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IRRIGATION IN SOUTHCENTRAL NORTH CAROLINA

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Introduction

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Agriculture is the predominant economic activity in southcentral North Carolina. More than 531,000 acres, about one-seventh of the total land area, is devoted to agriculture (NC Agricultural Statistics 1993, 27). Two of the region's counties, Robeson and Columbus, consistently rank among the top six counties in farm cash receipts and illustrate the region's apparent comparative advantage. Thus, continued and expanded agricultural production is an important component of the overall economic development in this part of the state. Though abundant arable land is available for increased production, expansion and refinement of the agricultural base is hindered more by the quality of the crops than by quantity. Although the region is included in the humid subtropical climate, it does experience frequent and sometimes severe droughts, associated with high temperatures and sandy soils. This results in reduced yields of poor quality crops that are not acceptable on most commercial markets. For example, although Campbell Soup Company has a large processing facility in the region and uses large quantities of fresh vegetables, Campbell purchases very little from local farmers because of the consistently poor quality of the produce. It is argued in this paper that increased rates and levels of irrigation applied to more acreage, given that only three percent of the cultivated land is irrigated, would result in a consistent and higher quality product. A secondary use of irrigation water would be to cool crops as they are harvested and to keep them cool after harvest. These two actions would significantly enhance an already important agricultural base.

The author's objective is to shown how important irrigation is to agriculture in southcentral North Carolina, and to raise questions concerning the availability of additional irrigation water

The feasibility of expanding irrigation acreage was the focus of a study made in 1988 in which more than 300 farmers and other water users were interviewed over a four month period (Ross, 1990a). This study was an attempt to gain a better understanding of the water situation in the region as it affected economic development. Questions pertaining to acres irrigated and adequacy of water supplies were important components of the survey. Much of the data presented in this paper were extracted from that study.

Frequent and sometimes severe droughts result in reduced yields of poor quality crops and therefore the need for irrigation

The purpose of this paper is to describe the extent of irrigation usage in south-central North Carolina, with particular emphasis upon the sources of irrigation water and the degree to which the region's surface and groundwater supplies are capable of supporting an increased irrigated acreage. A discussion of crops and land uses that benefit from irrigation water is also included.

The Study Area

South-central North Carolina, as defined in this study, includes the counties of Blade, Columbus, Cumberland, Hook, More, Montgomery, Richmond, Robeson and Scotland (Figure 1). It is a region of approximately 6,000 square miles, inhabited by more than 700,000 persons. Located astride the Piedmont and Coastal Plain physiographic regions, the study area's topography ranges from rolling and hilly Piedmont to undulating and level Coastal Plain.

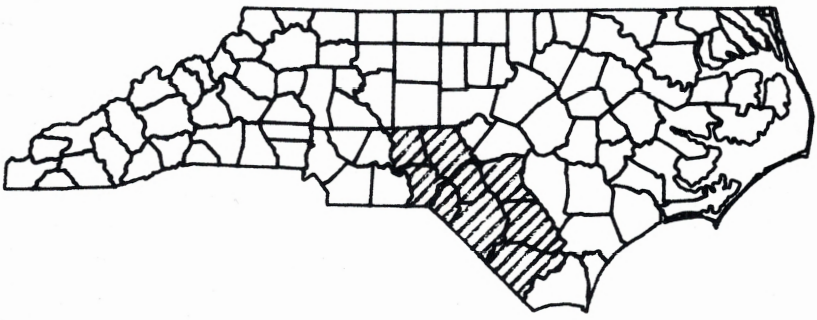

Figure 1. Study Area: Southcentral North Carolina

Underlying geologic material in the region is as varied as the topography and greatly impacts the availability and accessibility of groundwater. The rocks are divided into three major units, based on lithology and age. They include the Late Proterozoic to Cambrian metamorphic rocks of the Carolina Slate Belt, Triassic sedimentary and igneous rocks, and Cretaceous and younger sediments. Cretaceous sediments are found mainly in the Coastal Plain, although there are some small outliers in the Piedmont. In the Piedmont of Richmond, Montgomery and Moore counties, the rocks of the Carolina Slate Belt are mainly metamorphosed volcanic materials. Triassic rocks, also found in the same counties, are conglomerates, sandstones and mudstones with some intrusive igneous diabase dikes. Triassic sediments were deposited in a down-dropped fault basin that trends northeast-southwest. Cretaceous and younger sediments of the Coastal Plain

part of the study area consist mainly of interbedded sand, clayey sand, mud and clay layers and lenses.

