# Water Resource Management: Mapping of Current Land Use and Irrigated Agriculture Using Mutlitemporal Landsat Imagery

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State agencies, water providers and water users are constantly evaluating management of water resources in response to increases in population and demand, droughts, endangered species issues and reductions in Federal water program funding. A comprehensive decision support system (DSS) is being developed for each of the major river basins in Colorado. These will provide State of Colorado agencies, water users and managers a better means for organizing, accessing and evaluating a wide range of information and alternative strategies for managing their water resources. This, in turn, will help DSS users make informed decisions regarding major water issues and policy positions.

There have been major changes in land use and irrigation practices in each of Colorado's major river basins. An assessment of current irrigation water use, and changes in irrigation water use over the past 50 years, is needed by water users and water providers for water management purposes and for water rights administration by the State engineer. Such an assessment would address the following needs:

- Need of reliable mapping of current and historic land use and irrigated acreage by crop type
- Need to link irrigated areas with their sources of water supply. This will require mapping of ditch systems and well locations with their respective service areas.
- Need an assessment of major changes in land use and irrigation practices (i.e., changes in irrigated areas, transition to center pivot irrigation methods, and conversion of irrigation to municipal and industrial water use)
- Need of a system for mapping and analysis that is dynamic and efficient, fully documented, easily maintained and updated
- Need mapping of native vegetation category

NCDC Imaging utilized commercial image processing software and multitemporal Landsat satellite imagery to classify the crop type for each field parcel in the study area. County agricultural statistics was used as a reference. A limited but carefully selected set of ground information was also collected. The primary source of ground data was the Farm Service Agency's annual delineation of crop types provided by producers on high-resolution aerial photographs, which cover approximately 50 percent of farmlands in the study area. These FSA data was supplemented with data from ditch companies and irrigators. The goal of this data is to assist in making informed decisions regarding historic and future use of water.

**Inputs:**

1) Landsat TM (5 & 7) scenes over the AOI

   Dates: 2000/04/05, 2000/05/23, 2000/05/31, 2000/06/16, 2000/07/18, 2000/07/26, 2000/09/12, 2000/10/14

2) Field Boundaries

3) Ground Verification Data

**Methodology:**

1) We have found that the best classifier for crops is to use corrected NDVI so that we can follow the phenologic progress of the fields and thus, unequivocally ID crops. We corrected each of the 8 Landsat scenes to yield an atmospherically resistant form of NDVI. The correction is designated NDVI* that scales the NVDI from 0 to 1 to match the potential range of vegetation. This calculation enables us to follow each crop through the season.

2) During the pre-classification effort, we georeferenced the digital raster graphic (DRG0 files to match the field boundaries provided by CWCB. This provided us with the base data that we needed to create the training data for each crop type. See Figure 1 below for an overview of the 3 georeferenced DRGs with the field boundaries overlaid onto the false-color Landsat NDVI* scene.

