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NEEDS AND SOURCES PLANNING IN THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT: GOLF COURSE LAND AND WATER USE PROJECTIONS FOR 1995 AND 2010

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with contributions from

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PREFACE

This study grew out of discussions between Staff of the St. Johns River Water Management District concerned with the Water Supply Needs and Sources Assessment planning effort and Natural Resource and Environmental Economists within the Food and Resource Economics Department (FRED) at the University of Florida. This report reflects an extension of the projection effort detailed in the agricultural reports (See Lynne and Kiker, 1991, 1992). These reports can also be consulted for further description of the analytical system developed for the District to be utilized in future water use projections, for general recommendations regarding improvements in the District data base, and for further recommendations pertaining to improving the projection effort in Water Supply Needs and Sources Assessment in the future.

In addition to developing an analytical system for projecting water use, the contract called for preliminary golf projections using the same approach as that for projecting agricultural irrigated acreage and water use as discussed in Lynne and Kiker (1991, 1992). Due to problems subsequently found in the golf course irrigated acreage data base, the lack of information about golf courses in Florida, generally, and the variability found in the golf industry, another method for projecting golf course acreage based on population growth was developed in an extension of the contract. The same general method for projecting water use, however, was utilized for both the agricultural and golf cases. The same (and reusable) analytical system was also applied. This report describes the methods and provides projections of golf course irrigated acreage and water use.

The projections represented herein need to be used cautiously. More indepth studies of water use as related to the economic characteristics of the Florida golf industry are needed in order to improve projections.

The District along with the Institute for Food and Agricultural Sciences funded the effort.

ABSTRACT

Golf course land and water use projections are necessary for comparing water needs (demands) and sources (supplies) in the St. Johns River Water Management District. Irrigated acreage is projected to increase from 10,143 acres in 1990 to 18,403 acres under medium population growth projections for 2010, with a range of 10,667 to 27,815 acres given low to high population growth rates. Water use is estimated for the base year (1990) acreage and projected for 1995 and 2010 assuming 2-in-10 drought conditions. Golf course water use under 2-in-10 drought conditions for acreage in the base year is estimated at about 11 billion gallons per year (bgy), or about 40 acre inches per irrigated acre. Assuming medium population growth, use is projected to increase to 20 bgy by 2010, with a range from 12 to 30 bgy for low and high population growth. Highest golf course water use occurs in May and lowest in December.

Reliable research information about the way water is actually used (i.e., the managerial and behavioral aspects of water use) on golf courses is lacking. More indepth study of golf course water management and use as related to economic factors in Florida will help in improving projections. Economic factors (e.g., the price charged as greens fees and costs of irrigation) will likely influence the amount of water used.

Keywords: golf course water use, water economics, irrigation water use, projected water use, water demand, economic behavior

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Several of the same individuals involved in the earlier study on agricultural water use also contributed to this project.

Rom Alderman and Staff, in the Florida Agricultural and Resource Management (FARM) Laboratory, again provided valuable service. Word processing and secretarial services were provided by Sharon Bullivant and Gwen McCann. Janice Baisden produced the multiple copies.

The information obtained from county extension offices and local chamber of commerce offices, as well as selected golf course superintendents is appreciated.

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Principal Investigator
Gary D. Lynne

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Golf course water use projections are being established by the St. Johns River Water Management District in the Water Supply Needs and Sources Assessment effort as a part of the District Water Management Plan. The Plan is to be developed as per state water policy (Chapter 17-40, Florida Administrative Code).

Projections in golf course acreage were based on population growth changes as projected by the Bureau of Business and Economic Research at the University of Florida. The estimated 1990 irrigated acreage of 10,143 acres is projected to increase to 12,338 acres in 1995 and to 18,403 acres by 2010 (assuming medium population growth). By 2010, irrigated acreage may increase to only 10,909 acres or to as high as 27,815 acres, for low or high population projections.

An irrigation water simulation model was used to project water use for each acre under a multiple sprinkler system with an assumed 2-in-10 drought probability. The procedure was to estimate water use for a typical climate zone and soil type combination for each golf course. County water projections based on consumptive use permit (CUP) irrigated acreage were developed. A per acre coefficient was then derived for each county, and applied to the golf course irrigated acreage projections for each county.

Assuming 2-in-10 drought conditions, and medium population growth, the base water use of 11 billion gallons per year (bgy) is projected to increase to 14 bgy by 1995 and to 20 bgy by 2010. By 2010, Indian River and Orange counties will probably each use more than 2 bgy. May is the highest water using month, and December the lowest.

Detailed studies could be used to improve acreage projections, determine water management strategies, characterize the types of irrigation systems being used, and improve understanding of technology change for golf courses throughout the State. It might also reasonably be expected, for example, that golf courses with higher greens fees will use more water, suggesting the need to also determine the economic factors affecting golf course water use and expansion in golf course acreage.

1 INTRODUCTION

The St. Johns River Water Management District is engaged in an ongoing effort to provide and improve estimates of all types of water use for the Water Supply Needs and Sources Assessment as a part of the District Water Management Plan as established in state water policy (Chapter 17-40, Florida Administrative Code). This Report 1) considers various methods for projecting golf course acreage and water use, 2) further develops the analytical system designed in Lynne and Kiker (1991, 1992) for projecting irrigated acreage and water use, 3) provides a projection of golf course irrigated acreage and water use for 1995 and 2010 using data bases currently available, and 4) offers recommendations for improving data bases and for economic research needs important to future golf course water use projections.

2 METHODS FOR PROJECTING GOLF COURSE ACREAGE AND WATER USE

The task was separated into first projecting irrigated acreage, and then projecting water use associated with that acreage. Some general considerations are relevant to both projection problems.

2.1 General Considerations in Projecting

Timothy G. Taylor and Gary D. Lynne

Three general methods utilizing information on past trends in a variable can be used to formulate projections for that variable. These approaches are discussed in Granger and Newbold (1977).

First, business forecasting models (e.g. exponential smoothing) decompose historical observations on a given variable into trend and level components. This particular approach is described in detail in Lynne and Kiker (1991, pp. 4-3 to 4-5). Second, time series models can be used to examine a historical series of data on a given variable. The approach rests on the presumption of some unobserved stochastic process and attempts to approximate this process by constructing and estimating some type of Autoregressive Integrated Moving Average (ARIMA) based solely on past observations of the variable being explained. In both of these approaches, the underlying forces at work to affect golf course acreage are not a part of the model. Third, econometric models can be used in an attempt to model causal relationships between the variable being projected (e.g. golf course acreage) and factors which influence the development and operation of golf courses (e.g., willingness-to-pay, or price, for golfing services; costs of providing golf services; water law and regulations; income; population). Each of these methods has strengths and weaknesses that determine their appropriateness for formulating projections in any given situation.

Exponential smoothing models offer the advantage of relying only on past values of the variable being forecasted, and because these models are deterministic, they do not require as large a number of historical observations as time series models or econometric models. Even though this approach has modest data requirements, the currently available data base gave problems in projecting. Of more concern, such models work best in cases were changes are expected to be similar to those in the recent past, and where the changes are continuous rather than discrete and lumpy in character. On the latter point, in contrast to planting decisions made in agricultural enterprises that vary year to year, golf course development tends to occur infrequently and in large discrete changes. Due to data base problems, greater variability in recent years (as compared to relative stability in the agricultural acreage, see Lynne and Kiker, 1991), and the likely discrete nature of investment in golf courses, the method was rejected for projecting acreage.

Time series models, while using historical data only on the variable being projected, generally require a large number of observations. The large number is necessary in order to identify the structure of the ARIMA model and to estimate its parameters with an acceptable degree of statistical precision. A general rule of thumb is that a minimum of 100 observations are required. Currently available golf course acreage data do not provide anywhere near a 100 data point data series for either acreage or water.

Econometric modeling helps in identifying causal relationships, and generally is the preferred approach. Ideally, such a modeling process would consider the economic, social, political, and institutional (e.g., water district rules) forces at work to affect golf course development decisions. To gain the full benefits of this approach, studies would need to be conducted regarding the internal workings of the golfing industry relative to investment decisions and management of the water by firms composing the industry. Additionally, considerable improvements would be needed in data bases that describe the golfing industry. For full benefit, the approach requires an ongoing research effort on the economics of water use in the golfing industry.

Given the lack of such research knowledge about the golf industry, and the time and financial constraints on this study, a much less ambitious variant of the econometric modeling approach was developed for projecting golf course irrigated acreage. The approach links golf course irrigated acreage to population. Water use projections could also benefit from econometric modeling, but insufficient data on historical, actual water use preclude using the approach. A water use simulation model was used to project water use.

2.2 Population Growth Based Acreage Projection

The first task in projecting golf course irrigated acreage was to establish a 1990 base irrigated acreage. Population growth was then presumed to be the driving force in acreage change. Considerations in each case are now addressed.

2.2.1 Updating Base Golf Course Irrigated Acreage for 1990

Cynthia Moore

To obtain a current estimate of irrigated golf course acreage, a list of all golf courses located in the District was compiled. Data from the consumptive use permit (CUP) data base was supplemented with information from other popular and public sources including the Florida Atlas and Gazetteer (Delorme Mapping, 1989), the Official Florida Golf Guide (State of Florida, 1992), the Golf Industry of North East Florida and the Property Appraisers in each county. This information was collapsed into a single list of golf courses, which was then verified by the District.

