Paper Title

Agriculture in California: Basic Land Use Data Collection

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Paper Abstract

The task is to translate data collected 'in the field' to produce a viable, “queryable” spatially oriented dataset that could be displayed accurately with various base maps. The system needs to be able to incorporate historical data and changes in technology that result in savings of both time and money. Basic development has been done using AutoCad, GeoSql, ArcView, ER Mapper, aerial photography, DRG's, and DEM's. ArcGIS with Mobile GPS on Tablet PC's with DOQQ referenced satellite imagery for field data entry will be the future of this program. The result is an ever-changing "Big Picture" of Agriculture in California.

Agriculture in California: Basic Land Use Data Collection

I am going to take you on a trip, an odyssey so to speak of our Land Use Survey Program; where we came from, some of the pitfalls we have met along the way and where we would like to be in the future.

"We are currently overdrawing our water bank account in California by about 5,000,000 acre-feet per season, mostly by overdraft on our ground water basins…"

This statement was extracted from a publication of the State Water Resources Board in March of 1956 and was presented to the State Legislature in support of the establishment of the California Water Plan for the control, conservation, protection and distribution of the waters of California. The first California Water Plan was bulletin #3, which came out in 1957. Subsequent versions of the California Water Plan are due every five years.

The California Water Plan, now referred to as the Bulletin 160 series, is the driving force behind the majority of the Department of Water Resources (DWR) Land and Water Use Program's data collection and analysis. Bulletin 160-2003 is the latest version.

"The Bulletin 160 series assesses California's water needs and evaluates water supplies, to quantify the gap between future water demands and water supplies"

In order to project future water use we need data on water use now and in the past. To this end, the state was divided into four districts; North, Central, San Joaquin and Southern. The Northern District, shown in image 1, is comprised of the thirteen counties covering the Sacramento and Feather River drainage areas.

The Land and Water Use section in each district is tasked with performing agricultural surveys of each county in order to collect data on the crops being grown and the water source for these crops. The valley counties are surveyed approximately every five years and the mountain counties every seven to ten years because of a lesser degree of agricultural activity and change in these areas.

In the 1950's there was no readily available source for current land use data in California. Some studies had been done by other governmental entities but the focus or scope of these studies was not specific enough for DWR's purposes. These previous studies did at least give us a blueprint for conducting our surveys.

Aerial photography was obtained from sources outside DWR to use for field truthing. These photos served to define the scope of work. As an example, Tehama County is defined within 110 United States Geological Survey (USGS) 7.5 minute quad sheets with an average of nine photos per quad this results in more than 1,000 photos. Cursory reviews showed that most of the photos do not depict agricultural activity but were either mountain forestlands or native vegetation, which could be safely ignored for the purpose and scope of our study. The remaining photos that depicted agricultural activity at the time of the photo were used as field sheets to record crop information during the land use survey (see image two).

Since there was limited space on the photos, a set of codes representing crops and water sources was developed and a standardized legend was finalized. This legend developed in the 1950's is still in use today with minor changes.

Field boundaries of interest were delineated and data was added to the photos according to the legend definitions. For example the code nF2 tells us that at the time of the survey the field was non-irrigated safflower, iF6 refers to irrigated corn.

Data collection could take from two to six weeks depending on the size of the county, the number of personnel available for the work and the complexity of the agricultural activity. I want to emphasize that approximately 95% of all fields *are* visited. We have found that data collection methods that involve less field truthing, such as photo interpretation, are inherently prone to errors and can lead to faulty assumptions and projections. The early surveys collected data only on crop type and whether or not the crop was irrigated. Once the field data collection was completed all field boundaries were hand drawn on USGS 7.5 minute quads and the land use codes were added inside the corresponding boundaries for use in data tabulation.

The "Cut and Weigh" method of tabulation is a fairly simple but time-consuming process. Copies of the maps were made on special paper with a consistent weight-to-area quality. The field boundaries were cut out, painstakingly sorted as to crop type and placed in envelopes. The scale of the map was used to calculate the size of a one-acre piece of the paper and it was weighed. By weighing all the cutout shapes in each category we could calculate how many acres of each crop was being grown for a survey year.

