View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by IssueLab

Irrigated Acreage in Georgia's Altamaha River Basin During the Drought Year 2000

Water Policy Working Paper #2005-018

Prepared by:

Krawee Ackaramongkolrotn, Peter Terrebonne, and Ronald Cummings

with the assistance of graduate research assistants
Ki-whan Choi, Kovadio Dongo, Panupong Panudulkitti, and Abdul-Akeem Sadiq

Northern Georgia Water Planning and Policy Center
Andrew Young School of Policy Studies
Georgia State University

and
Elliott Marsh, Peta-Gay Major, and Nathan James

Coastal Rivers Water Planning and Policy Center
Georgia Southern University

June, 2005

*** The authors gratefully acknowledge financial support for this work received from the Georgia Soil and Water Conservation Commission, Contract No. 480-05-GSU1001; and the U.S. Department of Agriculture, Award Document No. 2003-38869-02007-1.**

Irrigated Acreage in Georgia's Altamaha River Basin During the Drought Year 2000

Abstract

Using a "mixed media" approach, which tracts changes in pixel (color) values over the summer indicating changes from dry land to wet land, we have developed estimates for irrigated acreage in the Altamaha River Basin that draws water from ground water or perennial surface water sources. The latter condition is assured given that our estimates come from identified irrigation during the summer of 2000, which was one of Georgia's worst drought years of record. It is improbable that irrigators reliant on non-perennial sources could have successfully irrigated a crop during this drought year.

Data provided here should be useful to the state in a number of ways. The state is moving forward with its plans to develop Basin Water Plans, and basic to such plans is information as to the agricultural sectors use of water under worst-case conditions -- conditions of drought. Further, such data can play important roles in efforts by the state to work out solutions to issues related to the use of interstate waters -- ground or surface waters.

Irrigated Acreage in Georgia's Altamaha River Basin
During the Drought Year 2000

I. Introduction

An estimate of the acres of land under irrigation during drought years in Georgia is critically important for the State of Georgia's interests in promoting basin water planning. It is still more important for the state's position in any litigation that might arise concerning Georgia waters shared by other states; examples include the ACT and ACF basin, as well as the Savannah River Basin along the state's eastern boundaries. Estimates for irrigated acreage are of particular importance in Georgia's coastal region, given ongoing efforts to develop basin water plans for the region.

Emphasis in this study is given to irrigation *during a drought year*. This follows from our interest in determining demands on areas' scarce water supplies during periods when such supplies are under greatest stress. Acreage that is irrigated from non-perennial water sources is not relevant for this purpose. Thus, unlike many other studies of irrigated acreage which focus on *all* acreage that has been irrigated at some point in time, this study's focus is limited to only those acreages irrigated from perennial sources. for this purpose, we measure irrigated acreage during one of Georgia's more severe drought years, the year 2000. Our study area is one of the Coastal Region's more important river basins: the Altamaha River Basin.

During 2004 researchers with the Georgia Water Planning and Policy Center explored the use of a method for estimating acres that were actually under irrigation using both aerial photographs and Landsat (satellite) data, an approach referred to as a "multi-media" approach that combines the two data sets.[1] To the end of assessing the effectiveness of this method, the multi-media approach was applied to Lee County for the June-August 2000 period. Results were then compared to other EPD-sponsored estimates for irrigated acreage in Lee County as a means for testing the reliability of the approach. This comparison is provided below in Table 1. The Litts, *et al.* study estimates acreage irrigated with center pivots in Lee County at 33,651 acres; our estimate was 33,228 acres; non-center pivot irrigation is estimated at 11,217acres by Litts, et al., 14,204 acres in our study. These two estimates for center pivot acreage are very similar because both use aerial pictures to identify center pivot acreage. However, with remote sensing techniques

Table 1: Irrigated Acres Estimated Comparison[2]

	Ours	**Litts et al.**	**EPD**
Center Pivot	33,228	33,651	36,970
Non-center Pivot	14,204	11,217	13,344
Total	**47,432**	**44,868**	**50,314**

we could identify center pivot farms that were *not* irrigated in the year 2000. On the other hand, the two estimates for non-center pivot acreage are quite different: our estimate is 27% higher than the Litts, et al. estimate. The Litts, *et al.* estimate for non-

[1] Cummings, Ronald G. and Krawee Ackaramongkolrotn, "Measuring Irrigated Acreage in Georgia: Methodological Issues," Water Policy Working Paper #2004-009, Georgia Water Planning and Policy Center (Albany: September, 2004).