The process of creating a current list of golf courses in the District was complicated by numerous inaccuracies in the various data sources, including duplicate entries of a single golf course spanning two counties, duplicate entries due to misspelling or use of an alternative name, inclusion of golf courses permitted in a bordering water management district and inclusion of golf courses no longer in operation. In addition, there was confusion over golf courses without a CUP. A CUP is required only for average withdrawals exceeding 100,000 gallons per day. As a result, some smaller golf courses and golf courses using recycled water generally are not required to obtain a CUP. Golf courses using recycled water generally do not need a CUP unless they have backup wells which exceed the exemption threshold. Of the thirteen golf courses using recycled water, only one currently has a CUP. Two golf courses were exempted from permitting because of withdrawals under the threshold.

Each golf course in the final list is associated with an estimate of irrigated golf course acreage. In most cases, this was obtained from the CUP data base, in contrast to agricultural sector land use projections (Lynne and Kiker, 1991) which relied on the Annual Water Use Survey acreage data base available in the District. The latter data base was found inadequate with respect to golf course acreage.

To maintain consistency between the golf and agricultural water use estimates, the method employed in obtaining base 1990 irrigated acreage at the withdrawal point from the CUPs in both studies is essentially the same. In some cases, the reported CUP irrigated acreage clearly includes some urban or landscape development. However, attempts to adjust the data by personal communication with golf course superintendents were unsuccessful.

The base 1990 irrigated acreage was then projected for 1995 and 2010 using three population growth rate estimates-- low, medium and high. Population projections were available from the Bureau of Economic and Business Research (Bureau) at the University of Florida. The low rate of population growth is defined as the average growth rate of population in Florida between 1975 and 1977. According to the Bureau, this period corresponds to the lowest rate of in-migration since World War II. The medium growth rate in population corresponds to net migration levels that typified the late 1970s and the 1980s. The high population projections are based on net migration levels experienced in the early 1970s. Appendix Table 5.1.1 shows population projections for 1995 and 2010, based on the 1990 population census.

2.2.2 Developing the Acreage Projection Model

Timothy Taylor, Cynthia Moore, and Gary D. Lynne

The underlying assumption in the forecasting model for golf course acreage was that the change in the number of golf course holes in any given county will vary in direct proportion to the change in population in the county. Change in golf course holes is linked to population change through the equation

$$\text{change in holes from t-1 to t} = k(\text{population}_t - \text{population}_{t-1})$$

or,

$$(h_t - h_{t-1}) = k(pop_t - pop_{t-1})$$

where t = year, and k = change in the number of golf course holes in the county for a change of 1,000 people in the county. The change in the number of holes was then linked to the irrigated acreage change. The model is reasonable for the current projections, as well as a base upon which to build for improving projection techniques in the future, for several reasons.

First, to the extent that the demand for recreational services provided by golf courses is related to population growth, and to the extent that many new courses are linked to real estate development, it can be expected that golf course development is connected with population growth. Second, there are sufficient historical data to estimate the relationship between population and golf course holes as reported in the Official Florida Golf Guide (State of Florida, 1992). Third, as noted, the Bureau (Bureau of Economic and Business Research, 1968 through 1991) annually publishes low, medium and high population projections for each county in Florida to 2010. Thus, published population projections are available to generate low, medium and high hole (and acreage) projections.

To estimate the parameter k a linear model was used

$$\text{holes}_t = \text{constant} + k(\text{population}_t)$$

or, more simply $h_t = \text{constant} + k(pop_t)$

where k is the slope coefficient, or the change in holes given a change in population of 1000 people (i.e., pop_t is measured in thousands). The dependent variable, holes in year t (h_t), is simply the total number of golf course holes in the county in a particular year t.

Only counties falling completely within the District (with the exception of Lake County) were included in the population growth analysis.

The file, Golf.dat, contains the data on golf course holes and initial year of operation. The data were obtained from the Official Florida Golf Guide (State of Florida, 1992), covering the period 1950 to 1992. Some supplemental information was obtained by contacting golf course superintendents.

Because some counties lacked a sufficient number of observations to allow reliable estimation, the data were pooled into three groups categorized according to population characteristics. Criteria for pooling counties were determined in consultation with District staff. Generally, the criteria related to the rate of growth. These discussions led to three groupings which are expected to be most representative: New Working, New Residential, and Rural (Table 2.1).

Despite numerous pooling rearrangements, two counties-- Brevard and Duval-- did not fit any of the established categories, nor did they form a separate category on their own. Because each county had a sufficient number of observations, projection models were developed for each of these two counties.

Table 2.1 presents the estimated models. In all cases the estimated k parameters on the population variables have the expected positive sign and are statistically significant. Additionally the estimated F-values suggest the equations explain a statistically significant portion of the variation in the dependent variable (golf holes). The R^2 values which measure the explanatory power of the model (on a scale of 0.0 to 1.0, 1.0 being perfect, or 100 percent) indicate that the level of population explains well over half (0.60 to 0.73, or 60 to 73 percent) of the variation in the number of golf course holes in a county over time.

While these R^2 values are not high relative to those found in many engineering applications, the estimates are quite acceptable for models based on pooled data. Also, while higher R^2 values could have been obtained by adding additional explanatory variables to the model, it must be remembered that the end use of these equations is projecting into the future. When projecting the number of golf holes, each new variable included in the regression equation must itself be projected. While the Bureau of Economic and Business Research is a ready source of projected changes in population, projections for most other variables that would be appropriate in the regression equation are not generally available. Hence gains in fit of the estimated regression equation could be lost in the errors associated with projecting the additional explanatory variables. More research could facilitate considering other variables. Clearly tradeoffs exist between accuracy in the equation and the usefulness of the equation for projecting.

Table 2.1 Golf Course Projection Models, St. Johns River Water Management District, Data for 1950 to 1992.

Group	Counties[a]	Partial Counties[b]	Projection Model[c]	Statistics[d]	
				R^2	F-value
New Working	Seminole Volusia	Orange	$h_t = 36.00 + 0.63\ (pop_t)$ (22.43) (0.11)	0.60	34.92
New Residential	Indian River Flagler Lake	Bradford Polk Marion	$h_t = 44.33 + 1.4\ (pop_t)$ (15.89) (0.19)	0.65	54.39
Rural	Putnam St. Johns Clay Nassau	Alachua Osceola Okeechobee Baker	$h_t = -16.32 + 2.44\ (pop_t)$ (19.18) (0.40)	0.69	36.34
Non-Pooled Counties	Brevard		$h_t = -4.75 + 0.51\ (pop_t)$ (25.24) (0.11)	0.73	27.28
	Duval		$h_t = -79.77 + 0.45\ (pop_t)$ (57.12) (0.11)	0.70	16.43

[a]Counties completely within the District. Lake county is included because most of it falls within the District.

[b]Counties split between two or more water districts.

[c]Numbers in parenthesis are standard errors. The symbol "h_t" refers to the total number of golf course holes in year t, and "pop_t" is total population (in thousands) in the county in year t.

[d]The R^2 shows the percentage of variation (multiply the number by 100) explained by the model. A large F-value suggests statistical significance of the equation.

Projections were made for each county using the slope coefficient of the pooled group model as the growth factor. Tables 2.1 - 2.4 present the steps taken in obtaining 1995 and 2010 county projections. For example, the growth equation for the group New Working is $h_t = 36 + 0.63(pop_t)$ (Table 2.1), which suggests that for each 1000 person increase in population in one of the counties in this group in year t there is an increase of 0.63 new golf course holes in that county. For the case of Seminole County, medium population in 1990 and 1995 is 287.5 thousand and 341.8 thousand people, respectively (Appendix Table 5.1.1). The number of new golf course holes by 1995 is then estimated to be

$$0.63 * (341.8 - 287.5) = 0.63 * 54.3 = 34.2 \text{ holes.}$$

It is assumed that new construction will not take place for less than nine holes. Thus, an additional course is assumed only when the projection model estimates a minimum of nine new holes in the given time frame. So, using this factor

$$34.2 \text{ holes}/ 9\text{-holes per course} = 3.8 \text{ courses}$$

as shown (Table 2.2). Or, using the integer value, three 9-hole golf courses (or one 18-hole and one 9-hole) will be constructed in Seminole County by 1995 (Table 2.3). Holes are then converted to irrigated acreage using the average acres per hole in the county in 1990. Only golf courses with hole information and seemingly reliable acreage estimates were included in calculating county averages. In 1990, Seminole County had 5.8 acres per hole in golf courses (Table 2.4). Using this factor

$$(5.8 \text{ acres/hole} * 9 \text{ holes/course} * 3 \text{ courses}) = 157 \text{ acres}$$

installed by 1995. Starting with 435 acres in 1990, the total is 592 acres in 1995 (Table 2.4).

For counties split between and among water districts, an additional adjustment was necessary. It was assumed that only a portion of the population change for these counties would occur in the District. In particular, it was assumed that 75 percent of the population change for Orange County would occur in the District, 2.5 percent for Polk County, 50 percent for Alachua, and 33 percent for Osceola County (Table 2.2).

These assumptions and steps were programmed into the modified analytical system. The District can easily modify projections in the future given changes in either the models of Table 2.1 or in the base irrigated acreage in each county.

2.3 AFSIRS Based Water Projection

Gary D. Lynne and Michael Martin

The lack of a historical record of actual water use on golf courses in Florida and of reliable research knowledge on how actual golf course

Table 2.2 Projected Increase in the Number of 9-Hole Golf Courses, St. Johns River Water Management District, 1992.

