Prepared in cooperation with the Bureau of Land Management

Irrigated Acreage Within the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah

Data Series 273

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of center-pivot sprinkler irrigation system and pump looking northeast from unnamed road near the junction of Atlanta and US Highway 93 in southern Lake Valley, Nevada. (Photograph taken by Ron Veley, U.S. Geological Survey, September, 26, 2005.)

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U.S. Department of the Interior
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Foreword

Water demands from the lower Colorado River system are increasing with the rapidly growing population of the southwestern United States. To decrease dependence on this over-allocated surface-water resource and to help provide for the projected increase in population and associated water supply in the Las Vegas area, water purveyors in southern Nevada have proposed to utilize the ground-water resources of rural basins in eastern and central Nevada. Municipal, land management, and regulatory agencies have expressed concerns about potential impacts from increased ground-water pumping on local and regional water quantity and quality, with particular concern on water-rights issues and on the future availability of water to support natural spring flow and native vegetation. Before concerns on potential impacts of pumping can be addressed, municipal and regulatory agencies have recognized the need for additional information and improved understanding of geologic features and hydrologic processes that control the rate and direction of ground-water flow in eastern and central Nevada.

In response to concerns about water availability and limited geohydrologic information, Federal legislation (Section 131 of the Lincoln County Conservation, Recreation, and Development Act of 2004; PL 108-424) was enacted in December 2004 that directs the Secretary of the Interior, through the U.S. Geological Survey (USGS), the Desert Research Institute (DRI), and a designee from the State of Utah, to complete a water-resources study of the basin-fill and carbonate-rock aquifers in White Pine County, Nevada, and smaller areas of adjacent counties in Nevada and Utah. The primary objectives of the Basin and Range carbonate-rock aquifer system (BARCAS) study are to evaluate: (1) the extent, thickness, and hydrologic properties of aquifers, (2) the volume and quality of water stored in aquifers, (3) subsurface geologic structures controlling ground-water flow, (4) ground-water flow direction and gradients, and (5) the distribution and rates of recharge and ground-water discharge. Geologic, hydrologic, and supplemental geochemical information will be integrated to determine basin and regional ground-water budgets.

Results of the study will be summarized in a USGS Scientific Investigations Report (SIR), to be prepared in cooperation with DRI and the State of Utah, and submitted to Congress by December 2007. The BARCAS study SIR is supported by USGS and DRI reports that document, in greater detail than the summary SIR, important components of this study. These reports are varied in scope and include documentation of basic data, such as spring location and irrigated acreage, and interpretive studies of ground-water flow, geochemistry, recharge, evapotranspiration, and geology.

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Conversion Factors

Multiply	By	To obtain
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.004047	square kilometer (km^2)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	259.0	hectare (ha)

Datums

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).

Altitude, as used in this report, refers to distance above the vertical datum.

Irrigated Acreage Within the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah

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Abstract

Accurate delineations of irrigated acreage are needed for the development of water-use estimates and in determining water-budget calculations for the Basin and Range carbonate-rock aquifer system (BARCAS) study. Irrigated acreage is estimated routinely for only a few basins in the study area. Satellite imagery from the Landsat Thematic Mapper and Enhanced Thematic Mapper platforms were used to delineate irrigated acreage on a field-by-field basis for the entire study area. Six hundred and forty-three fields were delineated. The water source, irrigation system, crop type, and field activity for 2005 were identified and verified through field reconnaissance. These data were integrated in a geodatabase and analyzed to develop estimates of irrigated acreage for the 2000, 2002, and 2005 growing seasons by hydrographic area and subbasin. Estimated average annual potential evapotranspiration and average annual precipitation also were estimated for each field.

The geodatabase was analyzed to determine the spatial distribution of field locations, the total amount of irrigated acreage by potential irrigation water source, by irrigation system, and by crop type. Irrigated acreage in 2005 totaled nearly 32,000 acres ranging from less than 200 acres in Butte, Cave, Jakes, Long, and Tippett Valleys to 9,300 acres in Snake Valley. Irrigated acreage increased about 20 percent between 2000 and 2005 and increased the most in Snake and White River Valleys. Ground-water supplies as much as 80 percent of irrigation water during dry years. Almost 90 percent of the irrigated acreage was planted with alfalfa.

Introduction

The Basin and Range carbonate-rock aquifer system (BARCAS) study area encompasses about 13,500 mi^2 and covers about 80 percent of White Pine County, and parts of Elko, Eureka, Nye, and Lincoln Counties in Nevada, as well as parts of Tooele, Millard, Beaver, Juab, and Iron Counties in Utah (fig. 1). White Pine County is within the carbonate-rock province, a relatively large area extending from western Utah to eastern California where ground-water flow is predominantly or strongly influenced by carbonate-rock aquifers. Much of the carbonate-rock aquifer is fractured and, where continuous, forms a regional ground-water flow system that receives recharge from high-altitude areas where fractured carbonate rocks are exposed. Most areas in White Pine County, Nevada, are within four regional ground-water flow systems (fig. 2)—the larger Colorado and Great Salt Lake Desert flow systems, and the smaller Goshute Valley and Newark Valley flow systems (Harrill and others, 1988). Water moving through the carbonate-rock aquifer provides some recharge to overlying basin-fill aquifers, sustains many of the large, perennial low-altitude springs, and hydraulically connects similar carbonate-rock aquifers in adjacent basins. The regional carbonate-rock aquifer typically is overlain by a basin-fill aquifer in the intermountain basins. The basin-fill aquifer is composed of gravel, sand, silt, and clay and often reaches thicknesses of several thousand feet (Harrill and Prudic, 1998). The gravel and sand deposits typically yield water readily to wells and this aquifer is the primary water supply in the area for agricultural, domestic, or municipal use.

The carbonate-rock aquifer extends beneath numerous surface-water drainage basins, or hydrographic areas[1]. Past studies have combined hydrographic areas to delineate basin-fill or regional ground-water flow systems, based primarily on the direction of interconnected ground-water flow in the underlying carbonate-rock aquifer and the location of terminal discharge areas (Harrill and Prudic, 1998). Although the boundary lines between hydrographic areas generally coincide with actual topographic basin divides, some boundaries are arbitrary or represent hydrologic divisions that have no topographic basis. Hydrographic areas were further divided into subbasins that are separated by areas where pre-Cenozoic rocks are at or near the land surface (Welch and Bright, 2007).

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[1] Formal hydrographic areas in Nevada were delineated systematically by the U.S. Geological Survey and Nevada Division of Water Resources in the late 1960s (Cardinalli and others, 1968; Rush, 1968) for scientific and administrative purposes. The official hydrographic-area names, numbers, and geographic boundaries continue to be used in U.S. Geological Survey scientific reports and Division of Water Resources administrative activities.

