

**Projecting South Florida County-Level Citrus Acreage Using Time-Series Analysis (SAS<sup>®</sup> Automatic Forecasting System) and Multivariate Analysis (PROC FACTOR).**

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**ABSTRACT**

The South Florida Water Management District has developed regional water supply plans for four planning areas within the South Florida area. These water supply plans are mandated by Florida Statute (Section 373.0361, Florida Statutes). One component of these plans is conducting “(a) quantification of the water supply needs for all existing and reasonably projected future uses within the planning horizon.” Citrus irrigation is a major water use in South Florida; regional patterns of citrus acreage have changed substantially since the mid-1960’s, with a general southward movement of citrus associated with a series of freezes in the mid-1980’s. The approach taken in the Regional Water Supply Plans was to estimate citrus acreage in each county with a single equation model. This paper presents results of alternative approaches to projecting citrus acreage using the SAS<sup>®</sup> Automatic Forecasting System on a county-by-county basis and using PROC FACTOR to describe systematic relationships in citrus acreage in different counties. Possible extensions of the analysis using PROC SYSLIN and/or the newly released (Version 8.1) VARMAX procedure will also be discussed.

**INTRODUCTION**

Under Section 373.0361, Florida Statutes, water management districts are mandated to prepare water supply plans “where it determines that sources of water are not adequate for the planning period to supply water for all existing and projected reasonable-beneficial uses and to sustain the water resources and related natural systems. Each regional water supply plan shall be based on at least a 20-year planning period and shall include, but not be limited to:

- (a) A water supply development component that includes:
  1. A quantification of the water supply needs for all existing and reasonably projected future uses within the planning horizon. The level-of-certainty planning goal associated with identifying the water supply needs of existing and future reasonable-beneficial uses shall be based upon meeting those needs for a 1-in-10-year drought event.

“Each regional water supply plan shall be based on at least a 20-year planning period . . .”

In addition, the South Florida Water Management District (SFWMD) is the local sponsor for the Comprehensive Everglades Restoration Project, which is based on a fifty-year planning horizon. The South Florida Water Management District operates in a multi-objective planning framework with four identified mission elements: flood control, water supply, environmental preservation and enhancement, and water quality. In order adequately to perform its mission, the District has developed procedures for projecting citrus water use and citrus acreage within the 16-county area that it encompasses. No commercial citrus acreage is reported for Monroe County, which encompasses the Florida Keys; the Key Lime acreage in the Florida Keys was largely destroyed by hurricanes in the 1920’s. Generally single equation regression or time-series estimation techniques were used for each crop for each county.

Citrus is a major water-using crop in South Florida. Citrus is classified as either non-bearing, those trees set within the past three years, or bearing, those planted more than three years previously. Details used by the Florida Agricultural Statistics Service, a part of the National Agricultural Statistics Service, in determining citrus acreage are described in the Commercial Citrus Inventory.

In the 2000-01 growing season, bearing acreage in Florida, totaling 756,000 acres accounted for approximately seventy percent of the total bearing citrus acreage in the United States. The sixteen counties partially or entirely within the boundaries of the South Florida Water Management District account for approximately 66 percent of the citrus acreage in Florida. The total on-tree sales value of Florida citrus in the 2000-01 season was \$760,375,000. The boundaries of the South Florida Water Management District are shown in Figure 1 below.

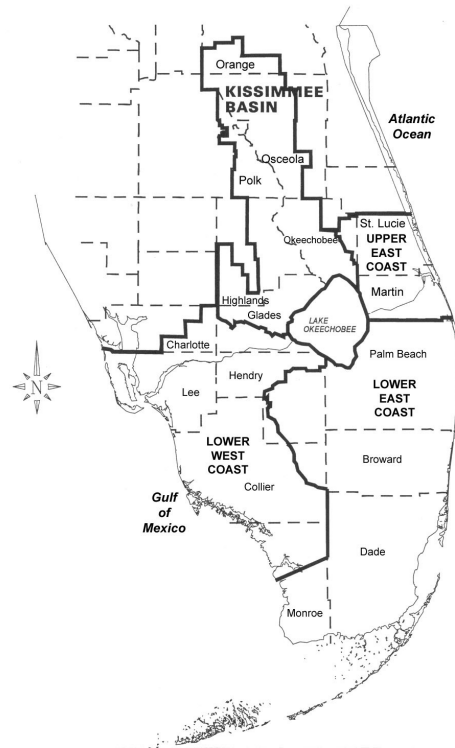


Figure 1: South Florida Water Management District Boundaries, Counties, and Planning Areas

**DATA AND METHODS**

The primary data in this analysis was collected from issues of the Citrus Summary, published by the Florida Agricultural Statistics Service, from 1966, when aerial photography was first used for the Commercial Citrus Inventory, through 2000. County-level acreage data is provided for major citrus-producing counties in Florida. Data for some counties, such as highly urban Broward County in South Florida, are not reported separately to avoid disclosure of data on individual operations. The focus of this paper is on the sixteen counties encompassing the South Florida Water Management District, as shown in Figure 1.

