2006 Irrigated Land Classification
for the
Eastern Snake Plain Aquifer

Introduction

IDWR is revising its Eastern Snake Plain Aquifer (ESPA) groundwater model. As part of that revision, the Geospatial Technology Section was asked to generate a new digital classification of the irrigated land within the boundary of the ESPA model. Water from irrigated land is a source of significant recharge to the aquifer, and is one of the factors that determines the accuracy of the model's predictions. The new classification would replace the old classification that is circa 1992. The area of the Eastern Snake Plain is illustrated in Figure 1.

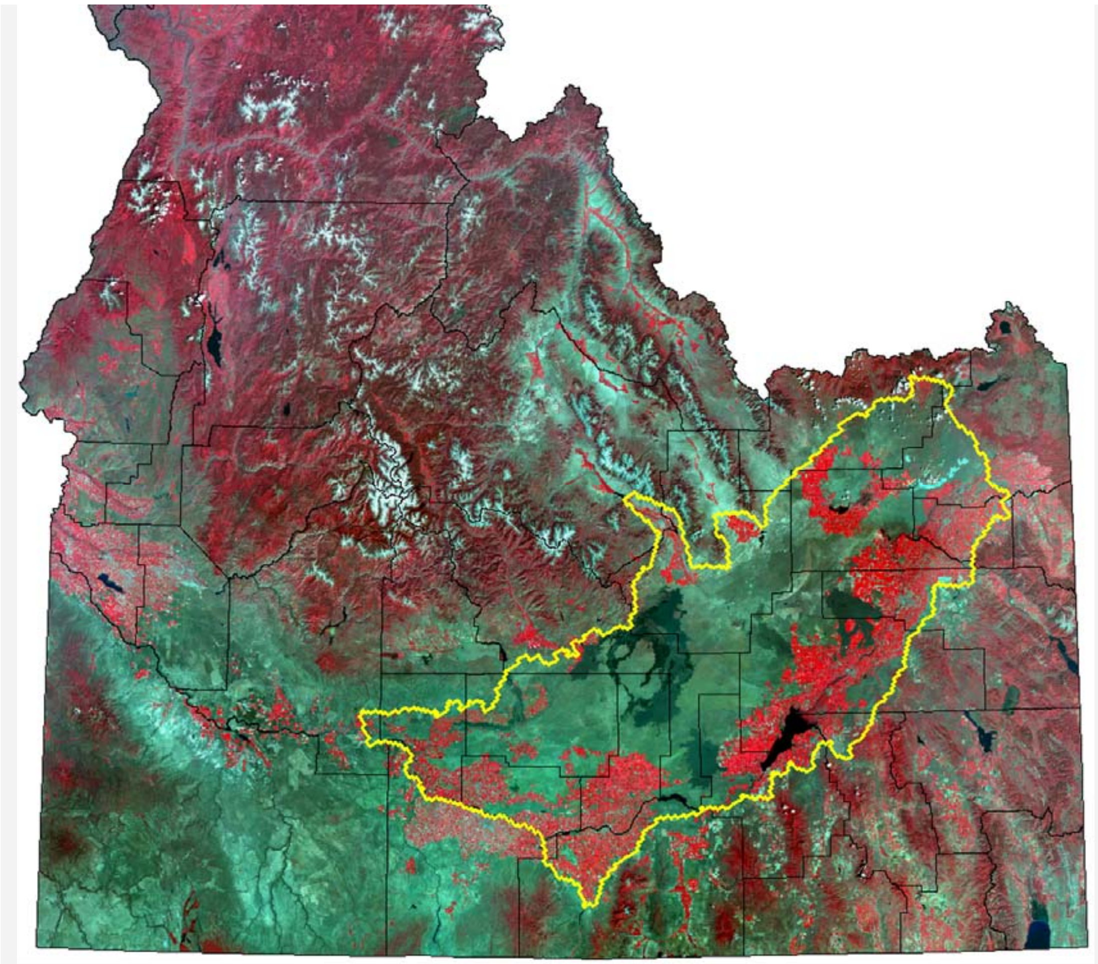

Figure 1. The boundary of the Eastern Snake Plain Aquifer Model in yellow.