An obvious problem with this system was the literal loss of data. Sizes of these agricultural units varied from extremely small to several inches in size. The smaller pieces of paper could be easily lost or covered up, or in one instance, someone walked into the room and turned on a fan, which blew the collected pieces all over the office.

The end result of the “Cut and Weigh” method was a hand compiled hardcopy tabulation of the survey results. Unfortunately, this report was only readily understandable to the experts involved in the survey. A “lay person” with a copy of the legend could determine crop type and acreage, and whether or not the crop was irrigated, but any further analysis was extremely difficult without an extensive background in agricultural water use and cultural practices in the area being analyzed. Aside from the Landuse Legends the only records of procedures and assumptions made for these old reports are the people that were involved in planning and performing the surveys. We are fortunate to still have a few of these people working for the department but the development of “Metadata” was becoming an increasingly important task.

Over time, some improvements were made to the field data collection process. Color 9X9 photography was introduced to help with photo interpretation of crops grown before the actual fieldwork. Color slide photography taken by DWR personnel from a chartered small plane allowed us to save costs over conventional 9X9 photography. Field boundaries were interpolated from the slides projected onto a screen and drawn on hard copy USGS 7.5 minute quad sheets and these sheets were used for field truthing.

The scope of the data collection has also been expanded. The need was seen for quantifying the water source, whether it was ground water, surface water or mixed surface and ground. We also try to identify the method and power being employed to pump the water and the entity delivering the water. We began to record special situations such as abandoned orchards and cover crops used for soil stabilizations and, more recently, ecosystem restoration. Also recorded now are various cultural practices, such as flooding for weed control or sprinklers for frost protection

Farmers, water districts and farm advisors are interviewed to obtain more detailed information for the areas to which we could not gain access and to verify any assumptions we may have made where crop type or irrigation and water source was not evident from field inspection.

Processing of the hard data in the office had not changed. We were still using the “Cut and Weigh” method into the late 1980’s. The advent of the computer changed all this.

With computers, we were able to trace the field boundaries in AutoCad using a digitizing tablet and enter the data as attributes. Procedures were developed to clean up the line work for GIS input and then this data was delivered to Headquarters for GIS processing. Our first attempt at developing a working GIS at the district level was GeoSQL.

GeoSQL was sufficient for data management but did not easily produce maps and its querying abilities were all code-based and frustrating. Meanwhile a GIS program called GRASS was being implemented at Headquarters. The GRASS program was a DOS monster that I believe was developed by UC Berkley. The program had several problems with input from AutoCad (such as island polygons) and again did not easily produce maps or query data. This piece of software was only available at Headquarters and was never useful to us at the district level.

Our second attempt at a GIS system at the District level was ArcView. This program would accept our cleaned up line work from AutoCad without the problems encountered with GRASS and produce excellent quality maps for analysis from easily input queries.

Now, The digital format of the data drawn on the USGS 7.5 minute quads was input for our GIS system instead of hardcopy input to the ““Cut and Weigh”” method. We now had the ability to produce on-demand maps showing our land use codes and produce easily understandable color-coded maps for analysis purposes. Data was exported from ArcView to Microsoft Access to produce reports that responded to data queries on a real-time basis. Various “canned” reports were developed for use to standardize data dissemination and allow comparison of surveys on a county-to-county and year-to-year basis. A metadata collector was developed for ArcView to standardize record keeping for procedures and standards used during the surveys.

So, we now had a system that would take us from data acquisition in fieldwork, to data compilation in the office and documentation. However, when we had two consecutive surveys for the same area in our GIS system we noticed that the acreage totals from survey to survey did not match and “Change Analysis” on these totals did not match reality.

Although we were using the same base maps (USGS 7.5 minute quads) the line work for each survey was still being interpolated from photos and placed on the maps by hand. Fields that had not changed shape in the real world were different sizes when they were digitized. Problems inherent with registering a paper map to a digitizing tablet and then tracing hand drawn pencil lines gave us erroneous results.

We now had to eliminate hand drawn field boundaries and their inescapable quality control problems, and to “heads up” digitize our line work on a digital base map that was reliably consistent from year to year. Digital photography seemed to be the answer to this problem but much to our dismay we realized that all imagery is not created equal or even easily understandable because of differences in ground resolution, photo quality and other problems.