Table 1 below shows the counties in which citrus acreage increased and decreased over the period of analysis (1966-2000) and the percentage change by county over the period

Table 1: Increasing and decreasing counties and areas in terms of citrus acreage in Florida, 1966-2000

| Increasing  |          | Decreasing    |        |
|-------------|----------|---------------|--------|
| Charlotte   | +331.0%  | Broward       | -98.9% |
| Collier     | +1255.2% | Orange        | -87.7% |
| Glades      | +643.5%  | Osceola       | -19.3% |
| Hendry      | +515.6%  | Polk          | -32.0% |
| Highlands   | +108.9%  | Miami-Dade**  | -74.6% |
| Lee         | +477.4%  | Rest          | -35.6% |
| Martin      | +104.4%  | Florida total | - 1.2% |
| Okeechobee  | +385.2%  |               |        |
| Palm Beach* | +53.4%   |               |        |
| St. Lucie   | +55.3%   |               |        |

\* Palm Beach County citrus acreage peaked in 1968 and has declined since then.

\*\* Monroe County has never had citrus acreage reported separately, Combined with Miami-Dade County.

Source: Florida Agricultural Statistics Service, Commercial Citrus Inventory, various issues., Orlando.

At the same time these changes have been occurring in the Florida citrus industry, there has been a rapid expansion of the citrus industries in Brazil and Mexico. Mexican citrus production increased from approximately 2.0 metric tons in 1966 to 5.8 metric tons in 1999. Similarly, Brazilian citrus production increased from approximately 2.9 million metric tons in 1966 to 20.8 million metric tons in 1999. (FAO, 2002)

The tools used to analyze the acreage data are PROC FACTOR, one of the procedures in SAS/STAT®, and the Time Series Forecasting System (TSFS) in SAS/ETS®. Factor analysis has been defined as: "Factor analysis is a generic term for a family of statistical techniques concerned with the reduction of a set of observable variables in terms of a small number of latent factors . . . The primary purpose of factor analysis is data reduction and summarization." (University of Texas, Information Technology Services, p. 2) An excellent discussion of factor analysis and issues arising in its use is contained in Goldberg. In the present application, the intent is to summarize as much of the information in the individual county time series of citrus acreages (represented in this case as percentage change between successive Commercial Citrus Inventories) in a small number of underlying factors

The other primary tool used in this analysis is the SAS® Time-Series Forecasting System, which is a component of SAS/ETS®. An excellent summary of the Time-Series Forecasting System was presented by Hallahan and Samy (1999). Another excellent introductory resource on the Time Series Forecasting System is found in Hallahan (2000). The particular feature of the time-series forecasting system, which is utilized in the present analysis, is the Automatic Mode of the Time Series Forecasting System.

## FACTOR ANALYSIS RESULTS

There are high correlations between citrus acreages in the sixteen counties of the SFWMD and with citrus acreage in the rest of Florida. These correlations generally range from -.8 to .9. Citrus acreage is generally decreasing in the parts of Florida outside of the sixteen-county area covered by the SFWMD, in the northern part of the District, and in the highly urbanized areas in the Lower East Coast portion of the SFWMD. In order to increase the ease of interpretability of the extracted factors the raw variable to be analyzed is the percentage change in citrus acreage between successive citrus inventories.

The SAS® code for this analysis is shown below.

```
proc factor DATA=work.citcountrotated
NFACTORS=3 out=output all
Method= Principal Rotate=Varimax;
run;
proc score data=output;
run;
```

When the above SAS® code was run a detailed output was obtained; the key points of this output are summarized below. One of the first things to examine in analyzing the results of a factor analysis is Kaiser's (also referred to as the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (MSA). "The KMO measure of sampling adequacy is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. A large KMO measure means that a factor analysis of the variables is a good idea, since correlations between pairs of variables can be explained by the other variables. (Rivera and Granaden)" In the present analysis, the value of the measure of sampling adequacy was .671, which is interpreted as "mediocre" or "acceptable" with regard to factorability. The MSA's on the individual county variables ranged from .28 for Miami-Dade/Monroe counties to .98 for Orange County. Another important statistic to look at when examining factor analysis output is communality, which may be defined as:

"For a given variable, communality is the proportion of variance accounted for by the factor solution . . . (Baer).