Several approaches to the classification were considered and for various reasons, rejected. The primary goals of the classification were to delineate agricultural land 1) as precisely as possible, 2) as accurately as possible, and 3) as recently as possible.

The classification scheme chosen achieves all three goals by using a combination of computer processing and human interpretation operating on both Landsat satellite data and on digital aerial photography acquired through the National Agricultural Inventory Program (NAIP). All image data are from the year 2006.

In conjunction with the image data, IDWR analysts used Common Land Unit (CLU) polygons of individual fields that were digitized from a combination of 2004 and 2006 NAIP imagery by the Farm Services Administration (FSA). Although FSA will allow access to CLU polygons, they deny all requests for access to the associated attribute data, including the land-cover codes. IDWR, therefore, used the unattributed CLU polygons. The CLU polygons were used because they are an existing, recent, highly-detailed, vector dataset that IDWR could attribute easily as irrigated or non-irrigated. Figure 2 shows CLU polygons superimposed on a NAIP image.

Figure 2. Common Land Unit (CLU) polygons in black superimposed on a National Agricultural Inventory Program (NAIP) image.

CLU Data

FSA created the CLU polygons as part of its crop compliance responsibilities. While the CLU data are extensive, and have been finished for all the counties on the ESPA, the polygons themselves needed editing to meet IDWR's needs. An examination of CLU data at the beginning of the project revealed the need for editing the polygons, sometimes in detail. Nevertheless, the need for editing sometimes clashed with the project deadline. While some counties would benefit from more editing, the effects of additional editing would be relatively small.

The Classifier

IDWR used a 3-step classifier to map irrigated land on the ESPA. The first step used Landsat satellite data, the second step used a combination of Landsat and NAIP digital photography, and the third step used NAIP photography and CLU data.

The First Step

The first classification step used Landsat satellite data exclusively. Landsat is a medium resolution satellite with square pixels that are 30 meters on each side. IDWR used 3 dates of Landsat data: June 20, 2006, July 22, 2006, and August 7, 2006. Those dates were used because they were the three that were available at IDWR for processing with the METRIC evapotranspiration model.

Landsat 5	Landsat 7
April 26	April 4
May 12	October 11
June 13	
July 15	
August 16	
September 1	
October 3	

Table 2. Landsat scenes dates for Orbital Path 39

Landsat 5	Landsat 7
May 3	April 25
May 19	August 31
June 20	
July 22	
August 7	
September 8	
September 24	
October 10	

Table 1. Landsat scenes dates for Orbital Path 40

As part of the METRIC processing, each pixel in each scene in transformed to produce a vegetation index, specifically the normalized difference vegetation index (NDVI), which is computed as

$$\frac{\text{band 4} - \text{band 3}}{\text{band 4} + \text{band 3}}$$

The actual computation is more complex, and involves converting the raw digital numbers in each pixel to radiance and reflectance. This is done as part of the METRIC processing to process a consistent set of data from scene to scene.

The NDVI is highly correlated with vegetation canopy characteristics, including leaf area index. Plotted through a growing season, the normalized difference nicely tracks the development of vegetation.

IDWR transformed all three dates of Landsat data to NDVI, then clustered and classified the data into 255 spectral classes. The 255 spectral classes were superimposed on the Landsat false color images and interpreted to either “irrigated” or “non-irrigated,” producing a Landsat classification of irrigated and non-irrigated pixels as illustrated by Figure 3.

