USING A SMALL SUB-SAMPLE TO PROJECT STATE-WIDE AGRICULTURAL IRRIGATION WATER USE IN 2000

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Abstract. The Agricultural Water: Potential Use and Management Program in Georgia program (Ag. Water Pumping) began instrumenting and collecting agricultural water use data in 1999. As of October 2000, at least 407 permitted agricultural withdrawals, and more than 600 individual sites are in the monitoring program across the state of Georgia. This represents, however, just a small subset of the more than 19,000 permitted sites in the state. In order to scale-up this subset to represent an estimate of total statewide agricultural irrigation water, the already collected data of the Ag Water Pumping project were used to estimate monthly average use amounts per crop type. Then, based on agricultural statistics data, the total amount of irrigated acreage for each crop in the state was estimated. These two sets of estimates were combined to project the total amount of agricultural irrigation water for the whole state. An initial rough estimate, based on permit numbers of agricultural irrigators who have the capacity to pump or withdraw 4.4 l/sec (100,000 gallons/day) from either surface or ground water, showed that if there are 22,000 such sites in the state then water use would be 330,000 M gallons/year for the whole state or 1,012,425 Acre-ft/year. The value arrived at using the actually measured Ag Water Pumping subset and scaling up was 489,000 M gallons/year or 1,501,457 Acre-ft/year. It is encouraging that this initial analysis to scale-up refined data has given a total state water use amount which is not radically different from the extremely gross estimate based on the number of permits and their allotted flow rates. Further analysis and additional data are needed to provide a legitimate estimate of agricultural water use in the state of Georgia.

INTRODUCTION

At the moment, the Georgia citizens at large are using the water resources of the state without any restrictions. So far, it is unknown how much water is available or how much would be available in the future based on projected rainfall and/or consumption. There is no criterion for establishing realistic standards of sustainable water use, and no real way of deciding who should be restricted and by how much. To determine a sustainable level of water use, some estimation of the state's water budget is needed. This can be accomplished by combining Geographic Information Systems (GIS), weather and climate data, geological and soil data, and computer simulation models, to develop a dynamic water balance for the state. A simple system, based on a computer model that predicts crop yield and water use, was developed by Alexandrov and Hoogenboom (1999). With these types of computer-based decision support tools, policy makers and regulators can determine the impact of different water use strategies on the overall supply of water in the state based on actual and potential weather patterns and water use.

The Ag. Water Pumping program was designed to determine agricultural water use from irrigation for the entire state of Georgia (Thomas et al., 1999, 2001). Initially, a very rough first estimate of state wide agricultural water use was made. Agricultural irrigations, who have the capacity to pump/withdraw 4.4 l/sec (100,000 gallons/day) from either surface or ground water, are required to have a permit. At present, more than 20,000 agricultural irrigation withdrawal permits have been issued, and nearly 2,000 permit applications are pending in the Flint River basin alone (Thomas et al., 2000). Based on a very rough estimate of the data presented by Thomas et al. (2000), it can be determined that half of the permits are located in southwest Georgia, so 10,000 is probably a conservative number. If we assume that they pump 75% of maximum capacity per day, and if there are 10,000 permits in the Flint river basin with a 200 day use per year, then this results in a total water use of 150,000 M gallons/year. If there are

22,000 such sites in the state then that would be 330,000 M gallons/year for the whole state or 1,012,425 Acre-ft/year. These results present an initial rough estimate. The objective of this study was to determine water use based on scaling-up actual monitored numbers of the Ag. Water Pumping Program (Thomas et al., 2001) and to evaluate the accuracy of the initial water use estimates.

PROCEDURE

In order to scale-up the data set collected by the Ag Water Pumping program, the data collected in 1999 and 2000 were used to estimate annual average irrigation amount per crop type. Then, using other resources such as the Georgia Irrigation Survey, Georgia Farmgate Value Report (from the Center for Agribusiness and Economic Development; www.agecon.uga.edu) and the Georgia Agricultural Statistics Survey (www.nass.usda.gov), the total amount of irrigated acreage for each crop by county was estimated. These two sets of estimates were combined to project the total amount of agricultural irrigation water for the entire state.