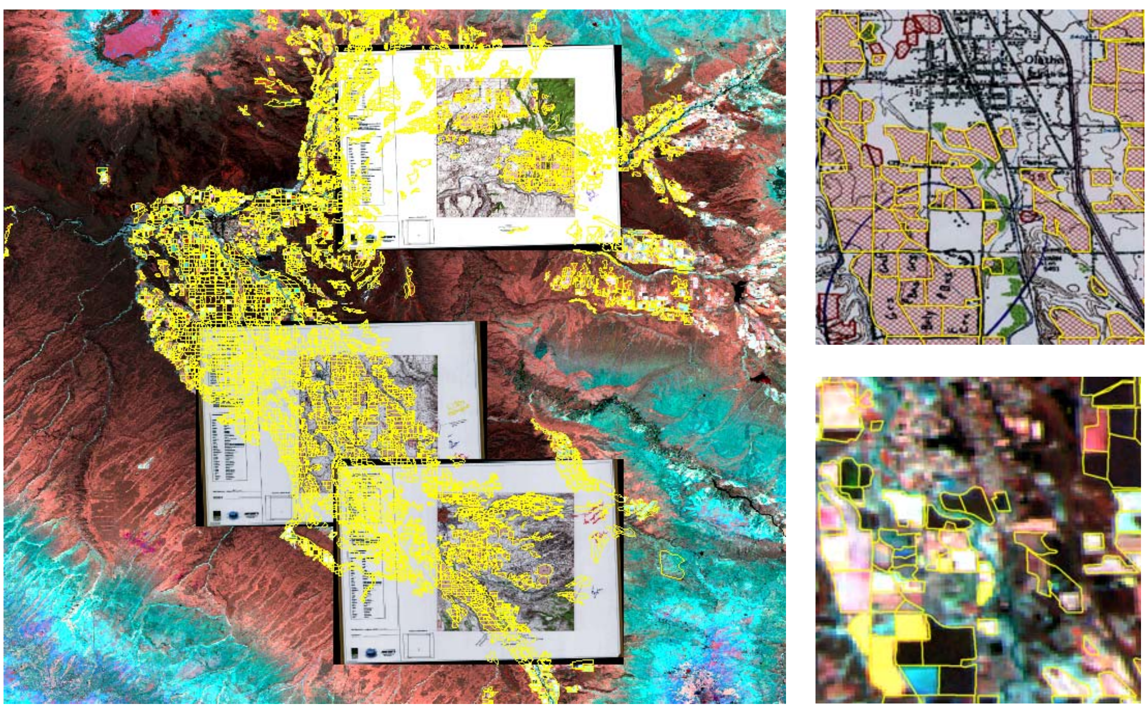
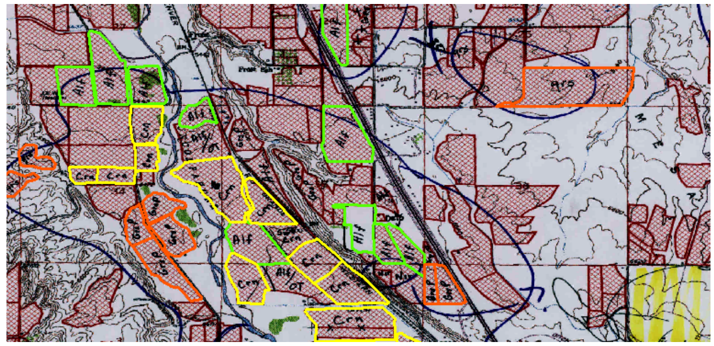


Figure 1: Georeferenced DRGs with CWCB-provided Field Boundaries and False-Color Landsat NDVI*

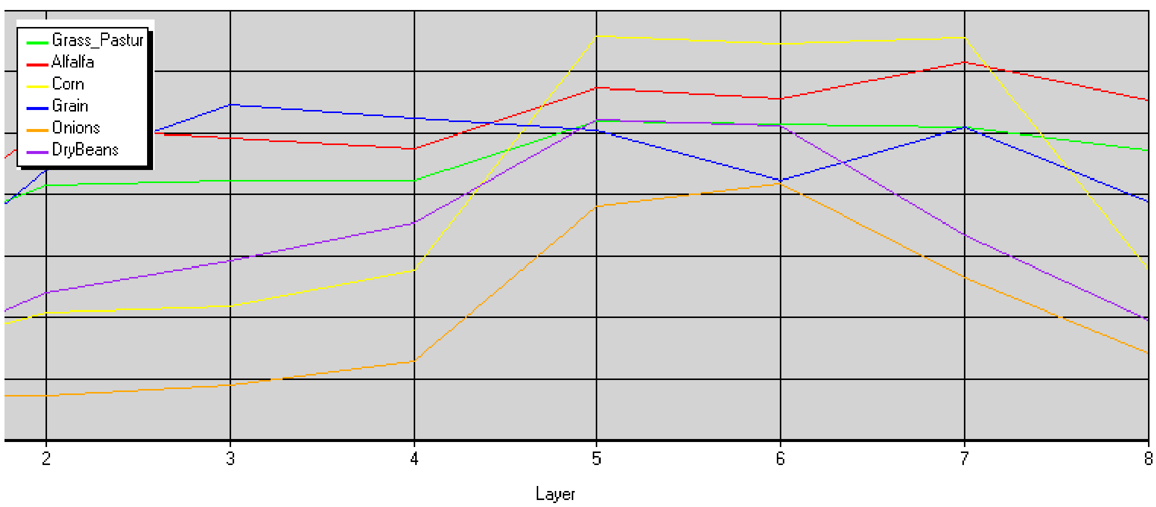
3) With the field boundaries, field verification DRGs and Landsat imagery now aligned, we selected the following breakdown of training samples (as entire fields) from the field boundaries polygon ESRI shapefile:

   a. Alfalfa – 37
   b. Corn – 24
   c. Grass/Pasture – 74
   d. Dry Bean – 3
   e. Grain – 3
   f. Onion – 2