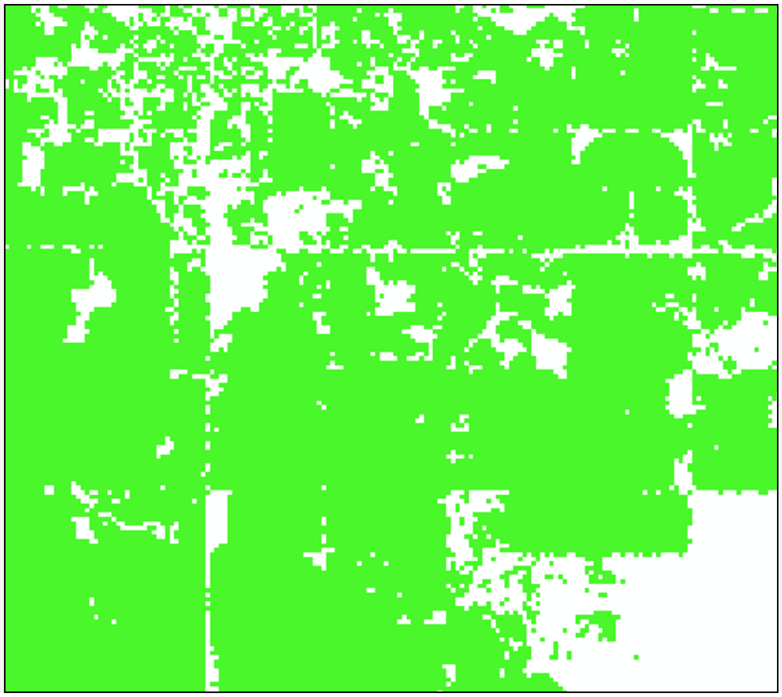

Figure 3. The initial Landsat-based classification output from Step1 of the classifier. Irrigated land is green

The Second Step

The second step in the classification was to overlay CLU polygons on the Landsat classification, as illustrated by Figure 4. A simple decision rule as applied that made a polygon irrigated if at least 75% of the area of the polygon was covered by pixels classified as irrigated. Figure 5 illustrates the result of applying that decision rule to Figure 4.

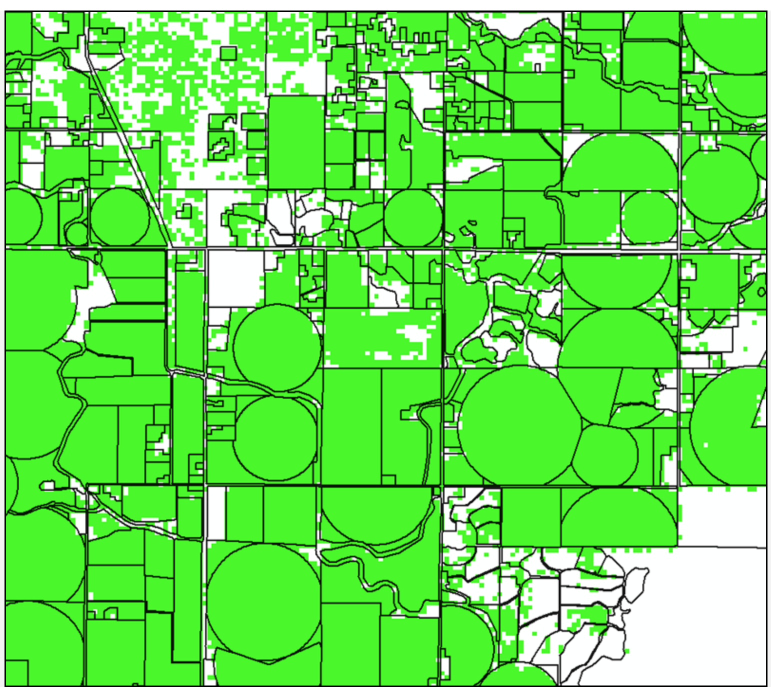

Figure 4. The initial Landsat-based classification output from Step 1 of the classifier with CLU polygons superimposed. Irrigated land is green.