Group and Counties	Holes in 1990	Rate of Change (holes per 1000 people)	Population Projection					
			Low[a]		Medium		High	
			1995	2010	1995	2010	1995	2010
New Working								
Orange[b]	54	0.63	2.3	3.2	5.3	18.3	8.4	36.4
Seminole	216	0.63	1.4	0.4	3.8	13.2	6.2	27.9
Volusia	396	0.63	1.7	2.3	3.9	13.3	6.1	26.5
New Residential								
Bradford	18	1.4	-0.1	-0.7	0.2	0.4	0.5	1.9
Flagler	108	1.4	0.8	1.4	1.4	5.0	2.0	9.1
Indian River	288	1.4	0.7	-0.5	2.3	7.9	3.9	17.5
Lake	684	1.4	1.5	2.2	3.6	12.3	5.6	24.4
Marion	81	1.4	1.8	-0.2	5.3	18.5	8.9	39.0
Polk[b]	18	1.4	0	-0.1	0.2	0.5	0.3	1.2
Rural								
Alachua[b]	54	2.44	0.8	1.5	2.1	7.1	3.5	14.5
Baker	18	2.44	-0.0	-0.5	0.4	1.4	0.8	3.6
Clay	36	2.44	1.8	0.0	5.2	17.9	8.6	38.4
Nassau	108	2.44	0.4	-0.0	1.4	4.6	2.4	10.2
Okeechobee	0	2.44	0.5	0.7	1.2	4.0	1.9	8.1
Osceola[b]	0	2.44	1.2	1.6	2.4	8.6	3.7	16.6
Putnam	27	2.44	0.4	-0.5	1.8	6.3	3.3	14.3
St. Johns	234	2.44	1.5	0.1	4.1	14.3	6.8	30.5
Non-Pooled Counties								
Brevard	324	0.51	1.4	1.8	3.3	11.3	5.3	22.8
Duval	360	0.45	0.5	0.1	2.3	7.4	4.1	16.9

[a]Some projections may be negative or decline from 1995 to 2010 due to projected decreases in population.

[b]Percentage of population for the portion of the county in the District set at 75 percent for Orange, 2.5 percent for Polk, 50 percent for Alachua, and 33 percent for Osceola.

Table 2.3 Projected Increase in the Number of 9-Hole Golf Courses for 1995 and 2010, Golf Course Equivalents, St. Johns River Water Management District, 1992.[a]

Group and Counties	Holes in 1990	Rate of Change (holes per 1000 people)	Population Projection					
			Low		Medium		High	
			1995	2010	1995	2010	1995	2010
New Working								
Orange	54	0.63	2	3	5	18	8	36
Seminole	216	0.63	1	1	3	13	6	27
Volusia	396	0.63	1	2	3	13	6	26
New Residential								
Bradford	18	1.4	0	0	0	0	0	1
Flagler	108	1.4	0	1	1	5	2	9
Indian River	288	1.4	0	0	2	7	3	17
Lake	684	1.4	1	2	3	12	5	24
Marion	81	1.4	1	1	5	18	8	39
Polk	18	1.4	0	0	0	0	0	1
Rural								
Alachua	54	2.44	0	1	2	7	3	14
Baker	18	2.44	0	0	0	1	0	3
Clay	36	2.44	1	1	5	17	8	38
Nassau	108	2.44	0	0	1	4	2	10
Okeechobee	0	2.44	0	0	1	4	1	8
Osceola	0	2.44	1	1	2	8	3	16
Putnam	27	2.44	0	0	1	6	3	14
St. Johns	234	2.44	1	1	4	14	6	30
Non-Pooled Counties								
Brevard	324	0.51	1	1	3	11	5	22
Duval	360	0.45	0	0	2	7	4	16

[a]Golf course construction is assumed to be irreversible. In case of a decline or a negative projection from Table 2.2, the number of holes is held constant.

Table 2.4 Projected Irrigated Acreage in Golf Courses for 1995 and 2010, St. Johns River Water Management District, 1992.

Group and Counties	Irrigated Acreage in 1990	Irrigated Acres Per Hole	Population Projection					
			Low		Medium		High	
			1995	2010	1995	2010	1995	2010
New Working								
Orange	1227	6.2	1339	1394	1506	2231	1673	3236
Seminole	435	5.8	487	487	592	1114	748	1844
Volusia	1137	4.2	1175	1213	1250	1628	1364	2120
New Residential								
Bradford	30	7.7	30	30	30	30	30	100
Flagler	40	7.5	40	108	108	378	175	648
Indian River	1584	4.9	1584	1584	1672	1893	1716	2334
Lake	1031	5.4	1080	1128	1177	1614	1274	2197
Marion	436	5.2	483	483	670	1278	810	2261
Polk	169	9.3	169	169	169	169	169	253
Rural								
Alachua	198	3.7	198	231	265	431	298	664
Baker	60	3.3	60	60	60	90	60	149
Clay	263	9.3	347	347	682	1686	933	3444
Nassau	609	5.0	609	609	654	789	699	1059
Okeechobee	0	0.0	31	31	61	245	92	490
Osceola	0	3.4[a]	0	0	0	0	0	0
Putnam	120	3.2	120	120	149	293	206	523
St. Johns	690	8.0	762	762	978	1698	1122	2850
Non-Pooled Counties								
Brevard	855	4.3	894	894	971	1281	1049	1706
Duval	1260	4.7	1260	1260	1345	1556	1429	1937

[a]The average of Alachua, Baker, and Putnam counties.

managers utilize water on golf courses led to using a simulation model. The same types of problems were found and the same simulation model was used for agriculture (see Lynne and Kiker, 1991).

It was decided the best estimating method would be to use the Agricultural Field Scale Irrigation Requirements Simulator (AFSIRS), which was developed by Smajstrla (1990a,b). The AFSIRS model provides for estimating turf grass water use under different rainfall conditions. The simulator operates on a daily time step over a historical record of rainfall, upwards of 20 to 25 years for some rainfall stations in Florida. By accounting for the rainfall patterns over the historical record, a probability distribution describing the irrigation water use can be developed.

While economic factors cannot be considered due to the lack of research information on golf course management behavior, AFSIRS will give a good first estimate. The following regarding AFSIRS indicates the basis for the water use estimate (Smajstrla, 1990b, p. 93):

> For golf courses, irrigations or rainfall are required very frequently to promote the high quality turf required... tees and greens be irrigated daily to apply 1-inch per week (1/7 inch per day), while fairways be irrigated every other day to apply 1-inch per week (2/7 inch per day). In Florida, the weekly depths of irrigation required would be expected to approach 2-inches per week during peak water use periods.
>
> These guidelines result in small depths of soil irrigated on greens and tees, but greater depths in fairways, even for sandy soils. For this reason, small, frequent irrigations are scheduled by the AFSIRS model. The irrigated root zone is assumed to average 9 inches and irrigations are scheduled at 50 percent depletion of available soil water in this zone.
>
> In practice, tees and greens are irrigated separately from fairways, and the model user can simulate the irrigation requirements of these two zones by running the model for each of the separate areas. In that case, a 1-ft irrigated root zone should be used for fairways, while greens should be irrigated to replace ET daily.

Unfortunately, even though AFSIRS facilitates estimates for each component part of a golf course, the CUP data base does not separate out greens and tees acreage from fairways acreage. Thus, for present purposes it was assumed that all the irrigated acreage was in fairways. The resulting water use estimate will likely be a reasonable approximation in that greens areas typically average only about three percent of the acreage in a golf course (Cisar, 1992). It is expected there will be considerable variability in the way golf course water is managed in greens areas (Cisar, 1992), suggesting the need for further study.

The user enters information on location (nearest rainfall station), soil type of the golf course, the irrigation system, and the water use management strategy being used by golf course managers. The model then projects water use for different drought probabilities, ranging from 5-in-10 to 1-in-10 severities. The 2-in-10 drought (as compared to a 5-in-10 or average year) probability was used, so estimates represent water use under modest drought conditions. More water would be wanted by the industry in drier years.

Water use was estimated for 33 distinct types of climate and soil type combinations. AFSIRS settings varied by climate zone and soil type, but all assumed the same type of irrigation system (multiple sprinkler). Also, all golf course managers were assumed to allow no turf water stress at any time during the year. This assumption suggests a highly favorable ratio of (irrigation cost)/(golf service price) (see Lynne and Kiker, 1991, esp. Section 6.5.2, and Lynne and Kiker, 1992, Appendix 7.3, for more discussion of price ratio effects). All golf courses were also assumed to have the same turf grass represented in the data base for the AFSIRS model. For the combinations considered, the AFSIRS model suggests water use will vary about 10 acre inches per year, depending upon the climate, soil, and system type.

The AFSIRS irrigation requirement coefficients for a 2-in-10 year drought were used to estimate per acre water use, as in Lynne and Kiker (1991, 1992). Estimates from AFSIRS were then multiplied by the number of acres pertaining to golf courses listed in the CUP data base, for which accurate irrigated acreage data could be found in the data base. Water application is divided equally among groundwater withdrawal points, except in the cases where the golf course was only a small part of a larger development. In such cases, all use was assigned to one withdrawal point.

3 IRRIGATED ACREAGE AND WATER USE PROJECTIONS

As for the agricultural projections (Lynne and Kiker, 1991), water use was first estimated assuming 2-in-10 drought conditions for the 1990 CUP irrigated acreage (see Appendix Table 5.2.1). The resulting per acre water use coefficient for each county was then multiplied by the county golf course irrigated acreage projections. The resulting golf course monthly and yearly water use projections by county are shown in Appendix Tables 5.2.2, 5.2.3, and 5.2.4 for 1995 and 2010 under conditions of low, medium, and high population growth.

3.1 Using the Analytical System

Cynthia Moore

The analytical system developed in Lynne and Kiker (1991, see esp. Sections 7.1 and 7.2) was utilized. A list of groundwater withdrawal points with their associated permit numbers was created from the CUP file

WELLS. Each withdrawal point was assigned an unique identification code (WD_ID), consisting of the county code, the permit number trimmed of the trailing descriptive characters, and a three digit code for the well number. A description of the created files is provided in Appendix Table 5.1.2.

