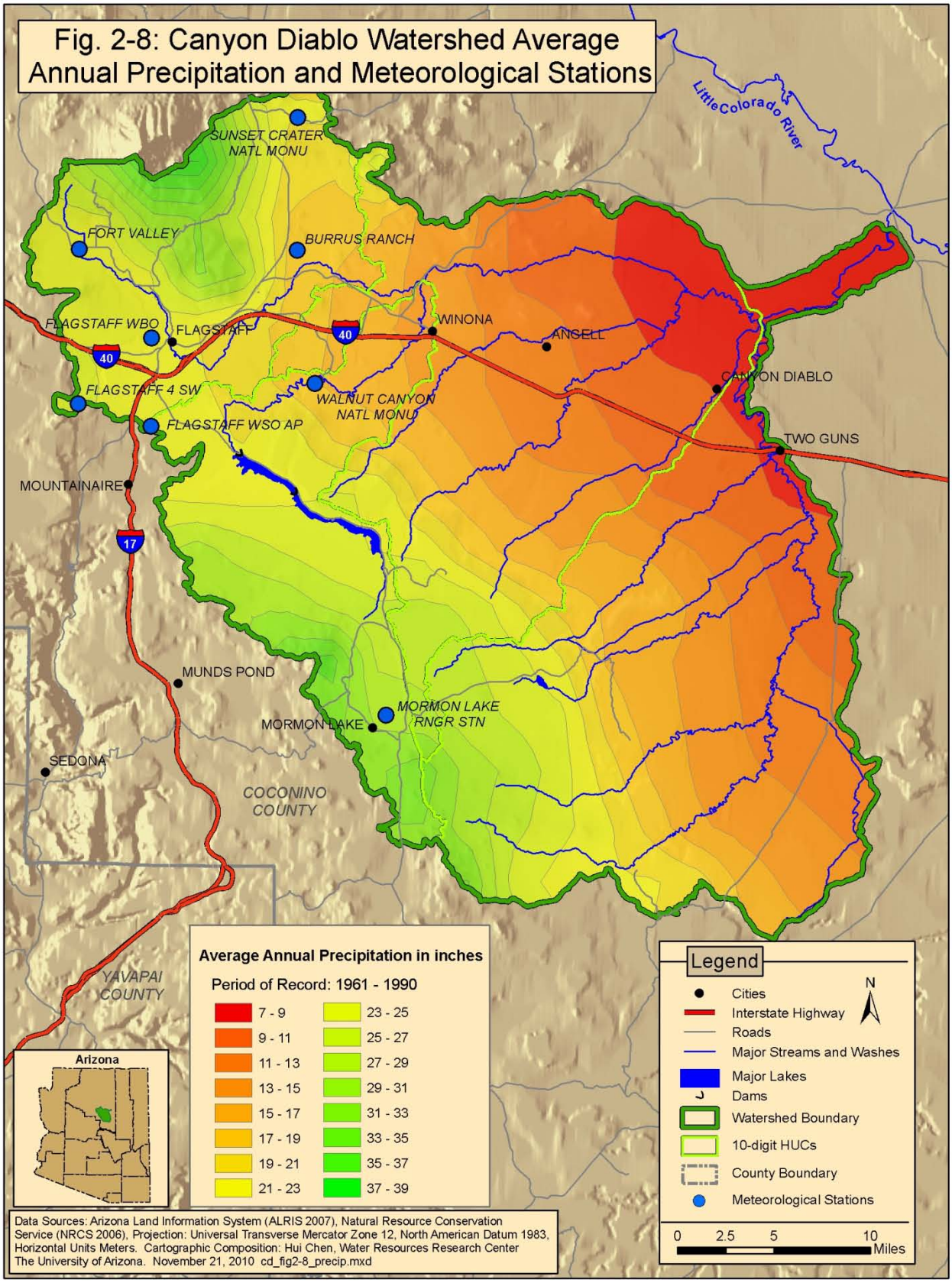
Fig. 2-8: Canyon Diablo Watershed Average Annual Precipitation and Meteorological Stations
Little Colorado River
SUNSET CRATER NATL MONU
FORT VALLEY
BURRUS RANCH
FLAGSTAFF WBO
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
FLAGSTAFF 4 SW
WALNUT CANYON NATL MONU
FLAGSTAFF WSO AP
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE RNGR STN
MORMON LAKE
SEDONA
COCONINO COUNTY
YAVAPAI COUNTY
40
17
Arizona
Average Annual Precipitation in inches
Period of Record: 1961 - 1990
7 - 9
9 - 11
11 - 13
13 - 15
15 - 17
17 - 19
19 - 21
21 - 23
23 - 25
25 - 27
27 - 29
29 - 31
31 - 33
33 - 35
35 - 37
37 - 39
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Meteorological Stations
N
0 2.5 5 10
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 21, 2010 cd_fig2-8_precip.mxd

Table 2-6: Canyon Diablo Watershed Meteorological Stations, Temperature and Precipitation.

Watershed	Meteorological Stations	Temperature (°F)			Precipitation (in/yr)		
		Ave. Ann. Min.	Ave. Ann. Max.	Avg	Avg.Min.	Avg.Max.	Weighted Average
Rio de Flag-1502001501	Flagstaff 4 SW	25.8	60.9	43.4	17	39	28
	Flagstaff WBO						
	Flagstaff WB City						
	Burrus Ranch	32.8	64.2	48.5			
	Fort Valley	25.8	60.3	43.1			
	Sunset Crater Natl. Monu.	28.3	63.3	45.8			
Walnut Creek-1502001502	Mormon Lake Rngr Stn.	32.6	61.5	47.1	15	35	25
	Flagstaff WB AP						
	Flagstaff WSO AP	31.1	61.2	46.1			
	Walnut Canyon Natl. Monu.	35.7	64.9	50.3			
San Francisco Wash-1502001503	-	-	-	-	7	33	20
Canyon Diablo (Local Drainage)-1502001504	-	-	-	-	7	33	20
Canyon Diablo Watershed					7	39	23

Data Sources: GIS data layer "precip_a_az" Water and Climate Center of the NRCS (1998); GIS data layer "NWS_Stations" Western Regional Climate Center (WRCC), Temperature data. July 15, 2004; http://www.wrcc.dri.edu/summary/climsmaz.htm

Land Ownership/Management

There are 8 different land ownership and/or management entities in the Canyon Diablo Watershed (Figure 2-9 and Table 2-7). Forest Land is the largest category, representing about 57% of the watershed, followed by Private with 20% and the State Trust Land with about 15%.

The Bureau of Land Management comprises the smaller amount of land in the watershed. The Navajo Indian Reservation comprises about 7% of the watershed.

Table 2-7: Canyon Diablo Watershed Land Ownership/Management (Percent of each 10-digit Watershed).

Watershed	Land Owner								Area sq. mi
	Indian Reservation	Forest	National Parks	Private	State Trust	Other	Military	BLM	
Rio de Flag 1502001501	0	63%	1%	29%	6%	<1%	<1%	0	201
Walnut Creek-1502001502	0	92%	2%	5%	<1%	0	0	0	194
San Francisco Wash-1502001503	17%	58%	<1%	13%	12%	0	0	0	356
Canyon Diablo (Local Drainage)-1502001504	5%	38%	0	27%	27%	3%	0	<1%	447
Canyon Diablo Watershed	7%	57%	1%	20%	15%	1%	<1%	<1%	1,199

Data Sources: GIS data layer "ownership", Arizona State Land Department, Arizona Land Resource Information System (ALRIS), October 27, 2007; GIS data layer "SGID_U024_LandOwnership.shp" Utah GIS Portal, November 2006 http://www.land.state.az.us/alris/index.html; http://agrc.its.state.ut.us/

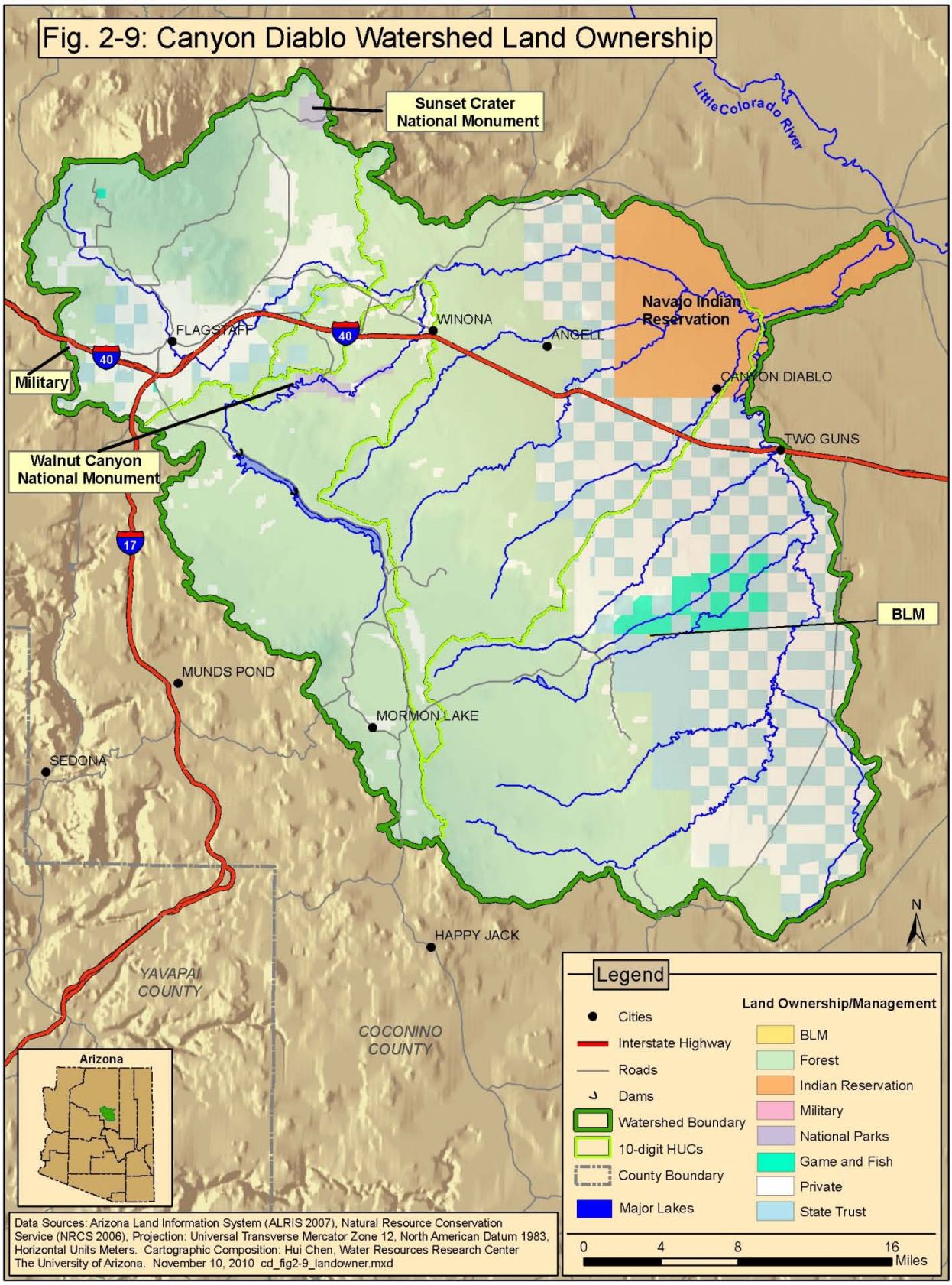
Fig. 2-9: Canyon Diablo Watershed Land Ownership
Sunset Crater National Monument
Little Colorado River
Navajo Indian Reservation
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
Military
Walnut Canyon National Monument
BLM
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
Arizona
N
Legend
Cities
Interstate Highway
Roads
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Major Lakes
Land Ownership/Management
BLM
Forest
Indian Reservation
Military
National Parks
Game and Fish
Private
State Trust
0 4 8 16 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 10, 2010 cd_fig2-9_landowner.mxd

Land Use

The Land Use map (Figure 2-10) was created from the Southwest Regional GAP Analysis Project land cover map (Lowry et. al, 2005).

The land use condition during the early 1990's was determined using the National Land Cover Dataset (NLCD).

The NLCD classification contains 21 different land cover and use categories (USGS, NLCD Land Cover Class Definitions); however, these categories have been consolidated into seven land cover types (Figure 2-10 and Table 2-8). The seven groupings for the land cover categories are:

- Barren Land, includes desolate barren deserts that produce inferior crops soil which produce little or no vegetation,
- Forest, includes areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover,
- Water, identifies all areas of surface water, generally with less than 25% cover of vegetation/land cover,
- Range, which includes herbaceous rangeland; mixed range; shrub and brush rangeland.
- Urban (high density & low density) includes residential areas; commercial and services; industrial and commercial complexes; mixed urban or built-up land; other urban or built-up land; strip mines quarries and gravel pits; transportation, communication and utilities.