[2] Comparisons to which reference is made are drawn from Litts, Thomas, Adrian Thomas, and Roy Welch, "Mapping Irrigated Lands in Southwest Georgia," project Report 45, Georgia Environmental Protection Division, Atlanta, 2001 (44 pp. plus appendices).; and Department of Natural Resources, Environmental Protection Division, Water Resources Branch, Drinking Water Compliance Program, SWAP Unit, *Agricultural Fields of the Upper Flint River Basin* (Atlanta: June 2003).

center pivot acreage was obtained from estimates provided by county extension agents, among other sources. Ours was obtained from direct observation of changes in vegetation indices.

The EPD study estimates acreage irrigated with center pivots in Lee County at 36,970 acres and non-center pivot irrigation is estimated at 13,344 acres. Our estimate for acreage irrigated under center pivot was only about 90% of the EPD's estimate. To some extent this difference may be attributable to the over-lapping of center pivot circles. When one examines aerial photos, one identifies center pivots by the signature circle that appears on the photo. In many cases, two center pivots overlap (see Figure 5 in our above-cited 2004 study). The area of *each individual center pivot* circle is included as irrigated in the EPD study, in which case acreage in the overlapping area is double counted.[3] Our estimates do not double count the overlapped areas. Our estimate for non-center pivot acreage was 106% of the EPD's. The EPD estimate is based on permit information which does not account for some acreage that farmers may irrigate without a permit, or may irrigate more acreage than is shown on the permit. Moreover, our study was based on the year 2000, while the EPD study is based on conditions extant in mid-2003 (reflecting, possibility new farms added since 2000). These differences could well account for the observed differences in estimated irrigated acreage.

[3] As one example, the EPD map shows acreage associated with two permits, A89-088-0073 and A89-088-0076 (rows 5057 and 5058 on the EPD Master worksheet), which have reported acreage of 206 acres and 163 acres, respectively. These acreage measures are the areas of two center pivot circles that overlap. The overlapped area is, therefore, double-counted.

These results appeared to us to provide compelling evidence that the multi-media approach to estimating land under irrigation is reasonably reliable.[4] It is therefore used in this study's efforts to estimate irrigated acreage in the Altamaha River basin.

This study is organized in the following manner. Data and methods used in this study to estimate acreage in the Altamaha Basin are discussed in section II. In section III estimates derived in this reported and are compared with those available from other sources. Concluding remarks are offered in section IV.

[4] The reader is referred to the study cited in footnote 1 for further discussion of the multi-media method and results.

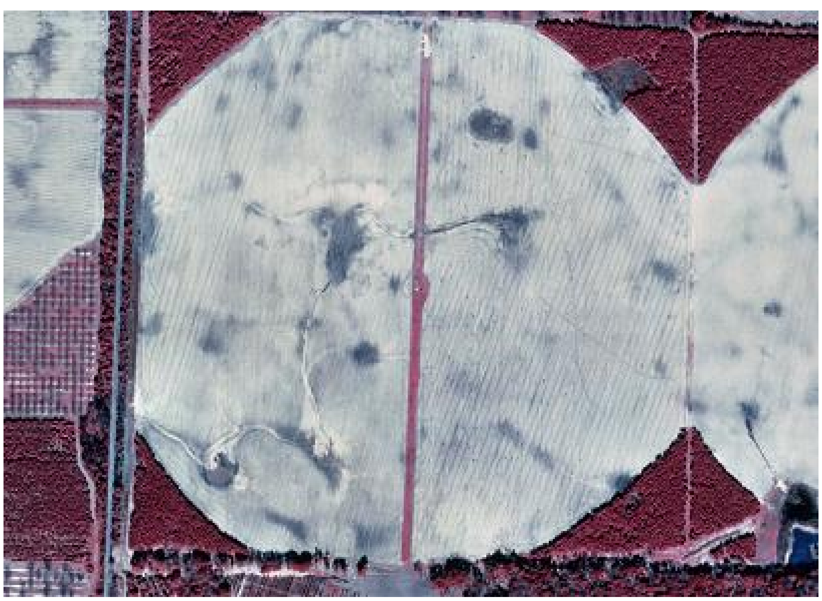
II. Data and Methods Used For Estimation of Irrigated Acres

Several data sources were used in this project to identify irrigated area accurately. These included: Digital Orthophoto Quarter Quadrangles (DOQQs) with 1:40,000-scale Color Infrared (CIR), 1999 National Aerial Photography Program (NAPP) and Landsat 7 ETM+ satellite images.

