Analysis and Utilization of the Arizona Cropland Data Layer Map as a Source of Crop Acreage in Consumptive Use Estimates of Irrigation Water Use, Arizona 2009

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Introduction

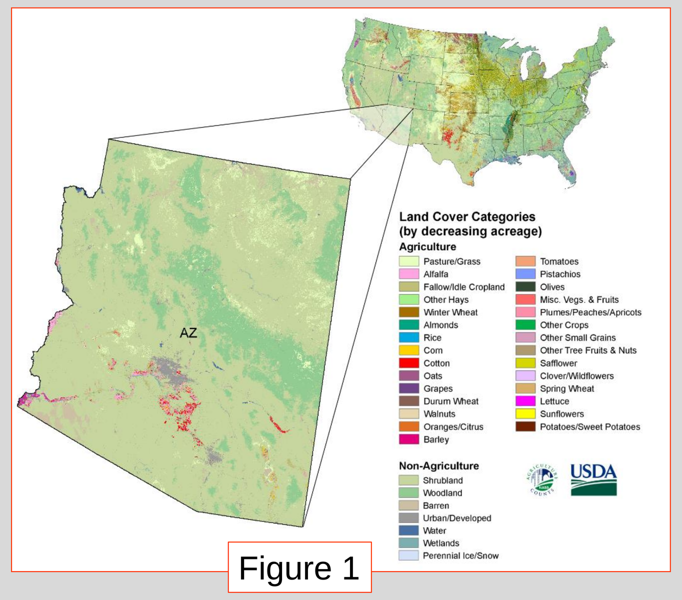

Figure 1

Irrigation water withdrawals are one of the leading components of the water budget for the western United States. Despite this dominance in use, standardized methods for determining agricultural water use estimates are limited by data availability state to state. Determining agricultural water budgets oftentimes must rely on voluntary survey data submitted by farmers to organizations such as the *Census of Agriculture* or *Farm Ranch Irrigation Survey*. The subsequent reported withdrawals undergo little scrutiny or quality assurance.

However, over the past decade, remote sensing imagery for agricultural mapping has become wildly available, mapping states' agriculture with increased accuracy at higher spatial resolutions. This is best illustrated by the most recent iteration of the USDA's Cropland Data Layer (Fig. 1). When combine with known climate and precipitation data, agricultural water withdrawals can be calculated based on known crop irrigation requirements (CIR). When accommodating additional factors such as the efficiency of the irrigation systems and conveyance losses, a robust yet simple method of estimating statewide agricultural water use can be determined. and applied to arid or semi-arid regions (where precipitation can be assumed to be negligible), agricultural water use estimates can be easily determined.

Background: Datasets to be Compared

USGS 2009 Field Verified Agricultural Map

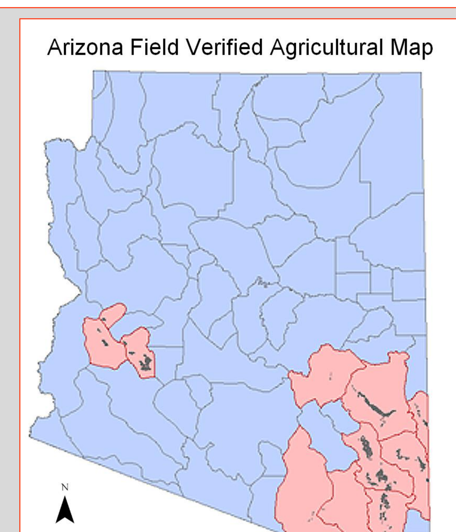

Figure 2

The USGS field verified agriculture (and region of study for this comparative analysis) is comprised of 177,000 acres of cropland, approximately 19% of all Arizona's 2009 agriculture (Fig. 2).

Cropland was mapped by 2-3 man teams in a USGS vehicle with a laptop linked to a GPS device. As the USGS personnel would drive alongside the farmland, croptypes were inputted into the corresponding map location for each field site.