The most common land cover type is forest which makes up about 58% of the watershed. Barren land is the next most common type with about 17% of the total area.

Mines - Primary Ores

Table 2-9 and Figure 2-11 show the types of ores being mined in the Canyon Diablo Watershed. The most common type of ore is pumice with 28 mines (Ward, J.S. and Associates, 1973). Other common known ore types are sand and gravel, perlite and stone.

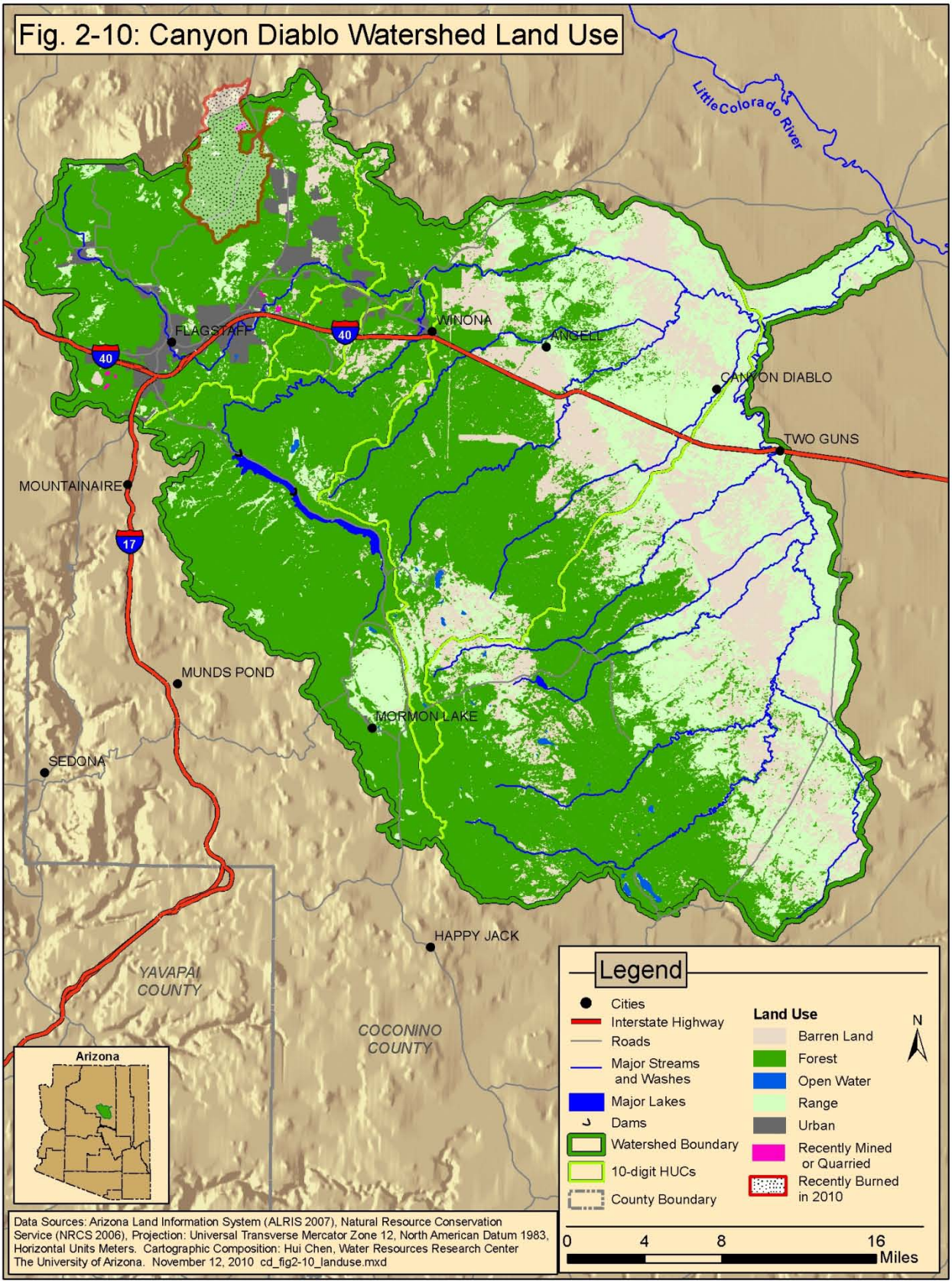
Fig. 2-10: Canyon Diablo Watershed Land Use
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Land Use
Barren Land
Forest
Open Water
Range
Urban
Recently Mined or Quarried
Recently Burned in 2010
N
0 4 8 16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 12, 2010 cd_fig2-10_landuse.mxd

Table 2-8: Canyon Diablo Watershed Land Use, Percent of 10-digit Watershed

Watershed	Barren Land	Forest	Open Water	Range	Recently Mined or Quarried	Urban High Intensity	Urban Low Intensity	Area sq mi
Rio de Flag-1502001501	6%	75%	<1%	5%	<1%	13%	1%	201
Walnut Creek-1502001502	3%	87%	1%	9%	<1%	1%	-	194
San Francisco Wash-1502001503	23%	51%	<1%	25%	<1%	1%	-	356
Canyon Diablo (Local Drainage)-1502001504	23%	43%	<1%	34%	-	<1%	-	447
Canyon Diablo Watershed	17%	58%	<1%	22%	<1%	3%	<1%	1199

Data Sources: GIS data layer "Southwest Regional GAP Program", originated by Southwest Regional GAP program, 2005. http://ftp.nr.usu.edu/swgap/

Table 2-9: Canyon Diablo Watershed Mines - Primary Ores

Ore Type	Total Number of Mines
Perlite	3
Pumice	28
Stone	17
Sand & Gravel	1

Note: If a mine contains more than one ore, only the major ore is noted.
Data Source: "mines" Arizona Land Information Service, 2006.

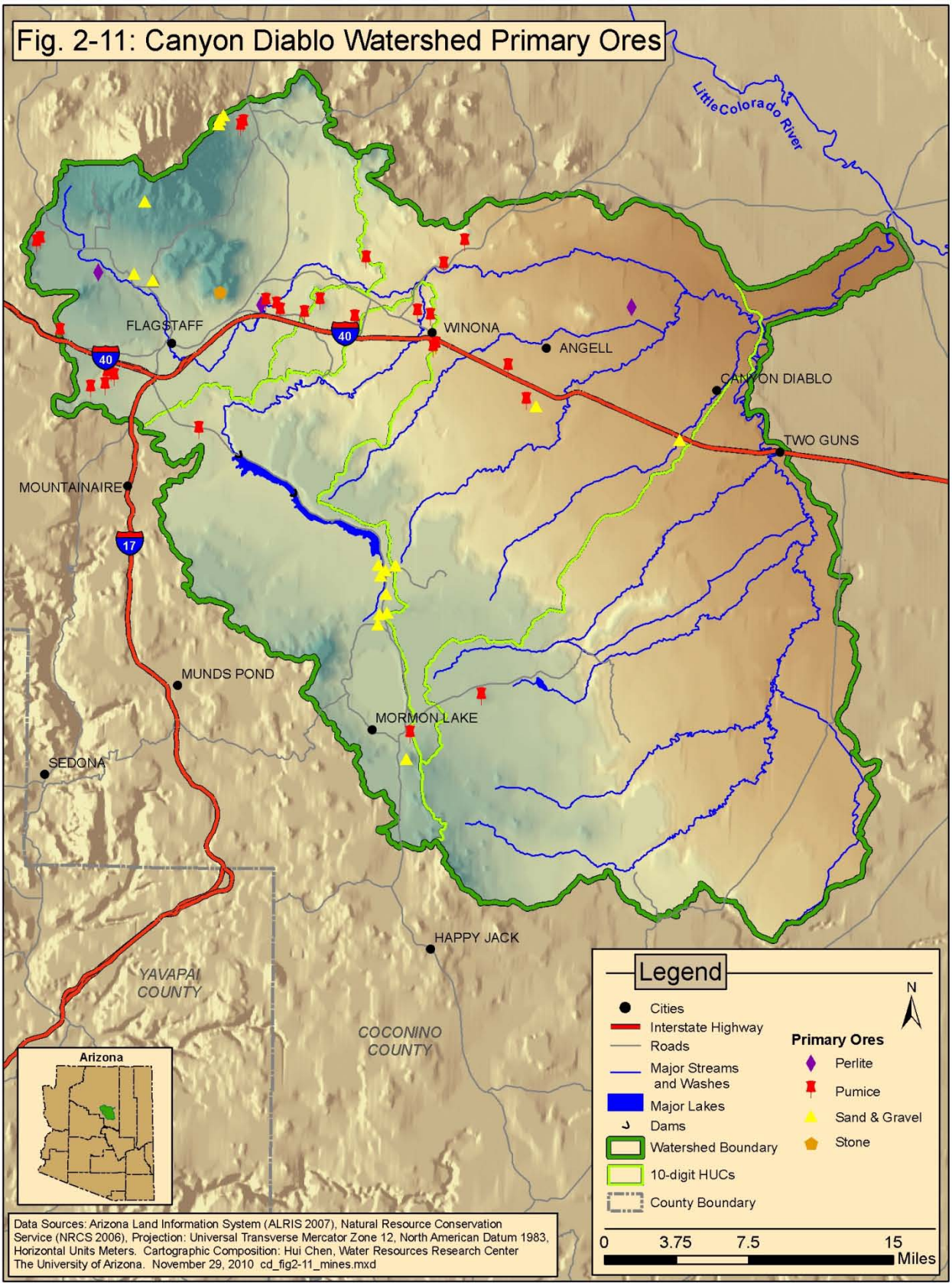
Fig. 2-11: Canyon Diablo Watershed Primary Ores
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Primary Ores
Perlite
Pumice
Sand & Gravel
Stone
N
0 3.75 7.5 15
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 29, 2010 cd_fig2-11_mines.mxd

Section 3: Resource Concerns

Introduction

Conservation Districts and other local leaders, along with NRCS and other resource management agencies, have identified priority natural resource concerns for this watershed. These concerns can be grouped under the broad resource categories of Soil, Water, Air, Plants, or Animals (SWAPA). Refer to Table 3-1 for a listing of priority resource concerns by land use within the Canyon Diablo Watershed.

Soil Erosion

Soil erosion from water and wind is a concern on rangelands and forests within the watershed. The sandy soils of this watershed are highly susceptible to erosive forces. This condition is exacerbated in areas where vegetative cover has been reduced due to prolonged drought, wildfire and other factors.

Soil erosion is defined as the movement of soil from water (sheet and rill or concentrated flow) or wind forces requiring treatment when soil loss tolerance levels are exceeded. Sheet and rill erosion is a concern particularly on rangeland in areas of shallow soils and poor vegetative cover. Soil loss results in reduced water holding capacity and plant productivity. Gully erosion can be a significant problem in areas of steep slopes and deep soils. Loss of vegetative cover and down-cutting of streams contribute to gully formation. Wind erosion (wind-borne dust) is locally significant where adequate vegetative cover is not maintained.

Conservation practices applied to address this resource concern are generally those that help improve vegetative cover, stabilize sites, and control water flows. Practices may include critical area planting, deferred grazing, grade stabilization structures, prescribed grazing, range planting, stream channel stabilization, tree and shrub establishment, water and sediment control basins, windbreak establishment, and wildlife upland habitat management.

Water Quantity

Excessive runoff and flooding is a resource concern within the watershed. Many factors contribute to this condition, including the presence of shallow soils and poor vegetative cover in many areas.

Conservation practices applied to address this resource concern are generally those that restore or maintain adequate vegetative cover on the watershed, or control water flow in channels. Practices may include brush management, deferred grazing, floodwater diversions, prescribed grazing, range planting, stream channel stabilization, tree and shrub establishment, water and sediment control basins, and wildlife upland habitat management.

Plant Condition

Plant condition is a resource concern whenever plants do not manufacture sufficient food to continue the growth cycle or to reproduce. Plant condition is a concern on rangelands and forest lands within the watershed as a result of the effects of prolonged drought, wildfire and other factors.