A. Aerial Imagery - Digital Orthophoto Quarter Quadrangles

In general, aerial photographs have a higher resolution compared to satellite images, and minimize the problem of cloud interference that may be encountered with satellite images because the photos are taken at lower altitudes than satellite images. With DOQQ resolution, we can clearly identify Center Pivot systems (Figure 1). DOQQs are taken on a 5- to 7-year cycle. Although DOQQs are a remote sensing product which we can use to identify irrigated areas, using DOQQ alone is not sufficient to identify irrigated areas for every crop since major crops in this study area are planted, irrigated, and harvest at different times of the year. As the result, aerial photographs appear to lack accuracy in identifying irrigation fields that are not irrigated *via* Center Pivot (CP).

Figure 1: Center Pivot Seen In DOQQ Photo.

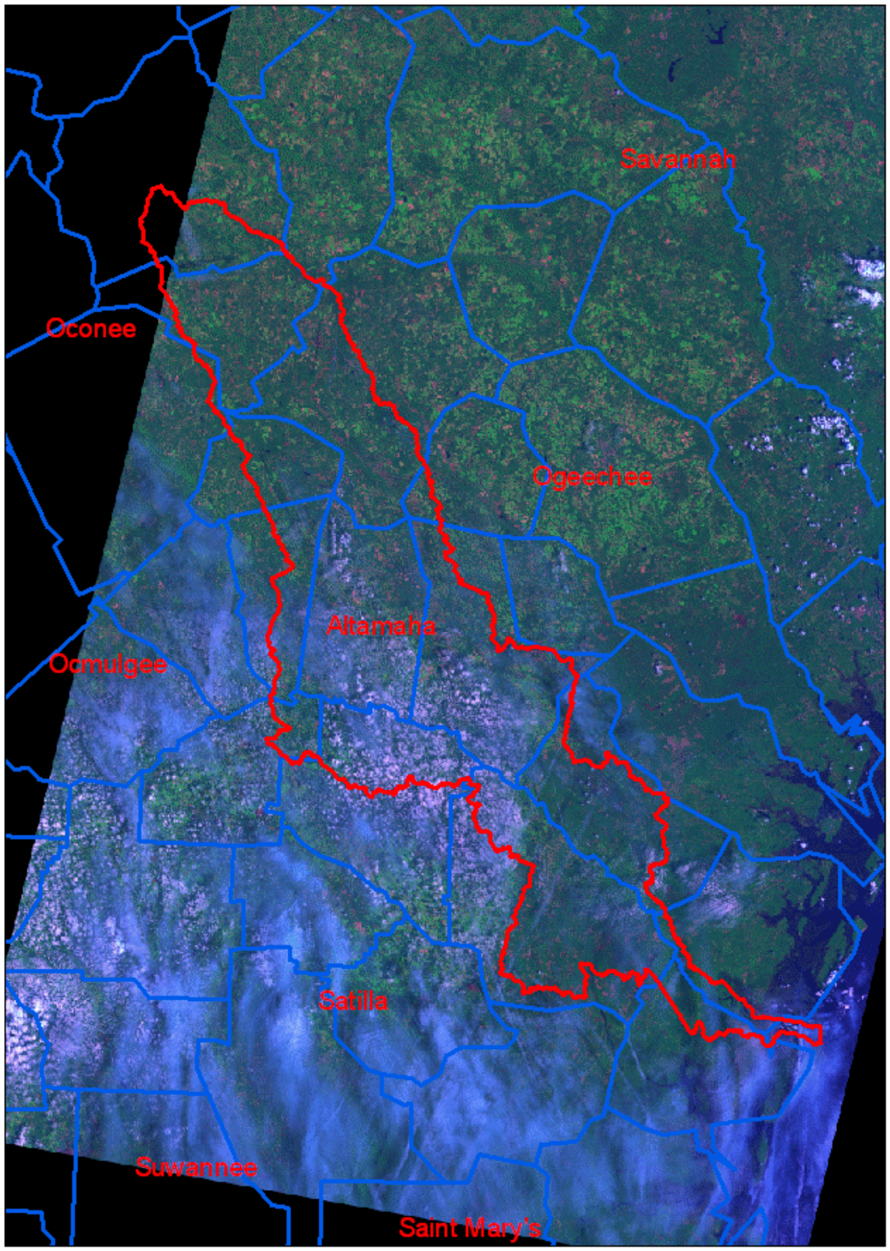


B. Satellite Imagery – Lansat 7 ETM+ (Figure 2)

Satellite images provide lower resolution images with multi-spectral bands which allow remote sensing analyses. An important difference between satellite images and aerial photographs is that the former are taken every 16 days, while the latter may be taken only over periods of years. When used during periods of drought, the actual use of center pivot irrigation is made clear by the color of the images. Thus, one can distinguish between land irrigated during non-drought periods and land irrigated during all periods. Problems with satellite images include problems associated with cloud interference and, perhaps most importantly, correctly classifying pixels so as to accurately distinguish between irrigated fields and non-irrigated lands. Given that fields are not perfectly homogeneous in terms of plant health, pixels within irrigated lands that are below the brightness threshold may appear as "holes" in identified irrigated lands. Such misclassified pixels can be cleaned up by means of focusing on smaller areas, and classifying pixels on the basis of the majority value of a defined set of pixels with a given geographical area. It is still difficult to classify pixels so as to distinguish between non-center-pivot irrigation and drought resistant grasses.