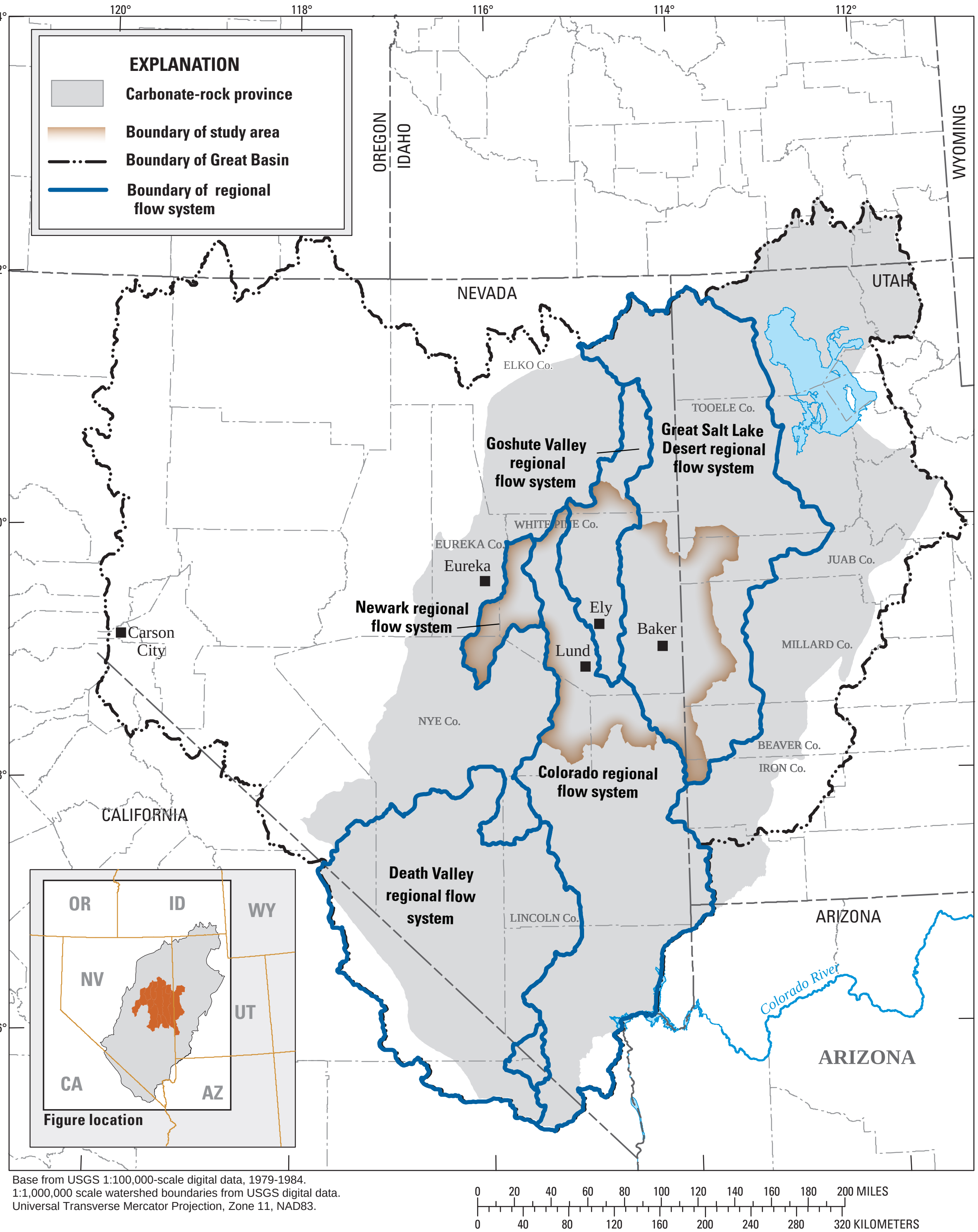


Figure 1. Carbonate-rock province, Basin and Range carbonate-rock aquifer system study area, and associated regional ground-water flow systems, Nevada and Utah.

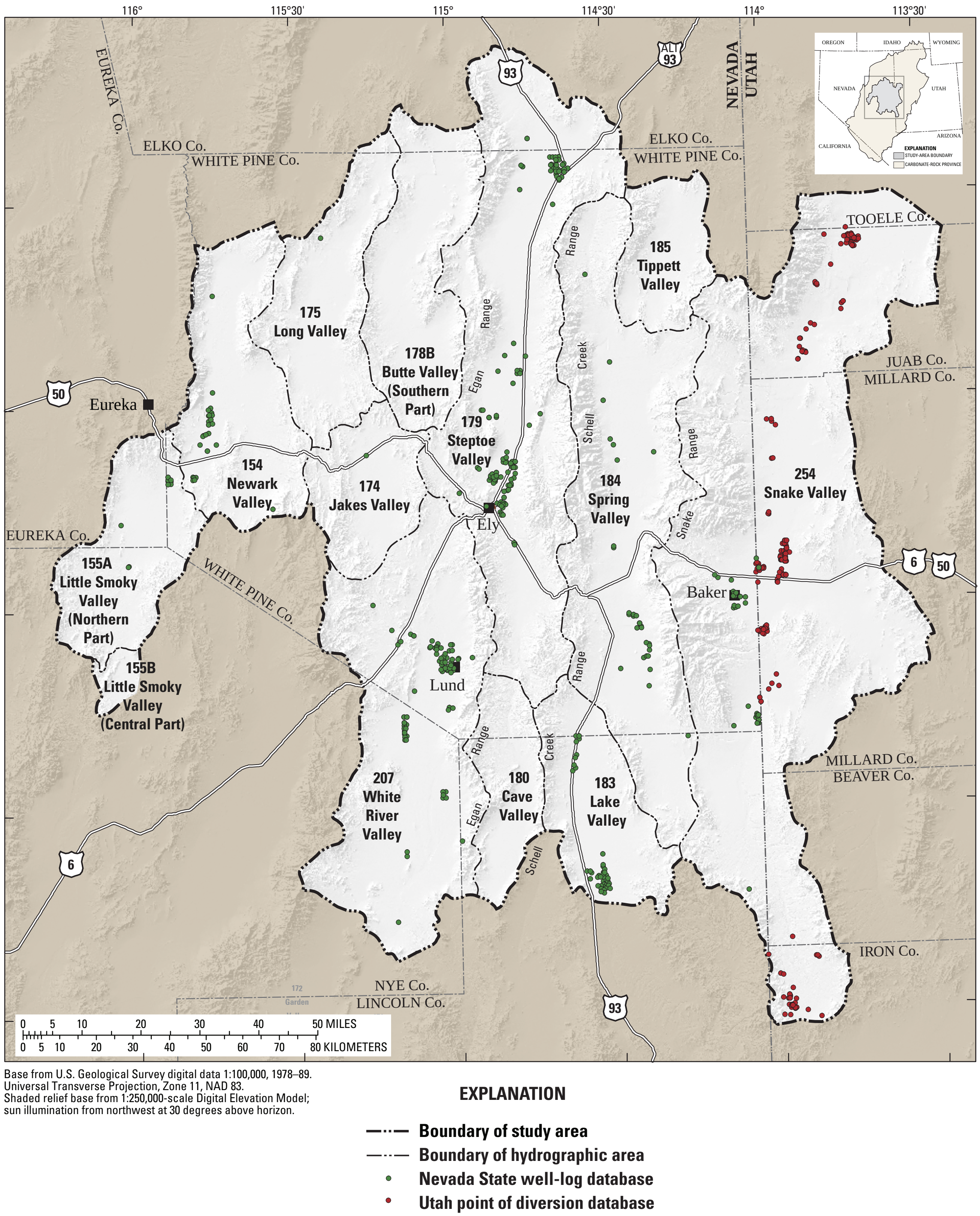


Figure 2. Irrigation wells from Nevada State well-log and Utah point of diversion databases for the Basin and Range carbonate-aquifer system, Nevada and Utah.

Hydrographic area names in this report generally refer to formal hydrographic areas of Harrill and others (1988) with two exceptions: (1) ‘Little Smoky Valley’ refers to hydrographic areas 155A and 155B, which are the northern and central parts of Harrill and others (1988) description of Little Smoky Valley, respectively, and (2) ‘Butte Valley’ refers only to hydrographic area 178B, which is the southern part of Harrill and others (1988) description of Butte Valley. For most figures and tables in this report, water-budget components were estimated for the northern and central parts of Little Smoky Valley, but were combined and reported as one value.

Water-use estimates are an important component of a water budget. Therefore, because almost 90 percent of water used in the Basin and Range carbonate-aquifer system (BARCAS) study area in White Pine County, Nevada, and adjacent areas in Nevada and Utah is for irrigation, accurate delineations of irrigated acreage are needed for development of these estimates for agricultural (fig. 1) use.

The Nevada Division of Water Resources (NDWR) has inventoried crops in only 3 of the 13 hydrographic areas in the study area (Nevada Division of Water Resources, written commun., 2005). In response to the limited data, a BARCAS-wide, comprehensive, irrigated-acreage geodatabase of spatial and tabular data was developed at a 1:100,000-scale to facilitate water-use estimates for 2000, 2002, and 2005. The geodatabase was developed using existing data sets, image interpretation from Landsat imagery, and field work to delineate irrigated acreage in the study area. Delineated irrigated acreage in 2005 was used to characterize irrigation methods, crop types, and water sources to improve the understanding of crop consumptive use and application rates, ground-water use, and the ground-water budget of the study area.

Purpose and Scope

The purpose of this report is to document and describe a comprehensive geodatabase of irrigated acreage developed for all hydrographic areas in the study area. Irrigated acreage was estimated for 2000, 2002, and 2005 for Little Smoky, Newark, Long, Butte, Steptoe, Cave, Spring, Tippett, White River, and Snake Valleys (fig. 2). The general framework and function of the geodatabase is reported. Methods and data sets used to create the geodatabase also are explained.

Agricultural Setting

Perennial streams are absent throughout much of the study area. The primary water source available to farmers for irrigation is ground water. Perennial surface-water and spring sources are used in some areas, but those sources may be supplemented by ground water pumped from wells when necessary.

Various water-application systems are used to distribute irrigation water in the study area. The three most commonly used irrigation systems are center-pivot sprinkler, wheel-line sprinkler, and furrow flood. Alfalfa production dominates the irrigated landscape and comprises the majority of irrigated acreage. During the average growing season, three cuttings of alfalfa are typical. The growing season typically begins in April and ends in September or October.