Table 3-1: Canyon Diablo Watershed Priority Resource Concerns by Land Use

Resource Category	Rangeland Concerns	Forest Concerns
Soil Erosion	✓ Sheet & Rill, Wind ✓ Concentrated Flow	Sheet & Rill, Wind Concentrated Flow
Soil Condition	✓ Rangeland Site Stability	
Water Quantity	✓ Excessive Runoff & Flooding	
Plant Condition	✓ Plant Prod, Health & Vigor Wildfire Hazard, Exc Biomass ✓ Noxious & Invasive Plants	✓ Plant Prod, Health & Vigor Wildfire Hazard, Exc Biomass ✓ Noxious & Invasive Plants
Fish & Wildlife	✓ Inadequate Food & Water ✓ Habitat Fragmentation	✓ Inadequate Food & Water ✓ Habitat Fragmentation
Domestic Animals	✓ Inadequate Quantities & Quality of Feed & Forage ✓ Inadequate Stock Water	✓ Inadequate Quantities & Quality of Feed & Forage ✓ Inadequate Stock Water

(NRCS, 2010)

Conservation practices applied to address this resource concern are generally those that maintain or improve the health, photosynthetic capability, rooting and reproductive capability of vegetation. Practices may include brush management, critical area planting, deferred grazing, fencing, prescribed grazing, prescribed burning, range planting, and wildlife upland habitat management.

<u>Noxious and Invasive Plants</u>

This concern relates to the invasion of unwanted and unproductive plant species. Pinyon and juniper encroachment, as well as increases in other invasive and noxious weeds, have decreased land productivity and exacerbated the wildfire danger on rangelands and forest lands within the watershed.

Noxious and invasive plants are a resource concern whenever these species cause unsuitable grazing conditions for livestock or wildlife and due to their potential to out-compete native species which are generally preferred for wildlife habitat value. Increases in noxious and invasive plants can result from drought and other causes.

Conservation practices applied to address this resource concern are generally those that control the establishment or reduce the population of noxious and invasive plant species. Practices may include brush management, deferred grazing, fencing, forest stand improvement, pest management, prescribed burning, prescribed grazing, and wildlife upland habitat management.

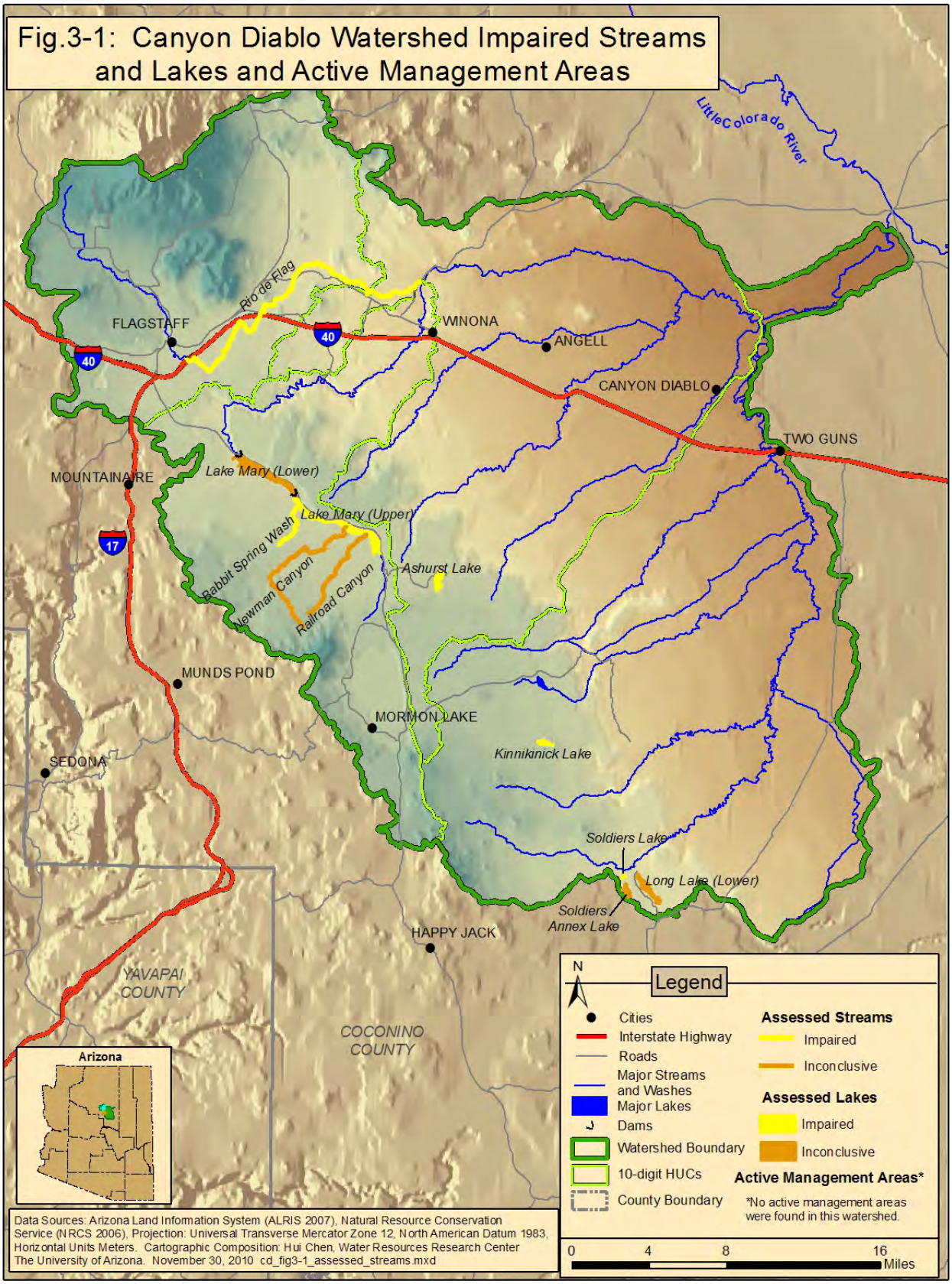
Fig.3-1: Canyon Diablo Watershed Impaired Streams and Lakes and Active Management Areas
Little Colorado River
Rio de Flag
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
Lake Mary (Lower)
Lake Mary (Upper)
Rabbit Spring Wash
Newman Canyon
Railroad Canyon
Ashurst Lake
MUNDS POND
MORMON LAKE
Kinnikinick Lake
SEDONA
Soldiers Lake
Long Lake (Lower)
Soldiers Annex Lake
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
Arizona
Legend
N
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
Assessed Streams
Impaired
Inconclusive
Assessed Lakes
Impaired
Inconclusive
Active Management Areas*
*No active management areas were found in this watershed.
0 4 8 16 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. November 30, 2010 cd_fig3-1_assessed_streams.mxd

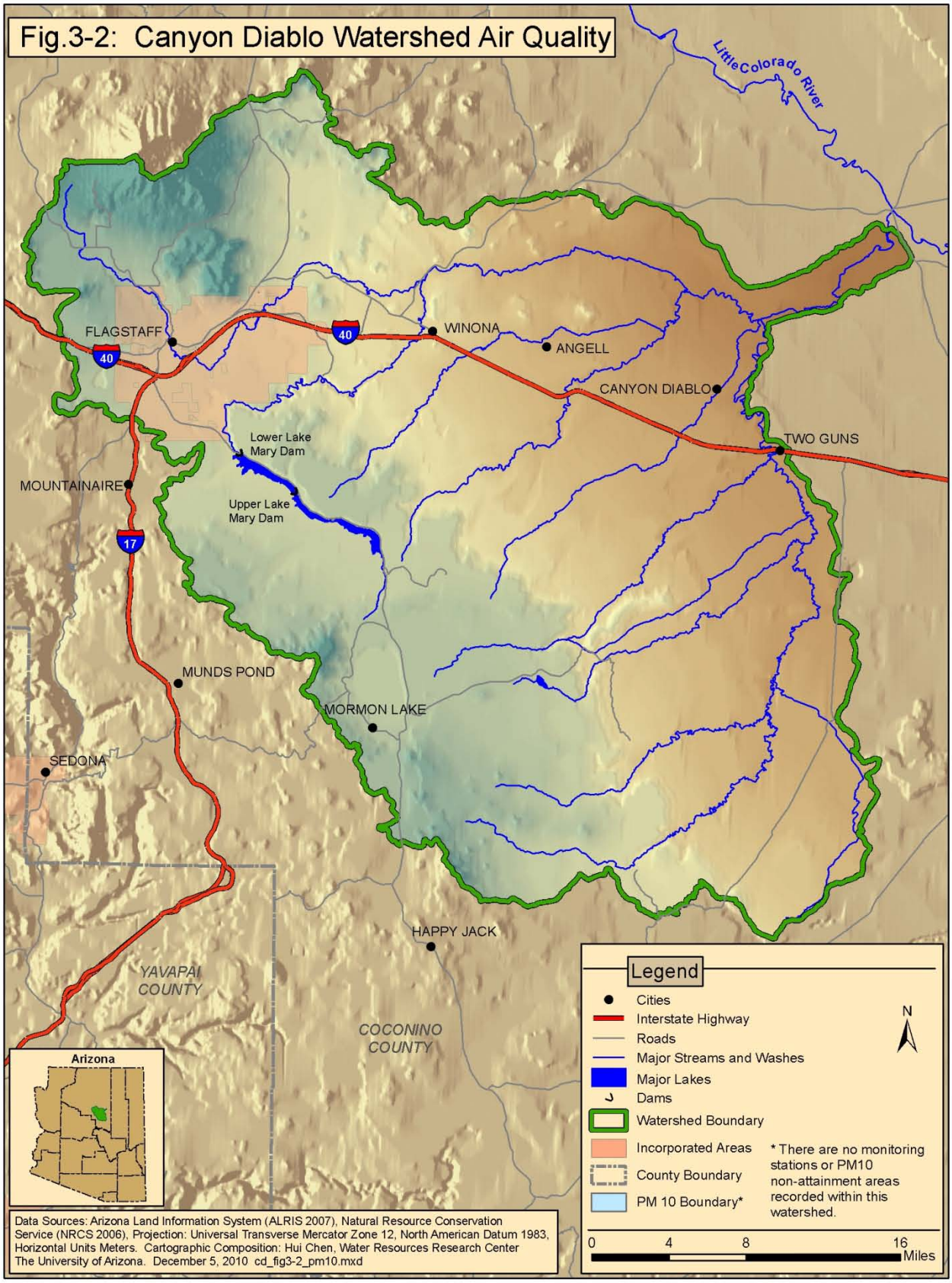
Fig.3-2: Canyon Diablo Watershed Air Quality
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
Lower Lake Mary Dam
Upper Lake Mary Dam
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
Incorporated Areas
County Boundary
PM 10 Boundary*
* There are no monitoring stations or PM10 non-attainment areas recorded within this watershed.
N
0 4 8 16 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. December 5, 2010 cd_fig3-2_pm10.mxd

Air Quality

There are no known air quality concerns in the watershed (Figure 3 – 2).

Environment Sites

There are no environmental Superfund or WQARF sites in the Canyon Diablo Watershed (Figure 3 – 3).

Drought and Wildfire

The Desert Southwest, including Canyon Diablo Watershed, has been in an extended drought since 1996. Drought conditions continue to persist, leading to high vegetation stress, high fire potential, and deteriorating range conditions. The Climate Assessment for the Southwest (CLIMAS) website (www.climas.arizona.edu) and the Arizona Department of Water Resources website (www.azwater.gov/azdwr/StatewidePlanning/Drought) provide information on drought status.

Wildfires Hazard, Excessive Biomass Accumulation

In urban areas, a priority resource concern relates to flooding and erosion following wildfire or other landscape disturbance. Much of the forested areas within the watershed contain high fuel loads (biomass) creating wildfire hazards that pose risks to human safety, structures, and natural resources. A recent example of this is the Schultz fire which burned about 15,000 acres of ponderosa pine forest on the eastern slopes of the San Francisco Peaks near Flagstaff on June 20 - 30, 2010.

Following the fire, a series of monsoon storms over the watershed resulted in heavy runoff and severe flooding and sediment damages throughout the community situated down-slope of the burned area.

Domestic Animal Concerns

Domestic animal concerns occur whenever the quantity and quality of food are not adequate to meet the nutritional requirements of animals, or adequate quantity and quality of water is not provided. This is a concern on rangelands within the watershed when changes in species composition resulting from drought and other factors reduce the availability of suitable forage.

Conservation practices applied to address this resource concern are generally those that maintain or improve the quantity, quality, and diversity of forage available for animals, reduce the concentration of animals at existing water sources, and insure adequate quantity and reliability of water for the management of domestic animals. Practices may include brush management, deferred grazing, fencing, pest management, prescribed burning, prescribed grazing, pipelines, ponds, range planting, watering facility, and wildlife upland habitat management.