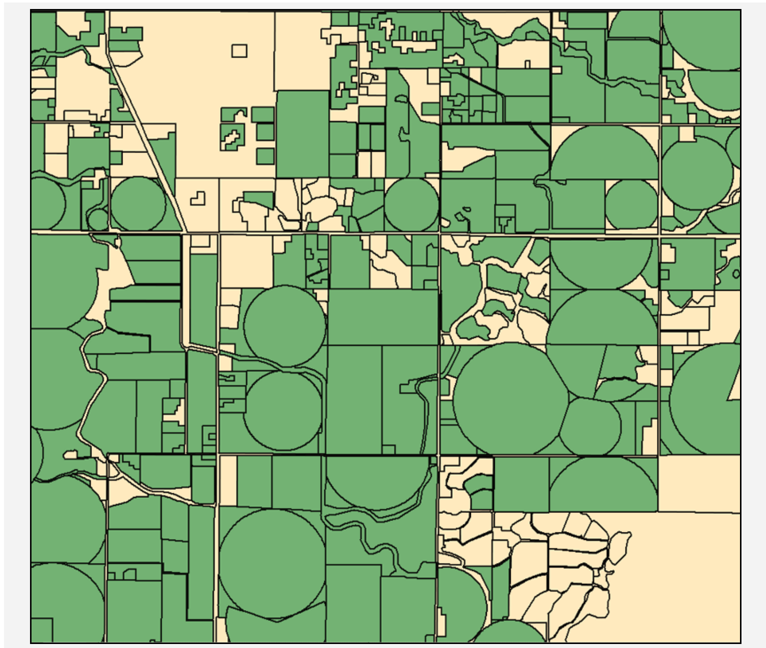

Figure 5. The Landsat-based classification output from Step 2 of the classifier with CLU polygons superimposed and all the CLU polygons classified as irrigated (green) or non-irrigated based on a 75% or greater rule.

The Third Step

The third step was to review the initial Irrigated/Non-irrigated classification by superimposing the classified image on top of the 2006 NAIP digital photography. This was done by alternately masking irrigated polygons (Figure 6), then by masking non-irrigated polygons (Figure 7), and finally by overlaying the masked image sequentially on all available dates of Landsat data, as illustrated by Figure 8, one date at a time, and on the NAIP images. IDWR used several dates of raw Landsat data that were not available as NDVI images.

Figure 6. Irrigated polygons masked to black and superimposed on 2006 NAIP image data.

Figure 7 shows masked irrigated polygons on a Landsat image. What is not masked is classified as non-irrigated. There are some irrigated fields (bright red in the color infrared image) being classified as non-irrigated. Those misclassifications were corrected by simple re-assigning as irrigated each CLU that showed up red. The process was repeated for available each date of Landsat data, and for the NAIP. This process caught land that was irrigated early or late in the season, periods that were not covered by the initial 3 dates of NDVI images or the NAIP.