Water movement is restricted to the more permeable sandy layers which lie between the less permeable layers of clay. This is known as confined, or artesian, water. Artesian wells, derived by overflow, are common along many of the streams in the Coastal Plain. Shallow groundwater also occurs in the zone of saturation, or water-table aquifer.

Regional Water Sources

More than 88 percent of the irrigation water used in the region came from surface sources in 1987 (Table 1). Of the more than ten million gallons used in the region, Moore County used 50.1 percent, of which about 95 percent was derived from surface sources. The second major user was Robeson County, with about 13.3 percent of the total used and about 96.6 percent of this coming from surface sources. Bladen and Cumberland were the only counties in which more than one-half of the irrigation water was derived from groundwater sources. About 57 percent of Bladen's water was groundwater sourced as was 52 percent of Cumberland's. Hoke and Richmond acquired all irrigation water from surface sources, and more than 99 percent of Montgomery's irrigation water was surface sourced. The spatial pattern of surface water withdrawals illustrates the high level of withdrawal in the Sandhills and Piedmont as compared to most of the Coastal Plain (Figure 2). More specifically, surface water irrigation is concentrated in the southern half of Moore, the northeastern part of Richmond and the eastern half of Montgomery. A secondary concentration exists along the Fall Line and extends across Scotland and Hoke into eastern Cumberland. In the Coastal Plain, surface water irrigation is important in southeastern Robeson and southern Columbus. Eastern Bladen is a fourth, less distinct area of surface water irrigation.

County	Surface Water	Groundwater	Total
Bladen	221.45	293.19	514.64
Columbus	253.60	36.50	290.10
Cumberland	423.09	464.17	887.26
Hoke	263.26	---	263.26
Montgomery	691.44	6.02	697.46
Moore	4,877.90	260.74	5,138.64
Richmond	781.02	---	781.02
Robeson	1,311.96	46.62	1,358.58
Scotland	232.77	83.55	316.32
Totals	9,056.49	1,190.79	10,247.28

Table 1. Water Withdrawals for Irrigation, 1987
Note. Data is provided in million gallons/year; to convert to million gallons/day divide by 180 under the assumption that water is applied over a six month period
Source: Ross 1990a

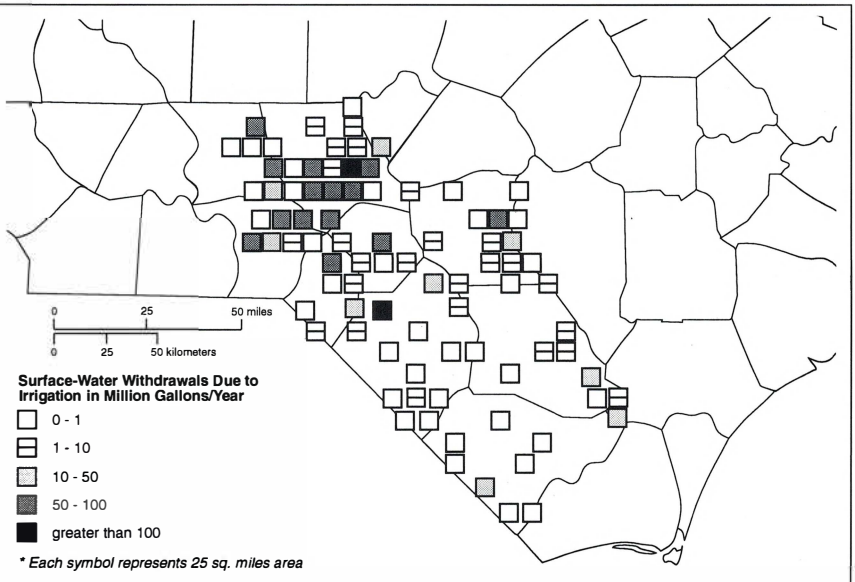

Figure 2. Surface Water Withdrawal

Surface water is taken from the rivers and swamps that wind through the region and from farm ponds maintained by groundwater discharge from the surficial aquifer. Rivers supplying water include the Pee Dee, Lumber and Cape Fear, and their tributaries. The average discharge of the Pee Dee is about 5,000 million gallons per day (mgd), the Cape Fear about 3,200 mgd and the Lumber River 950 mgd.