Species of Concern

In 1990 Arizona voters created the Heritage Fund, designating up to $10 million per year from lottery ticket sales for the conservation and protection of the state's wildlife and natural areas. The Heritage Fund allowed for the creation of the Heritage Data Management System (HDMS) which identifies elements of concern in Arizona and consolidates information about their status and distribution throughout the state. (Arizona Game & Fish website, 2010)

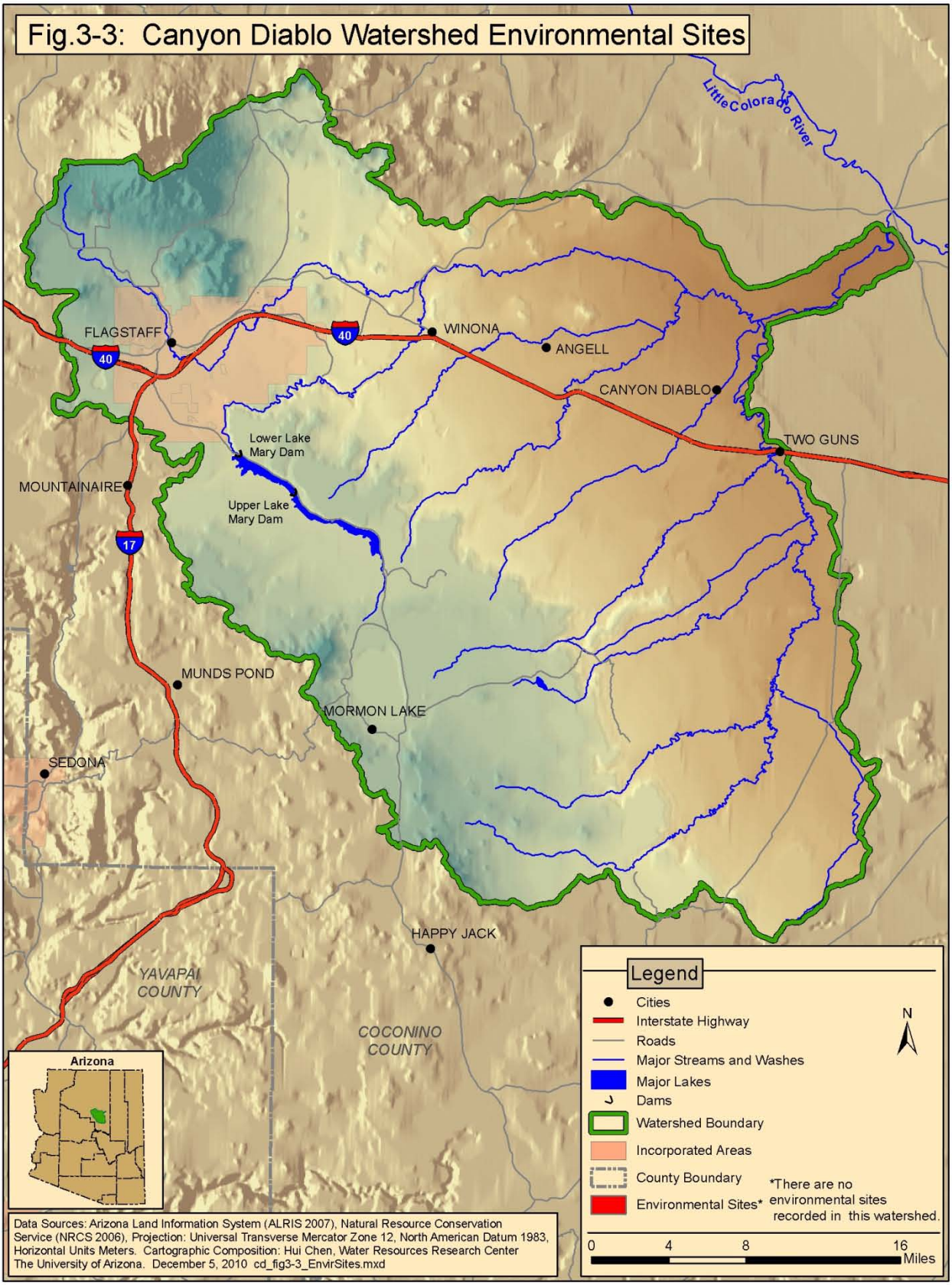
Fig.3-3: Canyon Diablo Watershed Environmental Sites
Little Colorado River
FLAGSTAFF
40
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
Lower Lake Mary Dam
Upper Lake Mary Dam
MOUNTAINAIRE
17
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
Incorporated Areas
County Boundary
Environmental Sites*
*There are no environmental sites recorded in this watershed.
N
0 4 8 16 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. December 5, 2010 cd_fig3-3_EnvirSites.mxd

Table 3-2: Canyon Diablo Watershed Species of Concern and Endangered Species Classifications and Observations [(1)]

Common Name	Scientific Name	USEASA (2)	USFS (3)	BLM (4)	State (5)
Northern Goshawk	*Accipiter gentilis*	SC	S	S	WSC
Western Burrowing Owl	*Athene cunicularia hypugaea*	SC		S	
Ferruginous Hawk	*Buteo regalis*	SC		S	WSC
Swainson's Hawk	*Buteo swainsoni*			S	
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	LE	S		WSC
American Peregrine Falcon	*Falco peregrinus anatum*	SC	S	S	WSC
Bald Eagle	*Haliaeetus leucocephalus*	SC	S	S	WSC
Osprey	*Pandion haliaetus*			S	WSC
Mexican Spotted Owl	*Strix occidentalis lucida*	LT	S		WSC
Maricopa Tiger Beetle	*Cicindela oregona maricopa*	SC	S		
Spotted Bat	*Euderma maculatum*	SC		S	WSC
Arizona Myotis	*Myotis occultus*	SC			
Maricopa Tiger Beetle	*Cicindela oregona maricopa*	SC	S		
Spotted Bat	*Euderma maculatum*	SC		S	WSC
Arizona Myotis	*Myotis occultus*	SC			

Hualapia Mexican Vole	*Microtus Mexicanus Hualapiaensis*	LE			WSC
Long-legged Myotis	*Myotis volans*	SC			
Rudy's Milk-vetch	*Astragalus rusbyi*		S		
Western Fairy Slipper	*Calypso bulbosa*				SR
Grand Canyon Evening-primrose	*Camissonia specuicola ssp. hesperia*	SC			
Tusayan Rabbitbrush	*Chrysothamnus molestus*	SC	S		
Arizona Bugbane	*Cimicifuga arizonica*	SC	S		HS
Clustered Barrel Cactus	*Echinocatus polycephalus var. polycephalus*				SR
Grand Canyon Cottontop Cactus	*Echinocatus polycephalus var. xeranthemoides*				SR
Fickeisen Plains Cactus	*Pediocactus peeblesianus var. fickeiseniae*	C	S		HS
Flagstaff Beardtongue	*Penstemon nudiflorus*		S		
Grand Canyon Rose	*Rosa stellata ssp. Abyssa*	SC	S	S	SR
Tusayan Flame Flower	*Talinum validulum*	SC			SR

(1) Status definitions as listed by the Arizona Game and Fish Department, Heritage Database, March 8, 2010. http://www.azgfd.gov/w_c/edits/species_concern.shtml.
:

(2) (USEA) Federal U.S. Status
ESA Endangered Species Act (1973 as amended)
US Department of Interior, Fish and Wildlife Service:
LE Listed Endangered: imminent jeopardy of extinction.
LT Listed Threatened: imminent jeopardy of becoming Endangered.
Candidate (Notice of Review: 2008):
C Candidate. Species for which USFWS has sufficient information on biological vulnerability and threats to support proposals to list as Endangered or Threatened under ESA. However, proposed rules have not yet been issued because such actions are precluded at present by other listing activity.
SC Species of Concern. The terms "Species of Concern" or "Species at Risk" should be considered as terms-of-art that describe the entire realm of taxa whose conservation status may be of concern to the US Fish and Wildlife Service, but neither term has official status (currently all former C2 species).

(3) USFS US Forest Service (1999 Animals, 1999 Plants: corrected 2000)
US Department of Agriculture, Forest Service, Region 3
S Sensitive: those taxa occurring on National Forests in Arizona which are considered sensitive by the Regional Forester.

(4) BLM US Bureau of Land Management (2008 Animals, 2008 Plants)
US Department of Interior, BLM, Arizona State Office
S Sensitive: those taxa occurring on BLM Field Office Lands in Arizona which are considered sensitive by the Arizona State Office.

(5) State Status
NPL Arizona Native Plant Law (1993)
Arizona Department of Agriculture

HS Highly Safeguarded: no collection allowed.
SR Salvage Restricted: collection only with permit.
WSC Wildlife of Special Concern in Arizona. Species whose occurrence in Arizona is or may be in jeopardy, or with known or perceived threats or population declines, as described by the Arizona Game and Fish Department's listing of Wildlife of Special Concern in Arizona (WSCA, in prep).

The Canyon Diablo Watershed contains 25 species of mammal, bird, plant, invertebrate or amphibian, that are listed as protected under the U.S. Endangered Species Act (ESA), or by BLM, USFS, or the State of Arizona (Table 3-2). The watershed contains two species, the Southwestern Willow Flycatcher (*Empidonax traillii extimus*) and the Hualapai Mexican Vole (*Microtus mexicanus hualapaiensis*), These are ESA listed as in imminent jeopardy of extinction.

Resource Concern Summary

The Coconino Natural Resource Conservation District (NRCD) and Little Colorado River Soil and Water Conservation District (SWCD) and other local resource experts have identified priority resource concerns for this watershed. For the upland areas, the primary concern relates to maintaining and improving the condition and productivity of the land.

This includes implementing conservation practices to protect soil from erosion and excessive runoff, improve the health and vigor of the vegetative communities, and enhance habitat for wildlife.

The Canyon Diablo Watershed also has important wildlife resources to protect and conserve, including three federally listed threatened species; the Mexican spotted owl (*Strix occidentalis lucida*), the Little Colorado Spinedace (*Lepidomeda vittata*), and the San Francisco Peaks Groundsel (*Senecio franciscanus*).

Conservation Progress/Status

To address the priority resource concerns within the Canyon Diablo Watershed, the Coconino NRCD and the Little Colorado River SWCD, in cooperation with the NRCS and other agencies, deliver a broad array of conservation programs and assistance to their Cooperators. Over the years, the Districts and Cooperators have accomplished numerous conservation projects within the watershed.

Ranchers within the watershed have taken an active role in implementing conservation projects designed to improve the health and productivity of the land, to enhance soil condition and water infiltration, and to restore wildlife habitat. This has included installing such conservation practices as fencing and pipelines necessary for prescribed grazing. Brush management is another common conservation practice, and typically involves removing pinyon and juniper (PJ) trees in climax grassland vegetation communities.

Upland and wetland wildlife habitat management practices are also implemented as part of complete resource management systems.

Many of these conservation projects have been accomplished by the ranchers on their own using private resources without benefit of any technical or financial assistance from the NRCS.

In addition to providing conservation assistance to individual land owners and operators, the Coconino NRCD sponsors numerous conservation projects and initiatives within the watershed. Some examples are briefly cited here.

The goal of the Rio De Flag Meander Restoration Project is to restore the fluvial processes of the stream and enhance the riparian corridor for habitat, recreation, and aesthetics. Beginning in 2002, clean-up projects were organized and coordinated. Natural Channel Design and the City of Flagstaff received a grant award from the Arizona Water Protection Fund to restore the natural meanders in the Picture Canyon area. Noxious weeds were removed, meanders created, and the streambanks were revegetated with native plants.

The Coconino NRCD actively supports the Four Forest Restoration Initiative and the Greater Flagstaff Forest Partnership (GFFP). The goal of the GFFP is to protect Flagstaff and surrounding communities from catastrophic wildfire by means of: a) An educated and involved public; b) Implementation of forest treatment projects designed to reduce wildfire threat and improve long-term forest health; and c) Utilization of FireWise building techniques and principles.

The Coconino NRCD actively promotes Coordinated Resource Management on ranches within the watershed. As an example, the mission of the Diablo Trust is to sustain healthy land resources and open space through education and active involvement of the broader community in maintaining ranches as long-term, economically viable land stewardship enterprises.

Conservation progress for the previous five years in the Canyon Diablo Watershed has focused on addressing the following primary resource concerns:

- ✓ Soil Erosion – Sheet and Rill
- ✓ Water Quantity – Excessive Runoff and Flooding
- ✓ Plant Condition – Productivity, Health and Vigor
- ✓ Fish and Wildlife – Inadequate Quantities and Quality of Feed and Water
- ✓ Domestic Animals – Inadequate Quantities and Quality of Feed and Water

The following table presents conservation accomplishments in this watershed during fiscal years (FY) 2006 through 2010, according to the NRCS Progress Reporting System. This listing represents only conservation practices completed with NRCS assistance. As stated above, ranchers within the watershed have accomplished much additional conservation work on their own.