Geodatabase Framework

The Environmental Systems Research Institute, Inc. (ESRI), ArcGIS personal geodatabase is built on the Microsoft© Access database. Geodatabase design uses a thematic approach to create layers of feature data within a geographic information system (GIS). The various features are stored as relational tables in the geodatabase on the basis of how the features interact and correspond to one another. These features, tables, and relations represent real-world spatial, temporal, and descriptive attribute interactions (Zeiler, 1999). The geodatabase is the framework for the delineation of irrigated acreage in the study area. Irrigated acreages are stored as polygon features, and the attributes that describe each irrigated polygon’s characteristics, such as potential irrigation source, irrigation system, and crop type, are stored as tables (table 1).

Wells

The NDWR well-log database at http://water.nv.gov/engineering/wlog/wlog.cfm and the Utah Division of Water Rights (UDWR) water rights point of diversion database at http://www.waterrights.utah.gov/gisinfo/wrcover.asp were used as the primary sources for well locations. NDWR well locations are reported in Universal Transverse Mercator (UTM) Zone 11, North American Datum 1927 (NAD 27), and UDWR well locations are reported in UTM Zone 12, NAD 27. Wells in both databases were plotted using a GIS and queried on the basis of database fields that describe active status and proposed use as irrigation. Wells that satisfied the query were reprojected to UTM Zone 11, North American Datum 1983 (NAD 83) and included in the database as point features, shown in figure 2.

Nevada Division of Water Resources Crop Inventories

The NDWR inventories irrigated acreage for Newark and Steptoe Valleys on an annual basis. The irrigated acreage is estimated from field observations between August and December (Nevada Division of Water Resources, written commun., 2005). The Newark Valley inventory includes irrigated acreage in the northern part of Little Smoky Valley. NDWR crop inventories identify and define irrigated acreage by township, range, section, quarter section, and quarter-

Table 1. Feature classes and tables in the delineated irrigated acreage geodatabase for the Basin and Range carbonate-rock aquifer system study area, Nevada and Utah.

Dataset	Data Type	Name	Definition
Irrigation_WaterUse	Polygon feature class	Ag_Irrigation	Spatial locations of delineated irrigated acreage coded as irrigated or non-irrigated for 200, 2002, and 2005.
	Polygon feature class	CropInventory	Spatial locations of Nevada Department of Water Resources (NDWR) Crop Inventories for Newark, Little Smoky, and Steptoe Valleys for 2000, 2002, and 2005. Crop inventories identify and define irrigated acreage by township, range, section, quarter, and quarter-quarter.
	Point feature class	Irr_FieldCheck	Spatial locations of Global Postioning System (GPS) waypoints and irrigated acreage attributes collected during field verification, September and November 2005.
StateWell_Database	Point feature class	NV_StateWellLog	Spatial locations of irrigation wells from the Nevada Department of Water Resources well log database. Source data were acquired October 26, 2005.
	Point feature class	Utah_POD	Spatial locations of irrigation wells from the Utah Point of Diversion shapefile generated from the Utah Division of Water Rights Database. Source data were acquired on October 26, 2005.
	Polygon feature class	HA_StudyArea	Spatial locations of Basin and Range carbonate-rock aquifer system study area, hydrographic areas, and subbasins.
	Table	tbl_Irr_2005	Non-spatial 2005 irrigated acreage attributes describing potential irrigation source, irrigation system, and crop type.
	Table	tbl_Zonal_Mean	Non-spatial zonal attributes of annual potential evapotranspiration, growing season April to September potential evapotranspiration, growing season April to October potential evapotranspiration, annual precipitaion, growing season April to September precipitation, and growing season April to October precipitation,
	Table	tbl_CropInventory	Non-spatial tabular information from Nevada Department of Water Resources (NDWR) Crop Inventories for Newark, Little Smoky, and Steptoe Valleys for 2000, 2002, and 2005.

quarter section. In addition to estimated irrigated acreage, the crop inventories include information on crop grown, pump and motor type, and meter number and a general description. Only NDWR crop inventories for 2000, 2002, and 2005 are stored in the geodatabase. Paper copies of the crop inventories were tabulated and identified by township, range, section, quarter section, and quarter-quarter section and related to the Bureau of Land Management's (BLM) 1:24,000-scale Land Survey Information System (LSIS) downloaded from the BLM Geocommunicator website at http://www.geocommunicator.gov/LSIS4/map.jsp. Where necessary, range polygons in the LSIS were divided to create quarters consistent with crop inventory records. LSIS polygons and tabulated annual crop inventory data for 2000, 2002, and 2005 were imported into the geodatabase.

Provisional Southwest Regional Gap Analysis Project

Provisional Southwest Regional Gap Analysis Project (SWReGAP) data sets were made available to the USGS in October 2005 (Kepner and others, 2005) and were used to aid in the delineation of irrigated acreage. SWReGAP used image classification from 1999 to 2001 Landsat 7 Enhanced Thematic Mapper (ETM+) imagery to map land cover at a 12-acre resolution (Jacobs and others, 2001). The SWReGAP data sets identify 125 land-cover classes as ecological systems. An ecological system represents recurring groups of biological communities found in similar physical environments (Comer and others, 2003).

Delineation of agricultural lands in the SWReGAP data sets is considered to be the preferable approach where multiple images throughout a season are used in the classification process. SWReGAP defined agricultural land as both pasture/hay and cultivated crops. Although the SWReGAP data sets identify regions of agricultural land, the extents of individual irrigated acreage tended to be larger than those obtained during field verification.

Landsat Imagery

Landsat imagery guided the delineation of irrigated acreage throughout the study area. The Landsat orbit trajectory locates the satellite over the same geographic location every 16 days. Landsat 5 Thematic Mapper (TM) and ETM+ sensors collect electromagnetic information across seven wavelength bandwidths referred to as bands. Of these bands, six (bands 1, 2, 3, 4, 5, and 7) collect distinctively different spectral patterns in the visible and near infrared regions of the electromagnetic spectrum at a resolution of about 100 ft. The seventh band, band 6, measures the thermal energy radiated from the Earth. Digital TM and ETM+ data can be processed to distinguish irrigated acreage from the surrounding land covers in arid regions (Kolm, 1985). Large-area irrigation delineations have been successfully completed using Landsat satellite data for Mesquite Valley, Penoyer Valley, Pahranagat Valley, and Amargosa Desert, Nevada and California (Moreo and others, 2003); Diamond Valley, Nevada (Arteaga and others, 1995); and other western States with similar land uses (Heimes and Luckey, 1983, Thelin and Heimes, 1987, and Qi and others, 2002).

Landsat satellite data are distributed as scenes defined by row and path numbers that image more than 13,000 mi^2. Six multipath scenes were assembled to encompass the study area. Scenes were selected on the basis of the time the image was taken in relation to peak crop potential and a minimum of cloud cover interference (table 2). Each scene was georeferenced by defining the images' geographic locations in a coordinate system. The 2000 imagery was georeferenced by the USGS in 2000 and 2001 using 1:24,000 USGS topographic maps and digital orthophoto quarter quadrangles (DOQQ) and 30 to 40 ground-control points per scene. The root mean square (RMS) error for scenes ranged from 66 to 82 ft. The 2002 imagery acquired for the BARCAS study was purchased in a georeferenced format from the Earth Resources Observation Systems (EROS) Data Center (EDC). The EDC

Table 2. Descriptions of Landsat imagery used to delineate irrigated acreage in the Basin and Range carbonate-rock aquifer system study area, Nevada and Utah.

Satellite	Path	Row	Date	Scene identification No.	Cloud cover (percent)
Landsat 5	39	32	07-12-05	lt5039032000519310	20
	39	33	07-12-05	lt5039033000519310	0
	39	34	07-12-05	lt5039034000519310	0
	40	32	07-03-05	lt5040032000518400	0
	40	33	07-03-05	lt5040033000518400	0
	40	34	07-03-05	lt5040034000518400	0
	39	32	08-21-02	lt5039032000223310	10
	39	33	08-21-02	lt5039033000223310	0
	39	34	08-21-02	lt5039034000223310	0
	40	32	08-12-02	lt5040032000222410	0
	40	33	08-12-02	lt5040033000222410	0
	40	34	08-12-02	lt5040034000222410	0
Landsat 7	39	32	05-03-00	lt7039032000012450	0
	39	33	05-03-00	lt7039033000012450	0
	39	34	06-04-00	lt7039033000015650	0
	40	32	04-24-00	lt7040032000011550	2
	40	33	04-24-00	lt7040033000011550	0
	40	34	05-10-00	lt7040034000013150	0

used a terrain correction algorithm that uses ground-control points and a digital-elevation model (DEM) that results in an RMS error of less than 100 ft to georeference the data. The 2005 imagery was georeferenced by the USGS using the geocorrected 2000 imagery as a reference data set. Geometric corrections were applied using a first-order polynomial equation. Thirty to forty control points were used per scene, and the overall RMS error was 100 ft. Multipath imagery from each year was used to create 2000, 2002, and 2005 color balanced mosaics of the study area.