When one is using satellite images for the purpose of identifying lands that are under irrigation at the time that the image is taken (as opposed to simply identifying circular fields which may or may not be under irrigation or have been under irrigation in past years), pixels are set so that one is searching for irrigated areas. Images for at least two months are required. These follows from the fact that, e.g., corn may be planted in late April/early May and be fully grown in May or June. But in May or June, other crops (such as peanuts and cotton) have not reached a stage of maturity such that they are identified by the chosen pixels in the satellite image. For images taken during late July or early August, peanuts and cotton will be fully grown but corn acreage has been harvested; thus, irrigated corn acreage will not appear as irrigated land in the satellite image. Thus, the need for images taken in June and July (or August). In some, but not all, cases, images taken in July may pick up all crops. In this study, we acquired several satellite images, many but not all with clear skies, during month of May through August.

Figure 2: Lansat 7 Satellite Images



C. Comments related to mapping methodology

We use Landsat 7 satellite images for the purpose of estimating irrigated acreage during the year 2000 – a drought year. Each image covers approximately 13,000 square miles. Multi-spectral bands were used for remote sensing analyses. The band ratio used in our earlier efforts is defined as the TM near-infrared band (band 4) divided by the visible-red band (band 3), which created a vegetation index, with a pixel value of 28.5 meters – a relatively coarse resolution but sufficient to identify irrigated lands inasmuch as most irrigated areas included 50 acres or more. Initially, we attempted to classify vegetation indices for each crop (Crop ID); however some of these indices are located in riparian areas or other wetland areas. We attempted to screen out riparian zones using National Land Cover Data (NLCD) from the USGS, but found the approach to be unsatisfactory. Other problems that we encountered include those associated with the fact that images for July and August were taken on a day with light cloud cover over many of the areas under study, and problematic plant health during this severe drought year.

Following considerable experimentation, we found one means by which we could avoid the difficulties associated with the problems described above. We shifted our focus to *changes* in vegetation indices over time. Figure 3 illustrates our use of Arcview for this purpose. A vegetation index from 1 to 25 is created with dry land indexed 1 and 2, and wet land indexed between 8 and 25 (all Crop IDs are also in this range). Thus, in June, 2000 (Figure 3 Panel A) we have the dry land parcel that is shown in red. Note the riparian "green" surrounding the dry land. In August, we again use ArcView to calculate indices; land which has been irrigated has a vegetation index that has substantially changed – the result is a marked change in color – from red to bright green. Land for which the vegetation index has not been changed retains the red color – such land is clearly not irrigated (Figure 3, Panel B). In this way we are able to identify and measure acreage that has been irrigated.

Figure 3: Change in vegetation indices.

A. May 9, 2000

B. August 20, 2000

While the method focused on changes in the vegetation index seems to provide us with a reasonably accurate measure for land placed under irrigation, application of the method across large areas is limited by the cloud cover problem: for some counties, we could not obtain a satellite image for all months that did not have some cloud cover over some of the counties of interest. In such cases irrigated areas were identified using the 1999 DOQQs (Figure 4) with their greater resolution. Once areas were so-identified, we could then analyze them with satellite images. This approach allows us to take advantage of the strengths of aerial photos – high resolution and no cloud cover problems – with those of satellite imagery: primarily, the advantage of remote sensing.

Our vegetation index-change method cannot be used to identify perennial crops such as pecan, peach orchards, etc, because there is little in the way of changes in their vegetation indices from month to month. For these crops, irrigated areas were identified by locating them DOQQs (Figure 5).

Finally, as still another resource to aid us in our efforts to identify and then quantify irrigated acreage, we also plot EPD's agriculture water withdrawal permit locations to help us identify possible farm land in questionable areas (see example given in Figure 6).

Figure 4: Create irrigated area from DOQQs.