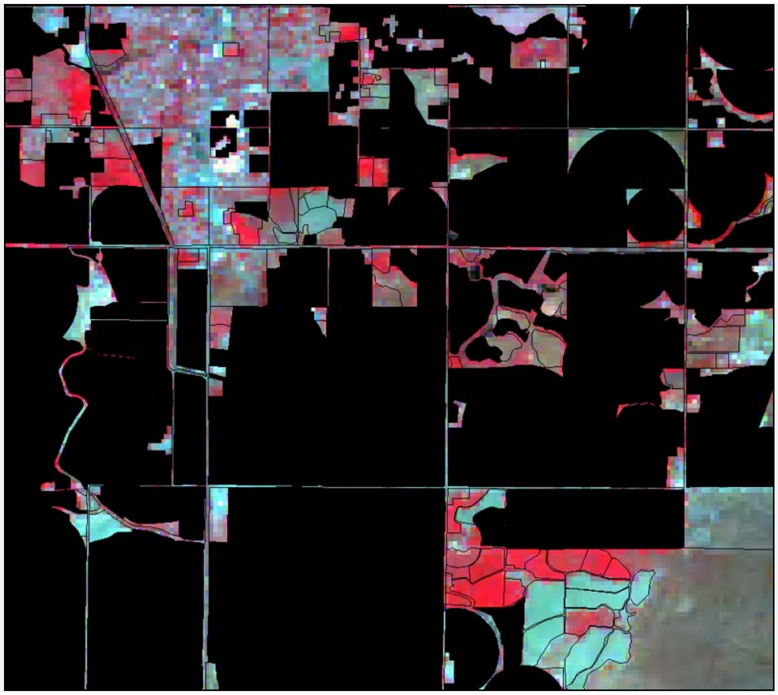

Figure 7. Irrigated polygons masked to black and superimposed on Landsat data from May 19, 2006.

The final result of the editing is illustrated by Figure 8.

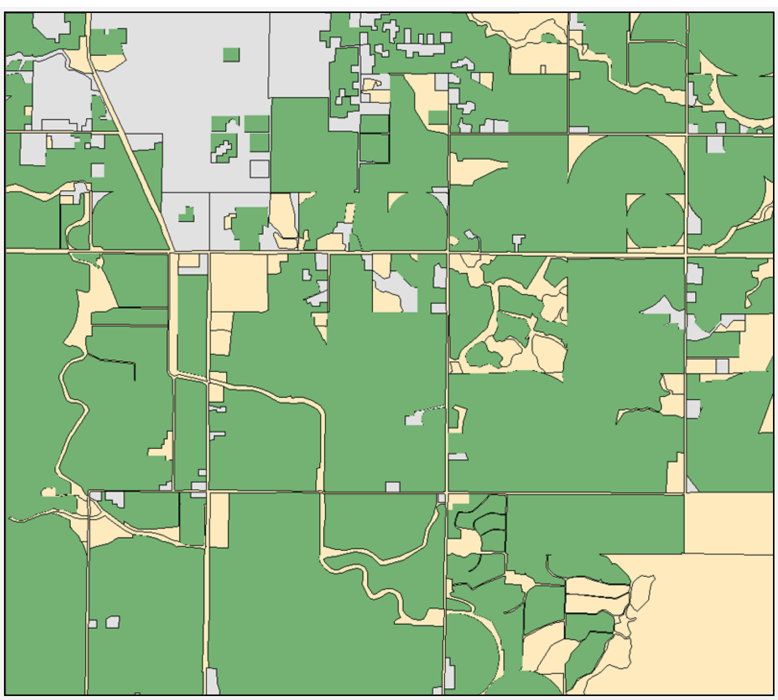

Figure 8. The final, edited classification with irrigated in green, non-irrigated in beige, and residential in gray.

The entire classification could have been done using just Step 3, but it would have taken longer and been more tedious. The first two steps were designed to classify quickly those fields that the computer could readily identify as irrigated. The third step was designed to use a human interpreter to make subtle decisions that were beyond the capabilities of the software, and to correct any classification errors. Figure 9 shows an example of one kind of those errors. Steps 1 and 2 resulted in small polygons of residential land being classified as irrigated. In Step3, those polygons were changed from “irrigated” to a third class not used in the first 2 steps: “residential.”

The residential class was added because there is generally irrigation occurring in residential areas, but the irrigation is not as intense or wide-spread as is the irrigation on agricultural land. The residential class captures that less-intense irrigation, allowing the hydrologic modelers to assign to that class an intermediate recharge value.

Figure 9. Non-Irrigated mask on NAIP. Arrows point to some residential land classified as irrigated. Those polygons are changed during editing.

Figure 10 shows the area with irrigated land mapped as of March 4, 2009.