Since the agricultural industry is a constantly changing enterprise in most areas, the most current photography was essential. We tried converting our 9X9 color photography into digital format. Photos were scanned, rectified and mosaiced and then registered to the four corners of digital USGS 7.5 minute quads. Due to the limitations of the software and procedures being used and the quality of the original photos the resulting image was far from perfect. In some instances there would be anywhere from ten to thirty meter offsets to roads or other features along the match line between photos. This turned out to be a fairly expensive method that did not produce the high quality, high resolution and consistent base mapping that was required. High quality image conversion from our own current photography was apparently beyond our expertise and budget.

We then discovered USGS Digital Orthophoto Quarter Quads (DOQQ’s). These images were based on the coverage of the USGS 7.5 min hard copy quads (nationwide). The image quality was excellent, resolution was more than acceptable, and they were relatively inexpensive at the time. Now, however, they can be downloaded for free from various internet sites.

We could do “heads up” digitizing on a high quality consistent digital base map that would allow easy comparison of consecutive surveys for the same areas. We would still have to obtain current hardcopy photos for fieldwork to allow us to interpolate boundaries that had changed since the time of the acquisition of the DOQQ's.

Suddenly, due to budget constraints we no longer had the resources to purchase any type of imagery.

For our future surveys we were bleakly looking at printing out our five-to-ten-year-old DOQQ imagery for field verification and then "heads up" digitizing on the same digital image without current photography to help us in field data collection or for correction of line work in the office.

The National Agricultural Imagery program (NAIP) came to our rescue. In concert with the US Department of Agriculture (USDA) and Farm Services Agency (FSA) the NAIP program is acquiring high quality digital imagery for the purposes of tracking agriculture. This is a nationwide effort to collect digital imagery on a yearly basis and make it available to governmental entities throughout the state. This imagery is captured from June through August of each year and made available in October of the same year. Field boundaries that were "heads up" digitized on the DOQQ's and overlaid on the NAIP photography matched almost perfectly. One-year-old imagery was not the perfect solution but was very palatable considering the limited alternatives.

It was time to update our equipment being used for data collection. Laptop computers were used with varying degrees of success. They were expensive, heavy, hot, fragile and the screens were hard to see. Then along came the Tablet PC (image 3). The Tablet PC is basically a handheld PDA with a 8½ X 11 screen large enough to be useful for large-scale imagery and fieldwork. These units are shock-resistant, water-resistant and have glare-proof screens, 256mb of RAM, wireless internet, detachable keyboard and a standard 40GB hard drive (80GB HD's are now available). I have upgraded our units to one GB of ram and a better video card.

The Table PC's operating system is a full version of Windows XP (in contrast to the limited version and capabilities offered on most PDA's) and has a standalone version of ArcGIS 9.0 loaded on it. A standard out-of-the-box ArcGIS toolbar allows for the use of a GPS unit for continuous updating of your field location. Character and voice recognition are also standard with this system.

Another standard out-of-the-box ArcGIS toolbar allows for data collection (writing directly on the screen) to be captured as graphics and then later converted to line shape files.

Our Tablet PC's have the ability to run ArcGIS in the field with both data collection and GPS capabilities. Also, we have the capacity to load the most current photography available from NAIP, the DOQQ's (MrSid compressed versions) for the entire county being surveyed and our field boundaries, which were "heads up" digitized on DOQQ's during prior surveys, for reference. There will no longer be any guesswork as to our location in the county, which field we are looking at, exactly where a particular well or dairy pond is or how many sites have yet to be surveyed.

Although this procedure greatly increases the efficiency and accuracy of our data collection we are still basically writing on the photos as we did in the past. In AutoCad we have a drop-down menu that allows for direct data input of crop and related data to attributes within the drawing file. I am currently working on an application for ArcMap that will allow data entry of all types (crop, well locations, infrastructure details, etc.) in the field directly to the database.