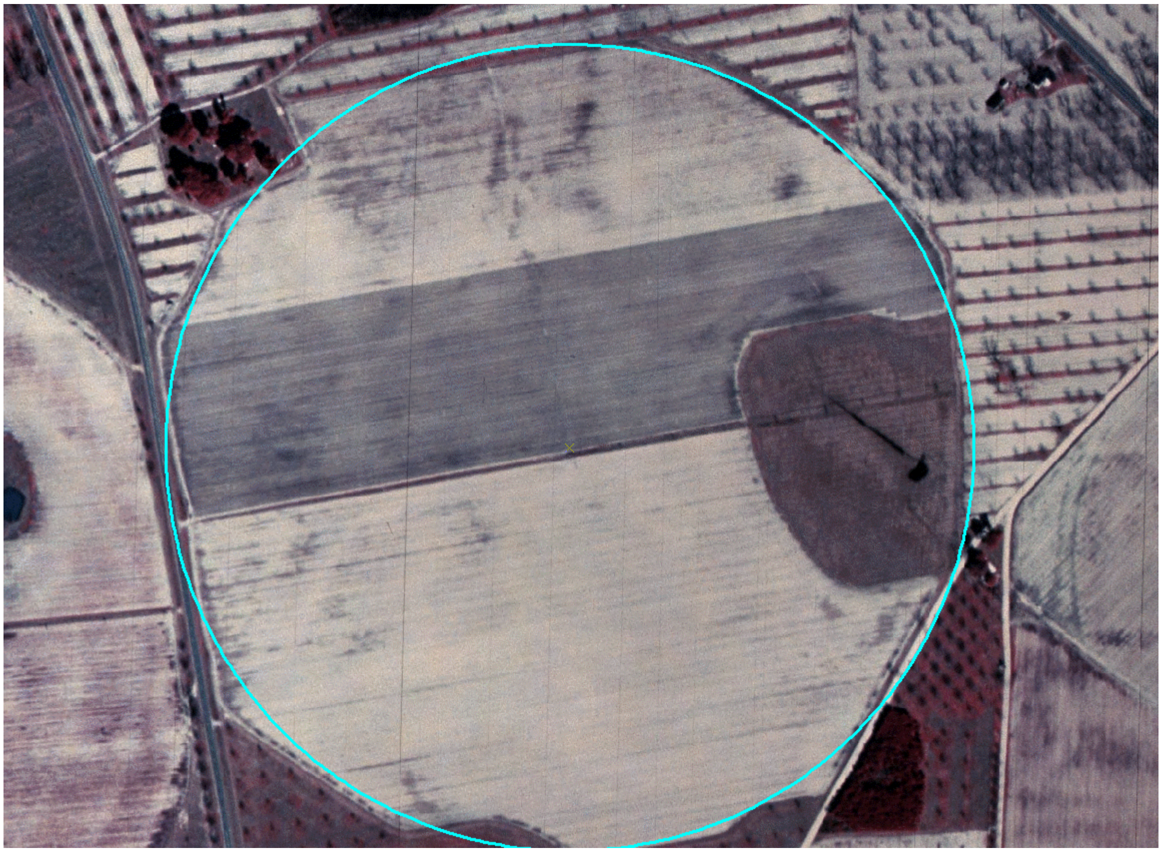
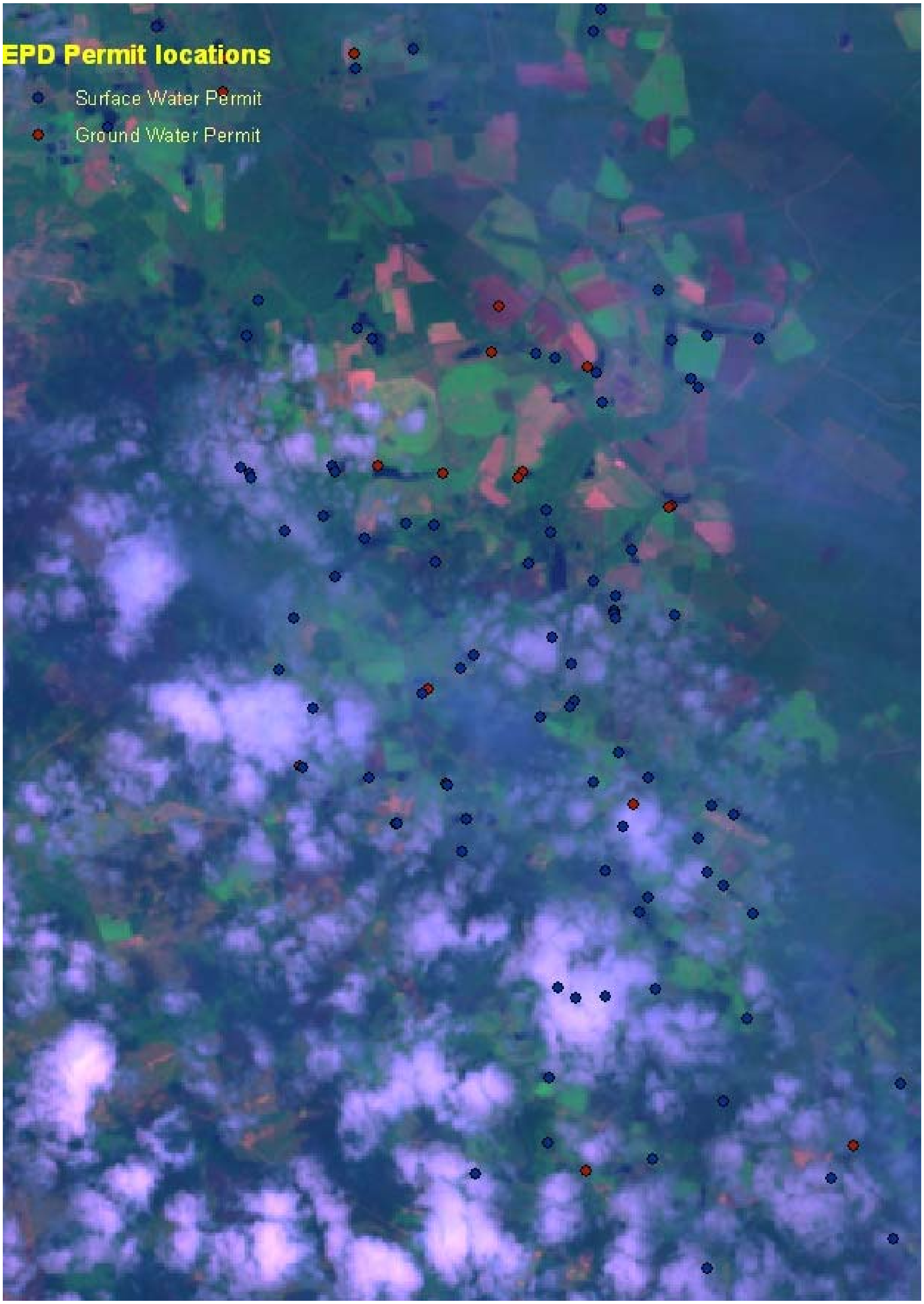