Visits were scheduled from May through August during the height of the Arizona growing season. The largest and most active agricultural regions were visited multiple times throughout the growing season to determine if muilti-cropping is occurring.

Basin	Date
Ranegrass Plain Basin	May 20th, 2009
Harquahala Basin	May 21st, 2009
Willcox Basin	May 26th, 2009
Willcox Basin	May 27th, 2009
Douglas Basin	May 28th, 2009
San Simon Sub-Basin	June 7th, 2009
Safford Basin	June 8th, 2009
Duncan Valley Basin	June 9th, 2009
Middle San Pedro	June 10th, 2009
Tonto Creek Basin	July 14th, 2009
Salt River Basin	July 15th, 2009
Cienega Creek Basin	July 16th, 2009
San Simon Sub-Basin	Aug. 3rd, 2009
Douglas Basin	Aug. 4th, 2009
Willcox Basin	Aug. 4th, 2009
Willcox Basin	Aug. 5th, 2009
Harquahala Basin	Aug. 10th, 2009
Ranegrass Plain Basin	Aug. 11th, 2009

Table 1

Arizona Cropland Data Layer Remote Sensed Agricultural Map

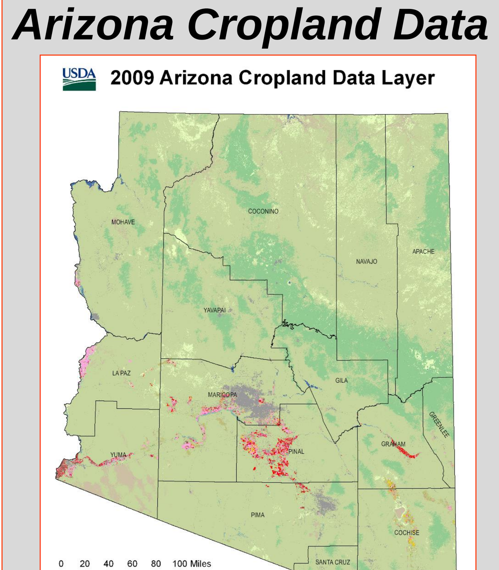

Figure 3

The USDA's National Cropland Data Layer is an annually generated agricultural raster (grid-based map) displayed at a 56 meter resolution (Fig. 3). The CDL utilizes a comprehensive archive of AWiFS satellite imagery from the Foreign Ag Service, Landsat TM, and MODIS data to map regions of agriculture by croptype. A decision-tree computer algorithm identifies each pixel by croptype. This algorithm is initially calibrated on one-million acres of field verified agricultural land monitored by the USDA. For additional information on the CDL Program visit *www.nass.usda.gov/research/Cropland/SARS1a.htm*

Purpose & Scope

In this study, a 2009 **remote sensed** agricultural map developed by the Arizona Cropland Data Layer (AZ CDL), was analyzed alongside a 2009 **field verified** agricultural map developed by the USGS's Arizona Water Science Center (USGS's AZWSC). With this analysis, the CDL's accuracy for identifying each individual croptype can be determined.

Additionally, crop acreages based upon the AZ CDL were used to calculate an irrigation water budget. This water use estimate was calculated based upon: (1) known crop irrigation requirements, (2) estimated statewide irrigation system efficiencies, and (3) estimated statewide conveyance losses. These results were subsequently compared to the USGS's most recent irrigation water use estimate for Arizona.