There are three eigenvalues of the correlation matrix with values greater than 1. The first of these eigenvalues accounts for 74.18% of the total variation; the first three eigenvalues cumulatively account for 93.23% of the total variability in the data set.

In order to improve the interpretability of the extracted factors, a Varimax rotation is applied to the extracted factors. Because of indeterminacy, "(ii)t is impossible to estimate population factor structures exactly because an infinite number of factor structures can produce the same correlation matrix. There are more unknowns than equations in the common factor model. Therefore, we cannot uniquely determine factor structures." (Pohlmann, 2001) The minimum eigenvalue and Varimax rotation are widely used; since the main purpose of the factor analysis here is the development of a multi-dimensional scale for concisely describing changes in county-level citrus acreage within the South Florida Water Management District, it was determined that these standard methods did not merit further refinement. The Factor Pattern Matrix, after Varimax rotation, is shown in a handout.

The values in the rotated factor pattern matrix may be interpreted as:

Factor 1-High positive values for rapidly growing counties; Negative values for declining counties. High negative value in Miami-Dade/Monroe area affected by Hurricane Andrew. This hurricane decimated the citrus industries in Miami-Dade and Palm Beach counties along Florida's Lower East Coast. Urbanization had already largely wiped out citrus in Broward County. Note that the total economic impact of Hurricane Andrew has been estimated at \$26.5 billion (\$35.0 billion in 2000 dollars). (Jarrell, et. al., 2001)

Factor 2- High positive values in the declining citrus areas including the Rest of Florida (outside of SFWMD), and Broward, Orange, and Polk counties; Negative values on the areas of increasing citrus acreage in Southwest Florida.

Factor 3- High positive values on Palm Beach and Martin counties. Both experienced moderate growth in citrus acreage over the entire period of analysis with declines associated with increasing urbanization and loss of agricultural land, since the mid-1990's.

The communalities of all the areas except Osceola County are in

excess of .85, with only Miami-Dade/Monroe area being between .85 and .95.

In interpreting the factor analysis results, it is useful to note the years identified by the Florida Freezes Research Group as "freeze years" (1981, 1983, 1985, 1987, and 1989) The Florida Freezes Research Group is an informal group within the Geography Department at the University of Florida to study freezes which affected northern Florida in the 1980's.

<http://www.geog.ufl.edu/faculty/floridafreeze.html>

It is interesting to note that there were no major freezes in the 1990's, and Caviedes (2000) addressed the question of changed risk perceptions. Three major threats to the citrus industry in Florida were identified: 1) damage caused by freezes; 2) the threat of citrus canker; and 3) international competition and price controls. Hurricanes were not listed, because the focus of the research was North-Central Florida, which is much less hurricane prone than is southeast Florida

Miller and Downton (1993) and Downton and Miller (1993) have analyzed the freeze risk to Florida citrus. They have concluded: "Estimates of freeze risk based on 1932-1985 daily minimum temperatures may appear unacceptably high for commercial citrus production over a substantial area of central Florida. The theoretical estimates of freeze risk and potential economic return . . . are consistent with the decision of growers in the later 1980's to move groves from central Florida to Southern Florida where initial costs are higher but the freeze risk is substantially less. (Miller and Downton, 1993, p. 355) "

## TIME-SERIES FORECASTING SYSTEM RESULTS

Two application of the SAS® time-series forecasting system are presented below: 1) a set of analyses treating the time-series data for individual counties as independent series analyzing each separately; and 2) an analysis of the factor scores on the factors extracted above.

### ANALYSIS OF COUNTY-LEVEL ACREAGE DATA

Individual applications of the automatic mode of the SAS® time-series forecasting system were made for the counties within the South Florida Water Management District, The "automatic" node was used with the minimum means square error the "rest" of Florida, and for Florida as a whole. It should be noted that no additivity restriction was imposed in the analysis, so the sum of the sixteen-county area and the "rest" of Florida forecasts will not necessarily equal the Florida total. These results are summarized in a handout.

Major conclusions which can be drawn from the data presented in the handout are: 1) In almost all cases the damped trend exponential smoothing or, in the case of declining areas, log damped trend exponential smoothing performed best in terms of the minimum mean square error criterion.

