The

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Population Location

The Florida Geographer is the official publication of the Florida Society of Geographers, and is distributed without cost to members of the Society. Two numbers per year will be published, pending receipt of an adequate number of acceptable manuscripts.

The Florida Geographer is a state-wide journal, with broad coverage of geographical topics relating to the state and its several regions. No restrictions are placed on the content of articles, providing that they deal with some aspect of the geography of Florida, i.e., local studies within the state, matters of the state generally, or studies of the U.S. South, of which Florida is a part.

Manuscripts are solicited from all who feel they have research worthy of dissemination. No specific format requirements are presently in force, although the editor would prefer manuscripts to be typed double-spaced following the general format of the articles in the present number. However, authors should not be dissuaded from submitting manuscripts because of format considerations; the editor is willing to undertake extensive revisions. As this number demonstrates, we are able to reproduce maps, charts, and tables.

We would like to publish an original map on the cover of each number, so a special request is made to all who have maps of the state or regions of the state which would be of interest to the Society's membership.

David Lee
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About the Cover ...

Geographers in Florida are enthusiastic about the appearance of the *Atlas of Florida* edited by Edward Fernald. Our lead article by James Anderson Jr. and colleagues describes the atlas. Among the 800 maps, graphs, drawings and photographs is the dot map of Florida population, reproduced on the cover. The outline of the state has been suppressed, but the shape of Florida is still easily seen from the location of the population. The original of this map and the maps on page 3 were printed in color, as were all the maps in the atlas, and our black-and-white reproductions do not do them justice. The cover map and the maps on page 3 were reprinted from *Atlas of Florida* edited by Edward Fernald by permission of the Institute of Science and Public Affairs of the Florida State University, copyright © 1981 by Institue of Science and Public Affairs.

THE FLORIDA

GEOGRAPHER

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THE ATLAS OF FLORIDA

James R. Anderson, Jr.,
Peter A. Krafft, and Craig Remington

The *Atlas of Florida* was prepared by the Florida State University and published in November, 1981.[1] Intended as a basic reference volume that can be used by a wide segment of the population, the atlas is the most comprehensive compiled to date for Florida. It is 276 pages long, and contains over 800 maps, graphs, drawings, and photographs. This paper briefly describes the contents and production organization of the atlas and some of the cartographic problems encountered in the course of production. These problems are not unique to atlases, and may occur in any cartographic project, large or small.

Organization and Production

The atlas is organized into eight sections. The introductory section contains basic reference maps, a mileage chart, and several indices for obtaining more detailed map and aerial photo information. The natural environment section details Florida's geology, climate, soils, flora and fauna, minerals, and water resources. The distribution, density, and characteristics of the state's population ---as well as the distribution of services such as health care and education---are presented in the next section. Florida's history and culture are well documented in the atlas with major historical and political events. Included are the Spanish influence, the Seminole Wars, the Civil War, and the growth of tourism. A section on the economy describes the economic structure of Florida, emphasizing manufacturing, agriculture, trade, financial institutions, and government. Because of their exceptional importance, recreation and tourism are treated separately. The atlas contains a wide range of information on recreation sites and activities, tourist attractions, and seasonal patterns of tourism. The transportation and communication section examines how people, goods and ideas move to, from, and within the state. The final section on energy and planning focuses on population growth, energy, and water, three problems Florida will have to solve to insure its future well-being.

The planning, research, and production of the atlas spanned several years. Faculty members at Florida State University were asked to serve as section editors and to participate on the atlas steering committee.[2] Each editor was given wide latitude in planning the contents of his section and in selecting additional contributors. Graduate students assisted in data collection.

Once the data were collected, the cartographic staff prepared individual page layouts which were consistent with overall design philosophy of the book. An attempt was made to align all map and text material in columns to enhance readability. The layout was shown to the author for approval if changes were made that affected the presentation of the data. After review by the author, the page was then assigned to a cartographer for full map presentation.

Three full-time cartographers and a number of student cartographers were employed in the production phase. The entire atlas was scribed at actual size. Once base maps were stripped in position and special information scribed, overlays were photomechanically prepared for each color to be used. Lettering was typeset and a type negative was prepared. Process color percentages were assigned to the various overlays so that the printer could do screening and compositing. The printer stripped signatures, prepared plates, and did the final printing and binding.

Problems and Solutions

In a project of this magnitude problems arise that are not anticipated in the planning phase. These range from the broad problems of time pressures and financing to the more specific problems of data handling and manipulation and space constraints dictated by the book size.

Metric Vs. English

One particularly difficult problem was deciding on the units of measurement to use on particular maps or graphs. In 1975 Congress passed the Metric Conversion Act. This act calls for the gradual changeover from the English to the metric system under a flexible program that encourages the various sectors of the economy to deal with their particular problems voluntary. This desired trend toward metric leaves the cartographer with a dilemma regarding choice of units. In the production of the atlas, this choice was influenced by considerations of space, ease of conversion, and comprehension.

The atlas was intended to appeal to a wide audience and to present information as clearly and concisely as possible. The physical limitations of the page format also necessitated generalizing data in some instances. For example, in the weather and climate section we provided maps of dew point.[3] Monthly dew point temperatures were indicated by bar graphs, the scales of which were in degrees Fahrenheit. We found that adding the celsius temperature scale to each bar graph limited map legibility. To simplify the presentation we added a single scale bar showing both units of measurement, degrees Fahrenheit and celsius (Fig. 1).

Data collected for map presentation are nearly always measured in one particular unit. We found that accommodating both metric and English units on a single map sometimes presented problems. An example can be drawn from the map of relief.[4] The data were originally collected in meters. Conversion led to awkward class boundaries for the scale in feet: 2.0 to 6.9 meters converts to 6.6 to 22.6 feet, for example. This requires the reader to think in terms of tenths of feet rather than the more usual inches. Further, there is room for some misconception concerning the overall accuracy of the measurements: although the intervals are rounded to tenths of a foot, the original metric data from which the map was constructed were rounded to the nearest meter.

A final question concerns the overall familiarity of the general public with the metric system. We had to ask if the reader would avoid pages on which information was expressed in unfamiliar units. For example, on the maps dealing with geophysics the geothermal gradient was expressed in degrees celsius per one hundred meters of depth from the surface.[5] We questioned: does a temperature gradient expressed in metric units detract from the value of the map? It was our conclusion that this particular page would appeal to a specialized audience who would likely be familiar with metric units, so we did not convert to English units. In other instances data were shown strictly in English units where it was felt that the audience would better comprehend this system. Until all data are collected in standard units, this problem will continue to confront cartographers.