Methods: Redefining the Datasets to Enable Analysis

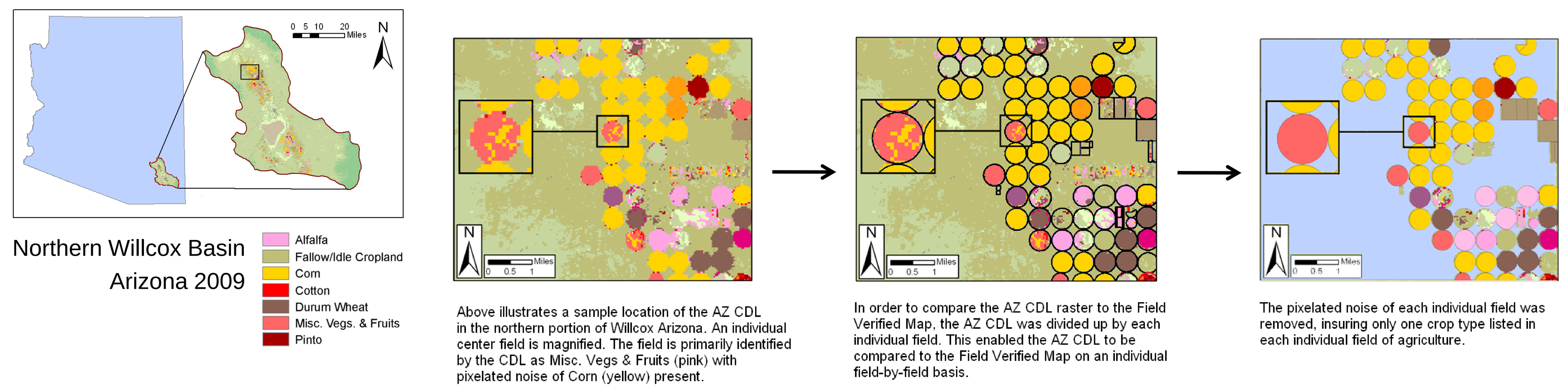

Figure 4

Since the AZ CDL dataset was raster-based (grid-based), and the USGS field verified data set was vector-based (polygon based), the CDL Raster was converted to a vector-based map. The CDL was re-illustrated removing any pixilated noise, and redigitized to a polygon layer that overlapped with the field verified polygon-based USGS data (Fig. 4). This allowed for each individual field of crops to be compared since the data visually formatted over the same exact location. The reason for converting the CDL raster to polygons (rather than converting the USGS polygons to a raster) is due to the fact that the USGS field verified data is more spatially accurate than the field verified raster data. Since both the field verified dataset and remote sensing dataset used their own unique list of crop terms to classify crops, a new set of crop terms were derived that could be applied to each dataset (Fig. 5). This defined a common link between the two sets of terms of each datasets. This enabled a clear definition of what would allow a correctly matched or incorrectly matched field of agricultural land.

