Mapping Irrigated Agriculture in the Colorado River Basin

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The Geospatial Centroid at Colorado State University (CSU) (gis.colostate.edu) was funded by The Nature Conservancy (TNC) to develop a geospatial database of existing irrigated agriculture in the Colorado River Basin (CRB). The CRB includes 246,000 square miles that produce 15 percent of the nation's crops from approximately 1.8 million acres of irrigated agriculture—a key component of consumptive use. This project has run in parallel with other CRB projects. The Environmental Defense Fund funded the Agricultural Water Governance Mapping project, and the U.S. Department of Agriculture funded a research project on agricultural water, both of which are described in this issue. We are exploring ways to integrate the entire suite of publicly available data collected from these projects into a singular dataset with the long term aim of delivering the data online. Such a dataset is unique in that data from multiple sources (i.e., U.S. Bureau of Reclamation [USBR], U.S. Geological Survey [USGS], National Agricultural Statistics Service, and agricultural water supply organizations of all basin states) and multiple themes, such as governance, agricultural lands, and hydrology, will be collected and organized to create a value-added dataset of the CRB.

The objective for the TNC project was to create comprehensive spatial coverage depicting the extent of irrigated agriculture, to uniformly map irrigated crops using existing data from the USBR, and to identify gaps in the spatial data. The database produced for this report juxtaposes the extent of irrigated agriculture across the landscape with the size and extent of the entire CRB.

Table 1. *Existing data collected for CRB Irrigated Agriculture mapping. Refer to Demonstration Mapping for Increasing Agricultural Water Security across the Colorado River Basin, January 2012, prepared for The Nature Conservancy by Ownby and Laituri for metadata.*

Data	Source	Year
Upper Colorado River Basin Consumptive Use and Loss Data: Irrigation by Status and Type[1]	Bureau of Reclamation	Five year reporting cycles: 1990 – 1995[2] 1996 – 2000 2001 – 2005
Irrigated Parcels from Division 4 (Gunnison), Division 5 (Colorado), Division 6 (Yampa/White), Division 7 (San Juan/Dolores)	Colorado Decision Support System	2005
Lower Colorado River Basin Consumptive Use and Loss Data: Crops (by season)[3]	Bureau of Reclamation	2005
Cropland Data Layer[4]	USDA - NASS	2010
Salinity Control Projects (Colorado only)	Bureau of Reclamation	2009
Salinity thresholds Irrigated Agriculture	SPARROW[5]	2009
303d listed streams	Environmental Protection Agency	2008
Selenium Areas[6]	USGS	1999

[1] Irrigation is mapped according to status or type in the UCRB. Status refers to lands that are fallow or irrigated. Irrigation type refers to general type: flood, sprinkler, or unknown. The BoR has generated or obtained new irrigated crop acreage estimates for all UCRB states for at least one year within each 5-year reporting period.
[2] The 1990-1995 irrigated crop layer was an early effort to map irrigation using a consistent methodology across the UCRB. Since then, BoR has produced crop maps of only portions of the UCRB that have not been mapped by their respective states.
[3] The Lower Colorado River Accounting System (LCRAS) is used to inform the CUL reports and was developed to refine estimates of agricultural consumptive use, based on ET and water balance. A GIS database is developed from the processing and interpretation of remotely sensed data. In addition, BoR collects ground reference survey data for approximately 12% of irrigated fields in study area, selecting survey sites in each major irrigated area.
[4] The CDL does not include irrigation or seasonal information explicitly.
[5] The 2009 dissolved-solids SPARROW (Spatially Referenced Regressions on Watershed Attributes) model was developed for the Upper CRB as a spatially explicit estimation of salinity loading. The current SPARROW model uses the 1991 climate year and the BoR 1990-1995 extent of irrigated lands layer.
[6] Selenium pollution data are from the USGS report – Areas Susceptible to Irrigation-Induced Selenium Contamination of Water and Biota in the Western United States.