Figure 5: Pecan Orchards

Figure 6: Example Of Plotted EPD Permit Locations



III. Estimated Irrigated Acreage in the Altamaha River Basin

Our estimates for irrigated acreage in the Altamaha River Basin during the drought year 2000 are given by county below in Table 2; we emphasize again that we include acreage in any county only in that part of the county that is within the Basin, and that our measures are for lands that were actually irrigated during the drought year 2000.

The reader can, based on our description of the methods used for the derivation of these estimates, make his/her own judgment as to the accuracy of acreage reported in Table 2. Ideally, we would have comparable measures for some counties that could be used to assess the accuracy of our estimates. Acreage estimates for some counties from two alternative sources are included in Table 2: acreage reported by Georgia's EPD (Department of Natural Resources, Environmental Protection Division, Water Resources Branch, Drinking Water Compliance Program, SWAP Unit, Agricultural Fields of the Upper Flint River Basin, Atlanta: June 2003); and irrigated acreage reported in the 2002 Census of Agriculture.

Unfortunately, neither of these sources provides data that are comparable with those derived in our study. The EPD study of irrigated acreage in the Altamaha Basin includes but a few of the Basin's counties (see comparisons in Figures 7 and 8). Moreover, we are told that their study is incomplete: they have permit locations, but have not created associated farm "shapes" that allows for an estimate of acreage. Also, their study (once completed) would appear to focus on acreage that *is permitted* for irrigation under a farmer's water use permit, as opposed to acreage that is irrigated from ground or perennial surface water sources -- thereby creating drafts on the region's water resources during periods of drought (which as noted in section I is our primary focus).

Table 2
Irrigated Acres in Counties (or portions thereof) In the Altamaha Basin

County	Irrigated Acres This study	Irrigated Acres EPD	Census of Agriculture
Appling	3,358	866	7,568
Candler	1,206	440	4,368
Emanuel	3,838	245	5,372
Evans*	25	0	2,719
Glynn	0	0	22
Jeff Davis	1,666	743	3,657
Jefferson	23	0	18,662
Johnson*	3,984	0	1,433
Laurens	521	0	6,415
Liberty*	0	0	11
Long	821	790	564
McIinosh	0	0	42
Montgomery	2,796	0	2,500
Tattnall	15,844	11,646	12,011
Toombs	14,879	8,712	10,138
Treutlen	1,871	520	1,156
Washington	3,825	0	8,133
Wayne	3,207	195	2,881