The Little and Deep Rivers and tributaries are the primary sources in Montgomery County. In Moore, the Little River , though not the Little River of Montgomery, and Drowning Creek drainage basins provide surface water. Tributaries of the Pee Dee are the source of much surface water used in Richmond, while Shoe Heel Creek, Gum Swamp and several Pee Dee tributaries are used in Scotland. Cumberland's farmers secure water from the South, Little and Cape Fear and their tributaries. Most of the water used in Robeson and Hoke is from the Lumber River drainage basin. The Lumber also provides water to Columbus, as does the Waccamaw River. Bladen counts upon the Cape Fear and South Rivers and their tributaries for the bulk of its surface water needs.

Average runoff of streams in the region is 0.6 to 1.0 mgd per square mile, a level which could support much more irrigation. An expansion of surface water consumption upwards to 50 percent of the runoff is realistic and probably would not compromise other water users or interfere with watershed or other natural actions associated with the water. With few exceptions, the surface water supply has for the past four or five decades been sufficient to meet demand. Surface water quality is good, but is un-

der increasing threat of pollution from expanded industrial and residential development and widespread use of agricultural pesticides. A more recent threat is waste from huge hog farms that have been established throughout the region. The waste from the several million hogs inhabiting these farms is required to be dumped in lagoons. During the summer of 1995 a number of lagoons overflowed due to excessive rains and/or poor construction with waste materials draining into and polluting adjacent rivers.

Groundwater quality is good, the major problem being a higher than desired level of iron (Ross 1990b). Yields vary from place to place, depending on the geologic structure which holds the water. The groundwater used in the region comes from the surficial sands aquifer, the Black Creek Formation, the Cape Fear Formation and basement rocks underlying the Cretaceous formations and the rocks of the Cambrian and Triassic. The latter, in the western end of the study area, are of minor significance as a source of irrigation water.

Water withdrawals from each of the groundwater sources vary greatly. The most important aquifer in the region is the Black Creek, which supplies most of the groundwater used in Robeson and Scotland. Portions of Cumberland, Bladen, Columbus and Moore also depend upon the Black Creek Formation. The primary groundwater source in Cumberland is the surficial sands aquifer, while Moore and Montgomery draw upon the Triassic rocks and the Cape Fear aquifer is of some value to Bladen County.

In the slate belt, at the western edge of the region, good water can be found at less than 300 feet below the surface. Average yields, though, are not high, usually much less than 100 gallons per minute (gpm). Regardless of the low yields, this large aquifer is a dependable supplier of water to the region. The best sites to find water in the slate belt zone are in valleys and other low places, in areas where the weathered zone (decomposed rock) is thick and near quartz veins and dikes. The Triassic rock region does not have a dependable water supply because the rocks are compacted and tightly cemented. Some water can be found near faults, but the supply is very small, usually less than 10 gpm. Deep drilling does not enhance the supply.

The Cretaceous aquifers, such as the Black Creek, Cape Fear and Pee Dee, are in many places more than 600 feet thick. In the clay aquifers, yields range from 10 to 20 gpm while the sand aquifer, which is 250 to 600 feet thick, has yielded more than five gpm per foot of depth, though one gpm per foot is more customary.

There are three distinct regions of groundwater withdrawal in the study area (Figure 3). All are closely related to the Coastal Plain: the largest is in eastern Cumberland and Bladen; second largest is in southern Moore; and a smaller withdrawal region is in Scotland.