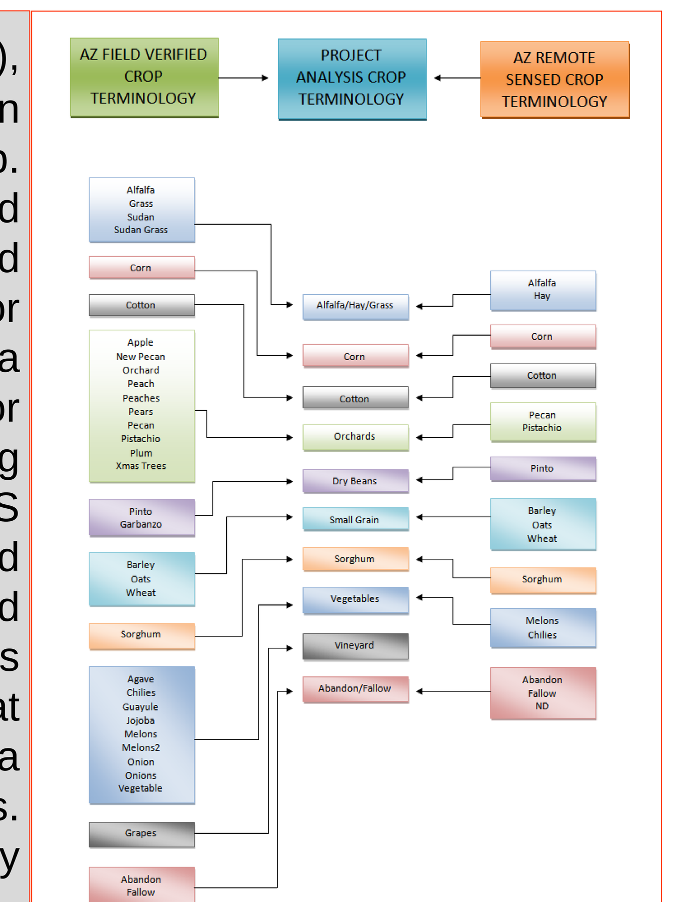

Figure 5

Methods: Calculating Agricultural Withdrawals from CDL

Additionally, the AZ CDL crop acreages were applied to the following equations to calculate a statewide consumptive use agricultural water withdrawal compared to the most recent USGS Agricultural Water Withdrawal Estimate for Arizona.

$$W_{total} = \sum \frac{(A_{crop} * K_{crop})}{E_{total}}$$

A_{crop} = Total acres of given crop
K_{crop} = Crop Irrigation Requirement
E_{total} = Overall Agricultural Efficiency

With:

$$E_{total} = (E_{IR\,system})(E_{conveyance\,loss})$$

$$E_{IR\,system} = \frac{(A_{sprinkler})(0.80) + (A_{flood})(0.70) + (A_{drip})(0.90)}{A_{total}}$$

Crop	Crop Irrigation Requirement (ft)
Alfalfa	4.58
Corn	2.38
Cotton	2.72
Sorghum	2.19
Pasture	3.72
Small Grains	1.67
Pinto	1.94
Wheat/Barley	1.76
Melons	1.31
Citrus	3.99
Vegetables	2.24
Orchard	3.29

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Results: Cropland Data Layer Accuracy

Results found the percent match between data sets were as follows: deciduous trees (100%), corn (95.7%), cotton (93.4%), vegetables (90.6%), small grain (90.4%), hay (88.1%), sorghum (59.6%), and dry beans (59.6%) (Fig. 5). The AZ CDL proved to be quite accurate for the primary crops. When the CDL crop acreages are applied to a consumptive use model, and adjusted to account for irrigation system efficiencies and conveyance losses, a statewide agricultural withdrawal estimate of 5,557,638 Acre-Feet/Year of water was calculated, relative to the most recent USGS agricultural water use inventory of 5,386,671 Acre-Feet/Year (2005) (Fig. 6). This is within 3.1% of the reported value.