As you can see, there is a significant difference in the number of training samples used in this classification. Ideally, we would have liked to see at least 10 dry bean, grain and vegetable training samples.

4) A spectral separability analysis was performed on these samples using the Transformed Divergence ("TD") method in ERDAS IMAGINE. TD values above 1700 indicate a good separation between classes and above 1900 indicate an excellent separation. Figure 2 illustrates the mean spectral signatures of the target crops and the TD separabilty.

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Signature Separability Listing

    Distance measure: Transformed Divergence

                       Best Average Separability

   Bands          AVE    MIN     Class Pairs:
                                 1: 2   1: 3   1: 4   1: 5   1: 6   2: 3   2: 4
                                 2: 5   2: 6   3: 4   3: 5   3: 6   4: 5   4: 6
                                 5: 6
  1  2  3  4     1859   1057     1057   1741   1768   2000   1932   1482   1982
  5  6  7                        2000   1999   1997   2000   1967   2000   2000
  8                              1960
```

Figure 2: Mean Crop Spectral Signature Plot and Transformed Divergence Separability Analysis Results

A quick evaluation of the TD separability would indicate that this classification should yield good results. Evaluating the NDVI scene and the TD results for Grass/Pasture versus Alfalfa showed that we would expect major confusion between these two classes (TD = 1057). We would also expect minor confusion between Alfalfa and Corn (TD = 1482).