The list of withdrawal points was used as the basis in the creation of the analysis files, Golf_Desc and Golf_Afsirs. These latter two files have essentially the same structure as their counterparts in the agricultural water use estimates (WD_Desc and WD_Afsirs). Descriptive data were appended to the file Golf_Desc from the original CUP files Main and Water, through linkage on the field Appnum.

Unlike the case of the agricultural permits, however, acreage devoted to golf course irrigation is not consistently recorded in the field Proj_acreage. Additional descriptive information about the irrigated golf course acreage was found in the field "Authorization" in the file WATER. A new field "Golfacre" was added to the file Golf_Desc, containing the corrected permit level acreage for golf. The District assisted in obtaining current irrigated golf course acreage through contacts with the golf courses and various other data base files available at the District. As noted, in some cases it was impossible to distinguish between irrigated acreage in golf courses in contrast to that in related urban or landscape development.

The permitted golf course irrigated acreage was then distributed equally among the withdrawal points in the file Golf_Desc, provided the permit was granted solely for golf course use. In the case of multiple use permits (e.g., permitted for irrigation of golf course and public supply), the permit was treated as having only a single withdrawal point. It was impossible to determine which of withdrawal points was associated with the golf course.

A LOCATION code was given to each observation, comprised of the county code, soil code, irrigation method code and crop code. Any observation missing one or more of these codes would be excluded from water use analysis because of insufficient data. Permits lacking soil data were assigned a specific location code containing an average monthly estimate of water use for the climate zone of the county.

Information from Golf_Desc was appended to the file structure of Golf_Afsirs, the file used in the water use estimates for withdrawal points. Golf_Afsirs was linked on the field LOCATION to the file AFOUTGOL, which contains the AFSIRS irrigation requirements in Acre_inch per month, for each of the unique location codes appearing in Golf_Desc. Water use in million gallons per month (mgm) for each observation having a complete LOCATION code was calculated by multiplying the AFSIRS monthly coefficient by the golf course irrigated acreage and the Acre_inch to million gallons conversion factor (0.027154).

3.2 Irrigated Acreage Projections

Gary D. Lynne and Cynthia Moore

As noted, golf course irrigated acreage was projected for low, medium, and high population projections. Projections in border counties with other water districts were also adjusted. It was assumed that 75 percent of the population change projected for Orange County would occur in the District, with an assumption of 2.5 percent for Polk County, 50 percent for Alachua County, and 33 percent for Osceola County.

Irrigated acreage is projected to increase over the 1990 base irrigated acreage of 10,143 acres from a low of 10,909 to a high of 27,815 acres by 2010 (Table 3.1). The medium projection suggests 18,403 irrigated acres in golf courses by 2010 (Table 3.1).

Considerable variability in growth is expected among counties. Under medium projections, irrigated acreage could double in Alachua, Orange and Putnam Counties. It could well triple in Marion, Seminole, and St. Johns Counties. Projections suggest over a 6-fold increase in Clay County and Flagler Counties, and an increase in Osceola County from no golf courses to 245 acres (Table 3.1). The largest absolute increase of about 1400 acres is shown for Clay County (Table 3.1).

3.3 Water Use Projections

Gary D. Lynne and Cynthia Moore

Water use was also projected for the low, medium, and high population projection (recall, water use is projected for a 2-in-10 drought). Water use could increase over the 1990 base estimate of 11 billion gallons per year (bgy) from a low of 12 bgy to a high of 30 bgy by 2010 (Figure 3.1, Table 3.2). A medium projection is 20 bgy (Figure 3.1, Table 3.2). These estimates suggest about 40 acre inches of water will be used on each irrigated golf course acre under 2-in-10 drought conditions. Again for the medium projection, monthly water use for golf courses is highest in May at 2.2 billion gallons (bg) and lowest in December at 0.6 bg (Figure 3.2, Appendix Table 5.2.3. See Appendix Tables 5.2.2 and 5.2.4 for low and high projections).

Golf course irrigation water use under a 2-in-10 drought for the base irrigated acreage in 1990 is shown to be highest in Indian River County at 1.8 bgy (Table 3.2). No golf course water use is shown for Osceola and Okeechobee Counties in the base year. Brevard, Duval, Lake, Orange and Volusia Counties range between 1.0 and 1.4 bgy (Table 3.2). All others are less than 1.0 bgy in the base year.

Focusing on the medium projection, by 2010 Orange County will use the most water for golf courses, at 2.5 bgy, followed by Indian River County at 2.1 bgy (Figure 3.3). Clay, Duval, Lake, St. Johns, and Volusia Counties all are in the range of 1.5 to 2.0 bgy by 2010 (Figure 3.3, Table 3.2).

Table 3.1 Golf Course Irrigated Acreage for 1990 with Projections for 1995 and 2010 Under Low, Medium and High Population Growth Projections, St. Johns River Water Management District, 1992.

		Population Projection					
		Low		Medium		High	
Counties	1990	1995	2010	1995	2010	1995	2010
		- - - - - - - - Acres - - - - - - - -					
Alachua	198	198	231	265	431	298	664
Baker	60	60	60	60	90	60	149
Bradford	30	30	30	30	30	30	100
Brevard	855	894	894	971	1281	1049	1706
Clay	263	347	347	682	1686	933	3444
Duval	1260	1260	1260	1345	1556	1429	1937
Flagler	40	40	108	108	378	175	648
Indian River	1584	1584	1584	1672	1893	1716	2334
Lake	1031	1080	1128	1177	1614	1274	2197
Marion	436	483	483	670	1278	810	2261
Nassau	609	609	609	654	789	699	1059
Okeechobee	0	0	0	0	0	0	0
Orange	1227	1339	1394	1506	2231	1673	3236
Osceola	0	31	31	61	245	92	490
Polk	169	169	169	169	169	169	253
Putnam	120	120	120	149	293	206	523
St. Johns	690	762	762	978	1698	1122	2858
Seminole	435	487	487	592	1114	748	1844
Volusia	1137	1175	1213	1250	1628	1364	2120
TOTAL	10143	10667	10909	12338	18403	13847	27815

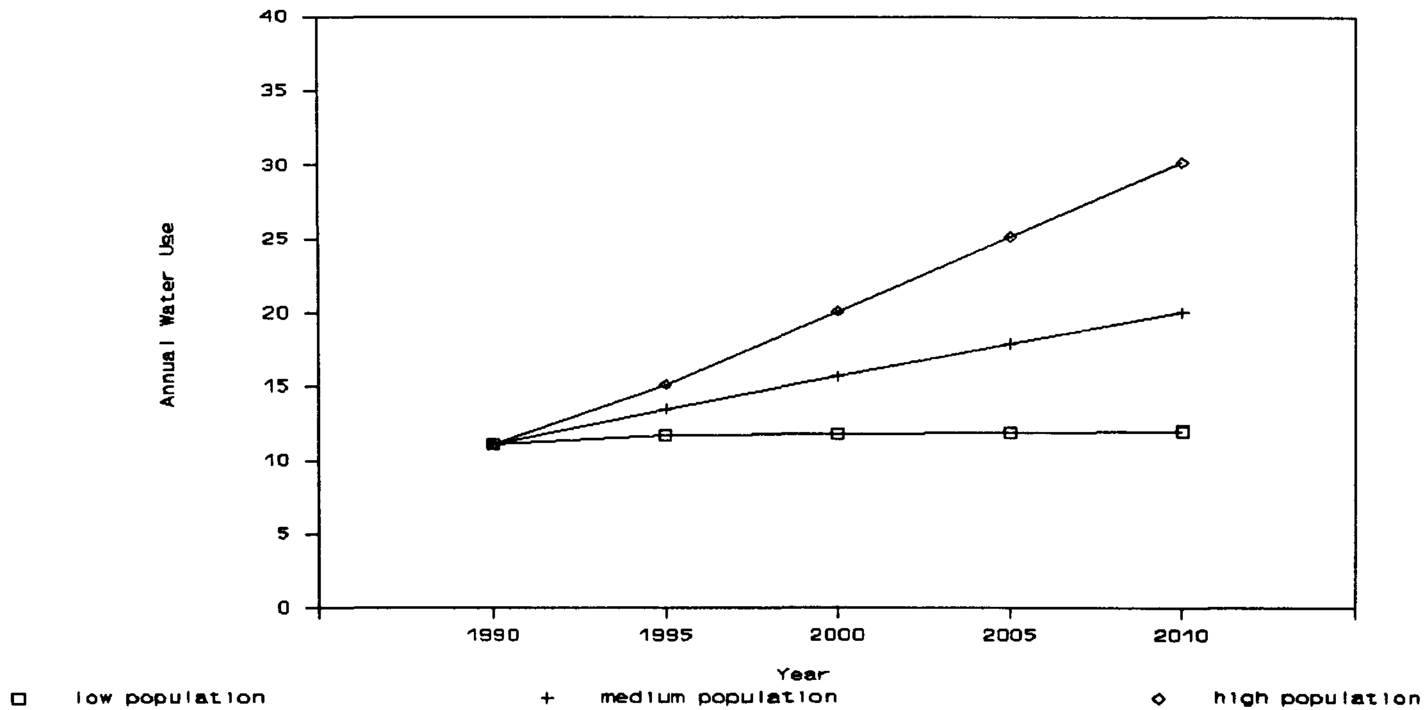

Figure 3.1. Projected water use for golf courses assuming 2-in-10 drought conditions and low, medium and high population growth, St. Johns River Water Management District, 1990, 1995 and 2010 (in Billions of Gallons).

Table 3.2 Golf Course Annual Water Use Estimate for 1990 with Projections for 1995 and 2010 Under Low, Medium and High Population Growth Projections, Assuming 2-in-10 Drought Conditions, St. Johns River Water Management District, 1992.