Availability of Data

Another problem encountered during the course of atlas production was data availability. A project of this magnitude requires the compilation of a detailed table of contents before any cartography can begin. After the table is complete, layouts of each page were prepared to meet each author's specifications. These initial steps were necessary to insure continuity in the graphic presentations throughout the book and to maintain a smooth flow through the production phase. After going to great lengths to create a page design that accommodated the anticipated information, we were forced to redo layouts when the data were subsequently found to be

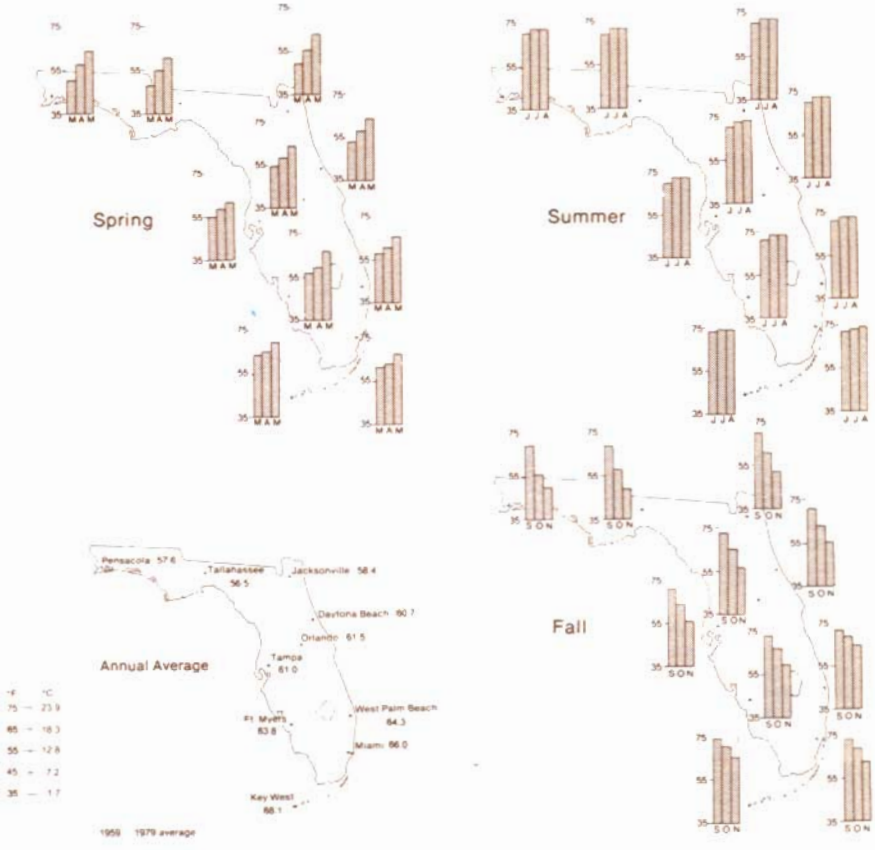

Fig. 1. Annual Average, and Three of Four Seasonal Dew Point Maps from *Atlas of Florida*, p. 51.

unavailable. Data problems were particularly troublesome when the needed information was to be drawn from the 1980 census. Census information was not released as scheduled because of accusations by many large cities that their populations had been undercounted. In some instances, estimates rather than final census statistics were used in order to prevent further delays in the completion of the project.

Computer generated isoline maps displaying temperature and rainfall statistics were also complicated by problems of data availability. These statistics were compiled from weather records kept throughout the state spanning the twenty-one years from 1959 through 1979. The data collected for 1959 came from 120 reporting stations. However, over the course of the twenty-one year span, twenty-eight of the 120 stations had inter-

rupted or discontinuous reports. The loss of data from these stations may have introduced some error into the contouring results. An additional problem with climatic data is that certain data were collected at only a few stations. In these cases, data were displayed by point locations.

The type of data available also affects the choice of map type. In some cases, a choropleth map is made in place of another type even though the choropleth map may not be the best way to illustrate a subject. Such was the case with Florida's historical population density.[6] Probably the best way to map population is with a dot map (Fig. 2, cover). This was not possible in most cases because the historical county population figures did not include where the people lived within the county. Therefore, we chose to construct choropleth maps of persons per square mile despite the shortcomings. In the earliest years, some counties, such as Alachua and Hamilton, differed greatly in size. A large county with a relatively large population (Alachua, for example), may fall into a class below a small county (e.g., Hamilton) with a significantly smaller population. This is the problem of mapping density rather than gross numbers; a false impression of the population characteristics of a county may result. Also, the populations of some counties were extremely concentrated. In Monroe County, for example, large areas of uninhabited land were included in computing density, although the great majority of the people lived in Key West. To try to moderate these effects, special symbols were used to pinpoint the locations of very high population concentrations. We arbitrarily defined these areas as having 50 to 75 percent of the county's total population. While this helped to reduce the shortcomings inherent in choropleth maps of density, it did not change the fact that Alachua County had a lighter shade than less-populated Hamilton County.

Class Boundaries

The division of the data into classes is of practical concern to anyone making a choropleth map. This can be done in several ways. The method used will determine the appearance and accuracy of the map. An accurate choropleth map can be thought of as one in which each individual observation is represented by a class most closely approximating the observation's value. A haphazard method will probably produce an ambiguous map, while careful consideration and selection of classes will greatly improve map accuracy.

What options are available? The most basic might be called the counting number method, in which divisions are made in the range of values at points of equal intervals, a second commonly used method generates classes according to natural breaks occuring in the range of numbers. A third way is to subdivide the data equally into quartile or quintile groupings. Each of these methods produces a different map although the same data set is used. A number of tests can be used to determine the accuracy of these techniques.

In the production of the *Atlas of Florida*, A counting routine developed at the University of Kansas was used. This method uses a computer program that determines the class breaks by statistical procedures. This program creates statistically more accurate categories that minimize the within-class and maximize the between-class variance.[7]

Conclusion

Problems such as these were encountered throughout the atlas. Numerous other technical and data-portrayal problems arose on individual pages. Although we do not pretend to have found the only answer to these problems, we feel that the end result was the best to be achieved under our particular set of circumstances.

* * *

1. Edward A. Fernald, ed., *Atlas of Florida* (Tallahassee, FL: The Florida State University Foundation, Inc., 1981). Hereafter referenced *Atlas of Florida*.

2. The Atlas Steering Committee consisted of Edward A. Fernald, James R. Anderson, Jr., William R. Brueckheimer, Charles B. Nam, Donald J. Patton, William F. Tanner, Frank A. Unger, and Morton D. Winsberg.

3. *Atlas of Florida*, P. 51

4. *Atlas of Florida*, P. 17

5. *Atlas of Florida*, P. 28

6. *Atlas of Florida*, PP. 122-23.