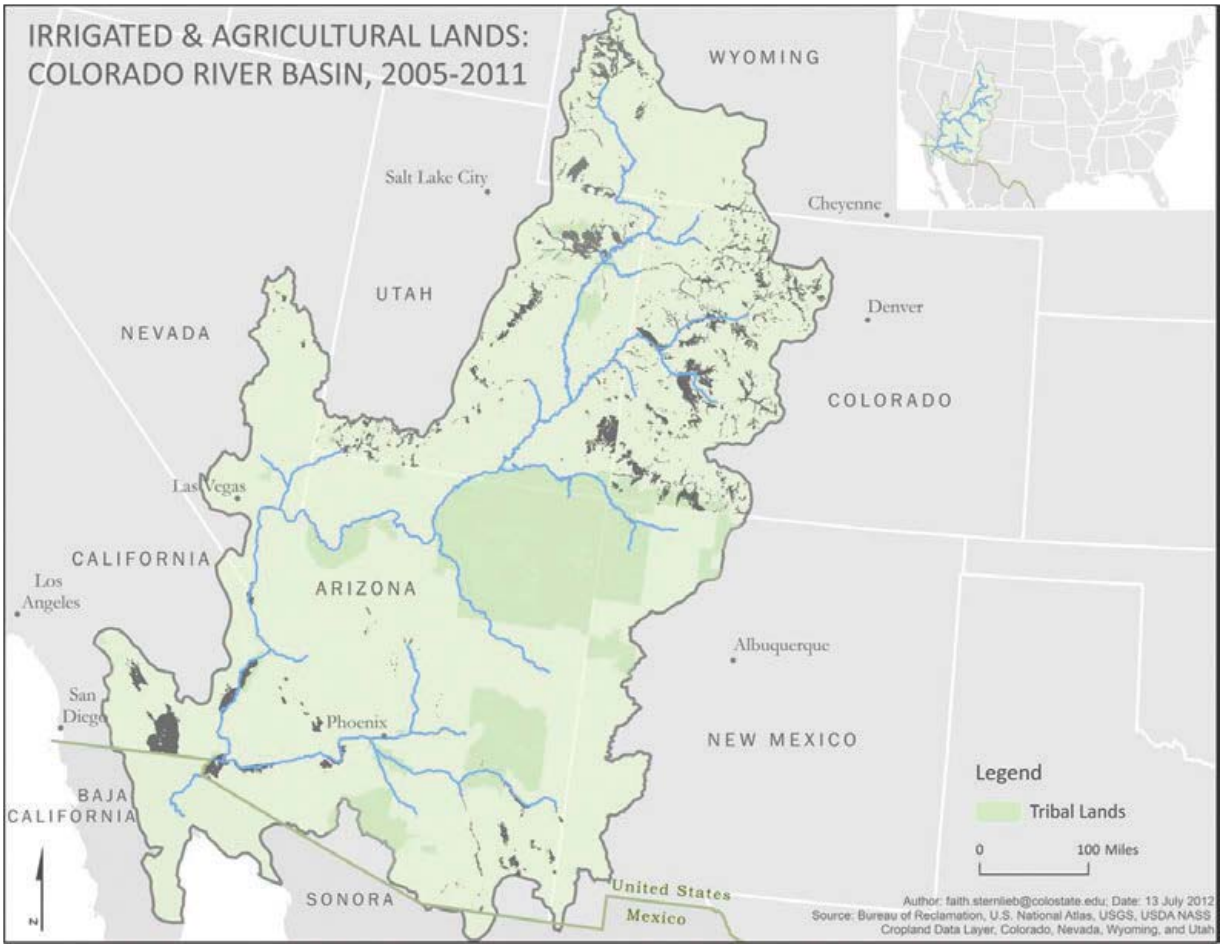

Figure 1. *Irrigated and agricultural lands of CRB, including the extent of both irrigated and dryland agricultural based on additional data collected from 2011.*

The database is made up of the following data derived from multiple sources. Base layers downloaded from the National Atlas include the Colorado River and its tributaries, the USBR management boundary, the boundary between the Upper and Lower Colorado river basins, state and county boundaries, and eight digit hydrologic units obtained from the USGS National Water Information System. A spatial and temporal database (Table 1) was created of digital data (1990-2005) provided by the USBR using the Consumptive Uses and Losses Reports (CULRs) in the Upper Colorado River Basin (UCRB). Spatial data were also provided by the USBR of irrigation for the lower main stem of the Colorado River. These data layers were compared with other data from USDA—Cropland Data Layer (CDL) and data from the Colorado Water Conservation Board's Colorado Decision Support System (CDSS). Additionally, USGS salinity and USBR selenium data for the Upper Colorado River Basin (UCRB) were examined. The EPA's 303d listed streams were also incorporated into the database.

The products created from this research include both a query-able ArcGIS geodatabase and an interactive set of PDF maps. In May, a workshop at CSU utilized the projection-based Google Liquid Galaxy (http://lib.colostate.edu/services/computers/google-liquid-galaxy) to present the results to TNC, USGS, the Environmental Defense Fund, and CSU. Since completion of this project, additional agricultural information has been added that encompasses dryland agriculture across the entire basin, including irrigated agricultural lands (Figure 1).