* A very small part of the county is in the Altamaha Basin

Figure 7: Location of irrigated acreage -- this study

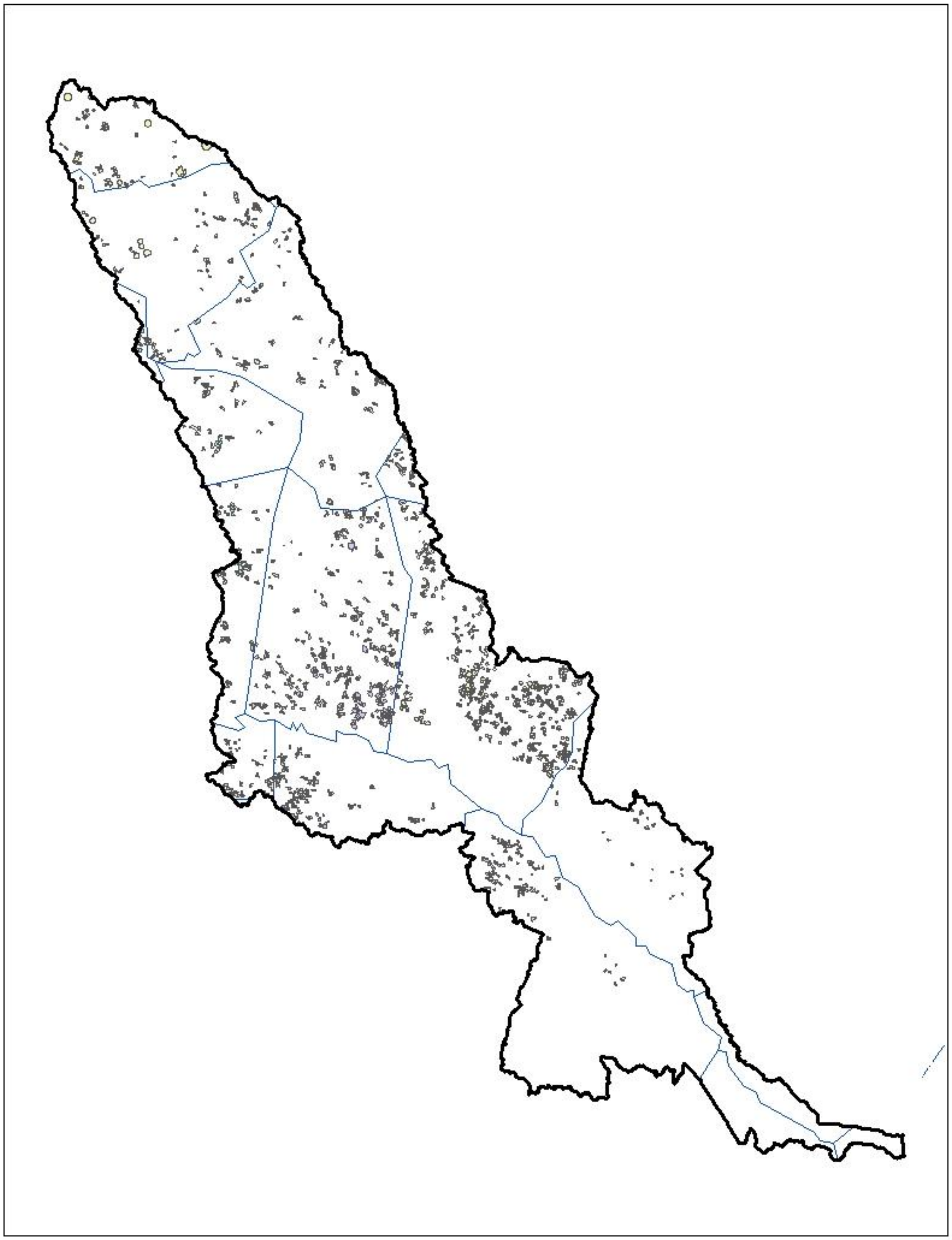
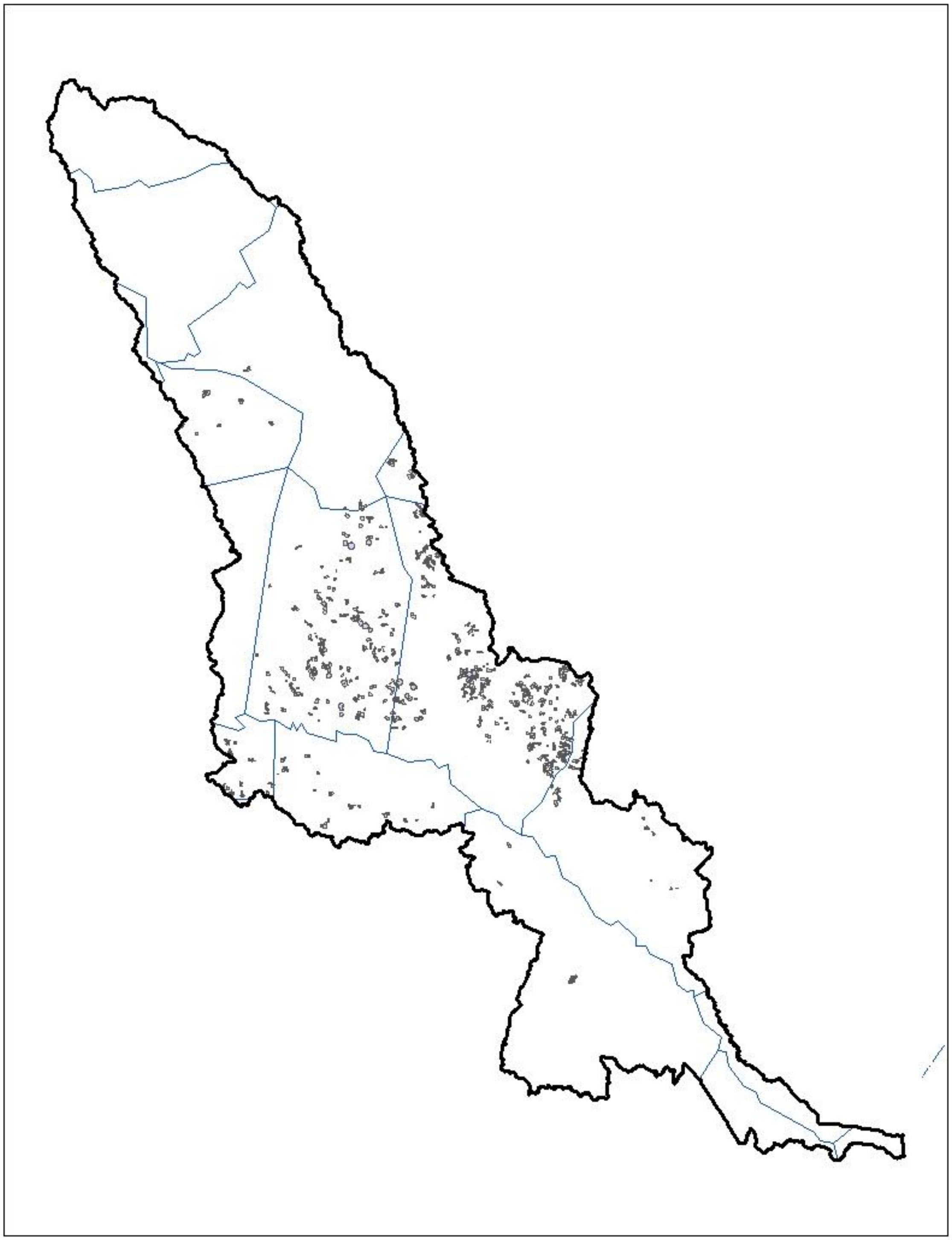