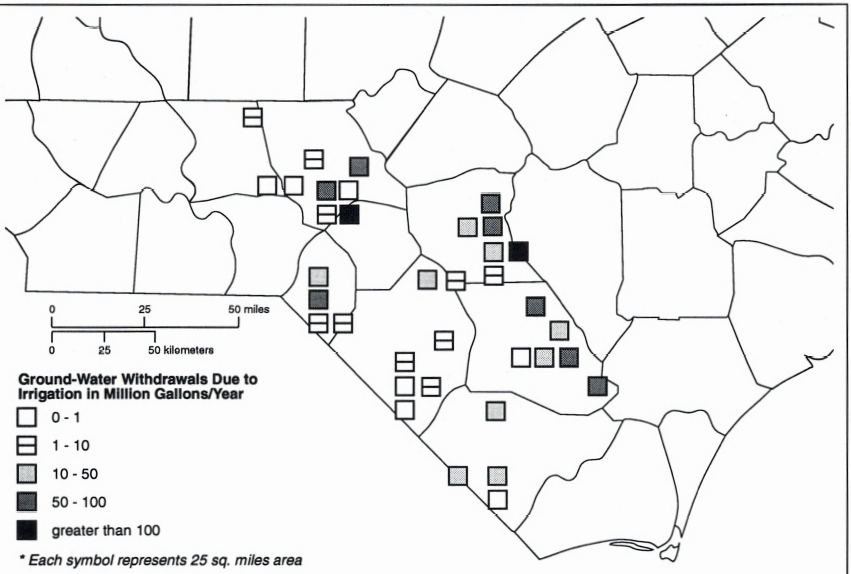

Figure 3. Ground Water Withdrawal

Three counties took irrigation water from the surficial sands aquifer: Cumberland mined the most, well over 100 million gallons per year (mgy). Columbus extracted a lesser amount and a small volume is produced in Moore. The Black Creek Aquifer provided irrigation water for all of the region's counties except Hoke and Richmond. Scotland, Moore, Robeson, Bladen and Columbus were the major users of this water. Cumberland and Montgomery used a lesser amount. The Upper Cape Fear Aquifer provided a small amount of water to Bladen and a small amount was also taken from Triassic and Cambrian bedrock in Montgomery and Moore.

Only two counties in the region, Bladen and Cumberland, used more ground than surface water for irrigation. No groundwater consumption was reported in Hoke and Richmond. Moore County uses the most water for irrigation, but of the 5,100 mgy used, 3,802 mgy were used to water golf courses.

Groundwater withdrawals are concentrated in the Coastal Plain portion of the region, with very little groundwater used in the Piedmont. The leading area of withdrawal in the region is that area in and near the Cape Fear Valley. Another area of importance is found in southern Moore. Southcentral Scotland and southeastern Robeson are also significant users of groundwater.

Application of Irrigation Water

A wide range of uses of irrigation water, as well as a substantial difference in the level of irrigation for each of the uses, exists throughout the region (Table 2). The only crop irrigated in every county of the study was

CROP	BLA	COL	CUM	HOK	MON	MOO	RIC	ROB	SCO
Corn	.261	.000	.264	.000	.082	.453	.162	.033	.184
Soybeans	.098	.000	.035	.218	.055	.401	.000	.000	.000
Tobacco	.203	.043	.334	.231	.201	.209	.252	.088	.158
Peanuts	.098	.000	1.316	.000	.545	.000	.000	.000	.000
Cucumbers	1.960	.817	.325	.000	.000	.000	.327	.014	.000
Vegetables	.799	.029	.386	.000	.349	.316	.274	.400	.308
Truck veg.	.000	.000	.755	.000	.181	.135	.293	.164	.000
Grains	.000	.000	.027	.000	.000	.000	.054	.041	.000
Grass	.000	5.881	.000	.000	10.209	1.608	.077	4.496	.000
Pasture	.000	.000	.000	.000	.000	.000	.054	1.742	.055
Strawberries	.156	.183	.490	.000	.521	.808	.545	.134	.217
Blueberries	.651	.193	.490	.000	.763	.000	.000	.000	1.429
Watermelons	.000	.000	.000	.000	.136	.343	.166	.215	.000
Cantaloupes	.000	.817	.000	.000	.135	.110	.104	.215	.000
Sw. potatoes	.000	.000	.081	.000	.136	.261	.111	.000	.000
Cotton	.000	.000	.000	.000	.000	.000	.000	.000	.109
Tomatoes	.000	.817	.000	.000	.000	.816	.251	.110	.000
Nurseries	.000	.816	.000	.000	1.225	.503	.000	.715	1.258
Peaches	.000	.000	.000	.000	.393	.149	.109	.000	.150
Misc.	.000	.000	.000	.871	.817	3.675	.719	.000	.000
Golf courses	.327	10.663	.000	.272	.982	2.198	.000	3.485	.855
Totals	.478	1.480	.310	.516	.806	1.036	.220	1.414	.263