2) Use of the damped trend prevents the generation of unrealistically high forecasts, based on external constraints on growth (available land, allocable water, market constraints, etc.).

3) Use of the automatic form of the time-series forecasting system masks the response of acreage to major external forces (freezes, diseases, market changes, etc.) It is more appropriate for baseline analyses for long-term forecasting than for development of short-term causal models.

4) In general, the selected models performed reasonably well (most  $R^2$ 's above .85, most MAPE's below .10, but for some areas (such as Lee, Miami-Dade, Broward, and Osceola counties) the results are marginal, at best.

5) Intervention analyses of the effects of freezes, hurricanes, citrus diseases, etc. are important extensions of the present analysis.

### ANALYSIS OF FACTOR SCORES DATA

The next phase of the analysis is a time series analysis of the factor scores derived earlier in this analysis. Interpretable results were obtained for the scores on the first two factors; the this factor

picked up the effects (increasing land values) which could not be adequately captured in a forecasting model. The TSFS showed the mean as the forecast which minimized the MSE. The forecasting models that best explained Factor Scores on factors 1 and 2 are shown below.

Factor 1- Linear exponential smoothing, R-squared=.682  
MSE=.299 MAPE=233.2826

Factor 2: -Damped trend exponential smoothing R-squared = .696  
MSE=.287 MAPE= 179.50 . The high MAPE values for these two analyses suggest that forecasting county level citrus acreage based on the factor analysis results, while it may address some of the problems of univariate time series forecasting, creates additional difficulties in interpretation of the forecasts.

## CLUSTER ANALYSIS RESULTS OF PERCENTAGE CHANGE DATA

A final multivariate cluster analysis was conducted on percentage change of county-level citrus acreage between successive Commercial Citrus Inventories between 1966 and 2000. These results are presented in a handout. The code for this analysis is provided below.

```
PROC FASTCLUS MAXCLUSTERS=3 out=outclus;  
VAR CY1968:CY2000;  
run;
```

The cluster analysis above yielded readily interpretable clusters with Broward and Dade-Monroe, highly urbanized counties, where citrus has largely disappeared, in one cluster, Lee and Palm Beach Counties, urban counties where development pressure is forcing out citrus out in another cluster, and the remaining counties in the South Florida Water Management District and the rest of Florida in the third cluster. The grouping of the counties of the SFWMD and the rest of Florida based on percentage changes in citrus acreage between Inventories is shown in a handout.

The difficulties in determining the number of clusters to extract are well-explained in the on-line SAS® documentation "Introduction to Clustering Procedures."

<http://www.zi.unizh.ch/software/unix/statmath/sas/sasdoc/stat/cha/p8/sect10.htm>

### FUTURE DIRECTIONS: DYNAMIC SPATIAL ECONOMETRICS AND SPATIO-TEMPORAL MODELING

Past and current District hydrologic modeling efforts have involved running dynamic hydrologic models driven by historic climatic data using static "current" of future land-use. These models, the South Florida Water Management Model, the Natural Systems Model, and the South Florida Regional Simulation Model (under development), are described in detail on the South Florida Water Management District web-site

<http://www.sfwmd.gov/org/pld/hsm/models/index.html>

It is hoped that in future generation of these models water demands can be dynamically modeled to take into account the dynamics of water demand and water use. Models which "optimize" agricultural land use, subject to a variety of constraints, are contained in the models for determining future agricultural land and water use in the California Water Plan (California Department of Water Resources, 1998) and the Texas 2002 State Water Plan (Texas Water Development Board, 2002). Utah also projects water use by basin and use type through 2050 in the Utah State Water Plan, although the models used in the Utah plan are much more simplistic than those used in the California and Texas Water Plans. (Utah Division of Water Resources, 2001) Work is currently underway to add an optimization component to the South Florida Regional Simulation Model, one of the primary modeling tools used by the South Florida Water Management District in its regional water supply plans and in the Comprehensive Everglades Restoration Model (see South Florida Water Management District, 2002). Variants of the models used in these plans could be developed using SAS/OR® software for use

in agricultural water use planning in South Florida.