7. George F. Jenks and Fred C. Caspall, "Error on Choropleth Maps: Definition, Measurement, Reduction," *Annals of the Association of American Geographers* 61 (1971): 217-44.

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Editor's Note:
The Atlas of Florida can be ordered from:

The Atlas of Florida
361 Bellamy
Florida State University
Tallahassee, FL 32306

The cost (including postage and handling) is $18.50 for FSG members, and $29.50 for non-members.

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THE FLORIDA RESOURCES AND ENVIRONMENTAL ANALYSIS CENTER[1]

Edward A. Fernald

The Florida Resources and Environmental Analysis Center (FREAC) is a unit within the Institute of Science and Public Affairs at Florida State University. FREAC originally developed in the Geography Department but eventually expanded to include many other physical and social science disciplines within the university. The spatial analysis methodology of the geographer has been continually in the forefront of the activities of the Center. One of the goals of FREAC has been to match university resources with the public needs of the state and local governments in Florida. Examples of studies completed in the last few years include: the use of state-owned lands as a resource, patterns of energy consumption in Florida, development of a geographic information system for the state, a number of land use and resource mapping and analysis projects, comprehensive plans for cities and counties, land use impacts of hazardous waste, development of a resource decision-making process model, and an analysis of water management in the state. Geographers have directed most of these studies. The multidisciplinary nature of the Center encourages geographers and geography students to interact with individuals of other disciplines, and, perhaps more importantly, members of other disciplines are able to learn about the abilities, interests, and competencies of geographers.

At Florida State University, the Center's activities continually fund six to fifteen geography students in a "hands-on" research assistant/internship experience. Students learn about developing grants, the politics of grant-getting, and many aspects of geographic research. In some cases, they become very adept in using cartographic and computer techniques.

On numerous occasions, agencies for whom projects were completed by the Center have employed post-graduate students. A frequently reported remark is, "we liked these geography students because they have a broad background and they don't need training in research or problem solving after they get to the agency." Generally these students have advanced rapidly in the state and local agencies.

As a result of the applied research undertaken by the Center and the Geography Department, the Florida State University personnel department has became aware of the capabilities of geographers, and state agency personnel are confident in the tasks geographers can successfully complete. Because agencies have confidence in the Center, Florida State has become the depository both for the LUDA geographic information system in the state of Florida and the only statewide aerial photography set used by state government.

The success of the Center's applied geography program makes state support for other projects easier to obtain. A very important aspect of the Center is a philosophy of accountability in both value and quality of output.

Presently, a Center staff member is executive director of the hazardous waste program. Hazardous waste is a serious societal problem and one which will continue to receive substantial funding despite cutbacks in funds in other areas. It is a problem area where goegraphers must work with members of other disciplines, yet one in which they can make significant contributions.

The Center has prepared a new comprehensive atlas of Florida, published in the fall of 1981,[2] and the state has appropriated funds for a Florida Water Atlas, which the Center will work on. In addition, applied geographers worked with

legislative reapportionment, data acquisition and research into the feasibility of using Department of Revenue ownership information as a source of resource management data.

The geographers of Florida State University believe that in the present time of decreasing funding, societal problems will not go away. There is still an opportunity for geographers to undertake applied studies with public agencies of all levels. The public agencies have been convinced that working with the university is an effective way to use public dollars. In the first place, the agencies save dollars because the university can complete a job on time, within budget, and at a high level of competency for less money than the agencies would spend with outside contractors. In Florida, the Attorney General's office regards FREAC as a state agency and therefore it is not required to meet the competitive negotiation provisions in the Florida constitution. Besides the initial savings of money, the university will use over 50 percent of the contracted dollars to pay for higher education costs such as research salaries, equipment, and student assistantships. The same dollars get a third use: the university can train students in practical, applied ways, which will allow them to move into both the public and private sectors at high competency levels.

FREAC is one of eleven research centers of the Institute of Science and Public Affairs of Florida State University. The director of the Institute is also the Executive Director of the Florida Resources and Environmental Analysis Center. The present co-directors of FREAC are Frank Unger, a geographers (for administration and technical affairs), and Roy Herndon, a nuclear physicist (for research). Some twenty-seven professors from seventeen departments have worked for the Center and as many as 110 students have been employed during one academic quarter, although the average is forty-seven. For more information about FREAC, write: Dr. Edward A. Fernald, Executive Director, Florida Resources and Environment Center, Florida State University, Tallahassee, Florida 32306.

* * *

1. This article is reprinted with minor revisions from the *AAG Newsletter*, vol. 16, no. 6 (June 1, 1981): 6-7, by permission of the Association of American Geographers.

2. The lead article of this *Florida Geographer* describes the *Atlas of Florida*.

RESIDENTS' CONSIDERATIONS IN SELECTING HAZARD-RESISTANT HOUSING

John A. Cross

Residents of the lower Florida Keys are faced with a high probability of hurricane dammage to their homes. Many owners have made architectural adjustments to ameliorate damage potential, but many others have ignored the danger. Nearly a third live in ground level houses, virtually all of which elevates the dwelling above the level of the lot---such as the "stilt house"---provides valuable flood protection. Yet less than half of the houses in the most vulnerable locations have been constructed on stilts.

In this research we ask: (1) What factors influenced the selection of homes, and (2) Why did residents select or reject stilt houses. The relationships in choosing their home type and the physical setting of their homesite were also investigated.

Selection Of The Home

Residents considered a number of factors when selecting a home (Table 1). The nearness of the home to the water, a good view, and price were the three most important considerations. The matter of safety during a storm was important to half the respondents. In other words, the desire to obtain the environmental amenities which brought them to the Florida Keys were much more important than avoiding potential hurricane loss.

Choice Of Stilt House Or Ground Level House

Both elevated and ground level houses were generally selected for similar reasons. No statistical relationships were found between the choice of an elevated vs. a ground level house, and price, architectural style, proximity to water, and nearness to stores, schools and work. Sixty-five percent of the occupants of elevated houses stated that storm safety was one reason they chose their home, but this is not significantly greater statistically than the 55 percent of ground level house residents who also claimed to have sought storm safety.

The deciding reason for selecting both ground level and elevated houses alike was nearness to water (Table 2). Price and view were also important. Hurricane safety was not. This disinterest in safety is not unexpected. Research by Kates,[1] Brinkmann,[2] and Oliver[3] indicates that the desire for waterfront property may overwhelm other considerations. White and Colleagues,[4] with respect to river floodplains, think that adjustment to the flood hazard is often secondary to other choices. The reasons expressed by residents of the lower Florida Keys certainly lends credence to these ideas.

Residents gave a variety of explanations why they specifically selected a stilt house. At the top of the list is concern for flood protection (selected by 62 percent), far more important than desire for breezes (35 percent), view (33 percent) and other factors (Table 3).