One of the problems was obtaining data that were collected in the same year to match up. The best data for actual measured irrigation collected by the Ag Water Pumping Project was 2000, due to availability of more data. The sample size was 3244 for the monthly data collected in 2000 as opposed to a sample size of 1350 for the data collected in 1999 (Table 1). In addition, the data were more consistently gathered in 2000 due to additional experience in sampling and data collection.

The 1998 irrigation survey was used to obtain total irrigated crop acres of the entire state of Georgia (Harrison and Tyson, 1999). This was compared to the 1999 data from the Georgia Agricultural Statistics Survey, to derive an estimate of percentage irrigated crops and total irrigated acreage for each crop for the year 1999. The average 2000 irrigation for each crop was applied to this acreage so that a total amount of acre-inches per crop was determined. The average irrigation for each crop was found by taking the total amount of water applied to each crop from a monthly report, created by the Ag Water Pumping data base (www.AgWaterPumping.net), and dividing it by the total amount of monitored acres from an annual report, created by the same data base. The derived average irrigation for each crop was then applied to the estimated acreage, wherever an appropriate match could be found, and this was used as the value for the total amount of water used in the state for this particular crop type.

Crop Assignment Assumptions

In the procedure to assign and match crops, certain assumptions were made. For instance, the categories of *winter*, *summer* and *permanent forage* were considered to correspond to the pasture crop measurements listed in the statistical data bases of oats, wheat, rye and hay. There was also a category called *cover crops* for which no match was determined, although the average irrigation was fairly high for cover crops (1.75 in). It was assumed that *silage* referred to both corn and sorghum silage. Since the 1998 irrigation survey, there has been no breakdown of vegetables. We, therefore, determined an average irrigation based on all monitored vegetables of the Ag Water Pumping Project. The standard error of this estimation was very low, so it seems to be a good general estimate for a generic irrigation application for vegetables. The *unknown* category was applied to the category of "all other crops." It made a somewhat significant contribution because the average irrigation for the unknown crops was 6.46 inches, based on only seven samples.

Data Quality Measurements

In order to apply an average irrigation amount from one year of measured data from a limited data set, an estimation of the reliability of the data was made. To determine the quality of our data, the standard error of the estimated irrigation for each crop was calculated by finding the standard error of the mean of all the estimated irrigations for each crop as listed in the monthly reports. The percentage of the total irrigated crop was also determined by comparing the total monitored acres to the estimated amount of total irrigated acres (Table 1)

RESULTS AND DISCUSSION

Quality of Average Irrigation Estimate

The standard error was low and less than one for most of the crops measured (Table 1). This means that in general there is an adequate sample size even if there is not more than 5% of any of the crops represented. The small standard error of the irrigation estimates indicates that the average irrigation amounts are reasonable numbers, which can be applied to estimate total irrigation for a particular crop. Notice that in general the average irrigation derived from 2000 data was greater than the average irrigation derived from the 1999 data (table 1). For the most part, however, the sample size was also greater for the 2000 data and the standard errors were low, compared to the 1999 data. It is therefore statistically legitimate to assume that these

Table 1. Irrigated acreage and average irrigation (inches/acres)