Table 2. Amount of Water Applied per Acre, 1987
Source: Ross, 1990a

the region's big cash crop, tobacco. Other widely irrigated crops included corn, vegetables and strawberries. Golf courses were irrigated in all counties except Richmond and Cumberland. It is most likely, however, that golf courses in these counties did receive irrigation just that data were not collected to verify this. In Bladen, cucumbers received the most water per acre, but only five acres were irrigated. In Columbus, Montgomery and Robeson, grass was the leading recipient of irrigation water while peanuts received the most in Cumberland.In Scotland, blueberries were the most intensely watered. The miscellaneous category led in Hoke, Moore and Richmond. The crop least likely to be irrigated was cotton, but it was not grown widely in the region.

CROP	BLA	COL	CUM	HOK	MON	MOO	RIC	ROB	SCO
Corn	250	0	1202	0	6	191	151	20	260
Soybeans	60	0	100	90	4	202	0	0	0
Tobacco	29	73	949	132	246	2159	874	465	105
Peanuts	40	0	76	0	4	0	0	0	0
Cucumbers	5	3	213	0	0	0	211	41	0
Vegetables	15	10	109	0	5	42	363	1	42
Truck Vegs.	0	0	152	0	15	55	97	23	0
Grains	0	0	20	0	25	0	30	8	0
Grass	0	10	0	0	0	312	55	260	0
Pasture	0	0	0	0	0	0	50	46	190
Strawberries	5	14	20	0	12	23	6	27	3
Blueberries	591	48	8	0	8	0	0	0	5
Watermelon	0	0	0	0	5	14	111	1	0
Cantaloupe	0	3	0	0	2	0	88	1	0
Sw. Potatoes	0	0	15	0	12	137	42	0	0
Cotton	0	0	0	0	0	0	0	0	391
Tomatoes	0	3	0	0	0	5	5	1	0
Nursery	0	14	0	0	8	38	0	65	10
Peaches	0	0	0	0	148	23	1450	0	5
Misc.	0	0	0	225	360	30	23	0	0
Golf Courses	80	18	0	63	5	1730	0	2	190
Totals	1075	196	2864	510	865	4961	3556	961	1201

Table 3. Acres Under Irrigation, 1987
Source: Ross 1990a

Crops and uses which consumed more than one billion gallons of surface water per acre were cucumbers in Bladen, vegetables in Cumberland, grass in Montgomery, Moore and Robeson, pasture in Robeson, blueberries in Scotland, nurseries in Montgomery and Scotland, miscellaneous in Moore and golf courses in Columbus, Moore and Robeson. Only four counties applied more than a billion gallons of groundwater per acre to any crop or use: Columbus to golf courses; Montgomery to nurseries; Moore to grass, nurseries, miscellaneous and golf courses; and in Scotland to golf courses.

As shown in Table 3, only 16,189 acres of farm land in the region is irrigated. For example, less than one-half of one percent of the cropland in Robeson was irrigated in 1987. There is little likelihood that the percentage of irrigated cropland varies substantially in other counties within the region. More than 50 percent of the land under irrigation was usually occupied by only one or two crops or uses. In Bladen, for example, 55 percent of the irrigated acres were in blueberries and 23 percent were in corn; in

Cumberland, corn accounted for 42 percent and tobacco for 33 percent; in Moore, tobacco was planted on about 43 percent of the irrigated land with golf courses occupying another 35 percent; peaches used 41 percent of Richmond's irrigated land and tobacco 25 percent; in Robeson, tobacco took 48 percent of the irrigated cropland and grass 27 percent; in Scotland, cotton accounted for 33 percent and corn 22 percent; 37 percent of irrigated land in Columbus was in tobacco and 24 percent in blueberries.