Counties	1990	Population Projection					
		Low		Medium		High	
		1995	2010	1995	2010	1995	2010
		- - - - - - Million Gallons Per Year - - - -					
Alachua	218.17	218.17	254.53	291.99	474.90	328.36	731.64
Baker	65.01	65.01	65.01	65.01	97.19	65.01	161.54
Bradford	31.28	31.28	31.28	31.28	31.28	31.28	103.75
Brevard	999.97	1045.24	1045.24	1135.76	1497.86	1226.29	1995.74
Clay	271.76	358.24	358.24	704.19	1742.02	963.65	3558.23
Duval	1280.72	1280.72	1280.72	1366.71	1581.69	1452.71	1968.65
Flagler	38.45	38.45	103.33	103.33	362.86	168.21	622.39
Indian River	1774.97	1774.97	1774.97	1873.80	2120.88	1923.22	2615.05
Lake	1143.44	1197.49	1251.40	1305.31	1790.47	1413.12	2437.36
Marion	452.75	501.93	501.93	696.54	1329.04	842.50	2350.78
Nassau	635.02	635.01	635.01	681.94	822.70	728.86	1104.24
Okeechobee	0	0	0	0	0	0	0
Orange	1389.61	1517.07	1579.39	1706.28	2527.70	1895.49	3666.36
Osceola	0	35.12	35.12	69.11	277.58	104.24	555.17
Polk	193.20	193.20	193.20	193.20	193.20	193.20	289.23
Putnam	124.99	124.99	124.99	154.99	304.98	214.99	544.97
Seminole	503.33	563.73	563.73	684.52	1288.51	865.72	2134.10
St. John	728.40	804.41	804.41	1032.43	1792.49	1184.44	3008.60
Volusia	1279.81	1321.77	1364.30	1406.83	1832.12	1534.42	2385.00
TOTAL	11130.87	11706.80	11966.79	13503.23	20067.50	15135.69	30232.80

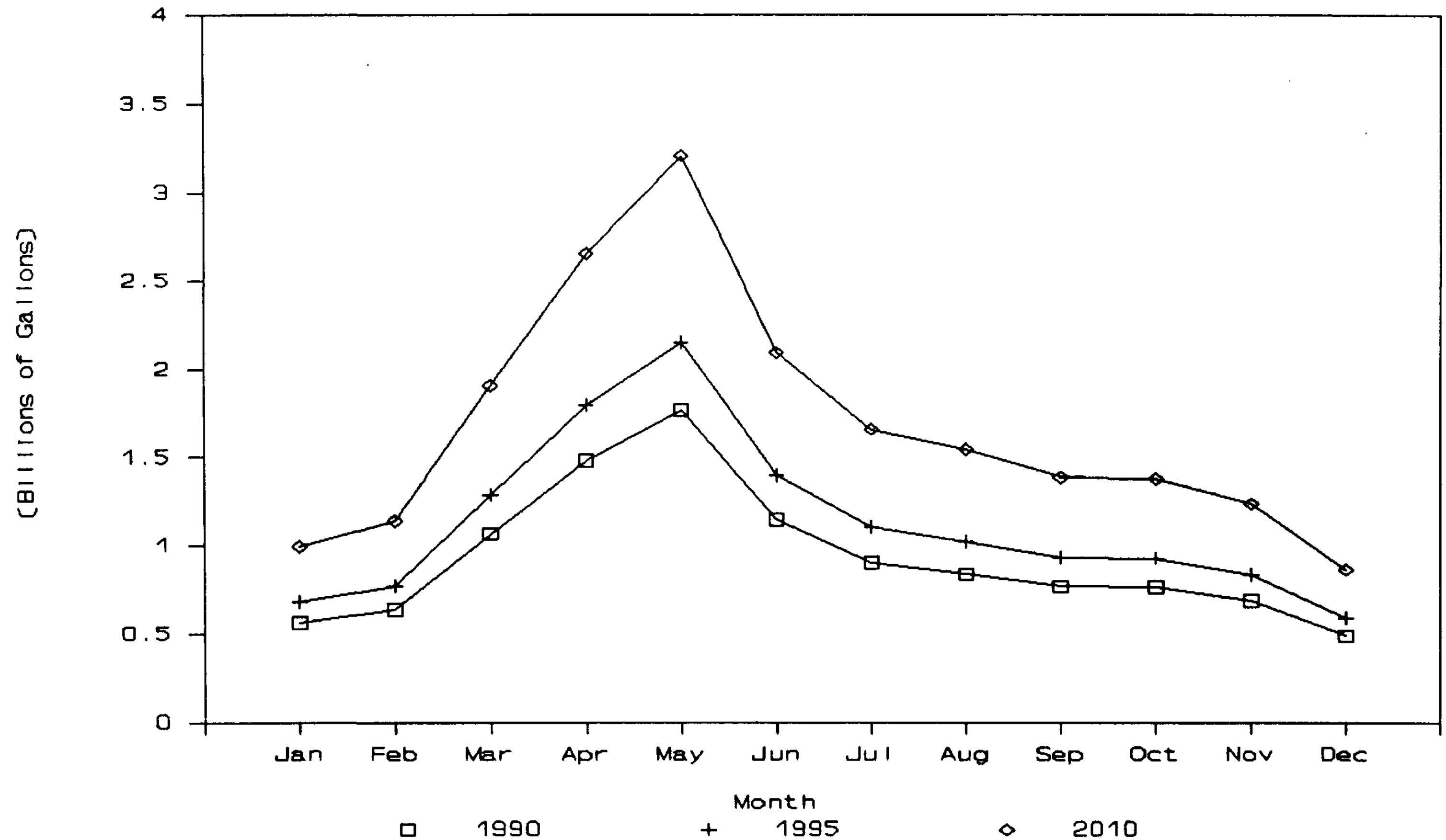

Figure 3.2. Projected water use for golf courses under current irrigation techonology, assuming 2-in-10 drought conditions and medium population growth, St. Johns River Water Management District, 1990, 1995 and 2010.

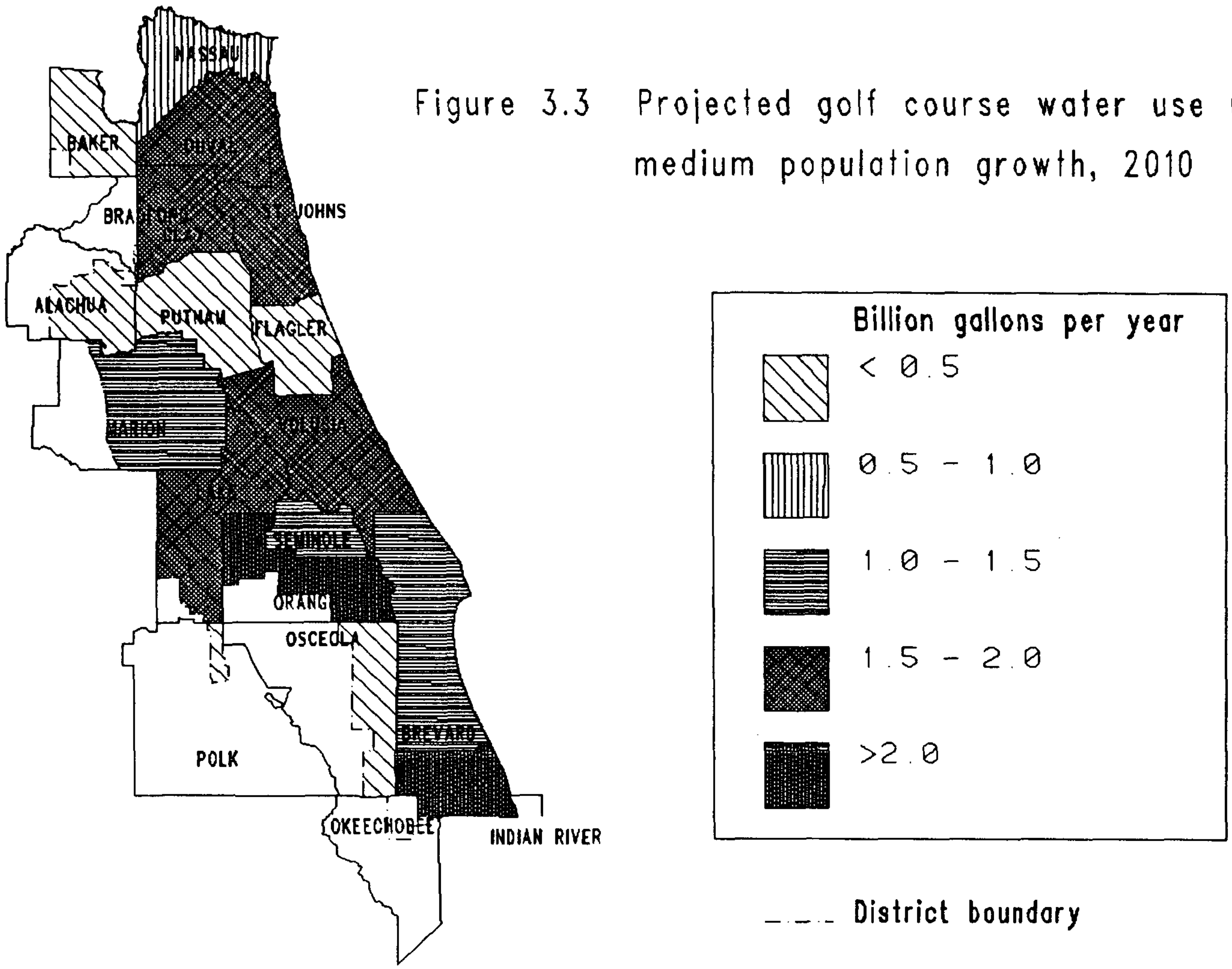

Figure 3.3 Projected golf course water use under medium population growth, 2010

The impacts of reuse could not be assessed in this study. No information was available on the amount of golf acreage irrigated with recycled water.