In conclusion, we have come a long way from the 1950's. Our methods for data collection have improved and expanded to include every facet of the agricultural industry. Field-quality computers will help us handle this expanded input faster thereby spending less of your state dollars in the process. Improved base mapping imagery gives us the most accurate field boundaries and acreages. The best software applications streamline our data processing and allow us to query our data spatially on a real-time basis.

Image 1

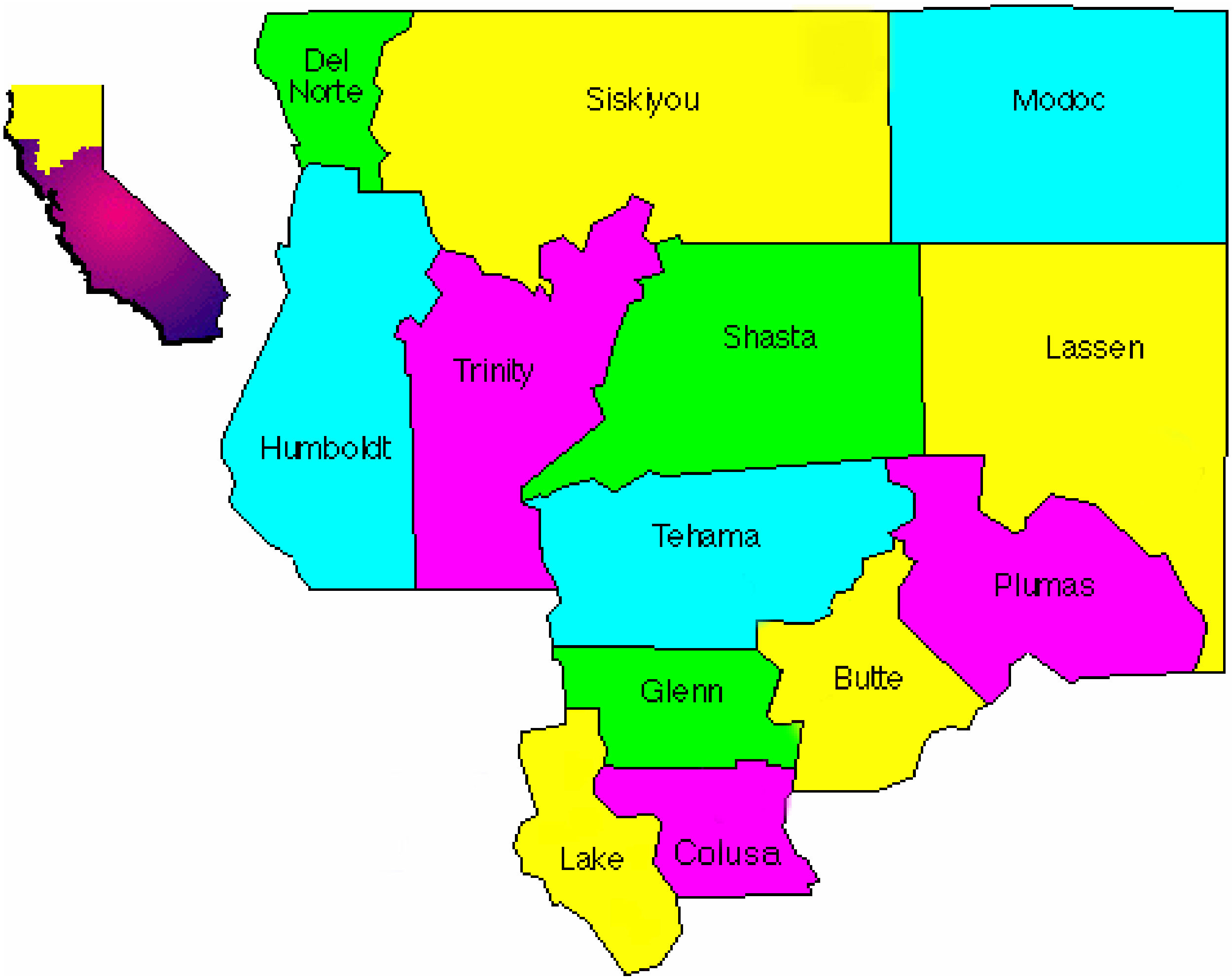
Del Norte
Siskiyou
Modoc
Shasta
Lassen
Trinity
Humboldt
Tehama
Plumas
Glenn
Butte
Lake
Colusa