Figure 8: Location of irrigated acreage -- EPD Data



Data from the Census of Agriculture are obtained from a survey of randomly selected tracts of land. The resulting total is then an estimate for total irrigated acreage. These Census numbers are for *entire counties*, however, not, as in our study, the portion of a county that is in the Altamaha River Basin. One curiosity about the 2002 Census of Agriculture data which we cannot explain is their seemingly very low estimate for irrigation in Lee County: 21,615 acres. This number is less than half of the estimate derived by the three sources presented above in Figure 1.

We can do little more at this point then than to report our findings, leaving to later studies efforts to validate them via comparisons with new, *comparable*, data.

IV. Concluding Remarks

Using a "mixed media" approach, which tracts changes in pixel (color) values over the summer indicating changes from dry land to wet land, we have developed estimates for irrigated acreage in the Altamaha River Basin that draws water from ground water or perennial surface water sources. The latter condition is assured given that our estimates come from identified irrigation during the summer of 2000, which was one of Georgia's worst drought years of record. It is improbable that irrigators reliant on non-perennial sources could have successfully irrigated a crop during this drought year.

Data provided here should be useful to the state in a number of ways. The state is moving forward with its plans to develop Basin Water Plans, and basic to such plans is information as to the agricultural sectors use of water under worst-case conditions -- conditions of drought. Further, such data can play important roles in efforts by the state to work out solutions to issues related to the use of interstate waters -- ground or surface waters.