The impact of best management practices on golf courses could not be ascertained. More detailed studies of golf course water management and investment decisions would be helpful in assessing the type and pace of technological change.

4 RECOMMENDATIONS

Gary D. Lynne, Cynthia Moore, Timothy Taylor, and Michael Martin

All five water management districts have to include information on golf courses in projecting water use in the Water Supply Needs and Sources Assessment effort. Unfortunately, information is lacking on actual golf course water use practices and the economic factors affecting golf course water use in Florida. Such information could be used to indicate the economic importance of golf courses in the State and improve projections of water use.

4.1 Many of the Recommendations Regarding Agricultural Acreage and Water Use Projections Also Apply to the Golf Projections Problem

The reader is referred to Section 6.0 in the agricultural reports (Lynne and Kiker, 1991, 1992). Recommendations pertaining to changes in the data base and analytical system of the District, and regarding further studies, are also generally relevant to the golf course water use projection process. Particular attention could beneficially be placed on improving both acreage and water use projection methods and the data bases.

This study (including Lynne and Kiker, 1991, 1992) has demonstrated that limited information is available about actual irrigated acreage and water use in both the agricultural and golf industries. Further research regarding how, when, how much, where, and why varying amounts of water are being used could serve to improve projections. The District should consider allocating more resources to collecting primary data on irrigated acreage and water use, and to increasing the understanding of economic factors affecting water use by Florida business firms generally.

4.2 Different Water Management Philosophies Result in Varying Data, Information, and Knowledge Needs

As emphasized in the agricultural reports (see esp. Lynne and Kiker, 1991, Section 6.5, pp. 33-34), a centralized water management approach will require a different kind of data, information, and knowledge about water use than will a decentralized approach. A Needs and Sources Assessment in an environment where individuals could buy, sell, or lease water in a decentralized approach, for example, would require quite different data and information needs than the same assessment under the current water management process. Under the current process, more information and knowledge is needed about the water economy because of the potential for impact on business decisions.

4.3 General Study of the State Golf Industry

Research will be needed on the golf industry in the State in order to obtain reliable water use and related economic information. In the early stages of such a research effort, the study team would need to determine the characteristics of course turf and soil types, watering systems and typical organizational structure for managing golf course water use, and main economic factors affecting the golf industry. A survey instrument for determining golf course maintenance and operation in various economic settings could be developed. A survey could then be conducted to help in understanding, explaining, and predicting water use at golf courses.

A random sample could be developed from the total number of Florida golf courses for surveying purposes. The sample could be stratified so as to insure a sufficient number of golf courses are sampled in each district. The survey could be designed to obtain data regarding irrigation systems, grasses covering the courses, and strategies used in deciding when to irrigate and how much water to apply at each irrigation. Information on actual water management behavior will help in insuring realistic projections.

It would also be beneficial to survey golf courses in order to obtain information regarding economic characteristics. It might reasonably be expected that golf courses charging higher prices would also use more water. It is likely that economic factors play a role in water use on golf courses because a significant portion of what a golf course sells is appearance.

Demographic characteristics may also play a role in golf course water use. Courses located closer to dense population areas, for example, may be smaller due to higher land value. Because of more intense use, such courses may also use more water per acre. Water use estimates for golf courses across the State would be based on the distinguishing characteristics of courses determined by the survey.

4.4 Final Note: A Maturing Water Economy

As argued in Lynne and Kiker (1991, 1992, see especially 1992, Section 6.5, pp. 33-34), Florida's water economy is maturing. In such a setting, water becomes scarce. Private and social costs pertaining to more supply development increase. Such costs tend to increase rapidly.

At the same time, the willingness-to-pay for additional water tends to decline (Lynne, 1991). The result is conflict over water, especially over the less expensive water. It is expected that Florida's water management districts will face ever more conflict among competing water users in the next 5 to 10 years.

As a result, projecting water use through the Water Supply Needs and Sources Assessment process will become more problematic in the future because competing users (e.g., commercial, industrial, and agricultural) will each want to have larger amounts projected as needs in order to insure their industry will not be limited by the availability of water. This view is understandable in that water is fundamental to Florida business. Water facilitates economic development and a favorable business climate. The districts can affect the character of that business environment with water use projection and allocation decisions. Projections need to be sensitive to this reality.

Thus, future projections will likely be improved if the process involves industry groups in assessing water wants, needs, and demands. Importantly, the methods developed in Lynne and Kiker (1991, 1992) and in this report for handling large quantities of acreage and water use data and for updating the actual projections will be helpful in interacting with such groups. The impacts of changes in assumptions which might be suggested by such groups can be examined with the models. Such involvement will insure that all affected parties will feel a part of the process, and, thus, whether winner or loser, at least all will have had a say, and thus will generally feel there was a mutual gain.

Overall, water issues in Florida have come to involve complex social, political, and economic factors in addition to physical, engineering, and biological aspects. This study as a part of the Water Supply Needs and Sources Assessment planning process has highlighted the importance of systematic inquiry into behavioral factors. Projections can be improved with such knowledge.

5 APPENDICES

5.1 Background Data Tables

Appendix Table 5.1.1. Population Projections for 1995 and 2010 for Counties in the St. Johns River Water Management District, 1992

County	1990	Population Projections					
		Low		Medium		High	
		1995	2010	1995	2010	1995	2010
		- - - - - - - Thousands of people - - - - - - -					
Orange	677.5	720.8	738.4	778.5	1026.1	837.7	1371.3
Seminole	287.5	307.9	293.9	341.8	476.5	376.3	685.9
Volusia	370.7	394.3	403.8	425.9	561.1	458.3	749.9
Bradford	22.5	21.7	17.7	23.5	25.3	25.4	34.4
Flagler	28.7	34.0	37.5	37.8	60.8	41.6	87.5
Indian River	90.2	94.4	86.9	104.8	140.8	115.4	202.7
Lake	152.1	162.0	166.4	175.0	231.2	188.3	309.0
Marion	194.8	206.4	193.6	229.1	313.9	252.3	451.8
Polk	405.4	411.8	387.0	444.7	537.7	478.5	718.7
Alachua	181.6	187.6	192.5	197.2	234.1	207.3	288.8
Baker	18.5	18.4	16.5	20.0	23.5	21.6	31.9
Clay	106.0	112.6	106.1	125.0	172.0	137.6	247.5
Nassau	43.9	45.3	43.8	48.9	60.9	52.6	81.4
Okeechobee	29.6	31.4	32.1	34.0	44.5	36.5	59.5
Osceola	107.7	121.6	125.4	134.9	203.4	148.6	292.7
Putnam	65.1	66.6	63.4	71.9	88.2	77.4	117.8
St. Johns	83.8	89.2	84.2	99.0	136.5	109.0	196.4
Brevard	399.0	423.2	431.2	457.1	599.2	491.8	800.8
Duval	673.0	682.9	674.6	718.2	820.3	754.8	1011.9

Source: Bureau of Economic and Business Research, 1990.

Appendix Table 5.1.2 Computer Files Used in Water Projections.

Files received from District:

- Main
- Water
- Pump
- Wells
- Gcsoils.dat

The following files were created for estimation and analysis purposes:

Golf_desc	contains descriptive variables under one file to facilitate quick descriptive analysis.
Gcsoil	contains the type of soil for each golf course and Wd-Id, the Identification number for each withdrawal point.
Golf_Afsirs	contains the variables needed to estimate AFSIRS coefficients and predict water use by each course and county. Variables include location, irrigation type (all sprinkler for this estimation), crop (all turf grass) and soil for AFSIRS estimation, as well as the number of acres irrigated on each golf course.
AFoutGol.dbj	Irrigation requirements in Acre-Inch, for each climate-soil-irrigation method-crop combination.
GCList.dbf	List of all golf courses located in the District.
Golf-gw.dbf	List of golf courses, for which a CUP permit is required.
Golfreus.dbf	List of golf courses using recycled water as source.

5.2 Water Projection Data Tables

Appendix Table 5.2.1 Estimated 1990 Golf Course Acreage and Water Use Assuming 2-in-10 Drought Conditions, St. Johns River Water Management District, 1992.

County	Acres	January	February	March	April	May	June	July	August	September	October	November	December	Total
							- - - - - - - Million Gallons Per Year - - - - - - -							
Alachua	198	10.16	11.29	20.43	27.96	34.47	24.14	19.36	17.15	14.52	15.59	13.98	9.14	218.17
Baker	60	2.77	3.26	6.19	8.47	10.59	7.01	5.70	5.05	4.40	4.73	3.91	2.93	65.01
Bradford	30	1.38	1.63	2.93	4.07	5.13	3.34	2.69	2.53	2.04	2.28	1.95	1.30	31.28
Brevard	855	59.93	62.39	103.72	138.00	150.85	95.01	66.13	61.80	65.16	74.11	70.04	52.83	999.97
Clay	263	11.61	14.28	24.38	34.47	45.80	30.52	22.85	22.14	17.85	19.38	17.76	10.71	271.76
Duval	1260	55.72	67.28	119.65	164.35	215.35	136.40	108.57	103.93	84.42	93.39	81.24	50.44	1280.72
Flagler	40	1.59	1.88	3.66	5.00	6.44	4.13	3.37	3.08	2.50	2.86	2.46	1.48	38.45
Indian River	1584	108.12	108.73	179.84	248.88	272.59	168.40	117.55	103.54	119.22	131.58	125.62	90.89	1774.97
Lake	1031	56.37	67.79	107.36	151.98	179.71	120.75	101.38	92.98	84.58	70.37	62.19	47.97	1143.44
Marion	436	20.62	23.65	41.62	58.74	76.04	48.66	37.77	36.66	29.56	32.99	28.57	17.88	452.75
Nassau	609	29.77	33.07	57.88	82.68	107.49	67.80	52.92	51.26	41.34	46.30	39.69	24.80	635.02
Okeechobee	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orange	1227	68.80	83.26	132.04	185.05	214.71	145.36	123.23	113.20	104.01	85.42	76.57	57.97	1389.61
Osceola	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polk	169	11.47	11.93	19.73	27.08	29.37	18.36	12.85	11.47	12.85	14.23	13.77	10.10	193.20
Putnam	120	5.84	6.52	11.41	16.27	21.14	13.35	10.41	10.10	8.15	9.11	7.82	4.88	124.99
St. Johns	690	32.87	37.83	67.67	94.67	120.26	78.44	62.62	57.79	47.54	53.00	46.15	29.56	728.40
Seminole	435	25.30	30.03	48.24	66.19	78.49	51.97	44.70	40.66	36.85	31.21	28.16	21.53	503.33
Volusia	1137	62.76	75.79	121.28	170.30	199.93	133.05	113.25	105.04	93.96	78.90	70.20	55.33	1279.81
Total	10143	565.09	640.60	1068.03	1484.16	1768.36	1146.68	905.34	838.36	768.95	765.44	690.08	489.76	11130.87