The reasons given for not selecting stilt houses are also quite varied (Table 4). The most frequently mentioned explanation (29 percent) is the absence of stairs, which is particularly important among the elderly and residents with small children. However, these worries should not be interpreted as meaning that the flood hazard was not considered, as is illustrated by the response on one questionnaire:

> The perpetual inconvenience of stairs outweighted the occasional risk of flooding.

Other explanations include the lower prices of ground level houses and the perceived unattractive appearance of stilt houses.

TABLE 1

REASONS RESIDENTS SELECTED THEIR HOMES

'DID YOU DECIDE TO BUY OR RENT YOUR PRESENT HOME IN THE FLORIDA KEYS BECAUSE IT:	YES	NO	NO ANSWER
WAS IN THE PRICE RANGE YOU WANTED?'	357 (77%)	105 (23%)	63
WAS NEAR THE WATER?'	426 (89%)	55 (11%)	44
HAD A GOOD VIEW?'	359 (74%)	119 (26%)	67
WOULD PROVIDE SAFETY IN A SEVERE STORM?'	219 (49%)	224 (51%)	81
WAS BUILT IN AN ATTRACTIVE ARCHITECTURAL STYLE?'	183 (42%)	253 (58%)	89
WAS LOCATED CLOSE TO WORK?'	74 (17%)	352 (83%)	99
WAS LOCATED CLOSE TO STORES OR SCHOOLS?'	57 (13%)	378 (87%)	90
OTHER (SPECIFY)?'			
BUILT HOME THEMSELVES	52		
LIKED THE NEIGHBORHOOD	24		
TO BE NEAR FRIENDS AND FAMILY.....	13		
INHERITED PROPERTY	6		
OWNED THE LAND BEFORE BUILDING....	13		
LOCATED ALONG A CANAL	9		
PRIVACY AND SECLUSION	22		
NEARNESS TO FISHING AREA	11		
MISCELLANEOUS REASONS	44		

NOTE: THE PERCENTAGE FIGURES REFER TO THE PROPORTION OF RESPONDENTS AGREEING OR DISAGREEING WITH THE REASONS.

TABLE 2

SINGLE MOST IMPORTANT REASON RESIDENTS OF ELEVATED AND GROUND LEVEL HOUSES CHOSE THEIR HOMES

	ELEVATED HOUSES		GROUND LEVEL HOUSES		BOTH TYPES	
	N	%	N	%	N	%
HOME NEAR WATER	53	50.5	91	46.7	144	48.0
VIEW FROM HOME	12	11.4	7	3.6	19	6.0
PRICE OF HOME	9	8.6	41	21.0	50	16.7
STORM SAFETY OF HOME	4	3.8	5	2.6	9	3.0
ARCHITECTURAL STYLE OF HOME..	2	1.9	5	2.6	7	2.3
HOME NEAR WORK.....	2	1.9	6	3.1	8	2.7
MISCELLANEOUS REASONS.....	23	21.9	40	20.5	63	21.0
TOTAL	105	100.0	195	100.0	300	100.0

TABLE 3

REASONS STILT HOUSES WERE SELECTED

'WHY DID YOU CHOOSE A HOME BUILT ON STILTS?'	NUMBER	PERCENTAGE*
FLOOD PROTECTION	64	62
BETTER BREEZES	35	34
GOOD VIEW	34	33
CARPORT AND SPACE BENEATH HOUSE	16	16
FEWER MOSQUITOES	13	13
REQUIRED BY ZONING LAWS	12	12
LIKED ARCHITECTURAL STYLE	5	5
POSSIBILITY OF CLOSING IN DOWNSTAIRS ...	4**	4
LOCATION	2	2
HOME PRICE	2	2
WIND PROTECTION	2	2
MISCELLANEOUS OTHER	7	7

*PERCENTAGE FIGURES INDICATE THE PROPORTION OF THE SURVEY POPULATION ANSWERING THE QUESTION WHICH MENTIONED THE PARTICULAR REASON, AND THUS DO NOT ADD TO 100 PERCENT.

**EIGHT ADDITIONAL RESPONDENTS STATED THAT THEY LIVE IN GROUND LEVEL HOUSES, SELECTED BECAUSE THEY HAD BEEN CONVERTED BY ENCLOSING THE AREA BENEATH A STILT HOUSE FOR STORAGE AND LIVING QUARTERS. WITHIN THIS STUDY THESE HOUSES ARE CONSIDERED AS STILT HOUSES.

TABLE 4

REASON GROUND LEVEL HOUSES WERE SELECTED*

"WHY DID YOU CHOOSE A HOME NOT BUILT ON STILTS?"

	NUMBER	PERCENTAGE**
ABSENCE OF STAIRS	60	29
PRICE OF HOME	25	12
HOME AVAILABILITY	23	11
HOME LOCATED ON HIGH GROUND	21	10
DO NOT LIKE THE APPEARANCE OF STILTS	19	9
WHIM	17	8
NO NEED, STILTS NOT IMPORTANT	13	6
LOCATION OF HOME	11	5
HOME LOCATED ON FILLED LAND	10	5
HOME HAD GOOD FOUNDATION	8	4
STILT HOUSE NOT SAFE IN WINDS	7	3
STILT HOUSE NOT SAFE FOR CHILDREN	4	2
GROUND LEVEL HOUSE MORE SPACIOUS	4	2
NO REASON GIVEN	29	--

*EXCLUDING HOUSES ON SHORT PIERS
**PERCENTAGE FIGURES INCLUDE THE PROPORTION OF THE SURVEY POPULATION ANSWERING THE QUESTION WHICH MENTIONED THE PARTICULAR REASON, AND THUS DO NOT ADD TO 100 PERCENT.

TABLE 5

SUMMARY TABLE OF SIGNIFICANT CHI-SQUARE RELATIONSHIPS OF HOME SELECTION CONSIDERATIONS AND PHYSICAL HOMESITE CHARACTERISTICS

HOME SELECTION CONSIDERATIONS	HOMESITE CHARACTERISTICS						
	ADJACENT TO SEA	ADJACENT TO CANAL	DISTANCE TO SEA	DISTANCE TO CANAL	LANDFILL	ELE-VATION	FLOOD ZONE
HOME PRICE	X		X		X		
HOME NEAR STORES AND SCHOOLS		+	X	X	X		
HOME NEAR WORK		X	X	X	X		
HOME NEAR WATER	X	X	X	X	X		X
HOME ARCHI-TECTURAL STYLE		X	X	X	X		
STORM SAFETY OF HOME		X	X	X	X		
VIEW FROM HOME	X	X	X	X	X		

X INDICATES CHI-SQUARE SIGNIFICANT AT .05 LEVEL.
+ INDICATES CHI-SQUARE SIGNIFICANT AT .10 LEVEL.