Image band combinations were manipulated in the GIS to highlight relations and differences in the spectral intensity of multiple bands of the electromagnetic spectrum between irrigated acreage and the surrounding land covers (fig. 3). Bands 2, 3, and 4 were combined to create a false color infrared composite to distinguish healthy, chlorophyll-rich vegetation. Because vegetation absorbs visible red wavelengths, healthy, irrigated vegetation appears bright red in an infrared composite and contrasts strongly with the arid rangeland and bare soils. Bands 1, 4, and 7 were combined to create a false color composite that enhanced the red wavelengths associated with chlorophyll production. Bands 1, 2, and 3 were combined to form a natural color composite. Natural color and false color composites allowed visual distinctions between uniform irrigated acreages and mottled natural vegetation.

A normalized difference vegetative index (NDVI) transformation also was developed and used to compare irrigated acreages and to further guide the delineation process. The NDVI helped distinguish between healthy and unhealthy vegetation and plant density by quantifying the difference in the reflected intensity of near-infrared (NIR) and visible red (R) wavelength. The NDVI was computed as

$$NDVI = {(NIR - R)} \big/ {(NIR + R)}. \quad (1)$$

Delineation of Irrigated Acreage

Irrigated acreage was manually delineated as circular and rectangular polygons from processed digital images. Each of the imagery band combinations was used during the delineation process. For example, riparian vegetation and field runoff may be inseparable from irrigated croplands based solely on the natural color composite but may be distinguished from irrigated croplands based on the false color infrared composite. Recently harvested fields also may not show the spectral characteristics typically associated with an irrigated field in the false color composite but may be clearly defined using the NDVI (fig. 3). Supplemental GIS data sets were used to aid in the delineation process. For this study, SWReGAP data sets (Kepner and others, 2005), the 1992 National Land Cover Database (Vogelmann and others, 2001), and USGS DOQQs, were used as secondary guides in the delineation process. Irrigated acreage was delineated for 2000, 2002, and 2005 on the basis of the following criteria: (1) visual designation from imagery band combinations, (2) uniform shape, (3) proximity to irrigation wells, and (4) proximity to crop inventory irrigated acreages (fig. 4).

Each field polygon was assigned a field identification and attributed as irrigated or not irrigated during 2000, 2002, and 2005. Because field geometry often changed from rectangular to circular as irrigation systems were converted from furrow flood or wheel-line sprinklers to center-pivot sprinklers, a delineated field often was divided into multiple polygons, each with the same field identification. The topology rules applied during development of the irrigated acreage polygon are that the polygons must not overlap and must not have gaps (Environmental Systems Research Institute, 2003). The topology rules preclude double accounting or exclusion of areas caused by geometric changes.

Field Verification

Delineated irrigated acreage in 2005 was field verified from September 26 to 29 and November 1 to 3, 2005. Fields were visited to confirm that irrigation had occurred in remotely delineated polygons. The irrigation method, crop type, and water source for each field also was inventoried. The location of each delineated field was checked using a handheld GPS. Digital photographs were taken of each field and the bearing and time of each photograph was documented (fig. 5). A point feature class was created in the geodatabase for each set of field verification attributes based on the GPS location.

Of the 38,800 acres delineated as irrigated, field verification indicated 12 percent were erroneously identified. Irrigated acreage that was not delineated was associated with irregularly shaped fields or fields that were missed during the delineation process. Erroneously delineated fields generally were associated with incorrect identification of wetlands, irrigated field run off, and rectangular and circular shaped areas that were no longer in use.

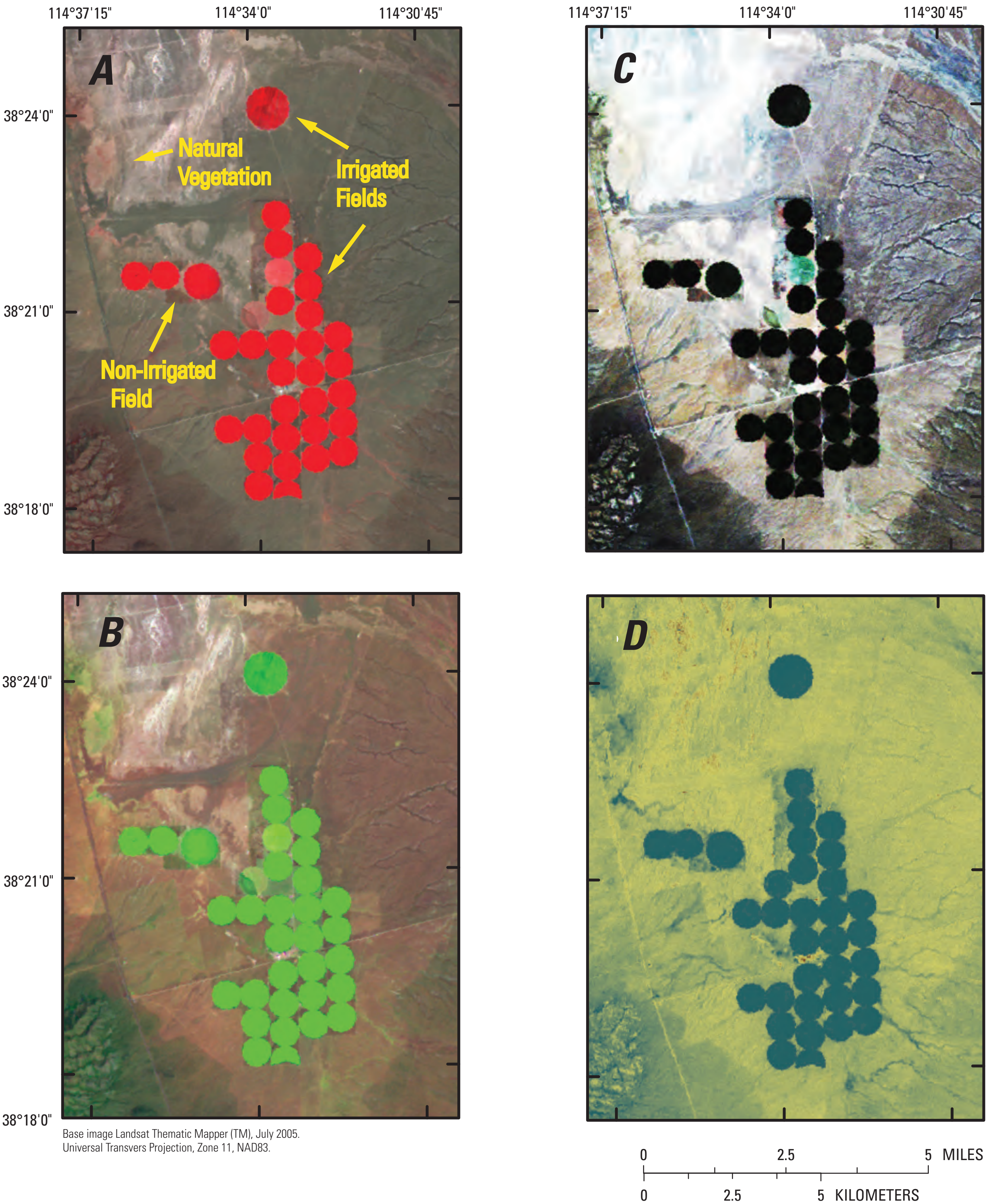


Figure 3. Landsat Thematic Mapper (TM) band combinations between irrigated acreage and surrounding land covers in the Basin and Range carbonate-aquifer system study area, Nevada and Utah. (*A*) False color infrared composition of bands 2, 3, and 4; (*B*) False color composite of bands 1, 4, and 7; (*C*) Natural color composite of bands 1, 2, and 3; and (*D*) Normalized difference vegetative index derived from July 2005 Landsat TM imagery used to delineate irrigated acreages and identify years of active irrigation in southern Lake Valley.