Appendix Table 5.2.2 Projected Golf Course Acreage and Water Use Under Low Population Growth Projection, Assuming 2-in-10 Drought Conditions, 1995 and 2010, St. Johns River Water Management District, 1992.

	Acres	January	February	March	April	May	June	July	August	September	October	November	December	Total
						- - - - - - - Million Gallons Per Year - - - - - - -								
Year: 1995														
Alachua	198	10.16	11.29	20.43	27.96	34.47	24.14	19.36	17.15	14.52	15.59	13.98	9.14	218.17
Baker	60	2.77	3.26	6.19	8.47	10.59	7.01	5.70	5.05	4.40	4.73	3.91	2.93	65.01
Bradford	30	1.38	1.63	2.93	4.07	5.13	3.34	2.69	2.53	2.04	2.28	1.95	1.30	31.28
Brevard	894	62.65	65.21	108.42	144.25	157.68	99.31	69.12	64.60	68.11	77.47	73.21	55.23	1045.24
Clay	347	15.31	18.83	32.13	45.44	60.38	40.23	30.13	29.18	23.54	25.54	23.41	14.12	358.24
Duval	1260	55.72	67.28	119.65	164.35	215.35	136.40	108.57	103.93	84.42	93.39	81.24	50.44	1280.72
Flagler	40	1.59	1.88	3.66	5.00	6.45	4.13	3.37	3.08	2.50	2.86	2.46	1.49	38.45
Indian River	1584	108.12	108.73	179.84	248.88	272.59	168.40	117.55	103.54	119.22	131.58	125.62	90.89	1774.97
Lake	1080	59.03	71.00	112.44	159.17	188.20	126.46	106.17	97.38	88.58	73.69	65.13	50.24	1197.49
Marion	483	22.86	26.22	46.14	65.12	84.29	53.94	41.87	40.64	32.77	36.57	31.68	19.82	501.93
Nassau	609	29.77	33.07	57.88	82.68	107.49	67.80	52.92	51.26	41.34	46.30	39.69	24.80	635.01
Orange	1339	75.11	90.90	144.16	202.02	234.40	158.70	134.53	123.58	113.55	93.25	83.59	63.29	1517.07
Osceola	31	1.74	2.10	3.34	4.68	5.43	3.67	3.11	2.86	2.63	2.16	1.94	1.47	35.12
Polk	169	11.47	11.93	19.73	27.08	29.37	18.36	12.85	11.47	12.85	14.23	13.77	10.10	193.20
Putnam	120	5.84	6.52	11.41	16.27	21.14	13.35	10.41	10.10	8.15	9.11	7.82	4.88	124.99
St Johns	762	36.30	41.77	74.73	104.54	132.81	86.63	69.16	63.81	52.51	58.53	50.97	32.65	804.41
Seminole	487	28.34	33.63	54.03	74.13	87.91	58.21	50.06	45.54	41.27	34.96	31.54	24.11	563.73
Volusia	1175	64.82	78.28	125.26	175.89	206.49	137.41	116.97	108.48	97.04	81.49	72.50	57.15	1321.77
Total	10667	592.98	673.52	1122.36	1560.00	1860.16	1207.48	954.53	884.18	809.43	803.73	724.41	514.04	11706.80
Year: 2010														
Alachua	231	11.85	13.17	23.84	32.62	40.21	28.16	22.58	20.00	16.94	18.19	16.31	10.66	254.53
Baker	60	2.77	3.26	6.19	8.47	10.59	7.01	5.70	5.05	4.40	4.73	3.91	2.93	65.01
Bradford	30	1.38	1.63	2.93	4.07	5.13	3.34	2.69	2.53	2.04	2.28	1.95	1.30	31.28
Brevard	894	62.65	65.21	108.42	144.25	157.68	99.31	69.12	64.60	68.11	77.47	73.21	55.23	1045.24
Clay	347	15.31	18.83	32.13	45.44	60.38	40.23	30.13	29.18	23.54	25.54	23.41	14.12	358.24
Duval	1260	55.72	67.28	119.65	164.35	215.35	136.40	108.57	103.93	84.42	93.39	81.24	50.44	1280.72
Flagler	108	4.28	5.06	9.83	13.43	17.32	11.09	9.05	8.27	6.71	7.69	6.61	3.99	103.33
Indian River	1584	108.12	108.73	179.84	248.88	272.59	168.40	117.55	103.54	119.22	131.58	125.62	90.89	1774.97
Lake	1128	61.69	74.19	117.50	166.33	196.67	132.15	110.95	101.76	92.57	77.01	68.06	52.50	1251.40
Marion	483	22.86	26.22	46.14	65.12	84.29	53.94	41.87	40.64	32.77	36.57	31.68	19.82	501.93
Nassau	609	29.77	33.07	57.88	82.68	107.49	67.80	52.92	51.26	41.34	46.30	39.69	24.80	635.01
Orange	1394	78.20	94.63	150.08	210.32	244.03	165.21	140.05	128.66	118.22	97.08	87.02	65.89	1579.39
Osceola	31	1.74	2.10	3.34	4.68	5.43	3.67	3.11	2.86	2.63	2.16	1.94	1.47	35.12
Polk	169	11.47	11.93	19.73	27.08	29.37	18.36	12.85	11.47	12.85	14.23	13.77	10.10	193.20
Putnam	120	5.84	6.52	11.41	16.27	21.14	13.35	10.41	10.10	8.15	9.11	7.82	4.88	124.99
St Johns	762	36.30	41.77	74.73	104.54	132.81	86.63	69.16	63.81	52.51	58.53	50.97	32.65	804.41
Seminole	487	28.34	33.63	54.03	74.13	87.91	58.21	50.06	45.54	41.27	34.96	31.54	24.11	563.73
Volusia	1213	66.91	80.79	129.29	181.55	213.14	141.83	120.73	111.97	100.16	84.11	74.83	58.99	1364.30
Total	10909	605.19	688.02	1146.95	1594.21	1901.53	1235.10	977.50	905.18	827.83	820.93	739.59	524.77	11966.80

Appendix Table 5.2.3 Projected Golf Course Acreage and Water Use Under Medium Population Growth Projection, Assuming 2-in-10 Drought Conditions, 1995 and 2010, St. Johns River Water Management District, 1992.