Table 3-3: Canyon Diablo Watershed Conservation Treatment Applied

Canyon Diablo Watershed (15020015) Conservation Treatment Applied	FY06-10 TOTAL
Brush Management (code 314) (acres)	8,003
Channel Bank Vegetation (322) (acres)	4,193
Fence (code 382) (feet)	8,994
Pipeline (code 516) (feet)	73,901
Prescribed Grazing (code 528) (acres)	11,059
Upland Wildlife Habitat Management (code 645) (acres)	28,583
Wetland Wildlife Habitat Management (644) (acres)	25

Section 4: Census, Social and Agricultural Data

This section discusses the human component of the watershed and the pressure on natural resources caused by humans, and by population change.

Population Density, 2000

Census block statistics for 2000 were compiled from information prepared by Arizona Land Information System (ALRIS 2007). These data were linked with census block data and used to create a density map (Figure 4-1) through a normalization process using a grid of 7 km squares. This process involves calculating density per census block and intersecting it with the grid, which is then used to calculate the number of people and thus density per grid square.

Table 4-1 shows the tabulated minimum, maximum and mean number of people per square mile in 2000 for each watershed. In 2000, the mean population density for the entire watershed was about 47 people per square mile. Rio de Flag, which contains the City of Flagstaff, had the highest population mean with 250 people per square mile, and a maximum of 5,216 people per square mile. Canyon Diablo Local Drainage Watershed had the lowest density with a mean of only about 0.46 people per square mile.

Population Density, 2000

The Census Block 2000 statistics data were downloaded from the Environmental Systems Research Institute (ESRI) website (ESRI Data Products, 2003) and are shown in Table 4-2. A population density map (Figure 4-2) was created from these data. The mean population density in 2000 was 62.4 people/square mile.

Population Density Change, 2000 - 2010

The 2000 and 2010 population density maps were used to create a population density change map. The resulting map and table (Figure 4-3 and Table 4-3) show population increase or decrease over the ten year time frame.

Overall, mean population density increased by about 9.1 people per square mile during this ten-year time period. Rio de Flag had the largest increase in mean population at 71.7 people per square mile. Two watersheds had decreases in mean population density

Housing Density, 2000 and 2030

The Watershed Housing Density Map for the years 2000 and 2030 were created with data developed by David M. Theobald (Theobald, 2005). Theobald developed a nationwide housing density model that incorporates a thorough way to account for land-use change beyond the “urban fringe.”

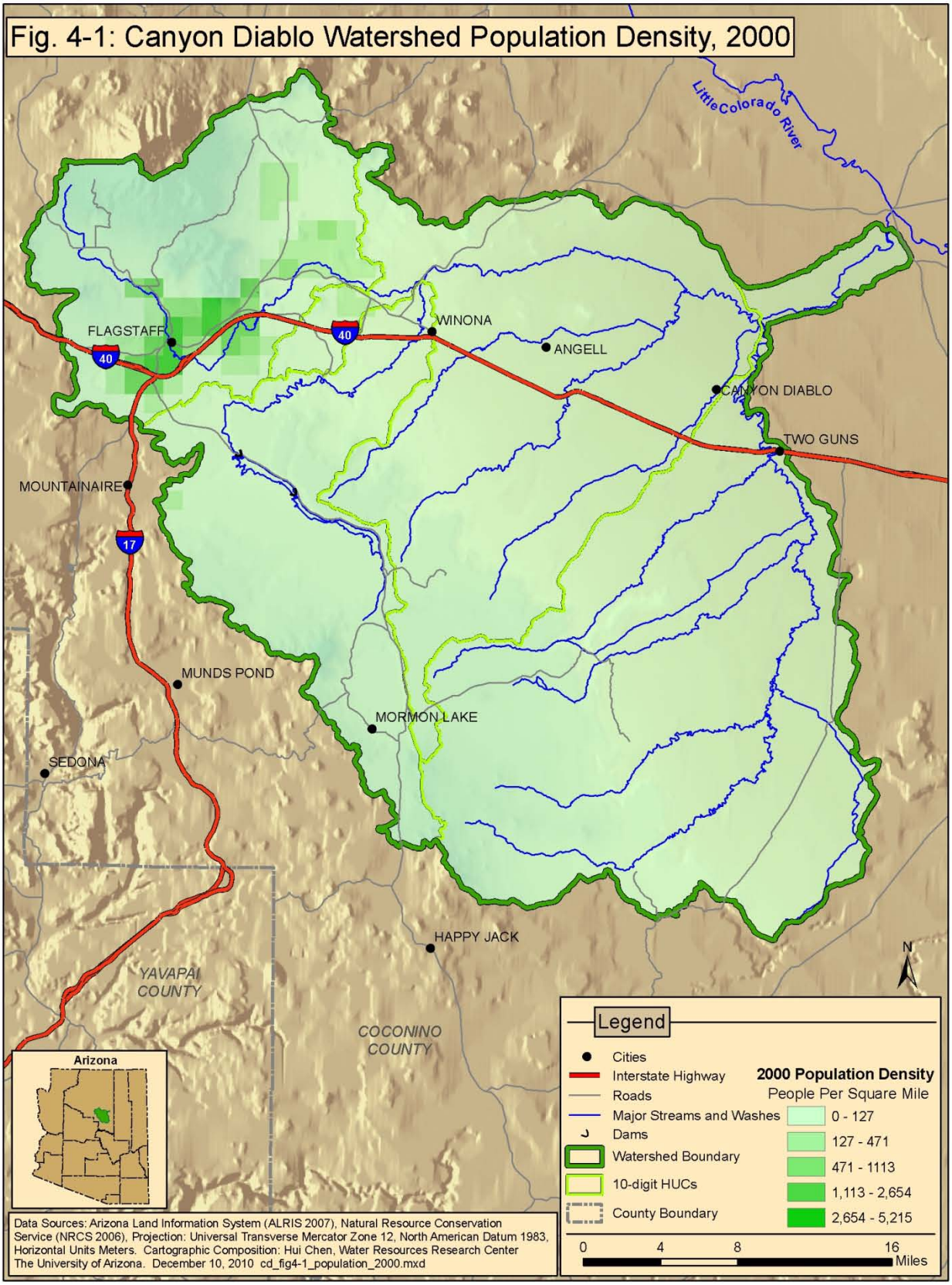
Fig. 4-1: Canyon Diablo Watershed Population Density, 2000
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
40
17
N
Arizona
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
2000 Population Density
People Per Square Mile
0 - 127
127 - 471
471 - 1113
1,113 - 2,654
2,654 - 5,215
0 4 8 16
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. December 10, 2010 cd_fig4-1_population_2000.mxd

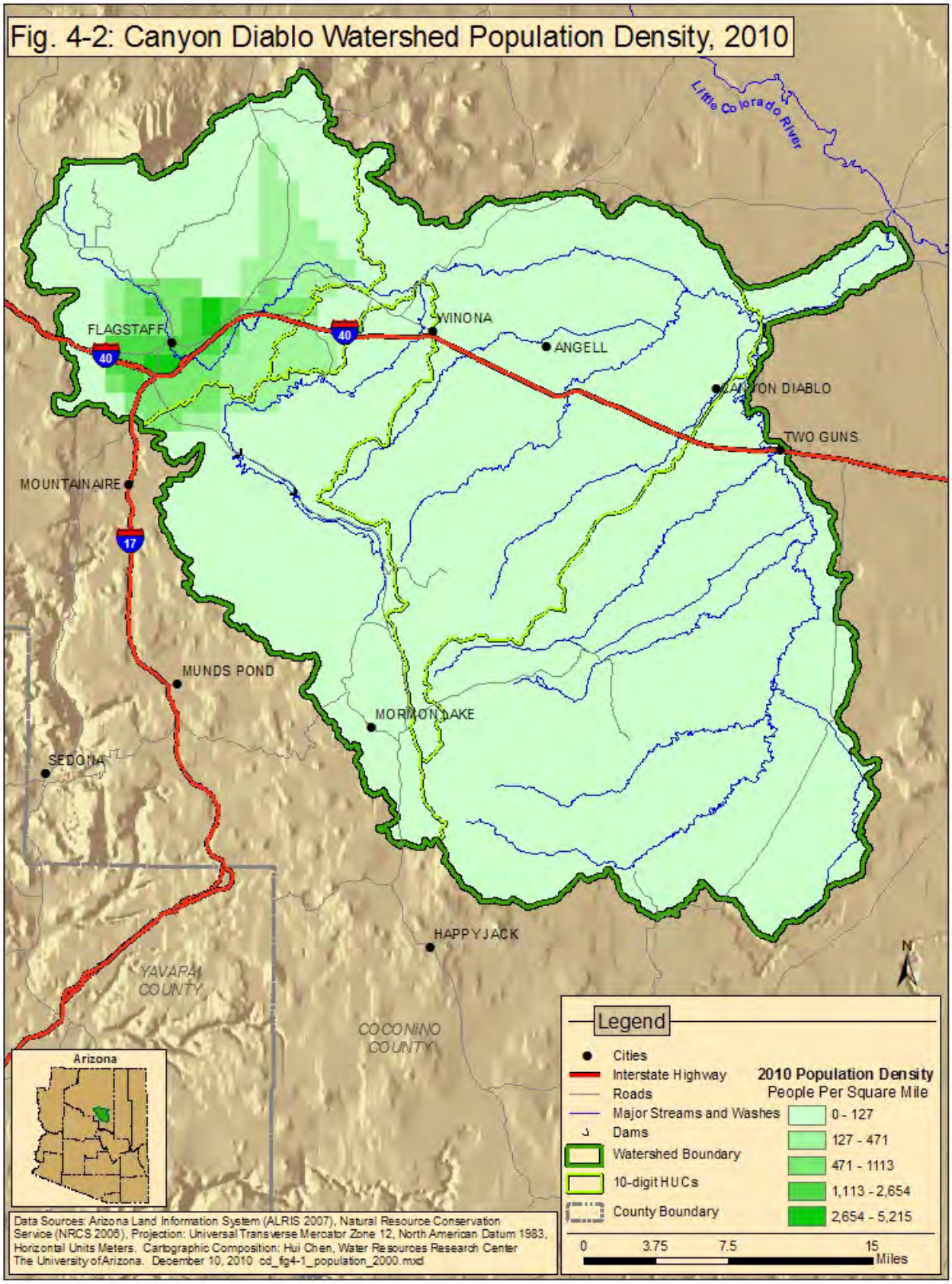
Fig. 4-2: Canyon Diablo Watershed Population Density, 2010
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
YAVAPAI COUNTY
COCONINO COUNTY
Arizona
N
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
2010 Population Density
People Per Square Mile
0 - 127
127 - 471
471 - 1113
1,113 - 2,654
2,654 - 5,215
0
3.75
7.5
15
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. December 10, 2010 cd_fig4-1_population_2000.mxd