Some of the residents of ground level houses indicated that they felt their houses were as safe or safer than stilt houses. Six percent stated there is no need for stilt houses, and 15 percent commented that they did not require stilt houses because their dwellings were on what they considered to be high ground or filled areas. A few ground level house residents felt that stilt houses are unsafe, being more vulnerable to high hurricane winds. Several responses to the open-ended question "Why did you choose a home not built on stilts?" Illustrate these concerns:

> Has nothing whatever to do with safety or permanence in storms... Stilt homes are first to go.

> Do not like stilts. Good idea for people who don't live here. Not practical in highwinds. Good only in certain areas.

Homesite Characteristics And Home Type Selection

The considerations which lower Florida Keys residents indicate influenced their selection of a home are statistically associated with many of the physical characteristics of their homesites (Table 5). Residents who selected their home because it was (1) in the price range they wanted, (2) close to stores or schools, or (3) close to work, were generally less likely to occupy homes along the shore or canals or on filled lands. On the other hand, those respondents who sought homes which (1) were near the water, (2) had a good view, or (3) were built in an attractive architectural style, were significantly more likely to be located along the shore or canals and upon filled lands. That residents selecting their homes for the latter three reasons would

be located near the water comes as no surprise. However, an explanation of the homesite preferences of those seeking appropriately priced homes near work, schools, or stores is more open to speculation.

Residents who indicated that they decided "to buy or rent their present home in the Florida Keys because it would provide safety in a severe storm" statistically differ with respect to several of the physical homesite variables from those not claiming this safety consideration. However, the direction of the relationships is not expected. Sixty-six percent of those who sought storm safety actually selected homes adjacent to canals, compared with 45 percent of those who did not cite storm safety as a reason they chose their home. Likewise, those seeking storm safety were more likely to locate on landfill than other residents. These relationships cannot be explained adequately by the distributions of the various home types. Indeed, even though a disproportionate number of stilt houses are located near the sea and canals, there residents did not claim storm safety as a determining factor significatly more often than those occupying ground level houses. Thus an apparent contradiction is discernable. Even though residents claimed they sought storm safety, their actions either cast doubts about their awareness of the hazard or are an indication of cognitive dissonance, whereby residents claimed they selected their house for its storm safety because in retrospect they felt they should have.

Responses to the specific question, "Why did you choose a home built on stilts" are generally unrelated to the locations of the homes. For example, 26 percent of the residents whose responses mentioned flood protection lived on lots adjacent to the seashore, compared with 34 percent of those who did not mention flood protection. However, the differences are not statistically significant. Similarly, with respect to the proximity of their homesites to canals, their elevations, and their flood zone, stilt house residents seeking flood protection do not differ from those citing other home selection factors. Likewise, there are no discernable relationships between any of the other stilt house selection factors and the homesite characteristics.

Residents living in ground level houses responded to the question "Why did you choose a home not built on stilts?" The responses were unrelated to the physical parameters of the homesites. While house price was frequently cited as a consideration in home selection, ground level house residents living along canals and by the sea were no more likely than other residents to cite price as a reason for avoiding stilt houses. Similarly, respondents selecting ground level houses to avoid stairs or for other reasons do not differ with respect to any of the physical variables except adjacency to canals.

Twenty-three percent of the people who lived in ground level dwellings and who claimed to live on the seashore---hardly "High Ground." Likewise, 62 percent of those claiming high ground lived on canals. Cognitive dissonance or environmental ignorance appears to have influenced some of the respondents' answers with respect to what constitutes "High Ground."

Conclusion

In the lower Florida Keys, residents claimed many factors influenced their home selection. Hazard considerations were not the most important. Some associations were noted between the general reasons residents gave for selecting homes and homesite locations. But those residents claiming to have considered storm safety were not significantly more likely to have selected safer house types or locations than the overall population. Furthermore, claims of some residents that their homesites were safe, thus not requiring elevated houses, appear unfounded. These findings, together with earlier findings that perception of the hurricane hazard is unrelated to the choice of home type in the Keys,[5] indicate that residents' re-

sponses can best be understood within the framework of a "disaster culture" as envisioned by Moore.[6] In addition they are supportive of the arguments of Mileti, Drabek, and Haas that hazard perceptions alone have "Not been particularly fruitful as a predictor of...adoption or not of lifesaving adjustments."[7]

* * *

1. R. W. Kates, "The Perception of Storm Hazard on the Shores of Megalopolis," in *Environmental Perception and Behavior*, ed. David Lowenthal, Department of Research Paper no. 109 (Chicago: University of Chicago, 1967), pp. 60-74.

2. W. A. R. Brinkmann, *Hurricane Hazard in the United States: a Research Assessment*, Program on Technology, Environment and Man Monograph, no. NSF-RA-E-75-007 (Boulder: University of Colorado Institute of Behavioral Science, 1975).

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4. G. F. White, W. A. R. Brinkmann, H. C. Cochrane, and N. J. Erickson, *Flood Hazard in the United States: a Research Assessment*, Program on Technology, Environment and Man Monograph no. NSF-RA-E-75-006 (Boulder: University of Colorado Institute of Behavioral Science, 1975).

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MASARYKTOWN: A SUCCESSFUL ETHNIC EXPERIMENT

Dewey M. Stowers, Jr., and Harry J. Schaleman, Jr.

One man's vision nearly sixty years ago blossomed into what is today one of Florida's more colorful and relatively unknown ethnic communities. Marsaryktown was the inspiration of Joseph Joscak, former editor of a now defunct daily Czechoslovakian newspaper, *The New Yorsky Dennik*. The small Florida settlement is a viable testimony to the pioneer spirit of its founder. The town was named for a philosopher-statesman and first president of Czechoslovakia, Thomas Garrique Masaryk (1850-1937).