	Acres	January	February	March	April	May	June	July	August	September	October	November	December	Total
						- - - - - - - Million Gallons Per Year - - - - - - -								
Year: 1995														
Alachua	265	13.60	15.11	27.34	37.42	46.13	32.30	25.91	22.95	19.43	20.87	18.71	12.23	291.99
Baker	60	2.77	3.26	6.19	8.47	10.59	7.01	5.70	5.05	4.40	4.73	3.91	2.93	65.01
Bradford	30	1.38	1.63	2.93	4.07	5.13	3.34	2.69	2.53	2.04	2.28	1.95	1.30	31.28
Brevard	971	68.07	70.86	117.81	156.74	171.33	107.91	75.11	70.19	74.01	84.17	79.55	60.01	1135.76
Clay	682	30.10	37.01	63.16	89.32	118.68	79.08	59.22	57.37	46.26	50.21	46.02	27.75	704.19
Duval	1345	59.46	71.79	127.68	175.39	229.80	145.56	115.86	110.91	90.09	99.66	86.69	53.82	1366.71
Flagler	108	4.28	5.06	9.83	13.43	17.32	11.09	9.05	8.27	6.71	7.69	6.61	3.99	103.33
Indian River	1672	114.14	114.78	189.85	262.74	287.77	177.78	124.10	109.30	125.86	138.91	132.62	95.95	1873.80
Lake	1177	64.35	77.39	122.56	173.50	205.15	137.85	115.73	106.14	96.55	80.33	71.00	54.77	1305.31
Marion	670	31.72	36.39	64.03	90.37	116.98	74.86	58.11	56.40	45.48	50.75	43.96	27.51	696.54
Nassau	654	31.97	35.52	62.16	88.79	115.43	72.81	56.83	55.05	44.40	49.72	42.62	26.64	681.94
Orange	1506	84.48	102.24	162.13	227.22	263.63	178.49	151.31	139.00	127.71	104.88	94.02	71.18	1706.28
Osceola	61	3.42	4.14	6.57	9.20	10.68	7.23	6.13	5.63	5.17	4.25	3.81	2.88	69.11
Polk	169	11.47	11.93	19.73	27.08	29.37	18.36	12.85	11.47	12.85	14.23	13.77	10.10	193.20
Putnam	149	7.24	8.08	14.15	20.17	26.22	16.55	12.91	12.52	10.10	11.30	9.69	6.06	154.99
St Johns	978	46.59	53.61	95.91	134.18	170.46	111.18	88.76	81.90	67.39	75.12	65.42	41.90	1032.43
Seminole	592	34.41	40.83	65.61	90.02	106.75	70.68	60.79	55.29	50.11	42.45	38.30	29.28	684.52
Volusia	1250	68.99	83.31	133.32	187.21	219.78	146.25	124.49	115.46	103.28	86.73	77.17	60.83	1406.83
Total	12338	678.44	772.94	1290.97	1795.31	2151.20	1398.33	1105.52	1025.44	931.86	928.27	835.81	589.13	13503.23
Year: 2010														
Alachua	431	22.11	24.57	44.47	60.86	75.02	52.54	42.13	37.33	31.60	33.94	30.43	19.90	474.90
Baker	90	4.14	4.87	9.26	12.67	15.83	10.47	8.52	7.55	6.58	7.06	5.85	4.38	97.19
Bradford	30	1.38	1.63	2.93	4.07	5.13	3.34	2.69	2.53	2.04	2.28	1.95	1.30	31.28
Brevard	1281	89.78	93.45	155.37	206.71	225.95	142.31	99.05	92.57	97.61	111.01	104.91	79.14	1497.86
Clay	1686	74.46	91.56	156.26	220.95	293.60	195.63	146.49	141.92	114.45	124.21	113.84	68.66	1742.02
Duval	1556	68.81	83.09	147.76	202.97	265.95	168.45	134.08	128.35	104.26	115.34	100.33	62.29	1581.69
Flagler	378	15.03	17.76	34.51	47.15	60.83	38.96	31.77	29.05	23.57	26.99	23.23	14.02	362.86
Indian River	1893	129.19	129.92	214.88	297.38	325.72	201.22	140.46	123.72	142.45	157.23	150.11	108.60	2120.88
Lake	1614	88.26	106.15	168.12	237.99	281.40	189.08	158.74	145.60	132.44	110.19	97.38	75.12	1790.47
Marion	1278	60.52	69.43	122.18	172.43	223.20	142.83	110.87	107.61	86.78	96.84	83.88	52.49	1329.04
Nassau	789	38.57	42.85	74.99	107.12	139.26	87.84	68.56	66.41	53.56	59.99	51.42	32.14	822.70
Orange	2231	125.15	151.45	240.19	336.60	390.55	264.41	224.15	205.91	189.20	155.38	139.28	105.45	2527.70
Osceola	245	13.74	16.63	26.38	36.96	42.89	29.04	24.61	22.61	20.78	17.06	15.29	11.58	277.58
Polk	169	11.47	11.93	19.73	27.08	29.37	18.36	12.85	11.47	12.85	14.23	13.77	10.10	193.20
Putnam	293	14.25	15.90	27.84	39.69	51.59	32.57	25.41	24.64	19.88	22.24	19.07	11.92	304.98
St Johns	1698	80.89	93.08	166.53	232.96	295.95	193.04	154.10	142.20	117.00	130.42	113.57	72.75	1792.49
Seminole	1114	64.77	76.86	123.50	169.45	200.93	133.05	114.43	104.08	94.33	79.90	72.09	55.11	1288.51
Volusia	1628	89.85	108.50	173.62	243.80	286.22	190.47	162.13	150.37	134.51	112.95	100.50	79.21	1832.12
Total	18403	992.38	1139.64	1908.51	2656.85	3209.39	2093.61	1661.06	1543.91	1383.87	1377.24	1236.90	864.14	20067.50

Appendix Table 5.2.4 Projected Golf Course Acreage and Water Use Under High Population Growth Projection, Assuming 2-in-10 Drought Conditions, 1995 and 2010, St. Johns River Water Management District, 1992.

	Acres	January	February	March	April	May	June	July	August	September	October	November	December	Total
						- - - - - - - Million Gallons Per Year - - - - - - -								
Year: 1995														
Alachua	298	15.29	16.99	30.75	42.08	51.87	36.33	29.13	25.81	21.85	23.47	21.04	13.76	328.36
Baker	60	2.77	3.26	6.19	8.47	10.59	7.01	5.70	5.05	4.40	4.73	3.91	2.93	65.01
Bradford	30	1.38	1.63	2.93	4.07	5.13	3.34	2.69	2.53	2.04	2.28	1.95	1.30	31.28
Brevard	1049	73.50	76.51	127.20	169.23	184.99	116.51	81.10	75.79	79.91	90.88	85.89	64.79	1226.29
Clay	933	41.19	50.65	86.44	122.22	162.41	108.22	81.04	78.51	63.31	68.71	62.97	37.98	963.65
Duval	1429	63.20	76.31	135.71	186.42	244.26	154.71	123.14	117.89	95.76	105.93	92.15	57.21	1452.71
Flagler	175	6.97	8.23	16.00	21.86	28.20	18.06	14.73	13.47	10.92	12.51	10.77	6.50	168.21
Indian River	1716	117.15	117.81	194.86	269.67	295.36	182.47	127.37	112.19	129.18	142.57	136.12	98.48	1923.22
Lake	1274	69.66	83.78	132.69	187.83	222.09	149.23	125.29	114.91	104.53	86.96	76.86	59.29	1413.12
Marion	810	38.36	44.01	77.45	109.31	141.49	90.55	70.28	68.21	55.01	61.39	53.17	33.27	842.50
Nassau	699	34.17	37.96	66.43	94.90	123.38	77.82	60.74	58.84	47.45	53.14	45.56	28.47	728.86
Orange	1673	93.85	113.57	180.11	252.41	292.87	198.28	168.08	154.41	141.88	116.51	104.44	79.07	1895.49
Osceola	92	5.16	6.25	9.90	13.88	16.11	10.90	9.24	8.49	7.80	6.41	5.74	4.35	104.24
Polk	169	11.47	11.93	19.73	27.08	29.37	18.36	12.85	11.47	12.85	14.23	13.77	10.10	193.20
Putnam	206	10.04	11.21	19.62	27.98	36.36	22.96	17.91	17.37	14.01	15.68	13.45	8.40	214.99
St Johns	1122	53.45	61.51	110.04	153.94	195.55	127.55	101.83	93.96	77.31	86.18	75.05	48.07	1184.44
Seminole	748	43.52	51.64	82.98	113.85	135.00	89.40	76.88	69.93	63.38	53.68	48.44	37.03	865.72
Volusia	1364	75.25	90.87	145.41	204.19	239.71	159.52	135.78	125.93	112.65	94.60	84.17	66.34	1534.42
Total	13847	756.39	864.11	1444.44	2009.39	2414.75	1571.21	1243.79	1154.75	1044.24	1039.86	935.43	657.34	15135.69
Year: 2010														
Alachua	664	34.07	37.85	68.51	93.76	115.58	80.94	64.91	57.50	48.68	52.29	46.88	30.65	731.64
Baker	149	6.88	8.10	15.38	21.05	26.32	17.41	14.17	12.55	10.93	11.74	9.72	7.29	161.54
Bradford	100	4.59	5.40	9.73	13.51	17.02	11.08	8.92	8.37	6.76	7.57	6.48	4.32	103.75
Brevard	1706	119.62	124.51	207.01	275.42	301.06	189.61	131.98	123.34	130.05	147.91	139.78	105.45	1995.74
Clay	3444	152.08	187.01	319.17	451.31	599.71	399.59	299.23	289.88	233.77	253.71	232.53	140.24	3558.23
Duval	1937	85.65	103.41	183.91	252.63	331.02	209.66	166.88	159.76	129.77	143.56	124.87	77.53	1968.65
Flagler	648	25.79	30.47	59.20	80.87	104.33	66.82	54.49	49.83	40.42	46.30	39.84	24.04	622.39
Indian River	2334	159.29	160.19	264.95	366.68	401.61	248.11	173.19	152.54	175.65	193.86	185.08	133.91	2615.05
Lake	2197	120.15	144.50	228.86	323.97	383.06	257.40	216.10	198.20	180.29	150.00	132.57	102.26	2437.36
Marion	2261	107.04	122.80	216.11	304.99	394.79	252.64	196.11	190.33	153.50	171.28	148.36	92.84	2350.78
Nassau	1059	51.76	57.51	100.65	143.78	186.92	117.90	92.02	89.14	71.89	80.52	69.02	43.13	1104.24
Orange	3236	181.52	219.68	348.39	488.23	566.48	383.52	325.12	298.67	274.42	225.37	202.01	152.95	3666.36
Osceola	490	27.49	33.26	52.75	73.93	85.78	58.07	49.23	45.22	41.55	34.13	30.59	23.16	555.17
Polk	253	17.18	17.86	29.54	40.53	43.97	27.48	19.24	17.18	19.24	21.30	20.61	15.11	289.23
Putnam	523	25.46	28.41	49.74	70.92	92.18	58.19	45.41	44.03	35.52	39.74	34.08	21.29	544.97
St Johns	2850	135.77	156.24	279.51	391.01	496.73	324.00	258.66	238.68	196.38	218.90	190.63	122.11	3008.60
Seminole	1844	107.27	127.31	204.55	280.65	332.79	220.37	189.52	172.39	156.24	132.33	119.41	91.27	2134.10
Volusia	2120	116.97	141.24	226.01	317.37	372.59	247.95	211.05	195.74	175.10	147.04	130.82	103.12	2385.00
Total	27815	1478.59	1705.76	2863.97	3990.62	4851.94	3170.75	2516.20	2343.35	2080.15	2077.52	1863.28	1290.67	30232.80

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