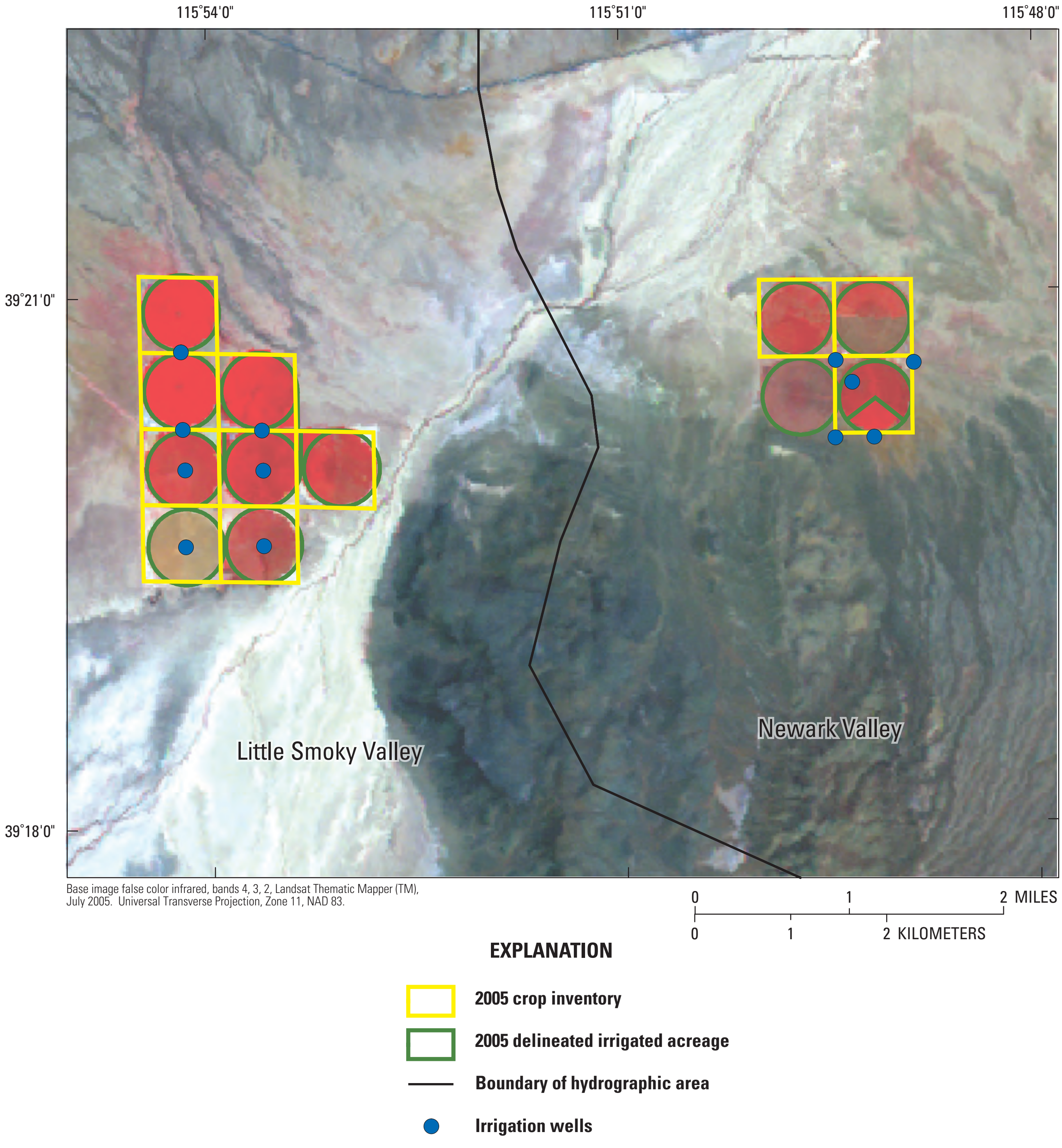
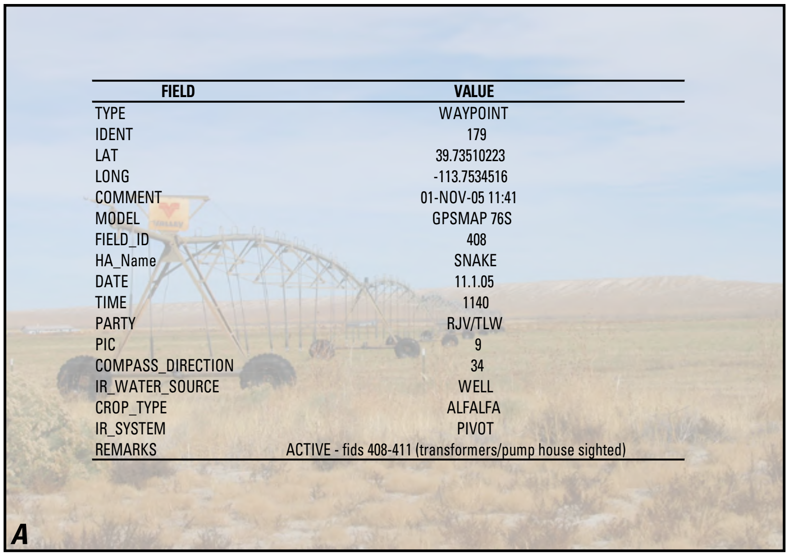
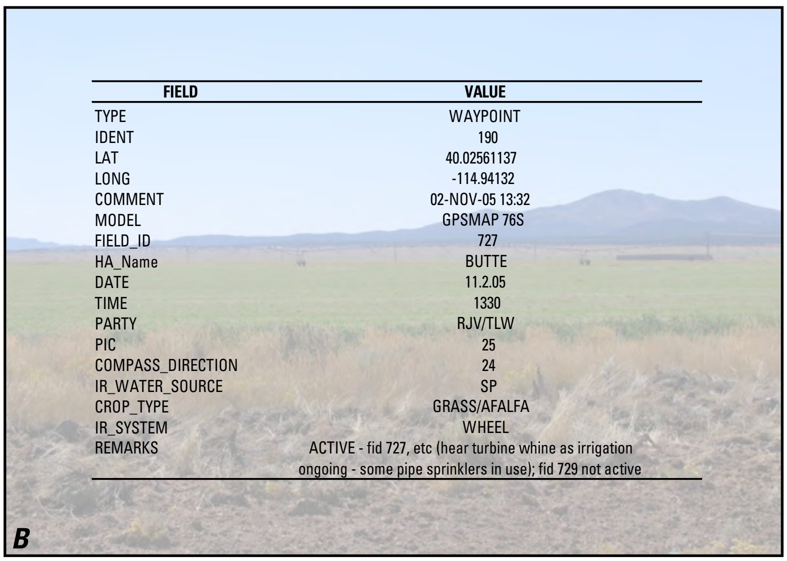


Figure 4. Imagery-delineated and State crop inventory irrigated acreages in 2005 and nearby irrigation wells in northern Little Smoky and southern Newark Valleys, Nevada.



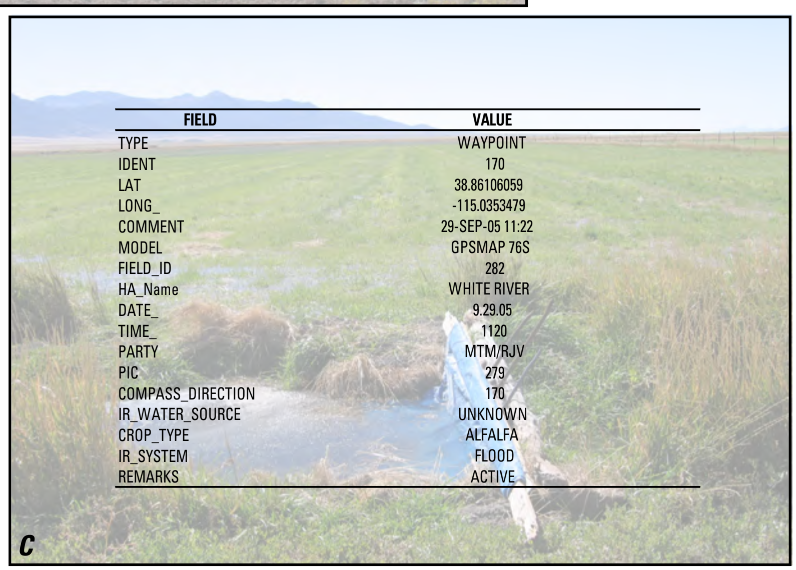
FIELD	VALUE
TYPE	WAYPOINT
IDENT	179
LAT	39.73510223
LONG	-113.7534516
COMMENT	01-NOV-05 11:41
MODEL	GPSMAP 76S
FIELD_ID	408
HA_Name	SNAKE
DATE	11.1.05
TIME	1140
PARTY	RJV/TLW
PIC	9
COMPASS_DIRECTION	34
IR_WATER_SOURCE	WELL
CROP_TYPE	ALFALFA
IR_SYSTEM	PIVOT
REMARKS	ACTIVE - fids 408-411 (transformers/pump house sighted)

A



FIELD	VALUE
TYPE	WAYPOINT
IDENT	190
LAT	40.02561137
LONG	-114.94132
COMMENT	02-NOV-05 13:32
MODEL	GPSMAP 76S
FIELD_ID	727
HA_Name	BUTTE
DATE	11.2.05
TIME	1330
PARTY	RJV/TLW
PIC	25
COMPASS_DIRECTION	24
IR_WATER_SOURCE	SP
CROP_TYPE	GRASS/AFALFA
IR_SYSTEM	WHEEL
REMARKS	ACTIVE - fid 727, etc (hear turbine whine as irrigation ongoing - some pipe sprinklers in use); fid 729 not active

B



FIELD	VALUE
TYPE	WAYPOINT
IDENT	170
LAT	38.86106059
LONG_	-115.0353479
COMMENT	29-SEP-05 11:22
MODEL	GPSMAP 76S
FIELD_ID	282
HA_Name	WHITE RIVER
DATE_	9.29.05
TIME_	1120
PARTY	MTM/RJV
PIC	279
COMPASS_DIRECTION	170
IR_WATER_SOURCE	UNKNOWN
CROP_TYPE	ALFALFA
IR_SYSTEM	FLOOD
REMARKS	ACTIVE

C

Figure 5. Examples of field verification documentation: (*A*) wheel-line sprinkler irrigation in Snake Valley; (*B*) wheel-line sprinkler irrigation in Butte Valley; and (*C*) furrow flood irrigation in White River Valley, Nevada and Utah.