Masaryktown is situated in the southeast part of Hernando County about thirty miles north of Tampa in the eastern section of the Pithlachoscotee Basin (Fig. 1). Using the circulation of his newspaper to promote his dream of establishing a community for Czechoslovakian immigrants, Joscak issued an appeal for settlers in 1924. He struck a re-

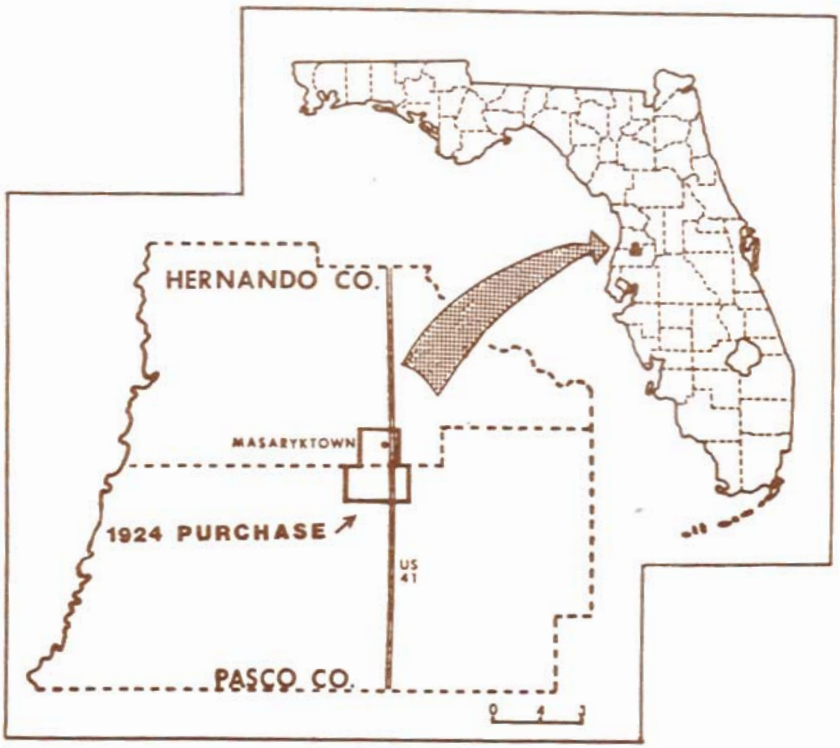

Fig. 1. Location of Masaryktown.

sponsive chord among his readers, many of whom were employed in the mines and factories of the industrial North.

Initial interest centered in the Orlando area, but later a tract of some 24,000 acres straddling the Pasco-Hernando County line appeared more desirable to the committee which had organized to investigate potential sites. Both land tracts had drawbacks; the Orlando region was reported "too swampy" and the Pasco-Hernando County area was labelled a "cold pocket" by University of Florida agriculturalists.[1] However, a check with local orange grove operators influenced the search committee to select the later site. The Hernando Plantation Company was formed, composed solely of Czechoslovaks. The company began to purchase the land and develop the community.

The new settlers or share holders, approximately 125 of them, came mainly from New York, New Jersey, Pennsylvania, and Ohio. Meeting in Washington, D.C., the group proceeded south to Tampa. For three days the group explored the area, then in a typical Slovak tradition of good luck, broke bread and burried it at the site of their new community.[2]

The serious task of clearing land, building structures, and planting orange groves began in 1925-26. The growing of oranges would be the economic foundation of the agricultural experiment. Construction of homes and public and commercial structures commenced. Layout conformed to the rectangular grid (Fig. 2). Imbued with patriotism for both their old and new countries, settlers named the north-south streets of Masaryktown after U.S. presidents and the east-west streets after literary, political, and military figures of Bohemia, Moravia, and Slovakia. Thus today bi-national junctions of Lincoln and Hviezdoslav, and Garfield and Stefanik are found. An exception to the street naming plan is Wilson Boulevard, a major east-west street. Woodrow Wilson died the year Masaryktown was founded. He had been a friend of Masaryk, the latter cementing intimate American associations by his marriage to a Brooklyn, New York woman.[3]

Except for Czechoslovakian names printed on street signs, mailboxes,

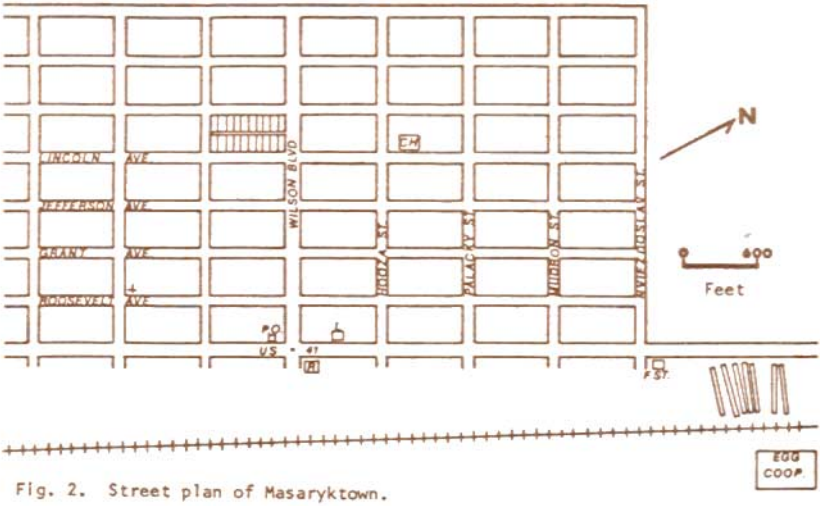

Fig. 2. Street plan of Masaryktown.

and a few small commercial or public buildings, there is little outward manifestation of the ethnic heritage of the community which would distinguish it from other small rural Florida towns. For the most part homes are modest, well-kept, one story structures with spacious lawns set well back from the relatively narrow residential streets. The abundance of trees and occasional unpaved streets helps to create a relaxed, rural atmosphere. The few non-residential structures such as the community volunteer fire department, small library-museum (containing more than 3000 books in English, Czech, and Slovak), minute post office, old roadside motel, large hardware-general store, and hotel-restaurant building, are strung out along both sides of U.S. Highway 41, the main artery of town. The civic center and community churches (Catholic, Lutheran, and Baptist) lie west of the highway in the residential sector.

By early 1926 new arrivals had formed a community of some forty-three families, twenty-four dwellings, a two-and-one-half story hotel, and a future that looked promising. More than 800 acres had been cleared and planted with fruit trees, primarily orange groves. Both a sawmill and rock crusher plant had been incorporated into the development. Mid 1926 was a boom period for the community. The hotel overflowed with visitors and newcomers set up tents and other temporary housing. A mayor was elected and a civic group began to work with the new European immigrants, instructing them in regard to their new American status and preparing them for citizenship. As 1926 came to a close, the inhabitants of Masaryktown numbered approximately 300.[4]

Killing frosts during the 1926-27 and 1927-28 winters devastated the newly planted groves. The economic disaster forced many residents to abandon the area, but others remained to experiment with alternate cash crops, such as onions, sweet potatoes, eggplant, and cucumbers. Market possibilities, however, were limited and unreliable, so many disappointed farmers returned to the north to resume their former lives. A few hardy and determined families remained during the Depression years eking out a living through truck farming and poultry raising. On the eve of World War II only thirty-six families lived in Masaryktown.

It was, however, during this ebb in the community's fortunes that Stephen Ostruba moved into the area and introduced poultry on a commercial basis that proved the salvation for Masaryktown. Soon incubators were installed, chicken houses were constructed, and a thriving egg and poultry industry resulted with ready markets in the expanding urban areas of Tampa and St. Petersburg.