Crop	Average irrigation		Average sample size		Standard error		Sample total irrigated acreage		Irrigated acreage (acres)	Irrigated acreage (%)
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Field corn	4.16	9.27	661	661	0.07	0.07	3,233	4,520	140,000	3.23
Cotton	4.61	5.5	538	1549	0.04	0.03	9,458	17,942	611,520	2.93
Peanut	5.08	6.88	282	894	0.07	0.04	4,227	7,764	317,292	2.45
Tobacco	0.83	3.67	53	176	0.04	0.13	343	1,300	27,225	4.78
Soybean	2.8	3.57	68	209	0.13	0.14	893	1,409	19,580	7.2
Forage	0.89	0.9	125	257	0.04	0.04	2,551	1,694	33,320	5.08
Sorghum	0.32	10.2	4	35	0.03	0.23	54	106	7,020	1.51
Grapes	0	0	0	9	n/a	0	0	35	644	5.43
Pecan	n/a	n/a	56	109	0.23	0.15	304	313	64,519	0.49
Vegetables	4.07	7.39	152	514	0.09	0.08	2,882	4,402	119,200	3.69
Sod	2.57	20.4	18	129	0.21	0.17	346	582	33,310	1.75
Nursery	n/a	n/a	16	36	0.5	26.8	28	101	8,623	1.17
Fallow	0.14	0.08	781	1464	0.01	0	17,333	15,358	n/a	n/a
Unknown	1.32	6.46	2	7	0.25	0.25	20	10	n/a	n/a
Cover crop	0.81	1.75	108	295	0.04	0.03	3,226	3,015	n/a	n/a
Silage	11.3	6.3	18	45	0.26	0.22	166	638	19,260	3.31
Field Preparation	0	0.33	2	87	0	0.03	255	3,256	24,649	13.21
Pine trees	0	7.01	0	10	n/a	0.33	0	120	n/a	n/a
Research Plots	0	6.19	0	38	n/a	0.15	0	229	n/a	n/a

values are correct. It could be argued that the two years could be combined to give a better estimate of average irrigation. However, the monitoring program was just getting started in 1999 and the year 2000 represents the first full year of complete data.

Data Needs and Problems

This initial analysis has identified some clear data needs and gaps. The crops that are being monitored currently do not include some of the critical fruit crops, such as blueberries, peach, and apples, as well as sweet potatoes. Grapes are shown as a monitored crop, but so far no irrigation has been reported.

A big concern are the nurseries, which showed a large amount of water being applied in the initial analysis. Although it is known that nurseries apply a large amount of irrigation, further analysis and possibly additional samples might be needed. This can also be seen by the relatively large standard error deviation of the sampled nurseries.

Another issue relates to crop identification. As seen in table 1, several of the crops currently do not have any data available due to a poor match between the different data bases. In general, it needs to be made clearer how our monitored data corresponds to already existing databases of crop acreage so that applications of our data can be made more accurate and with greater assurance.

Based on the standard error analysis, it can be stated that more nursery sites are needed. There are adequate sites for field corn, cotton and peanut for now, but the number of tobacco, soybean, pecan, sod, and silage sites should probably be increased. This recommendation is based on the relatively higher standard errors observed for these crops. In addition, apple, peach and sweet potato should be added as monitoring sites.

CONCLUSIONS

The Ag Water Pumping program is planning to conduct a county by county assessment of average irrigation amounts. However, the data resolution at this point is more suited for the type of gross analysis presented in this paper. If it is difficult to do an accurate gross analysis, imagine how much more difficult it would be to conduct a more refined analysis. In addition, this type of gross statewide analysis quickly reveals where data gaps and needs are, as well as some other basic questions about how this data base relates to other existing data bases. It is encouraging to see that this gross analysis attempting to scale-up refined data has resulted in a total statewide water use amount, which is not radically different from the previous extremely rough estimate that was based on the number of permits and their allotted flow rates. The similarity of results indicates that the procedure may be correct and that we may be focusing in on a legitimate estimate of agricultural water use in the state of Georgia.

As the project continues to add new monitoring sites and therefore collect more data, we will obtain a more refined estimation of average irrigation for a particular crop, and the values derived from the 2000 data alone will undoubtably change. Eventually, we will be able to derive a variable, such as an irrigation crop constant, that can be entered into crop models and GIS simulations to help estimate total water use under different farm management strategies (Tsuji et al., 1998).

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