Metadata

Metadata were created for each spatial component and complies with Federal Geographic Data Committee (FGDC) standards (Federal Geographic Data Committee, 1998). Metadata document the basic characteristics of data contained within the geodatabase and include publication elements such as the title, abstract, and citations; geographic elements such as projection and spatial extent; and database elements such as attribute label definitions and attribute domain values. Metadata are included as an XML document in the geodatabase.

Delineated Irrigated Acreage Geodatabase

Six hundred and forty-three fields were identified and delineated (fig. 6). Delineations are stored in a geodatabase for documentation and future use. Each irrigated field was plotted in the GIS and was evaluated for irrigation activity during 2000, 2002, and 2005 (fig. 7). The irrigated acreage identified by this process was totaled by hydrographic area and by component subbasins and is given in table 3. Irrigated acreage in the study area totaled 26,400 acres in 2000; 29,200 acres in 2002; and 32,000 acres in 2005 and accounted for 0.3 percent of the total study area. Irrigated acreage increased about 11 percent from 2000 to 2002 and about 9 percent from 2002 to 2005. As a general trend, irrigated acreage increased between 2000 and 2005 (fig. 7).

Snake and White River Valleys had the largest percentage increases in irrigated acreage from 2000 to 2005 at 43 and 25 percent, respectively. Snake Valley consistently had the largest amount of irrigated acreage in the 3 years for which irrigated acreage was evaluated. Subbasins 4 in Snake Valley and in 3 White River Valley had the largest increases of irrigated acreage from 2000 to 2005 at approximately 1,200 and 1,000 acres, respectively. This increased the irrigated acreage in each of the subbasins by 171 and 27 percent, respectively. Subbasin 1 in Steptoe Valley had the largest decrease of irrigated acreage from 2000 to 2005. Irrigated acreage in that subbasin decreased by 700 acres, a decrease of about 30 percent. The highest densities of actively irrigated acreages occur in the vicinity of Baker, Nevada, near the Utah-Nevada State line (subbasin 3 in Snake Valley, fig. 6 and table 3); in central Spring Valley (subbasins 2 and 3); southern Lake Valley (subbasin 2); northeastern White River Valley (subbasin 3); central Newark Valley (subbasin 2); and northern Little Smoky Valley.

Table 3. Estimates of irrigated acreage by hydrographic area and subbasins in the Basin and Range carbonate-rock aquifer system study area, Nevada and Utah, 2000, 2002, and 2005.

Hydrographic area	Subbasin	Irrigated acres (rounded to 100)		
		2000	2002	2005
Newark Valley	1	300	300	300
	2	1,500	1,900	1,700
	3	0	0	0
	Total	1,800	2,200	2,000
Little Smoky Valley (Northern part)	–	1,200	1,100	1,200
Little Smoky Valley (Central part)	–	0	0	0
	Total	1,200	1,100	1,200
Jakes Valley	–	200	200	200
Long Valley	–	0	0	0
Butte Valley	1	200	200	200
Steptoe Valley	1	2,300	1,300	1,600
	2	1,300	1,800	2,100
	3	0	0	0
	Total	3,600	3,100	3,700
Cave Valley	1	0	0	0
	2	0	0	0
	Total	0	0	0
Lake Valley	1	300	300	300
	2	3,500	4,100	4,100
	Total	3,800	4,400	4,400
Spring Valley	1	0	0	0
	2	2,700	2,400	2,700
	3	1,500	2,000	2,200
	4	0	0	0
	Total	4,200	4,400	4,900
Tippett Valley	–	0	0	0
White River Valley	1	800	700	700
	2	200	400	400
	3	3,700	4,300	4,700
	4	200	200	300
	Total	4,900	5,600	6,100
Snake Valley	1	1,300	1,300	1,600
	2	800	700	1,100
	3	3,700	4,100	4,600
	4	700	1,900	1,900
	5	0	0	100
	Total	6,500	8,000	9,300
Total		26,400	29,200	32,000

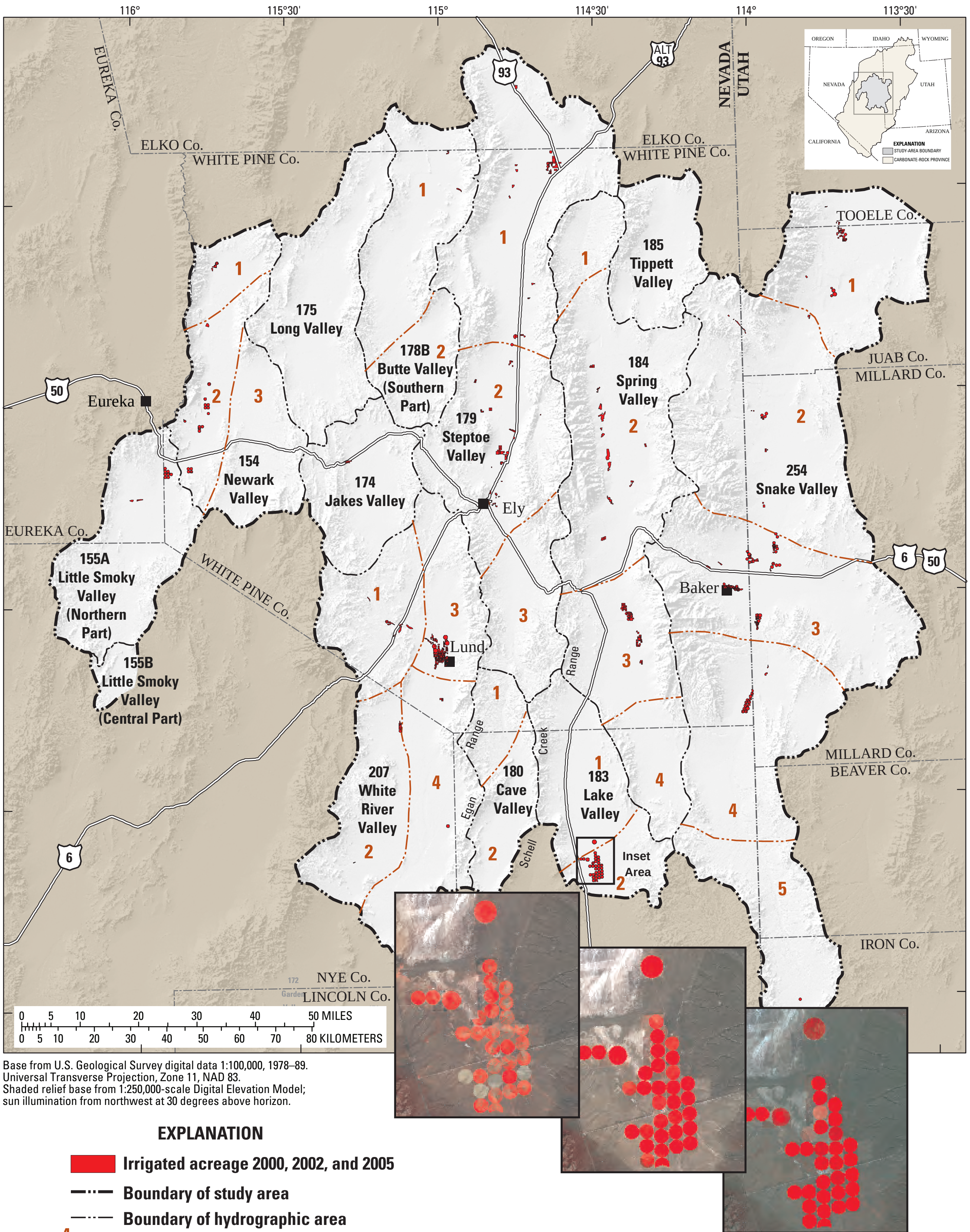


Figure 6. Irrigated acreage in Basin and Range carbonate-rock aquifer system study area delineated from 2005 Landsat Thematic Mapper (TM) imagery of irrigated acreage in southern Lake Valley for 2000, 2002, and 2005 (photograph insets).