In summary, the four largest crops or uses of irrigated land in the region were, in order, tobacco (5,032 acres), golf courses (2,088 acres), corn (2,080 acres) and peaches (1,626 acres). These occupied 67 percent of the irrigated acres. Of this, 31 percent was in tobacco, while golf courses and corn each took about 13 percent, and peaches occupied 10 percent. Other crops accounted for four percent or less.

Although the amount of water available for irrigation does not appear to be a major factor in whether a farmer uses irrigation or not, there is a distinct regional pattern in terms of how much water is applied to crops, and to which particular crops (Table 2). For example, tobacco is one crop for which irrigation is especially beneficial. Irrigation leads to increased yields and better quality tobacco, which translate into more profit for the grower. Yet, the amount of water applied ranged from about 43,000 gallons per acre in Columbus to 334,000 in Cumberland. Another crop with wide geographic differences in the amount of water application is corn. Robeson farmers applied just 32,800 gallons of water per acre, but Cumberland producers used about 264,000 gallons per acre. Moore corn farmers led the region in water applied, committing more than 452,000 gallons per acre. For all crops, however, Columbus applied more water per acre than any other county in the region, averaging about 1,500,000 gallons per year per acre. Robeson was second and Scotland applied the least amount per acre.

The amount of water used for irrigation purposes depends upon several characteristics of the soil and land surface form. For example, sandy soil with sparse vegetation located on a steep slope is much more likely to need irrigation than an area with abundant vegetation on a clay-loam soil in a gently sloping area. In terms of crops irrigated, the westernmost counties of Richmond, Montgomery and Moore irrigate a wider range of crops, while Hoke has the smallest range.

Generally, tobacco and golf courses are the two largest recipients of irrigation activity. The situation is fluid, however, especially in view of the projected demise of tobacco production by the early part of the twenty-first century, and it poses some interesting questions. One, will the volume of water presently applied to tobacco be used for other crops or products, such as produce or aquaculture, especially since

Tobacco and golf courses are generally the largest users of irrigation water, though the projected demise in land requirements of the former and the probable increase in the latter raise interesting questions

the infrastructure to get the water to the fields is already in place? What about the increasing demand for golf courses as more people in the region demands quality courses? The variations between crops and locales within the region could be the result of physical factors, such as soil texture and depth, precipitation patterns, rates of evapotranspiration, slope of land, and availability of water at a reasonable cost. For example, an acre inch of precipitation is about 27,000 gallons of water.

Cultural factors also affect the level of irrigation in terms of how receptive landowners are to investing in the equipment necessary to have a successful irrigation operation. None of the farmers surveyed in 1988 could document the impact of irrigation upon yield or profit. Nor could they offer more than estimates (guesses) on the return on investment of their irrigation systems. Most of them assumed that irrigation was cost effective.

Summary and Conclusions

This study has established data that show how much water was used for irrigation throughout the region in 1987. It does not provide insight into how much drawdown is occurring in the aquifers or the effect of the withdrawal and subsequent use for irrigation on the overall quality of the water. Before farmers in the region greatly increase the number of acres under irrigation, the issues of quantity and quality of water capable of sustaining additional irrigated acreage must be addressed.

Increased use of irrigation practices will result in improved yields and product quality and improved agriculturally linked prosperity

Several questions evolved out of the study. What is the effect of irrigation upon crop yields and profit, or the difference in yields with irrigation when there is normal rainfall and when there are drought conditions? What effect does chemical applications on farm lands have upon surface and groundwater? What are the consequences of expansion of golf courses and amenity settlements in southcentral and southeastern North Carolina upon the availability of water for crop irrigation?

In conclusion, water is a critical resource for agricultural activities in the region and other activities related to economic development. It is apparent that the region has access to enough water to put more acres under irrigation, and thus produce a higher quality crop, which would greatly enhance farm income. Higher quality crops would most likely lead to the establishment of additional agriculturally based industries and convert the region from a typical southern farm region to a prosperous farm region.

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