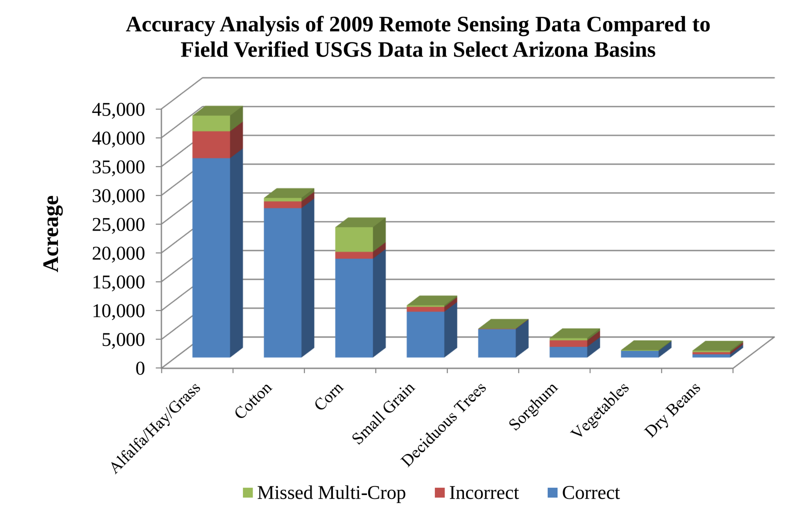

Figure 5

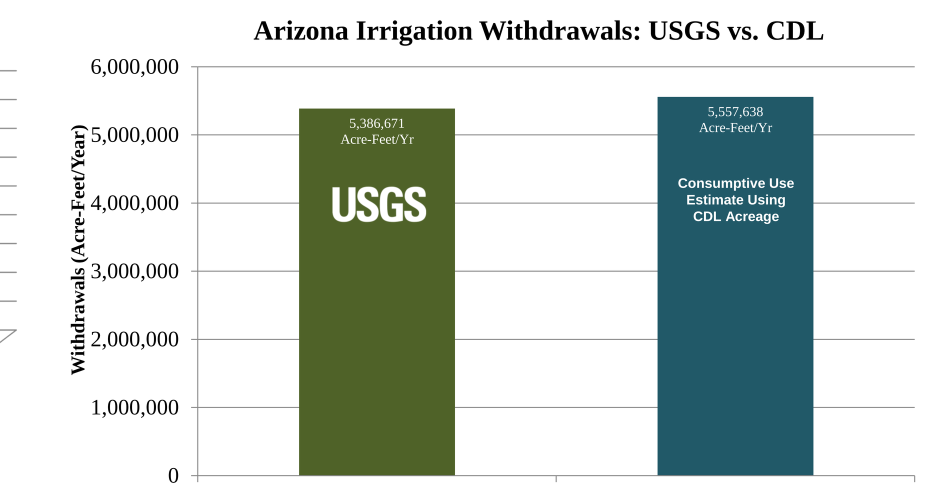

Figure 6

The results carry even further reaching conclusions when this project's analysis is overlain with to the CDL's Confidence Layer – the USDA's own internal quality analysis of the CDL data layer. It is a calculation of each individual pixel's probability that the given pixel was correctly identified through the CDL's decision-tree algorithm (Fig. 7). Values range between 0-100%. Essentially, a measurement of 'confidence' for each individual pixel. There is a strong correlation between correctly identified, and pixels with high confidence (Fig. 8). Thus the quality analysis presented here, and measured confidence presented by the CDL appear to both be valid assessments of the CDL's overall accuracy. This suggests that for future agricultural water use estimates, crop acreages provided by the CDL, can be used in a consumptive use calculation to determine agricultural withdrawals. This is under the conditions that (1) it is applied to a region such as the semi-arid southwest where precipitation's effect is negligible, (2) uses reasonable estimates for system efficiencies and conveyance losses, (3) uses reasonable crop irrigation requirements are applied..This will enable an additional method to validate questionable farmer survey data.

Figure 7

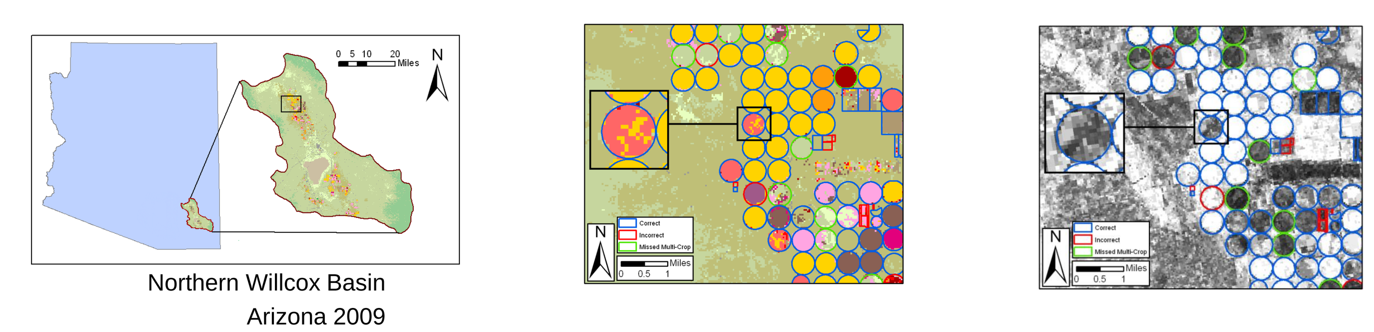

Figure 8