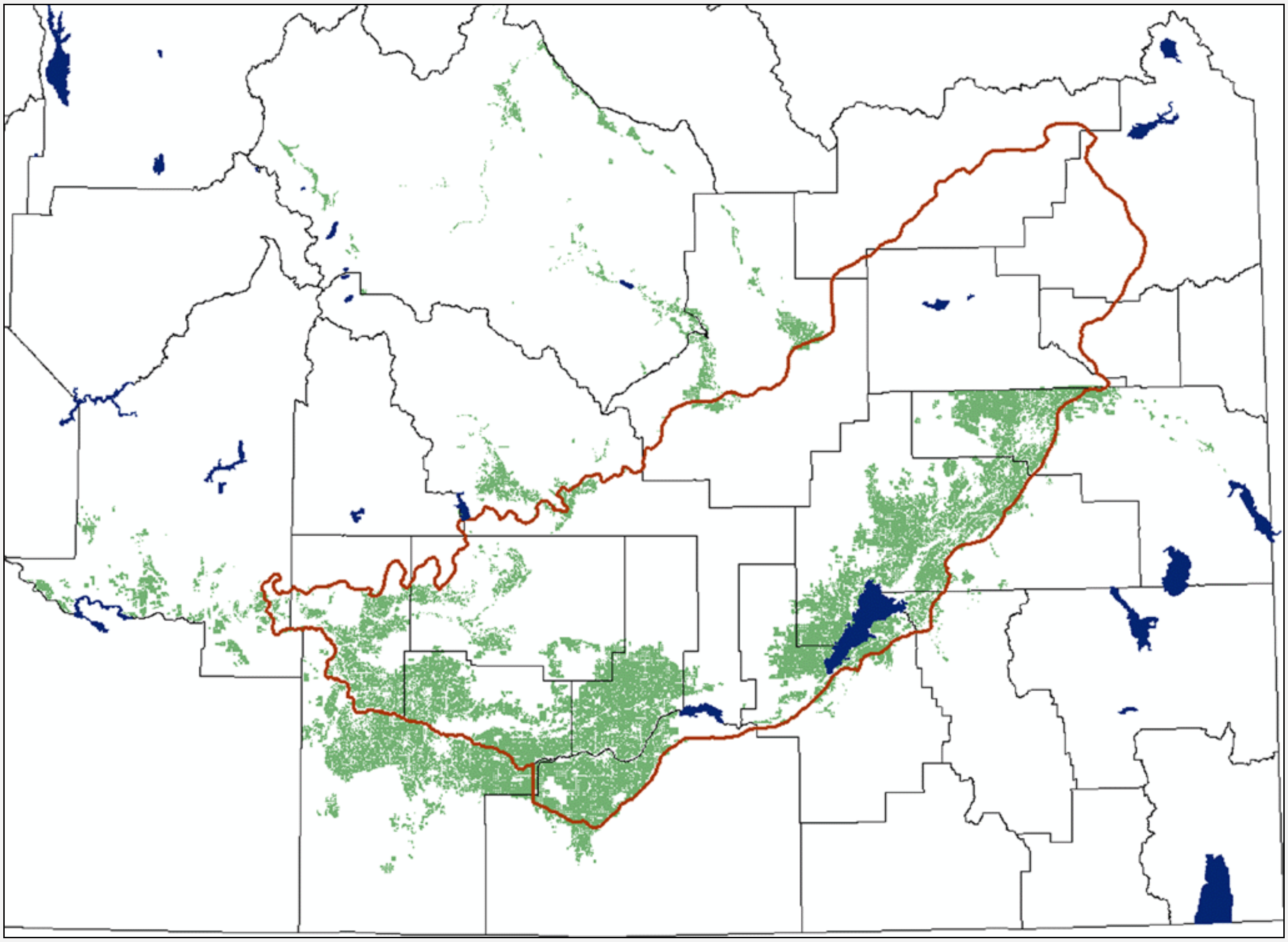

Figure 10. Status of the irrigated land classification on the Eastern Snake Plain Aquifer as of March 4, 2009. The aquifer boundary is brown, the irrigated land is green.

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Version 6
March 6, 2009