There were several challenges associated with the development of this dataset. The USBR does not create maps of irrigated agriculture as part of their CULRs in either the Upper or Lower Basins. Rather, the spatial information about irrigated agriculture is used in analysis to inform the accounting for consumptive use, presented in tabular format. Creating spatial products from the USBR data is inherently imperfect as these data are a snapshot in time, where often further accounting metrics are assigned to determine the areal extent of irrigated agriculture from other data sources (i.e., Census of Agriculture) for an output that is not spatial but tabular. Additionally, the USBR's accounting of irrigated agriculture is an estimation built upon best available data collected from a variety of sources. In constructing this dataset, the data were stitched together across the entire CRB and amalgamated and standardized to present a holistic snapshot of the CRB.

USBR methods of data collection for the CULR are different for the Upper and Lower basins. In the Upper Basin, states estimate their consumptive uses and losses of CRB water using methods different from those used by the USBR and between states, so estimates may differ between entities. The CULR use USBR methodologies to estimate consumptive uses and losses based on the modified Blaney Criddle method for all Upper Basin states with the exception of New Mexico. The

USBR uses a process to further refine their statistics on irrigated agriculture in which data are collected from the USDA Census of Agriculture (COA) that is conducted every five years and state's annual County Agricultural Statistics (CAS). In the Lower Basin, the USBR accounts for use on the main stem using a "diversion minus flow" methodology for all water users within the Lower Basin states, as published in Water Accounting Reports and the CULR. Until 2000, the CULR included irrigated acreage and estimated consumptive use and losses in the Lower Basin tributaries. The USBR recognizes that there are discrepancies between the various accounting approaches and are seeking to resolve these discrepancies in both the Upper and Lower basins.

To map irrigated agriculture, a common crop type classification was developed to map crop types across the entire basin and to compare against the crop types from the CDL and CDSS. This Common Classification was adapted from the classification procedures developed for the South Platte Decision Support System in Colorado (Table 2). Without the Common Classification, crop types would be classified differently between the Upper and Lower Basins. The data were reclassified to represent consistency of crop types across the basin, and assumptions have been made in re-categorizing data. For example, the original CDL classification included 91 different crop types within the basin that were reclassified for this project by aggregation (such as pasture, hay) or exclusion (such as dryland agricultural crops; crops not found in the CRB) into the 10 crops types of the Common Classification System.

Changes are underway with respect to mapping the CRB irrigated lands. For example, the USGS is developing a spatial dataset from the mid to late 2000s of irrigation for the Upper CRB. This mapping will be used to improve the outputs from the SPARROW model, will refine the extent of irrigation in the Upper CRB by status and type, and will be used as a baseline for monitoring change in salinity loading from irrigation. Also, the USBR is working on changing procedures for estimating evapotranspiration in the UCRB from crop maps combined with surface weather information to remote sensing-based energy balance models for 2006-2010. However, relationships between crop types will need to be made explicit to estimate consumptive water used by agriculture.

Collection of agricultural data for the CRB has continued after the completion of the TNC project. Efforts to include recent, available data from various entities are essential to creating a current and holistic database of the CRB. Governmental organizations in partnership with universities are developing classification techniques utilizing remotely sensed data with the long term aim of creating real-time representation of irrigated agriculture in the CRB. If you are interested in learning more or would like to include your data in the CRB database, please contact Melinda Laituri, melinda.laituri@colostate.edu.

Table 2. *Common Crop Classification used for the CRB. adapted from Schneider, Martin, and Woodward, 2006, SPDSS Memorandum 89.2 – Crop and Land Use Classification Procedures for Year 2001.*

Crop	Characteristics
Alfalfa	A flowering plant cultivated as an important forage crop in Colorado. It usually greens up during April and early May and is harvested 3-4 times during the growing season that ends in early October.
Bluegrass/Sod	A lawn grass, which comprises less than 2% of total irrigated area in Water Divisions 4-7 in Colorado. Sod or turf is grass used to establish lawns. This comprises a negligible portion of the irrigated areas in Water Divisions 4-7 in Colorado.
Corn	Includes corn used for grain or silage. Planted between late April to early May and harvested from September through November. Includes sorghum and sudan.
Cotton	Cotton
Dry Beans	Includes pinto beans, white beans, and others. Planted between May to early June and harvested from late August to late September.
Grass Pastures	Includes pastures with cultivated grass and hay. It greens up in spring and early summer
Orchard	May include Ground Cover. Apples, peaches, plums, and grapes are the major crops grown in orchards in the region.
Small Grains	Includes winter wheat, spring wheat, oats, barley, rye, and millet. Winter wheat is planted in September of the previous year and is harvested around early July. Oats and barley are planted in March or early April and harvested in July.
Vegetables	Includes a variety of crops such as potatoes, squash, onions, pumpkins, lettuce, spinach, and broccoli.
Other	Includes everything else: Aquaculture, Blueberries, Camelina, Clover/Wildflowers, Cranberries, Herbs, Hops, Mint, Other Crops, Rice, Sugarbeets, Sugarcane, Sunflower, Vetch.