5) We then ran a Maximum Likelihood supervised classification in ERDAS IMAGINE using these mean signatures above and the field boundaries as an area of interest. The resulting raster classification is illustrated in Figure 3.

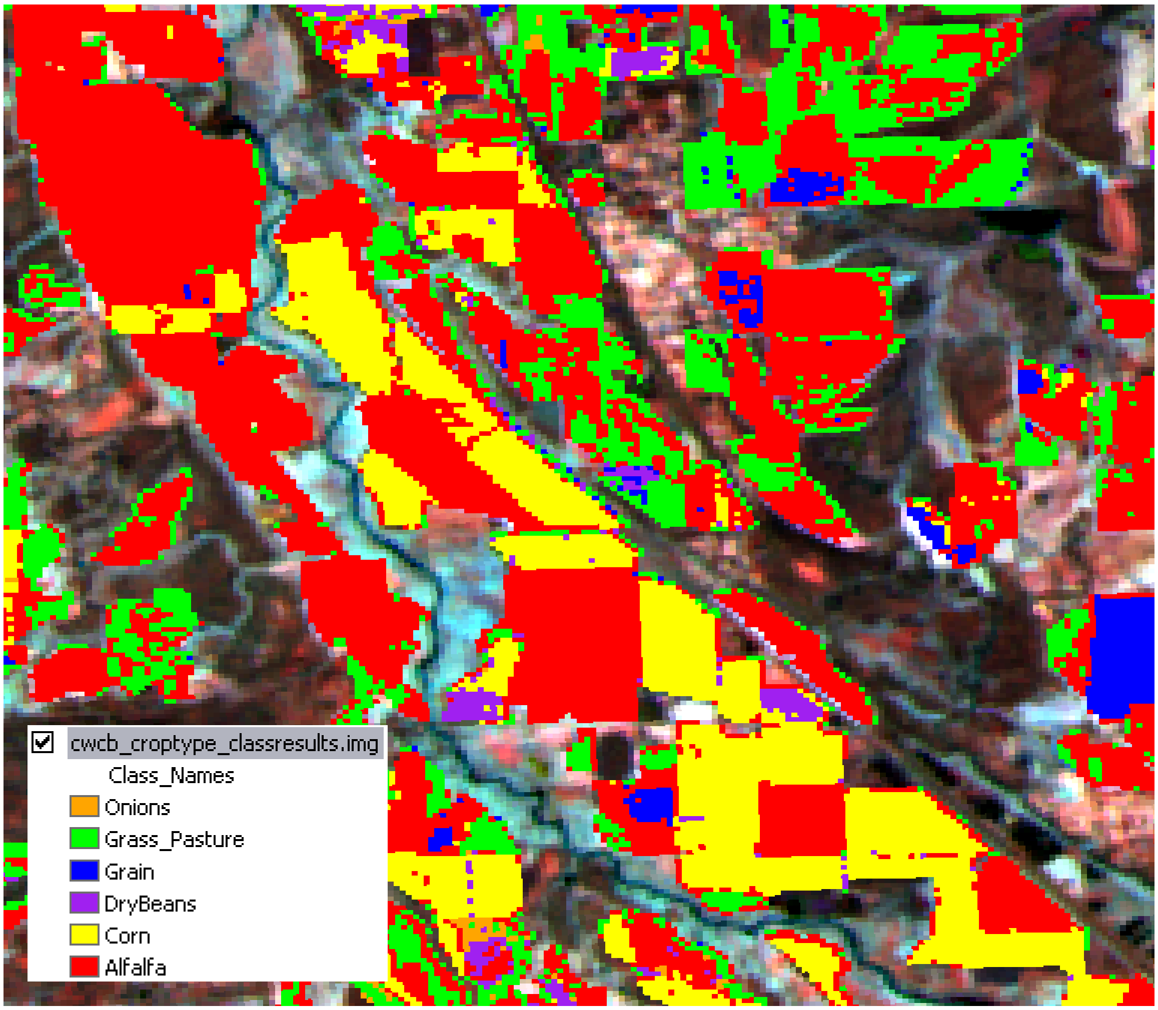


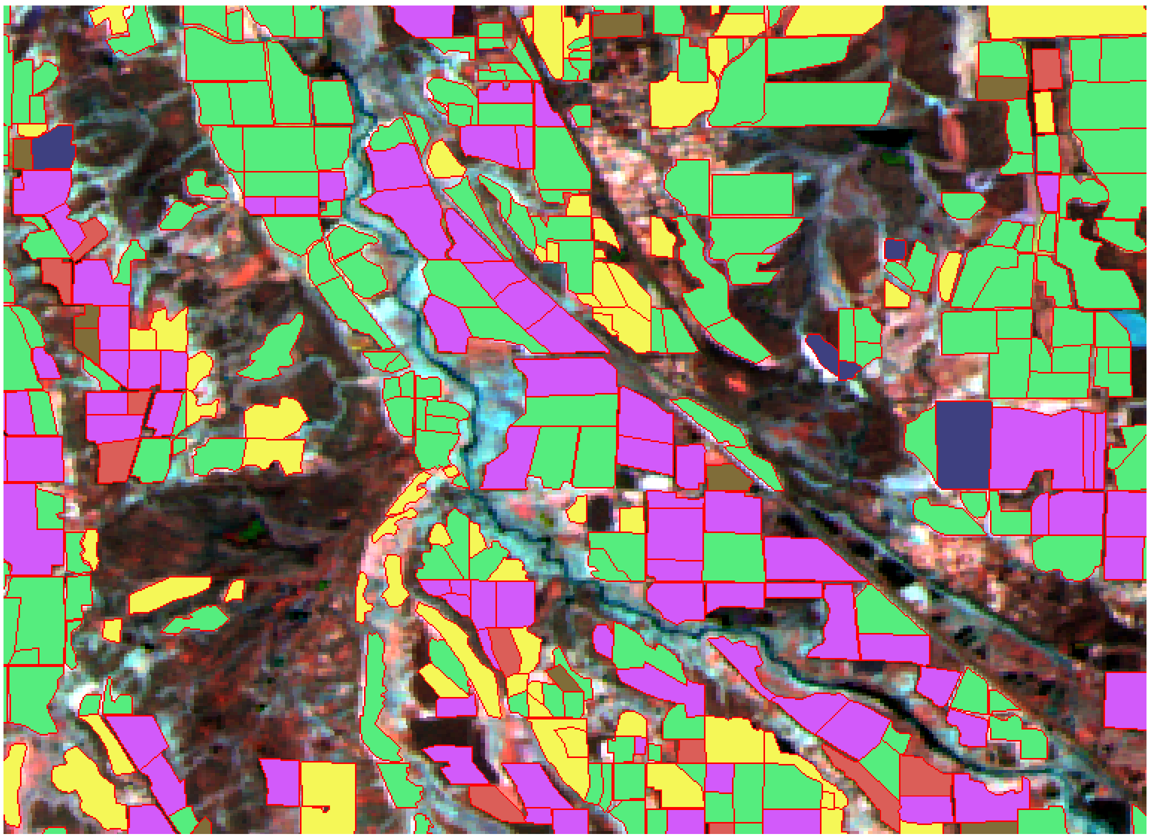

Figure 3: Maximum Likelihood Supervised Classification Results

6) Next we converted the raster classification into a vector shapefile using the Raster to Polygon tool in ArcToolbox. We simplified the polygons into simple shapes to reduce file size.

7) We intersected the vector classification shapefile with the field boundaries in order to generate area statistics by crop type for each field. We then summarized this shapefile by Parcel_ID to get a sum of crop acres for each field.

8) We then summarized by Parcel_ID again to get the maximum crop acreage for each field and calculated a maximum crop percentage of the total field acreage where, maximum crop percentage equals maximum crop acres divided by field acres.

9) In order to get to the final product of one field has one crop type, we joined the maximum crop type percentage shapefile with the field boundaries and removed duplicate attributes. The resulting shapefile also has a confidence attribute that was calculated using the MaxCropPct field. If the MaxCropPct was greater than 90%, then the confidence is 9. This means that more than 90% of the field is covered by a single crop classification. The scale goes down to zero, but these are fields that are outside of the Landsat image. Figure 4 shows an example of the resulting vector dataset with the associated attribute table.