With their new found success the poultrymen of Masaryktown embarked on an egg cooperative in 1934, the Hernando Egg Company. Expansion and success continued except for the war years of the 1940's when all but two of the community's young men joined the armed forces, resulting in a manpower shortage and production slowdown. The return of the veterans to their homes and families helped to accelerate growth of the industry and community. Soon Masaryktown farmers were leaders in the state's poultry industry. Prior to 1950, Florida was and importer of eggs and produced less than half its needs. The 1950's and '60s, however, were periods of exceptional expansion and growth, and it was during this period that Florida became an egg exporter. Masaryktown was the leader in the state's poultry industry. Local resident A. G. Mazourek was recognized as the prime mover by his foresight in helping to organize a new cooperative in 1952, the Hernando Egg Producers, Inc. With the new cooperative and with guidance from the agricultural departments at the University of Florida, the farmers' collective began to purchase feed and sell their products more efficiently. Individual farmers were no longer at the mercy of the narrowing margin of profit which was found in the old system.

Today, Masaryktown is recognized as having the leading egg producers' cooperative in the southeastern United States. High standards in the cooperative and the processing of more than 2000 cases of eggs per week help make Masaryktown the largest egg handler in Florida.[5] This success story has evolved out of struggle, not only with war, labor shortage, market fluctuations, and other human institutions, but also with natural calamities. In addition to the killing frosts of the early years, a disastrous flood in the spring of 1960 following a two-day deluge inundated lowland areas and created an inland lake in the community some seven feet deep. More than 20,000 laying hens drowned.[6] As a result of this catastrophe, a successful drainage canal was constructed along the eastern and southern boundaries of the town to prevent excessive run-off into the basin from the higher ridges on the east.

Such disasters and shared experiences within the community served to bolster the support system of the proud people. It is difficult to produce a definitive statistic of the Czecho-Slovak ancestry of the community's 800 or so inhabitants. The ethnic flavor is still there, however. Traditionally each year on the Sunday closest to October 28th, Czechoslovakian Independence Day, the community presents a folk festival in the local civic center. Food and dancing highlight the annual event, but "chicken-plucking" contests and a "Miss Drumstick" competition have been included in the festivities. The women work diligently to prepare special Slavic delicacies including *kolacki*, danish-like nut rolls, and a giant apple strudel. The strudel prepared for the 1981 celebration measured 75 feet in length and required 150 pounds of flour, 25 pounds of butter, 3 bushels of apples and many crates of eggs. The menu also included, appropriately, 1,000 pounds of baked chicken garnished with a special rice dish and locally grown beans and cabbage slaw.[7]

Although this celebration was begun as a local one, it now attracts visitors from all parts of Florida. In 1981 over one thousand people attended the festivities. Following the serving of dinner, which lasted three hours, the crowd was treated to a program highlighted by singing and dancing reminiscent of the "old country." Traditional Czechoslovakian folk dances were performed by the local Beseda dancers attired in handmade costumes. They were accompanied by a local band that delighted the audience with their color, one could hear plans being made for an even more lavish future celebration. Masaryktown has indeed maintained its distinct identity and maintains its link between old and new worlds.

* * *

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2. Ibid., p. 2

3. Richard J. Stanaback, "a History of Herando County," Bicentennial Edition, Daniels Publ., 1976, pp. 223-25.

4. Ibid., p. 224.

5. J. C. Walthrup, Hernando Egg Cooperative, Masaryktown, personal communication, March 1981.

6. "Devastating Flood," *St. Petersburg Times*, April 25, 1960, p. 2B.

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HURRICANE RAINFALL IN SOUTH FLORIDA[1]

Donald Brandes

It is commonly recognized that hurricanes and tropical storms are responsible for substantial amounts of rain in Florida, but how much? This study examines this question.

Study Area and Sources

The research area is the South Florida Water Management District (Fig. 1). Setting the district boundaries as the limit for the study provides an area which is defined physically by watershed divides and at the same time is a discrete administrative unit with its own water management policies. The time span is a sixty-year period from 1919 through 1978. Information on the dates and routes of hurricanes and tropical storms was obtained from several sources. The most useful reference was Neumann *et al.*[2] This book contains numerous maps illustrating the routes of tropical cyclones and textual descriptions of the geographical and temporal distributions of the storms. Tannehill's *Hurricanes* contains similar descriptions of tropical cyclone tracks.[3] Other references were consulted as well.[4]

Forty-one hurricanes and forty-four tropical storms influenced rainfall in the South Florida Water Management District from 1919 through 1978 (Table 1). Rainfall data were recorded for the dates on which the storms influenced South Florida. Values were summed to obtain the total rain which resulted from hurricanes during the sixty-year period. In addition to daily rainfall data for the dates on which tropical storms were passing, rainfall was also tabulated for each year, and for the months of peak tropical cyclone activity from June through October of each year.[5]

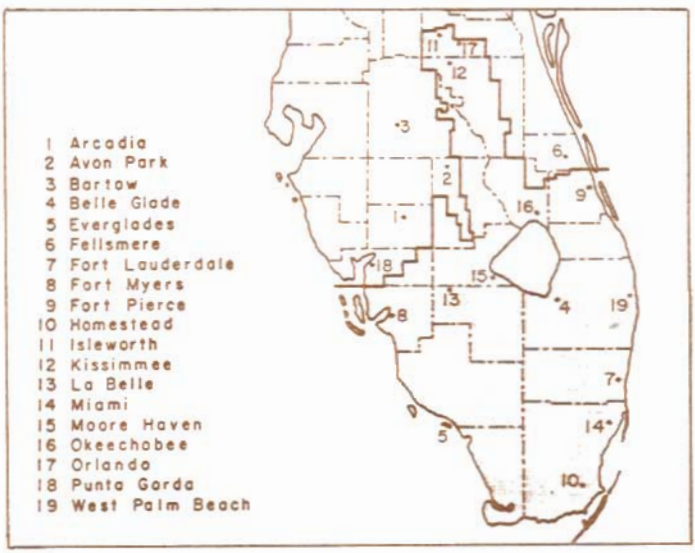


Fig. 1. South Florida Study Region. Shading indicates the location of the South Florida Water Management District. Weather stations are numbered.