## CONCLUSION

This paper has demonstrated the usefulness of the Automatic Forecasting feature of the SAS® Time-Series Forecasting System for generating long-range projections for water demand forecasting and capital facilities planning. It has also demonstrated the usefulness of factor analysis (PROC FACTOR) and cluster analysis (implemented here through PROC FASTCLUS) in analyzing and interpreting agricultural land-use data. A review of the literature on the Florida citrus industry shows the importance of random or pseudo-random "interventions," including freezes, citrus canker and other diseases, urbanization and rising land prices, foreign competition and market volatility. The South Florida Water Management District is mandated to conduct water supply planning with a minimum 20-year planning horizon.

Specific conclusions of the analysis are:

1. Over the thirty-four year period of analysis, citrus acreage in Florida has remained fairly flat, declining only 1.2 percent over the period of analysis.
2. There has been a major shift in citrus acreage from central Florida to Southwest Florida. The percentage of Florida – citrus acreage within the 16-counties encompassing the South Florida Water Management District has increased from approximately 48% to 66%.
3. Although the statistical techniques used here cannot be used to infer causality, major factors believed to be associated with the inter-county shift of citrus include freezes, urbanization and rising land prices, diseases, foreign competition, water availability and cost, poor water quality, low on-tree prices for citrus, and foreign competition, particularly from Mexico and Brazil.
4. The multivariate statistical techniques employed here are useful for describing and interpreting changes in the Florida citrus industry. Their utility for long-range forecasting is more limited, although given the dynamic nature of the Florida agricultural economy, it may not be possible to produce consistently accurate long-term forecasts.

Federal water resources planning is conducted in accordance with the Principles and Guidelines of the U. S. Water Resources Council. The Principles and Guidelines "establish standards and procedures for use in formulating and evaluating alternative plans for water and related land resources implementation studies." The Principles and Guidelines contain specific sections relating to forecasting (Section 1.4.9) and risk and uncertainty (section 1.4.11). In addition to the Principles and Guidelines, Corps of Engineers projects such as the Central and Southern Florida Flood Control Project and the Comprehensive Everglades Restoration Project are conducted under a Corps of Engineers Planning Guidance Notebook (U. S. Army Corps of Engineers, 2000), last revised in April, 2000. This Guidance Notebook provides that:

" Project NED (National Economic Development) benefits and costs shall be compared at a common point in time. . . . Use the same period of analysis for all alternative plans. Appropriate consideration should be given to environmental factors that may extend beyond the period of analysis . . . .

"The period of analysis for comparing costs and benefits following project implementation is further defined and limited to the lesser of:

- (1) The period of time over which any alternative plan would have significant beneficial or adverse effects
- (2) A period not to exceed 50-years except for major multiple purpose reservoir projects; or
- (3) A period not to exceed 100-years for multiple purpose reservoir projects.

The Water Resources Development Act of 2000 specifically provides that:

"Notwithstanding section 209 of the Flood Control Act of 1970 (42 U.S.C. 1962-2) or any other provision of law, in carrying out any activity authorized under this section or any other provision of law to restore, preserve, or protect the South Florida ecosystem, the Secretary may determine that--

(i) the activity is justified by the environmental benefits derived by the South Florida ecosystem; and

(ii) no further economic justification for the activity is required, if the Secretary determines that the activity is cost-effective."

In 1999, a National Research Council committee recommended that the Principles and Guidelines be updated. This proposal was incorporated in proposed legislation, not yet adopted, "The Corps of Engineers Reform Act," which would among other objectives, "to ensure that environmental analyses are considered to be co-equal to economic analyses in the assessment of Corps of Engineers projects, recognizing the need for sound science in the evaluation of the impacts on the health of aquatic ecosystems." These efforts to reform Federal water resources planning, in general, and the Corps of Engineers planning process, in particular, are discussed in two recent reports by Nicole T. Carter of the Congressional Research (Carter, 2002a and 2002b).

It is clear that in its regional water supply planning efforts and in its role as local sponsor of the Comprehensive Everglades Restoration Plan, the SFWMD will need to continue to be involved in long-range forecasting of water demands, including urban, agricultural, and environmental water demands. A major emphasis will be placed on ensuring the consistency, to the degree practicable, between the minimum 20-year projections mandated under state law and the 50-year projections mandated by Federal statutes, rules, and guidelines. Regional water supply plans are revised every five years; the Comprehensive Everglades Restoration Plan

In addition, at the state level, the South Florida Water Management District is subject to the provisions of Chapter 216, F. S. which relate to program planning and budgeting and state oversight of District expenditures on the Comprehensive Everglades Restoration Program. SAS® has been a leader in "e-government" working with Federal, state and local governments in responding to reporting and operational mandates and identifying cost savings that can "justify additional technology investments that speed the advent of e-government."

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