Attributes of cwcb_croptype_final

| FID | Shape | DIV | CAL_YEAR | PARCEL_ID | IRRIG_TYPE | ACRES | COMMENT | Class_name | Cnt_PARCEL | Max_CropAc | MaxCropPct | Confidence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6584 | Polygon | 4 | 2000 | 8487 | UNKNOWN | 2.677 | | | 0 | 0 | 0 | 0 |
| 6585 | Polygon | 4 | 2000 | 8522 | FLOOD | 70.802 | | | 0 | 0 | 0 | 0 |
| 1095 | Polygon | 4 | 2000 | 1859 | FURROW | 34.777 | | Grass_Pasture | 25 | 6.280044 | 0.18058 | 1 |
| 3096 | Polygon | 4 | 2000 | 4125 | UNKNOWN | 2.614 | | DryBeans | 11 | 0.484951 | 0.185521 | 1 |
| 3463 | Polygon | 4 | 2000 | 4682 | FURROW | 17.412 | | Alfalfa | 30 | 3.153164 | 0.181091 | 1 |
| 3995 | Polygon | 4 | 2000 | 5343 | FURROW | 33.942 | | Onions | 36 | 6.021664 | 0.17741 | 1 |
| 4264 | Polygon | 4 | 2000 | 5659 | UNKNOWN | 57.323 | | Alfalfa | 62 | 8.283278 | 0.144502 | 1 |
| 4430 | Polygon | 4 | 2000 | 5834 | FURROW | 53.78 | | Grass_Pasture | 45 | 10.181772 | 0.189323 | 1 |
| 4503 | Polygon | 4 | 2000 | 5910 | FURROW | 44.915 | | Alfalfa | 55 | 4.720437 | 0.105097 | 1 |
| 4703 | Polygon | 4 | 2000 | 6153 | FURROW | 45.266 | | Corn | 39 | 8.29409 | 0.18323 | 1 |
| 4718 | Polygon | 4 | 2000 | 6168 | FURROW | 23.095 | | Onions | 24 | 4.327039 | 0.187358 | 1 |

Record: 0 Show: All Selected Records (0 out of 6586 Selected) Options

Figure 4: Illustration of Final Results – Above: Resultant Vector Shapefile; Below: Associated Attribute Table