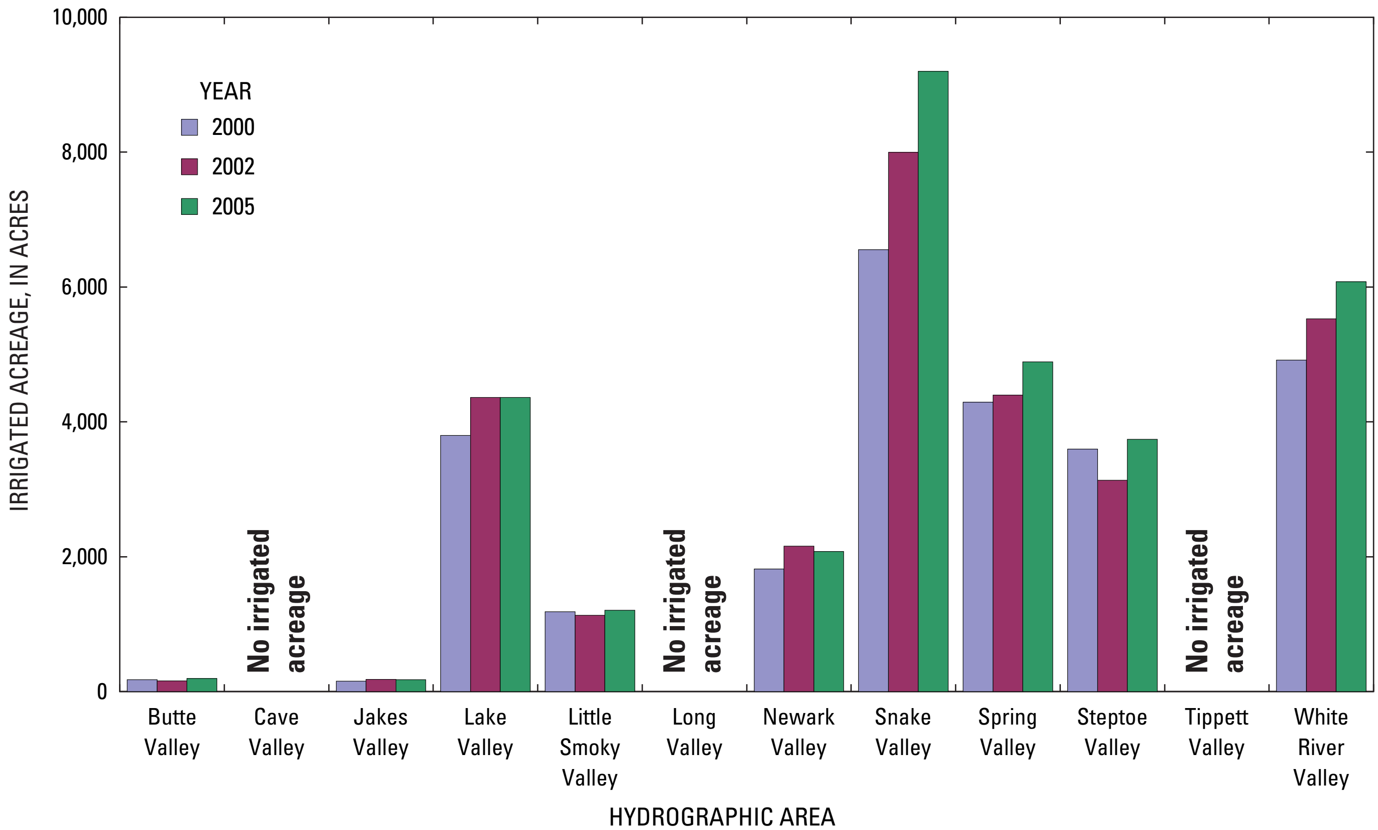


Figure 7. Estimates of irrigated acreage by hydrographic area in Basin and Range carbonate-rock aquifer system study area, Nevada and Utah, 2000, 2002, and 2005.

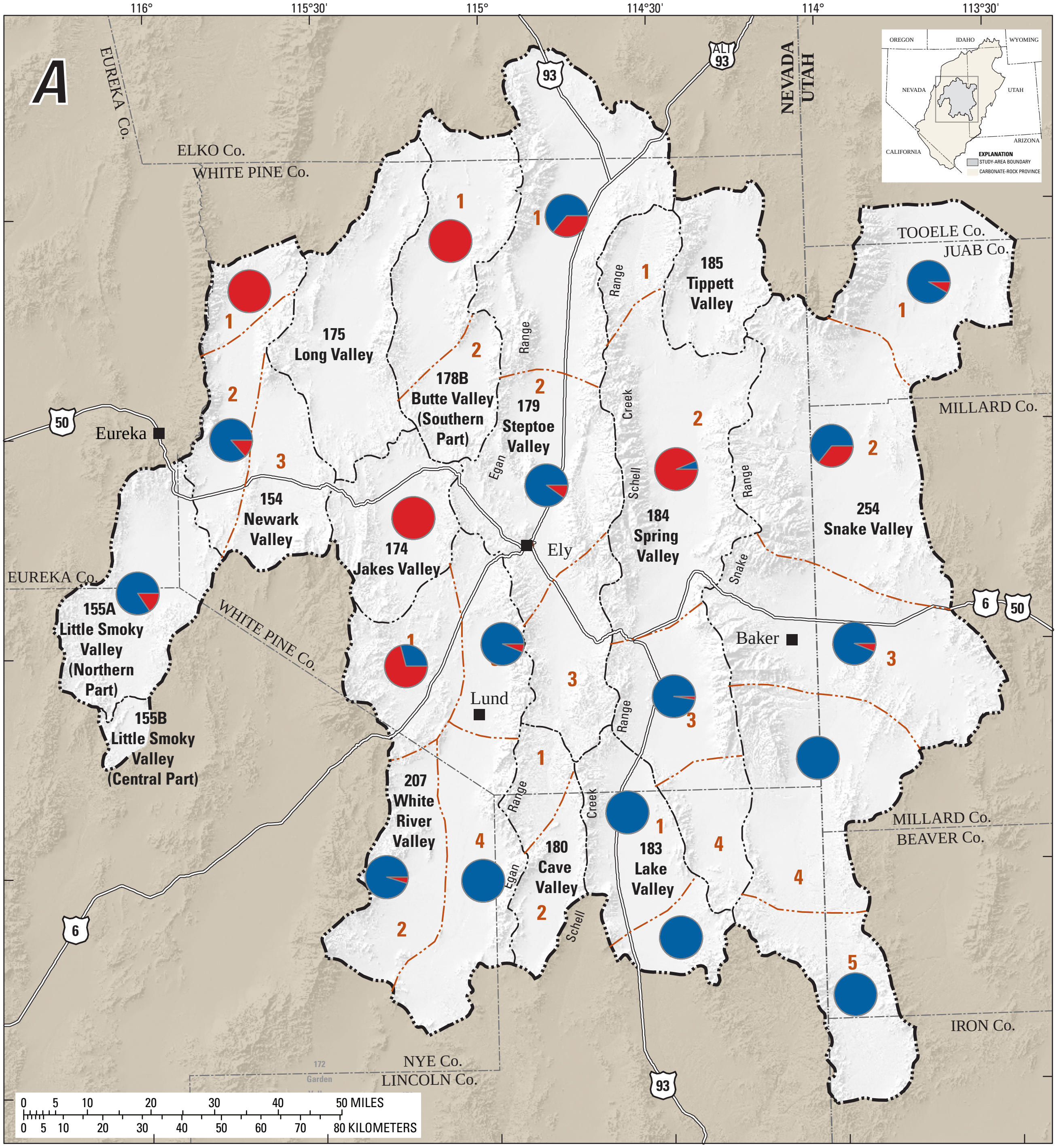
Ground water supplied 80 percent of the water used for irrigated acreage during dry periods (fig. 8). This estimate was based on the proximity between supply well(s) and irrigated fields and on observations made during field verification. For example, in subbasin 3 in Spring Valley, ground water pumped from wells was used primarily as a supplement to intermittent early season runoff caused by snowmelt. These wells supplied between 0 and 40 percent of total irrigation during wet and dry years, respectively. Water for the remaining 20 percent of irrigated acreage was supplied by perennial surface water, which is sustained by spring flow and snowmelt. Heavily irrigated subbasins relied primarily on well sources except for subbasin 2 in Spring Valley (fig. 7).