Image 2

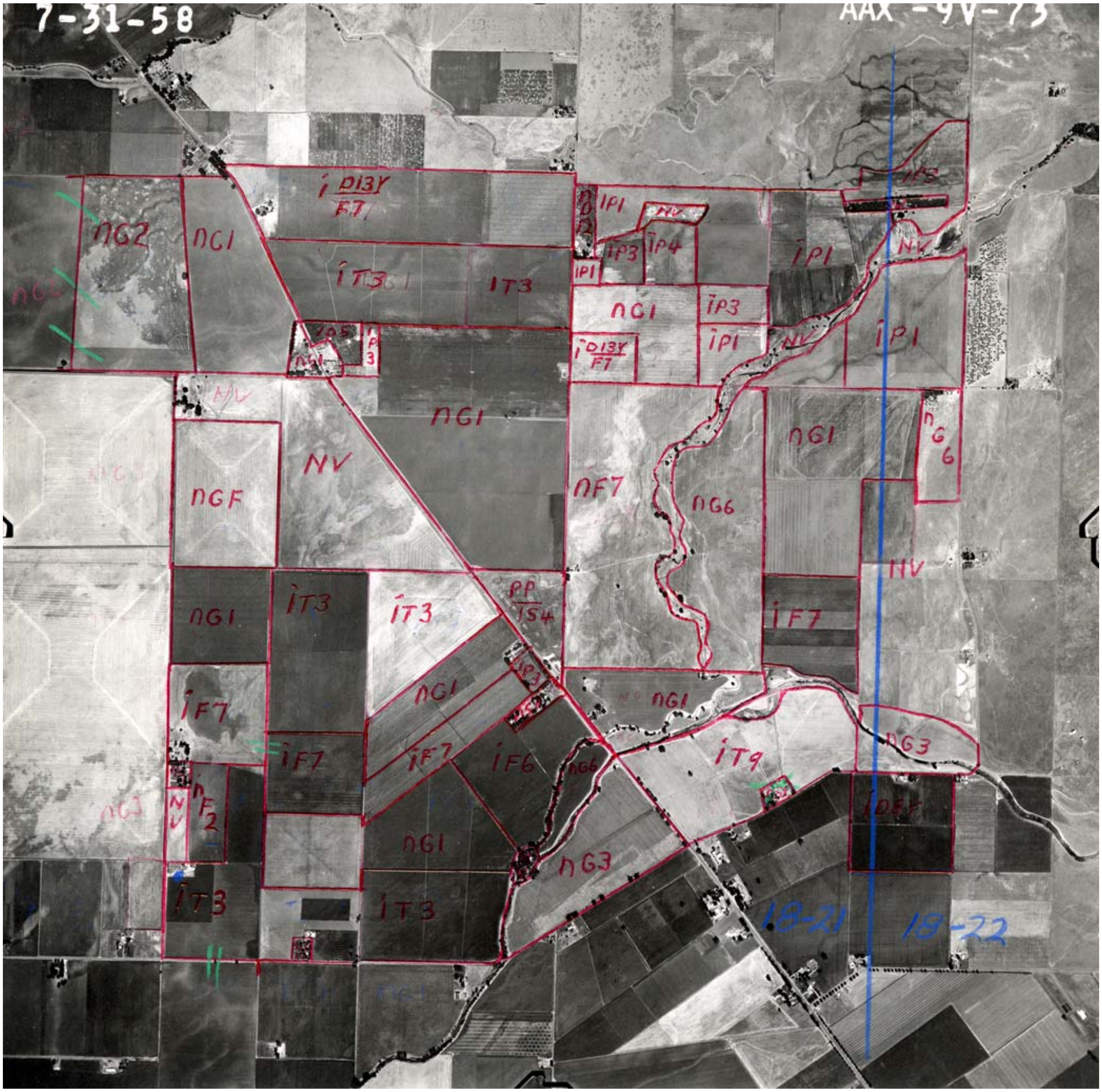

Image 3