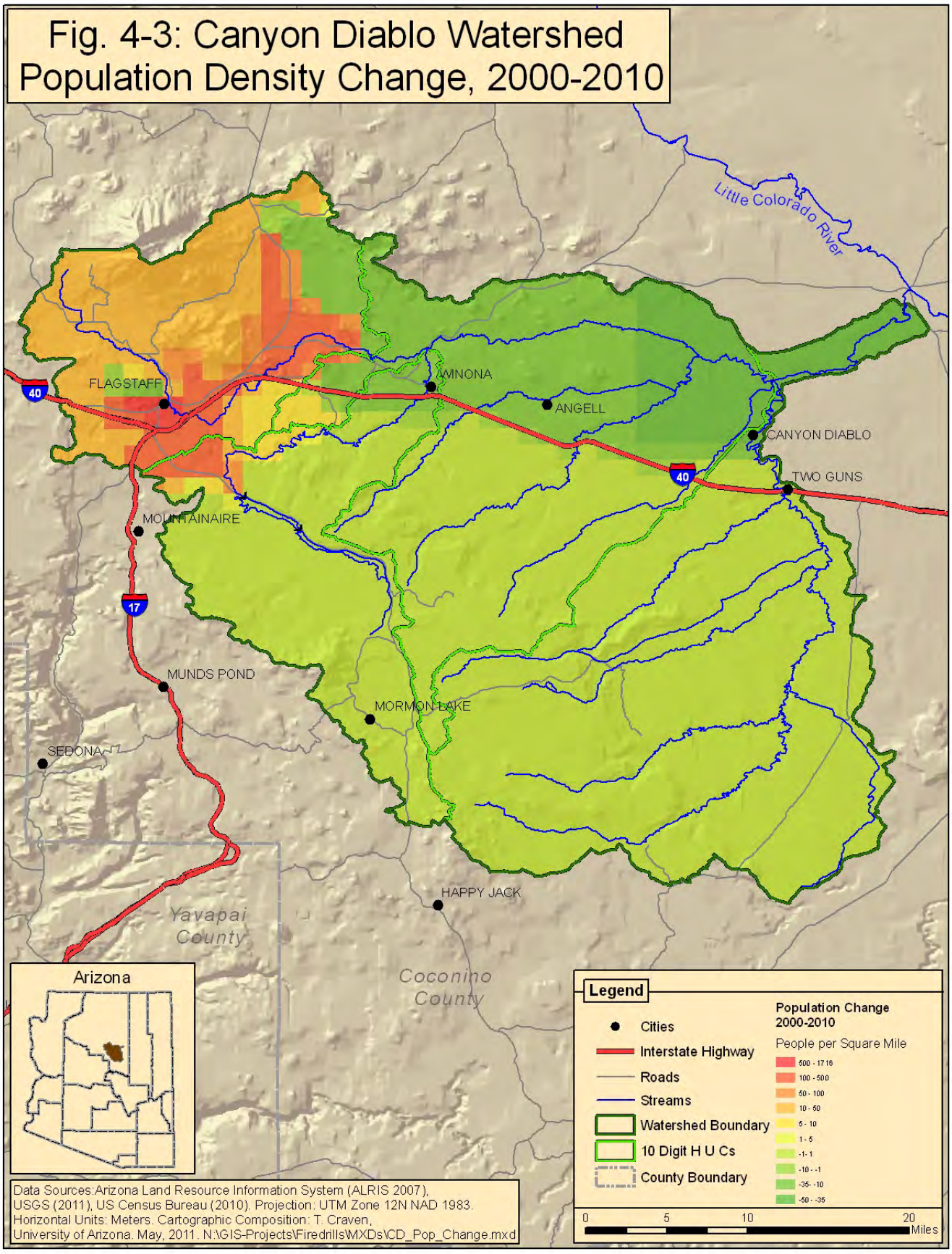
Fig. 4-3: Canyon Diablo Watershed
Population Density Change, 2000-2010
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
HAPPY JACK
Yavapai County
Coconino County
40
17
Arizona
Legend
Cities
Interstate Highway
Roads
Streams
Watershed Boundary
10 Digit H U Cs
County Boundary
Population Change 2000-2010
People per Square Mile
500 - 1716
100 - 500
50 - 100
10 - 50
5 - 10
1 - 5
-1 - 1
-10 - -1
-35 - -10
-50 - -35
0
5
10
20
Miles
Data Sources:Arizona Land Resource Information System (ALRIS 2007), USGS (2011), US Census Bureau (2010). Projection: UTM Zone 12N NAD 1983. Horizontal Units: Meters. Cartographic Composition: T. Craven, University of Arizona. May, 2011. N:\GIS-Projects\Firedrills\MXDs\CD_Pop_Change.mxd

Exurban regions are the “urban fringe”, or areas outside suburban areas, having population densities greater than 0.68 – 16.18 ha (1.68 – 40 acres) per housing unit. Theobald stresses that exurban areas are increasing at a much faster rate than urban sprawl, are consuming much more land, and are having a greater impact on ecological health, habitat fragmentation and other resource concerns.

Theobald estimates that the exurban density class has increased at a much faster rate than the urban/suburban density classes. Theobald’s model forecasts that this trend will continue and may even accelerate by 2030. This indicates that development patterns are shifting more towards exurban, lower density, housing units, and are thereby consuming more land. He suggests that exurban development has more overall effect on natural resources because of the larger footprint and disturbance zone, a higher percent of impervious surfaces, and higher pollution because of more vehicle miles traveled to work and shopping.

Table 4-4 and Figure 4-4, Canyon Diablo Watershed Housing Density for 2000, identifies that about 6% of housing is located in “rural” areas, while about 22% is located in “undeveloped private” areas. Table 4-5 and Figure 4-5, Canyon Diablo Watershed Housing Density for 2030, projects “rural” areas remaining the same at 6% and “undeveloped private” areas being reduced to 19%.

Table 4-1: Canyon Diablo Watershed 2000 Population Density (people/square mile)

10-digit Watershed Name	Area (sq. miles)	Population Density (people/sq.mi.)		
		Min	Max	Mean
Rio de Flag-1502001501	201	45.4	3484.0	244.4
Walnut Creek-1502001502	194	4.7	249.9	26.3
San Francisco Wash-1502001503	356	4.7	510.2	40.9
Canyon Diablo (Local Drainage)-1502001504	447	4.6	87.7	11.3
Canyon Diablo Watershed	1199	4.6	3484.0	62.4

Note: Adjacent watersheds may share a grid square. Data Sources: Census block statistics for 2000 were compiled from a CD prepared by Geo-Lytics (GeoLytics, Inc.1998. Census 2000. Census CD + Maps. Release 3.0).

Table 4-2: Canyon Diablo Watershed 2010 Population Density (people/square mile)

10-digit Watershed Name	Area (sq. miles)	Population Density (people/sq.mi.)		
		Min	Max	Mean
Rio de Flag-1502001501	201	35.7	4112.7	316.0
Walnut Creek-1502001502	194	4.1	483.3	37.2
San Francisco Wash-1502001503	356	4.1	574.9	29.6
Canyon Diablo (Local Drainage)-1502001504	447	3.9	3866.2	7.3
Canyon Diablo Watershed	1199	3.9	4112.7	71.5

Note: Adjacent watersheds may share a grid square. Data Sources: Census block statistics for 2010 were compiled from a CD prepared by Geo-Lytics (GeoLytics, Inc.1998. Census 2010. Census CD + Maps. Release 3.0).

Table 4-3: Canyon Diablo Watershed Population Density Change 2010 – 2000 (people/square mile)

10-digit Watershed Name	Area (sq. miles)	Population Density (people/sq.mi.)		
		Min	Max	Mean
Rio de Flag-1502001501	201	-27.9	1716.7	71.7
Walnut Creek-1502001502	194	-15.3	274.4	10.9
San Francisco Wash-1502001503	356	-49.1	176.7	-11.2
Canyon Diablo (Local Drainage)-1502001504	447	-43.6	-0.6	-4.0
Canyon Diablo Watershed	1199	-49.1	1716.7	9.1

Data Sources: Census 2000 and Census 2010.
Note: Adjacent watersheds may share a grid square. Data Sources: Derived from data from the GIS data used for tables 4-1 and 4-2.

Table 4-4: Canyon Diablo Watershed Housing Density 2000 (Percent of Watershed)

10-digit Watershed Name	Housing Density				
	Undeveloped Private	Rural	Exurban	Suburban	Urban
Rio de Flag-1502001501	3%	5%	17%	2%	3%
Walnut Creek-1502001502	1%	<1%	4%	<1%	<1%
San Francisco Wash-1502001503	22%	15%	1%	-	-
Canyon Diablo (Local Drainage)-1502001504	39%	2%	<1%	-	-
Canyon Diablo Watershed	22%	6%	4%	<1%	<1%
Canyon Diablo Watershed (sq mi)	262	70	46	5	5

Table 4-5: Canyon Diablo Watershed Housing Density 2030 (Percent of Watershed)

10-digit Watershed Name	Housing Density				
	Undeveloped Private	Rural	Exurban	Suburban	Urban
Rio de Flag-1502001501	1%	<1%	15%	9%	4%
Walnut Creek-1502001502	1%	<1%	4%	<1%	<1%
San Francisco Wash-1502001503	14%	18%	6%	<1%	-
Canyon Diablo (Local Drainage)-1502001504	39%	2%	<1%	-	-
Canyon Diablo Watershed	19%	6%	5%	2%	1%
Canyon Diablo Watershed (sq mi)	224	76	59	21	9

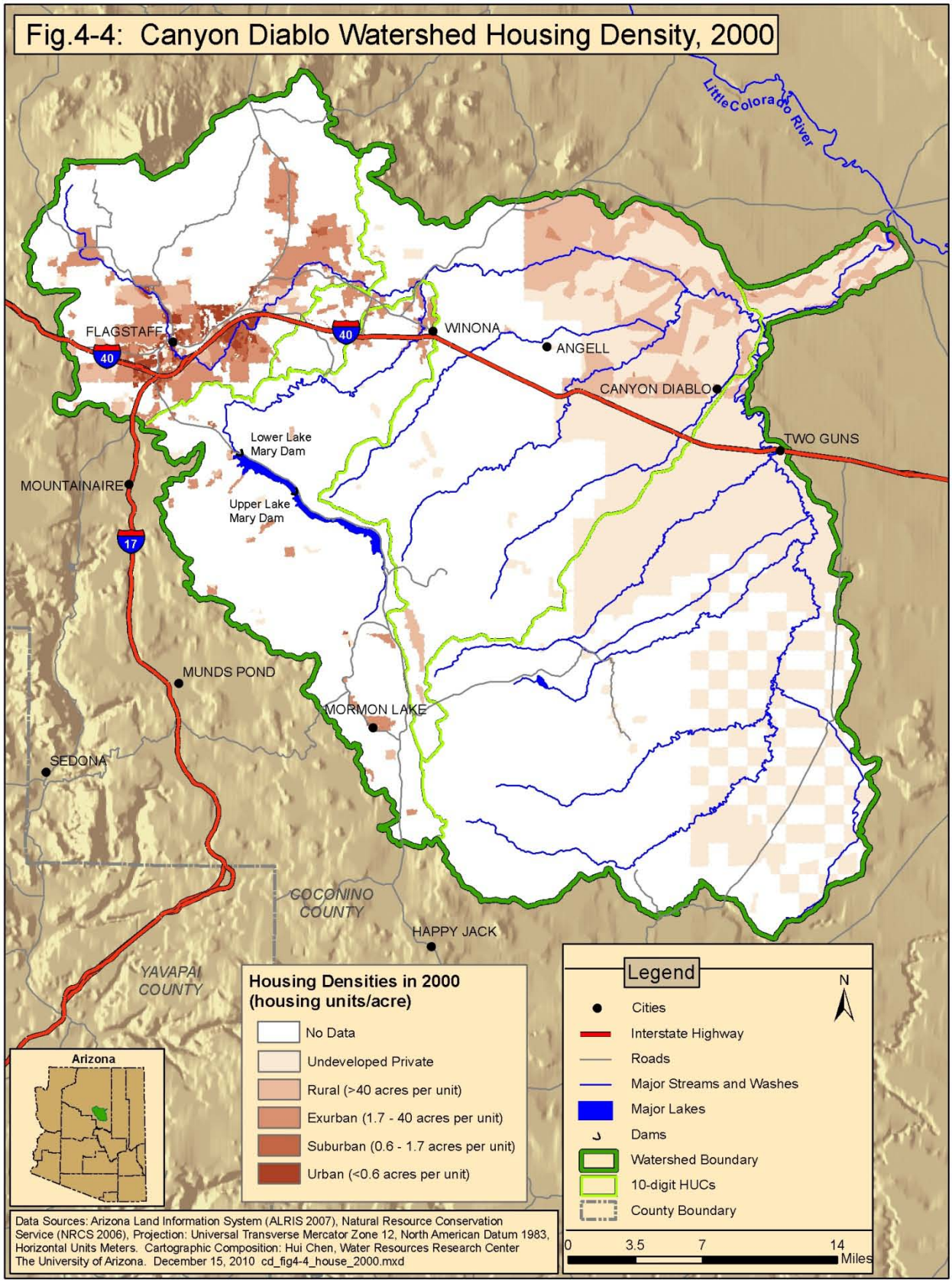
Fig.4-4: Canyon Diablo Watershed Housing Density, 2000
Little Colorado River
FLAGSTAFF
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
Lower Lake Mary Dam
Upper Lake Mary Dam
MOUNTAINAIRE
MUNDS POND
MORMON LAKE
SEDONA
COCONINO COUNTY
HAPPY JACK
YAVAPAI COUNTY
40
17
Arizona
Housing Densities in 2000 (housing units/acre)
No Data
Undeveloped Private
Rural (>40 acres per unit)
Exurban (1.7 - 40 acres per unit)
Suburban (0.6 - 1.7 acres per unit)
Urban (<0.6 acres per unit)
Legend
N
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
0 3.5 7 14 Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. December 15, 2010 cd_fig4-4_house_2000.mxd