Center-pivot sprinkler irrigated acreages currently dominate the study area landscape (fig. 8). About 53 percent of the delineated acreage is irrigated by center-pivot sprinklers, about 22 percent is irrigated by furrow flooding, and about 25 percent is irrigated by wheel-line sprinklers. The primary irrigation method used varies spatially and is unequally distributed between center-pivot sprinklers, wheel-line sprinklers, and furrow flooding throughout the study area.

Landsat delineated irrigated acreage generally agreed with estimates based on NDWR crop inventories. Crop inventory estimates differed from Landsat delineations by an average of 12 percent (21 percent in 2000, 6 percent in 2002, and 9 percent in 2005). Differences ranged from 33 percent for Little Smoky Valley in 2000 to 3 percent for Steptoe Valley in 2002. Differences in estimated irrigated acreage between Landsat delineations and NDWR crop inventories for Little Smoky, Newark, and Steptoe Valleys are consistent with differences noted by Moreo and others (2003).

Irrigated acreage estimates likely differ because imagery acquisition and NDWR field verification occurred more than 3 months apart. Field activity and crop conditions at the time of satellite-data acquisition may have been different from those during field verification. Smaller acreage differences are attributed to differences in field geometry—the crop inventory designations assume a rectangular field geometry based on the legal description (township, section, range, quarter section, and quarter-quartersection) and imagery delineations assume a geometry fit to the resolution of the satellite imagery.

The irrigated acreage geodatabase was supplemented with zonal statistics for precipitation and potential evapotranspiration (PET) estimates from Flint and Flint (2007). These zonal values were calculated to determine the average annual precipitation and PET from each individual field in the study area. PET and precipitation were calculated for a long growing season (April through October) and a short growing season (April through September).



Base from U.S. Geological Survey digital data 1:100,000, 1978–89.
Universal Transverse Mercator Projection, Zone 11, NAD 83.
Shaded relief base from 1:250,000-scale Digital Elevation Model;
sun illumination from northwest at 30 degrees above horizon.

EXPLANATION

Boundary of study area

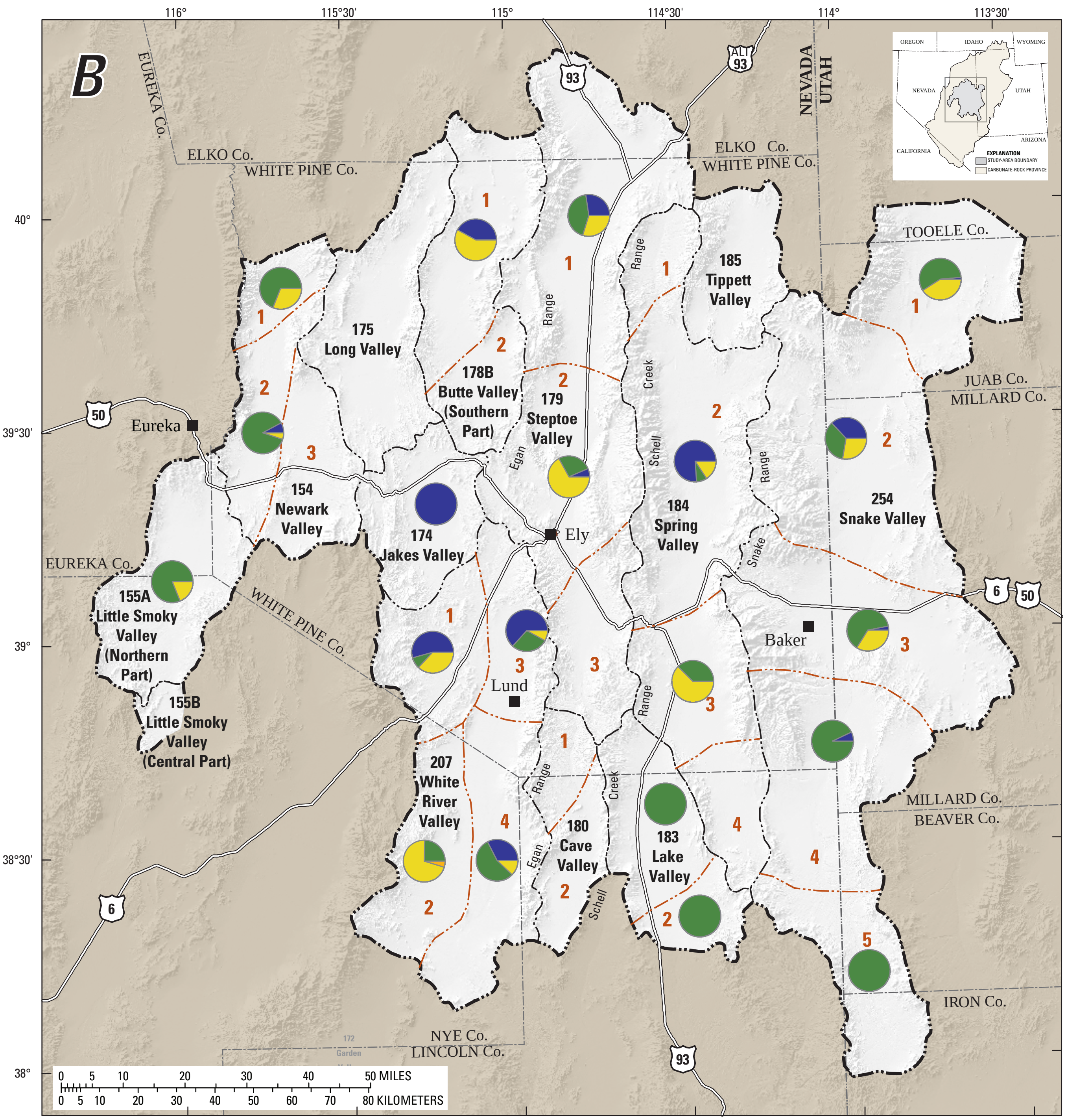
Boundary of hydrographic area

4 Boundary of subbasin and No.

Ground water

Surface water

Figure 8. Distribution of (*A*) potential irrigation sources and (*B*) irrigation systems in Basin and Range carbonate-rock aquifer system study area by subbasin, Nevada and Utah.



Base from U.S. Geological Survey digital data 1:100,000, 1978–89.
Universal Transverse Mercator Projection, Zone 11, NAD 83.
Shaded relief base from 1:250,000-scale Digital Elevation Model; sun illumination from northwest at 30 degrees above horizon.

EXPLANATION

- Boundary of study area
- Boundary of hydrographic area
- 4 Boundary of subbasins and No.

Center pivot — Furrow flood — Wheeled sprinkler — Unknown

Figure 8.—Continued

Summary

Accurate delineations of irrigated acreage are needed for development of water-use estimates and water-budget calculations for the Basin and Range carbonate-rock aquifer system (BARCAS) study area. Existing data sets were evaluated and used to improve the understanding of the irrigated acreages. Irrigation wells from the Nevada Division of Water Resources (NDWR) State well-log database and the Utah Division of Water Rights (UDWR) water rights point of diversion database were imported as point features. State crop inventories for Newark, Little Smoky, and Steptoe Valleys were tabulated within the geodatabase. Irrigated acreages were delineated as polygon features using image interpretation multiple band combinations derived from 2000, 2002, and 2005 Landsat Thematic Mapper and Enhanced Thematic Mapper imagery. Delineated irrigated acreage in 2005 was field verified, and irrigation method, crop type, and water source were identified. Data set accuracy was estimated to be about 12 percent on the basis of field verification.

The geodatabase was analyzed to determine the spatial distribution of field locations, the total amount of irrigated acreage by hydrographic area and subbasin, by irrigation water source, by irrigation system, and by crop type. Differences between imagery-delineated and State crop inventory irrigated acreages were explained, and zonal precipitation and potential evapotranspiration values were calculated.

Irrigated acreage in 2005 totaled about 32,000 acres and ranged from less than 200 acres in Jakes, Long, Butte, Cave, and Tippett Valleys to 9,300 acres in Snake Valley. Irrigated acreage increased about 20 percent from 2000 to 2005. Snake and White River Valleys had the largest percentage increases. The source for about 80 percent of irrigation water applied during dry years and by the end of the growing season is ground water pumped from wells. About 80 percent of irrigation water applied in 2005 was through sprinkler systems, and about 20 percent was through flood systems. Fields planted in alfalfa comprise the majority of the irrigated acreage.

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