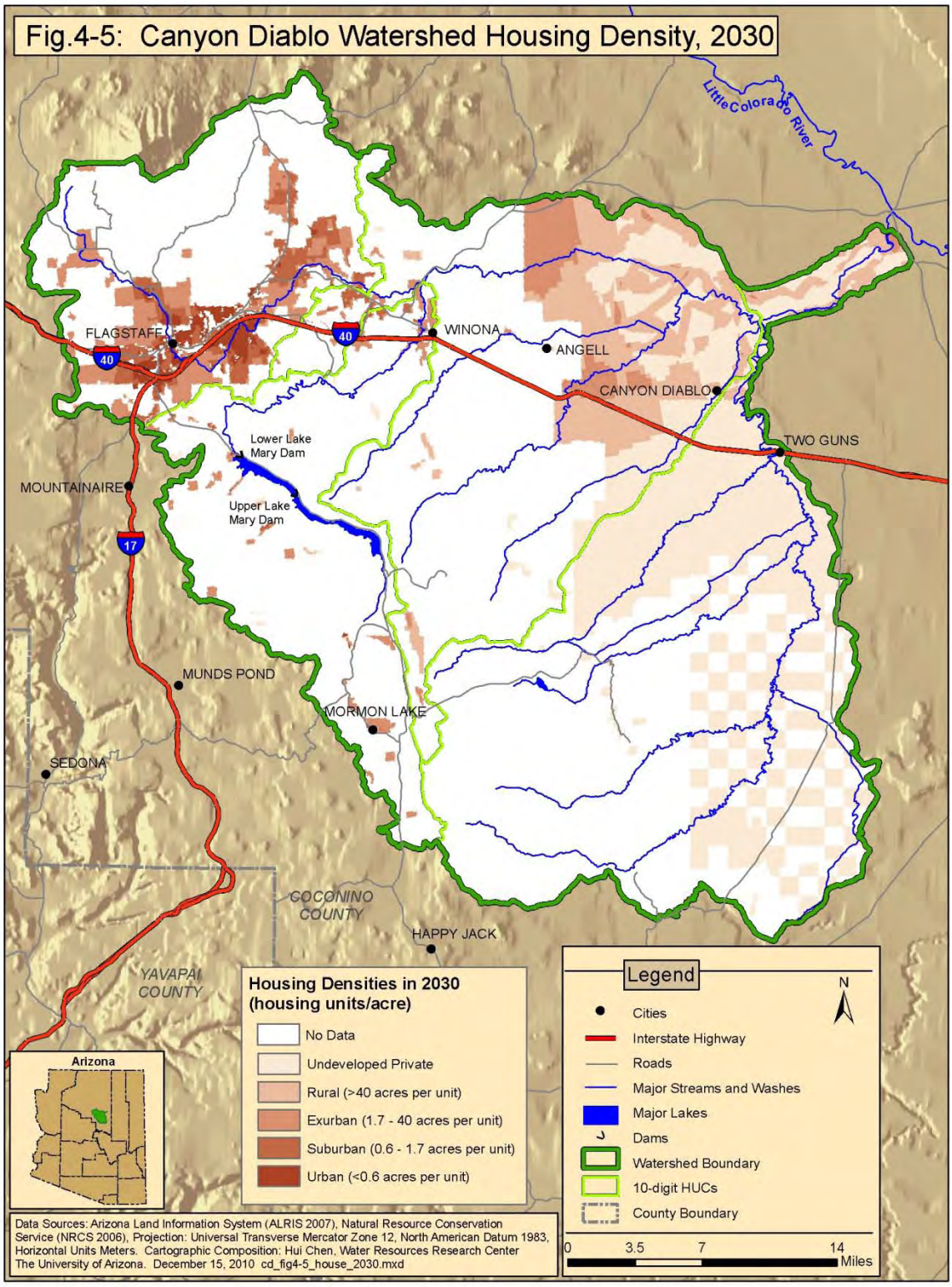
Fig.4-5: Canyon Diablo Watershed Housing Density, 2030
Little Colorado River
FLAGSTAFF
40
WINONA
ANGELL
CANYON DIABLO
TWO GUNS
Lower Lake Mary Dam
Upper Lake Mary Dam
MOUNTAINAIRE
17
MUNDS POND
MORMON LAKE
SEDONA
COCONINO COUNTY
HAPPY JACK
YAVAPAI COUNTY
Arizona
Housing Densities in 2030 (housing units/acre)
No Data
Undeveloped Private
Rural (>40 acres per unit)
Exurban (1.7 - 40 acres per unit)
Suburban (0.6 - 1.7 acres per unit)
Urban (<0.6 acres per unit)
Legend
Cities
Interstate Highway
Roads
Major Streams and Washes
Major Lakes
Dams
Watershed Boundary
10-digit HUCs
County Boundary
N
0 3.5 7 14
Miles
Data Sources: Arizona Land Information System (ALRIS 2007), Natural Resource Conservation Service (NRCS 2006), Projection: Universal Transverse Mercator Zone 12, North American Datum 1983, Horizontal Units Meters. Cartographic Composition: Hui Chen, Water Resources Research Center The University of Arizona. December 15, 2010 cd_fig4-5_house_2030.mxd

Section 5: Resource Assessment Tables

The following Resource Assessment Tables summarize current and desired future natural resource conditions for the Canyon Diablo Watershed. The tables present information on benchmark and future (5-year planning period) conservation systems and practices, qualitative effects on primary resource concerns, and estimated costs for conservation implementation. Conservation District board members, NRCS conservationists, and other people familiar with conservation work in the watershed were consulted for estimating current and future natural resource conditions.

The tables show three levels of conservation treatment (Baseline, Progressive, Resource Management System) for the major land use within the watershed (range). **Baseline** is defined as a low level of conservation adoption with landowners who are typically not participating in conservation programs. There may be, however, a few practices that have been commonly adopted by all landowners in this watershed. **Progressive** is defined as an intermediate level of conservation adoption with landowners who are actively participating in conservation programs and have adopted several practices but not satisfied all of the Quality Criteria in the NRCS Field Office Technical Guide.

Resource Management System (RMS) is defined as a complete system of conservation practices that addresses all of the Soil, Water, Air, Plant, and Animal (SWAPA) resource concerns typically seen for this land use in this watershed

The results of the assessment are presented in two parts. Part 1 (Assessment Information) summarizes the conservation practices at each treatment level and the quantities of practices for current benchmark conditions and projected future conditions. Part 1 also displays the four primary resource concerns, along with individual practice effects and an overall Systems Rating (ranging from a low of 1 to a high of 5) indicating the effectiveness of the conservation system used at each treatment level. Part 2 (Conservation Cost Table) summarizes the installation, management, and related costs by conservation practice and treatment level for the projected future conditions by federal and private share of the costs. Part 2 also displays the benchmark and future conservation conditions status bars.

Credit goes to NRCS in Oregon for development of the template for these Resource Assessment Tables.

WATERSHED NAME & CODE	CANYON DIABLO - 15020015				LANDUSE ACRES			298,000
LANDUSE TYPE	RANGE				TYPICAL UNIT SIZE ACRES			50,000
ASSESSMENT INFORMATION					CALCULATED PARTICIPATION			20%
	Benchmark Conditions	Future Conditions			RESOURCE CONCERNS			
Conservation Systems by Treatment Level	Total Units	Existing Unchanged Units	New Treatment Units	Total Units	Soil Erosion – Sheet and Rill	Water Quantity – Excessive Runoff, Flooding, or Ponding	Plant Condition – Productivity, Health and Vigor	Domestic Animals – Inadequate Quantities and Quality of Feed and Forage
Baseline				**System Rating ->**	**0**	**0**	**0**	**0**
No Conservation Practices being applied at this level	0	0	0	0	0	0	0	0
Total Acreage at Baseline	**149,000**	**119,200**	**0**	**119,200**				
Progressive				**System Rating ->**	**0**	**0**	**0**	**0**
Fence (ft.) 382	7,867	6,294	1,573	7,867	1	1	1	1
Pipeline (ft.) 516	7,867	6,294	1,573	7,867	1	1	1	1
Total Acreage at Progressive Level	**74,500**	**59,600**	**14,900**	**74,500**				
RMS				**System Rating ->**	**4**	**3**	**5**	**4**
Brush Management (ac.) 314	3,725	3,725	1,490	5,215	4	2	5	3
Fence (ft.) 382	39,336	40,909	14,161	55,070	1	1	1	1
Pipeline (ft.) 516	39,336	40,909	14,161	55,070	1	1	1	1
Prescribed Grazing (ac.) 528	74,500	74,500	29,800	104,300	5	3	5	5
Upland Wildlife Habitat Management (ac.) 645	3,725	3,725	1,490	5,215	3	3	4	1
Total Acreage at RMS Level	**74,500**	**74,500**	**29,800**	**104,300**				

WATERSHED NAME & CODE	CANYON DIABLO - 15020015				LANDUSE ACRES			298,000
LANDUSE TYPE	RANGE				TYPICAL UNIT SIZE ACRES			50,000
CONSERVATION COST TABLE					CALCULATED PARTICIPATION			20%
	FUTURE	FEDERAL				PRIVATE		
Conservation Systems by Treatment Level	New Treatment Units	Installation Cost 50%	Management Cost - 3 yrs 100%	Technical Assistance 20%	Total Present Value Cost	Installation Cost 50%	Annual O & M + Mgt Costs 100%	Total Present Value Cost
Progressive								
Fence (ft.) 382	1,573	$2,360	$0	$472	$2,832	$2,360	$94	$2,769
Pipeline (ft.) 516	1,573	$6,294	$0	$1,259	$7,553	$6,294	$252	$7,384
Subtotal	**14,900**	**$8,654**	**$0**	**$1,731**	**$10,385**	**$8,654**	**$346**	**$10,153**
RMS								
Brush Management (ac.) 314	1,490	$89,400	$0	$17,880	$107,280	$89,400	$1,788	$97,141
Fence (ft.) 382	14,161	$21,241	$0	$4,248	$25,490	$21,241	$850	$24,920
Pipeline (ft.) 516	14,161	$56,644	$0	$11,329	$67,973	$56,644	$2,266	$66,453
Prescribed Grazing (ac.) 528	29,800	$22,350	$0	$4,470	$26,820	$22,350	$0	$22,350
Upland Wildlife Habitat Management (ac.) 645	1,490	$0	$5,811	$1,162	$6,437	$0	$1,937	$3,111
Subtotal	**29,800**	**$189,635**	**$5,811**	**$39,089**	**$233,999**	**$189,635**	**$6,840**	**$213,976**
Grand Total	**44,700**	**$198,289**	**$5,811**	**$40,820**	**$244,384**	**$198,289**	**$7,187**	**$224,128**

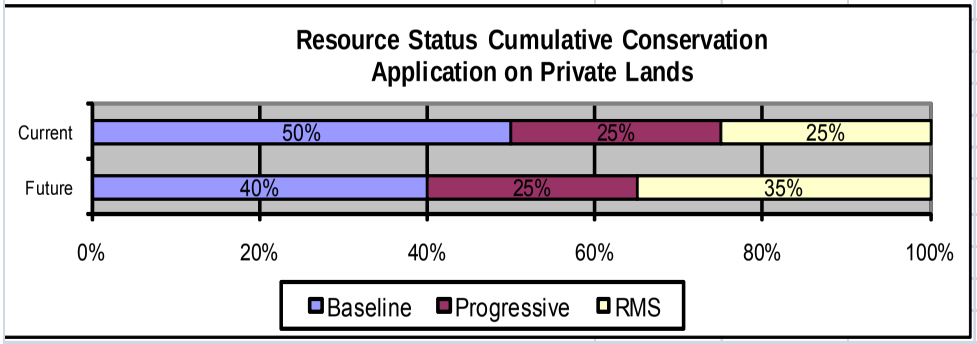

Chart Refers To	
Landuse Type	RANGE
Calculated Participation Rate	20%

Average PV Costs per Ac		
System	Federal	Private
Prog	$0.70	$0.68
RMS	$7.85	$7.18

WATERSHED NAME & CODE	CANYON DIABLO - 15020015				LANDUSE ACRES	434,000		
LANDUSE TYPE	FOREST				TYPICAL UNIT SIZE ACRES	50,000		
ASSESSMENT INFORMATION					CALCULATED PARTICIPATION	20%		
	Benchmark Conditions	Future Conditions			RESOURCE CONCERNS			
Conservation Systems by Treatment Level	Total Units	Existing Unchanged Units	New Treatment Units	Total Units	Soil Erosion – Sheet and Rill	Plant Condition – Productivity, Health and Vigor	Fish and Wildlife – Inadequate Food	Domestic Animals – Inadequate Quantities and Quality of Feed and Forage
Baseline				**System Rating ->**	**0**	**0**	**0**	**0**
No Conservation Practices being applied at this level	0	0	0	0	0	0	0	0
Total Acreage at Baseline	**217,000**	**173,600**	**0**	**173,600**				
Progressive				**System Rating ->**	**0**	**0**	**0**	**0**
Fence (ft.) 382	11,458	9,166	2,292	11,458	1	1	1	1
Pipeline (ft.) 516	11,458	9,166	2,292	11,458	1	1	1	1
Total Acreage at Progressive Level	**108,500**	**86,800**	**21,700**	**108,500**				
RMS				**System Rating ->**	**4**	**4**	**3**	**3**
Fence (ft.) 382	57,288	59,580	20,624	80,203	1	1	1	1
Pipeline (ft.) 516	57,288	59,580	20,624	80,203	1	1	1	1
Prescribed Grazing (ac.) 528	108,500	108,500	43,400	151,900	5	5	1	5
Upland Wildlife Habitat Management (ac.) 645	5,425	5,425	2,170	7,595	5	5	5	1
Total Acreage at RMS Level	**108,500**	**108,500**	**43,400**	**151,900**				

WATERSHED NAME & CODE	CANYON DIABLO - 15020015			LANDUSE ACRES	434,000		
LANDUSE TYPE	FOREST			TYPICAL UNIT SIZE ACRES	50,000		
CONSERVATION COST TABLE				CALCULATED PARTICIPATION	20%		
	FUTURE	FEDERAL			PRIVATE		
Conservation Systems by Treatment Level	New Treatment Units	Installation Cost 50%	Management Cost - 3 yrs 100%	Technical Assistance 20%	Total Present Value Cost	Installation Cost 50%	Annual O & M + Mgt Costs 100%	Total Present Value Cost
Progressive								
Fence (ft.) 382	2,292	$3,437	$0	$687	$4,125	$3,437	$137	$4,033
Pipeline (ft.) 516	2,292	$9,166	$0	$1,833	$10,999	$9,166	$367	$10,753
Subtotal	**21,700**	**$12,603**	**$0**	**$2,521**	**$15,124**	**$12,603**	**$504**	**$14,786**
RMS								
Fence (ft.) 382	20,624	$30,936	$0	$6,187	$37,123	$30,936	$1,237	$36,293
Pipeline (ft.) 516	20,624	$82,495	$0	$16,499	$98,994	$82,495	$3,300	$96,781
Prescribed Grazing (ac.) 528	43,400	$32,550	$0	$6,510	$39,060	$32,550	$0	$32,550
Upland Wildlife Habitat Management (ac.) 645	2,170	$0	$8,463	$1,693	$9,375	$0	$2,821	$4,531
Subtotal	**43,400**	**$145,980**	**$8,463**	**$30,889**	**$184,551**	**$145,980**	**$7,358**	**$170,155**
Grand Total	**65,100**	**$158,584**	**$8,463**	**$33,409**	**$199,675**	**$158,584**	**$7,862**	**$184,941**

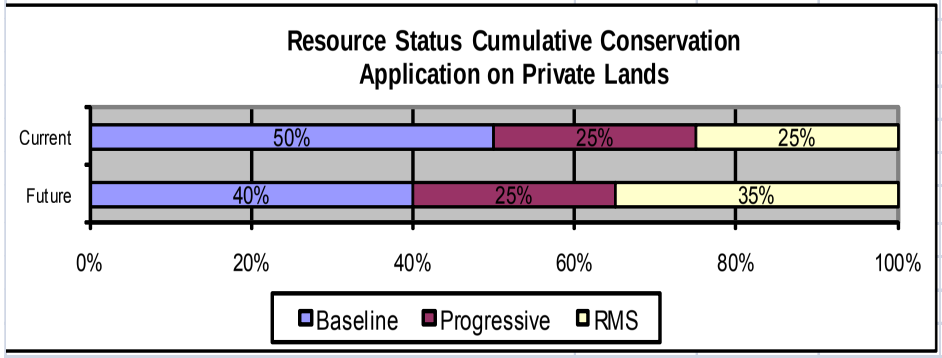

Chart Refers To	
Landuse Type	FOREST
Calculated Participation Rate	20%

Average PV Costs per Ac		
System	Federal	Private
Prog	$0.70	$0.68
RMS	$4.25	$3.92

Section 6: References

Arizona Association of Conservation Districts (http://www.aaocd.org/).

Arizona Department of Agriculture, Arizona Native Plant Law, (http://www.azda.gov/).

Arizona Department of Agriculture, 2010, Electronic correspondence with Karol Brill, Program Coordinator, Livestock and Crop Conservation Grant.

Arizona Dept. of Environmental Quality Water Quality Monitoring & Assessment (http://azdeq.gov/environ/water/assessment/assess.html).

Arizona Department of Environmental Quality (ADEQ). 2008 Status of Ambient Surface Water Quality in Arizona – Arizona's Integrated 305(b) Assessment and 303(d) Listing Report. Arizona Department of Environmental Quality, Phoenix, Arizona.

Arizona Department of Environmental Quality, Air Quality Division, (http://www.azdeq.gov/environ/air/plan/notmeet.html#phoenix).

Arizona Department of Water Resources, Arizona Drought Preparedness Plan, Background & Impact Assessment Section, Governor's Drought Task Force, Governor Janet Napolitano, October 8, 2004. (http://www.azwater.gov/dwr/content/find_by_program/GDTF/conclusion/Background_Section_100804FINAL.pdf).

Arizona Department of Water Resources (ADWR), 2009. Arizona Water Atlas, Vol. 2, web published at (http://www.azwater.gov/dwr/).

Arizona Game & Fish Dept. Heritage Database (http://www.azgfd.gov/w_c/edits/species_concern.shtml).

Arizona Game & Fish website, 2006, (http://www.azgfd.gov/w_c/heritage_program.shtml).

Arizona State Land Department, Arizona Land Resource Information System (ALRIS), GIS data layers "Geology," "Lakes," "mines", "natveg", "ownership", "Streams", February 7, 2003. (http://www.land.state.az.us/alris/index.html).

Brown, David E., and Charles H. Lowe, Biotic Communities of the Southwest 1:1,000,000 scale, August 1980.

Bureau of Land Management Arizona Website (http://www.blm.gov/az/st/en.html).

Climate Assessment for the Southwest (CLIMAS) website (www.ispe.arizona.edu/climas), information on Arizona's drought status.

Environmental Protection Agency (EPA) website (http://epa.gov/air/airtrends/aqtrnd95/pm10.html).

ESRI Data Products, (http://arcdata.esri.com/data/tiger2000/tiger_download.cfm) Census 2000. October 17, 2003.

Feth, J.H., and N.D. White, J.D. Hem, 1954. Preliminary Report of Investigations of Springs in the Mogollon Rim Region, Arizona. U.S. Geological Survey Open-File Report, Tucson, Arizona.

GeoLytics, Inc. 1998. Census 1990. Census CD + Maps. Release 3.0.

Gordon, N.D., T.A. McMahon, and B.L. Finlayson. 1992. Stream Hydrology; Chapter 4- Getting to know your stream. John Wiley & Sons, New York, New York.

Grand Canyon Explorer (http://www.bobspixels.com/kaibab.org/geology/gc_layer.htm#kl).

Lowry, J. H, Jr., R. D. Ramsey, K. Boykin, D. Bradford, P. Comer, S. Falzarano, W. Kepner, J. Kirby, L. Langs, J. Prior-Magee, G. Manis, L. O'Brien, T. Sajwaj, K. A. Thomas, W. Rieth, S. Schrader, D. Schrupp, K. Schulz, B. Thompson, C. Velasquez, C. Wallace, E. Waller and B. Wolk. 2005. /Southwest Regional Gap Analysis Project: Final Report on Land Cover Mapping Methods/, RS/GIS Laboratory, Utah State University, Logan, Utah.

National Agricultural Statistics Service (http://www.nass.usda.gov/).

National Parks Service (http://www.nps.gov/grca/naturescience/faults.htm).

Natural Resources Conservation Service (NRCS), 2010, Table generated by NRCS Phoenix Office.

Natural Resources Conservation Service (NRCS), 2010, Text generated by NRCS Phoenix Office.

Natural Resources Conservation Service Arizona GIS Webpage (http://www.az.nrcs.usda.gov/technical/gis/index.html).

Natural Resources Conservation Service Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/).

Natural Resources Conservation Service Water & Climate Center (http://www.wcc.nrcs.usda.gov/).

Parker, John T.C., and M. E. Flynn. 2000. Investigation of the Geology and Hydrology of the Mogollon Highlands of Central Arizona: A Project of the Arizona rural Watershed Initiative. In cooperation with the Arizona Department of Water Resources. USGS Fact Sheet 159-00.

Southern Arizona Data Services Program, GIS data layer "Arizona Gap Analysis Project Vegetation Map", University of Arizona, 2004, (http://sdrsnet.srnr.arizona.edu/index.php), originated by Arizona Game & Fish Department, Habitat Branch, 1993, this dataset was digitized from the August 1980 David E. Brown & Charles H. Lowe 1:1,000,000 scale, 'Biotic Communities of the Southwest'.

Southwest Regional GAP Project (http://fws-nmcfwru.nmsu.edu/swregap/).

Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. [online] URL: (http://www.ecology and society.org/vol10/iss1/art32/).

United States Department of Agriculture (USDA) website (http://www.usda.gov/).

United States Department of Agriculture, 2007 Census, http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp.

United States Environmental Protection Agency, Surf Your Watershed (http://www.epa.gov/surf/).

United States Environmental Protection Agency, Air Quality Trends, (http://epa.gov/air/aritrends/aqtrnd95/pm10.html).

United States Fish & Wildlife Service, Threatened and Endangered Species Listed for Arizona, (http://ecos.fws.gov).

United States Fish & Wildlife Service Arizona Ecological Services (http://www.fws.gov/southwest/es/arizona/).

United States Forest Service (USFS), Terrestrial Ecosystem Surveys. Surveys are available for National Forest Lands within the watershed.United States Geological Survey, April 8, 2003, derived from DEM, (http://edc.usgs.gov/geodata/).

United States Geological Survey, NLCD Land Cover Class Definitions, (http://landcover.usgs.gov/classes.php).

United States Geological Survey, Arizona Water Science Center (http://az.water.usgs.gov/).

United States Geological Survey website, National Water Information System (http://waterdata.usgs.gov/nwis/).

Ward, Joseph S. and Associates, 1973, Report of environmental protection study, hazards and land-use planning: Field notes [Arizona Bureau of. Mines], v. **...** www.azgs.state.az.us/Earth%20Fissures/OFR_95_8.pdf.

Western Regional Climate Center (WRCC), Temperature data. July15, 2004. (http://www.wrcc.dri.edu/summary/climsmaz.html).

GLOSSARY

Drainage Basin	A region or area bounded by a topographic divide and occupied by a drainage system, also known as a watershed.
Drought	There is no universally accepted quantitative definition of drought. Generally, the term is applied to periods of less than average precipitation over a certain period of time; nature's failure to fulfill the water wants and needs of man.
Flood	A flood is an overflow or inundation that comes from a river or other body of water and causes or threatens damage. It can be any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream. It is also a relatively high flow as measured by either gage height or discharge quantity.
Ground Water	The supply of fresh and saline water found beneath the Earth's surface which is often used for supplying wells and springs. Because ground water is a major source of drinking water, there is a growing concern over areas where leaching agricultural or industrial pollutants are contaminating ground water.
Soil Moisture Regimes	**Aridic** is a soil moisture regime that has no water available for plants for more than half the cumulative time that the soil temperature at 50 cm (20 in.) below the surface is >5°C (41° F.), and has no period as long as 90 consecutive days when there is water for plants while the soil temperature at 50 cm (20 in.) is continuously >8°C (46°F.). **Udic** is a soil moisture regime that is neither dry for as long as 90 cumulative days nor for as long as 60 consecutive days in the 90 days following the summer solstice at periods when the soil temperature at 50 cm (20 in.) below the surface is above 5°C (41° F.). **Ustic** is a soil moisture regime that is intermediate between the aridic and udic regimes and common in temperate subhumid or semiarid regions, or in tropical and subtropical regions with a monsoon climate. A limited amount of water is available for plants but occurs at times when the soil temperature is optimum for plant growth.
Soil Orders	A soil order is a group of soils in the broadest category. In the current USDA classification scheme there are 12 orders, differentiated by the presence or absence of diagnostic horizons.
Soil Temperature Regimes	**Hyperthermic** is a soil temperature regime that has mean annual soil temperatures of 22°C (72°F.) or more and >5°C (41° F.) difference between mean summer and mean winter soil temperatures at 50 cm (20 in.) below the surface. **Thermic** is a soil temperature regime that has mean annual soil temperatures of 15°C (59°F.) or more but <22°C (72°F.), and >5°C (41° F.) difference between mean summer and mean winter soil

	temperatures at 50 cm (20 in.) below the surface. **Mesic** A soil temperature regime that has mean annual soil temperatures of 8°C (46°F.) or more but <15°C (59°F.), and >5°C (41° F.) difference between mean summer and mean winter soil temperatures at 50 cm (20 in.) below the surface.
Surface Water	Water on the earth's surface. Lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, wetlands, marshes, inlets, canals, and all other bodies of surface water, natural or artificial, inland or coastal, fresh or salt, navigable or non-navigable, and including the beds and banks of all watercourses and bodies of surface water, that are wholly or partially inside or bordering the state or subject to the jurisdiction of the state; except that waters in treatment systems which are authorized by state or federal law, regulation, or permit, and which are created for the purpose of waste treatment.
Watershed	The area of land that contributes surface run-off to a given point in a drainage system and delineated by topographic divides.

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