TABLE 1

DATES OF HURRICANES AND TROPICAL STORMS

DATES OF HURRICANE RAINFALL DATA

1919	Sept.	9-10	1945	Sept.	14-16
1920	Sept.	25, 29-30	1946	Oct.	7- 8
1920	Oct.	24-25	1947	Sept.	17-18
1924	Oct.	19-21	1947	Oct.	11-12
1926	July	26-28	1948	Sept.	21-23
1926	Oct.	20-21	1948	Oct.	4- 5
1928	Aug.	7- 9	1949	Aug.	26-28
1928	Sept.	16-17	1950	Sept.	3- 6
1929	Sept.	27-29	1950	Oct.	15-18
1933	July	29 - Aug. 1	1951	May	17
1933	Sept.	1	1959	Oct.	16-19
1933	Sept.	4- 6	1960	Sept.	9-11
1933	Oct.	3- 5	1964	Aug.	26-28
1935	Sept.	2- 5	1964	Sept.	9-11
1935	Sept.	28-29	1964	Sept.	27-28
1935	Nov.	4- 5	1964	Oct.	5- 6
1936	July	29-30	1964	Oct.	14-15
1939	Aug.	11-13	1965	Sept.	7- 9
1941	Oct.	6	1966	June	8- 9
1944	Oct.	16-19	1966	Oct.	2- 9
1945	June	21-24	1968	Oct.	16-19

DATES OF TROPICAL STORM RAINFALL DATA

1925	Nov.	30 - Dec. 1	1953	Aug.	27-31
1926	Sept.	15-17	1953	Oct.	3- 5
1928	Aug.	12-14	1953	Oct.	7-10
1930	Sept.	8-10	1959	June	16-20
1932	Aug.	29-31	1960	Sept.	21-25
1934	May	26-28	1962	Aug.	24-26
1934	July	22-23	1964	June	5- 6
1936	June	13-15	1967	Sept.	7- 8
1936	Aug.	21-22	1968	June	2- 6
1937	July	28-30	1968	June	17-20
1937	Aug.	29-31	1968	Aug.	9-10
1938	Oct.	13-17*	1969	Sept.	6- 7
1940	Aug.	2- 3	1969	Oct.	1- 4
1941	Sept.	15-17	1970	Sept.	13-15
1941	Oct.	17-21	1970	Sept.	26-27
1945	Sept.	3- 5	1971	Aug.	10-12
1946	Nov.	1- 2	1972	Sept.	4- 6
1947	Aug.	19-20	1974	June	24-28
1947	Sept.	22-23	1974	Oct.	6- 7
1947	Oct.	5- 6	1975	June	26-27
1951	Oct.	1- 3	1976	Aug.	17-19
1952	Feb.	2- 3			

* two storms overlapped

Although there are numerous weather stations within and near the study area, few of them have been in existence at the same site for the entire sixty-year period. After eliminating numerous stations because of short or erratic records, nineteen weather stations were chosen as being suitable (Fig. 1).

The rainfall data provide the following: (1) amounts of annual rainfall (Table 2 and Fig. 3); (2) seasonal rainfall for the five-month period of peak tropical cyclone activity for all nineteen stations (Table 2 and Fig. 2), and (3) annual and seasonal rainfall for each individual station (Table 3 and Fig. 3).[6]

Discussion of Rainfall Data

Mean annual rainfall from hurricanes for all stations for the sixty-year period is 2.05 inches. This amounts to 3.8 percent of the annual total rainfall and 5.8 percent of the seasonal rainfall. Mean rainfall from tropical storms is 1.74 inches, or 3.2 percent of the annual rainfall and 4.9 percent of the seasonal rainfall. Hurricanes and tropical storms combined comprise 3.79 inches of rain or 7.0 percent of the annual rainfall and 10.6 percent of the seasonal rainfall.

Table 2

**** ALL STATIONS ****
**** TROPICAL CYCLONE RAINFALL ****

DATES	NO YRS RECORD	ANNUAL TOTAL RAIN	HURR. SEASON (JUNE - OCT) TOTAL	HURRICANE RAIN TOTAL	% ANN	% SEA	TROP. STORM RAIN TOTAL	% ANN	% SEA	HURR + TROP. ST. TOTAL	% ANN	% SEA
1919	1	55.02	28.49	0.92	1.7	3.2	0.00	0.0	0.0	0.92	1.2	3.2
1920	1	54.49	32.72	1.67	3.1	5.1	0.00	0.0	0.0	1.67	3.1	5.1
1921	1	47.13	29.89	2.86	6.1	9.6	0.00	0.0	0.0	2.86	6.1	9.6
1922	1	58.81	44.10	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1923	1	49.41	32.90	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1924	1	63.64	43.69	6.24	9.8	14.3	0.00	0.0	0.0	6.24	9.8	14.3
1925	1	58.34	28.33	0.00	0.0	0.0	3.56	6.1	12.6	3.56	6.1	12.6
1926	1	61.90	40.99	3.29	5.3	8.0	6.53	10.6	15.9	9.82	15.9	24.0
1927	1	39.64	30.44	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1928	1	57.78	43.71	8.18	14.2	18.7	3.16	5.5	7.2	11.34	19.6	25.9
1929	1	59.59	43.40	4.33	7.3	10.0	0.00	0.0	0.0	4.33	7.3	10.0
1930	1	64.84	38.06	0.00	0.0	0.0	2.61	3.9	6.9	2.61	3.9	6.9
1931	1	48.04	25.32	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1932	1	53.16	33.54	0.00	0.0	0.0	3.72	7.0	11.1	3.72	7.0	11.1
1933	1	59.72	41.26	12.34	20.7	29.9	0.00	0.0	0.0	12.34	20.7	29.9
1934	1	54.81	32.31	0.00	0.0	0.0	2.74	5.0	8.5	2.74	5.0	8.5
1935	1	51.57	37.11	6.53	12.7	17.6	0.00	0.0	0.0	6.53	12.7	17.6
1936	1	63.27	38.27	1.07	1.7	2.8	6.76	10.7	17.7	7.83	12.4	20.5
1937	1	56.53	35.06	0.00	0.0	0.0	2.68	4.7	7.6	2.68	4.7	7.6
1938	1	40.82	29.28	0.00	0.0	0.0	3.02	7.4	10.3	3.02	7.4	10.3
1939	1	54.14	39.94	1.75	3.2	4.4	0.00	0.0	0.0	1.75	3.2	4.4
1940	1	58.01	36.27	0.00	0.0	0.0	1.34	2.3	3.7	1.34	2.3	3.7
1941	1	40.24	34.40	0.53	0.5	1.5	4.12	6.8	11.9	4.65	7.7	13.4
1942	1	52.32	29.48	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1943	1	49.06	33.89	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1944	1	45.73	33.15	5.35	11.7	16.1	0.00	0.0	0.0	5.35	11.7	16.1
1945	1	53.45	42.24	11.00	20.5	25.7	2.56	4.8	6.0	13.56	25.3	31.7
1946	1	51.13	32.58	1.48	2.9	4.4	1.57	3.1	4.7	3.06	6.0	9.1
1947	1	38.10	52.28	6.22	16.5	12.6	4.58	5.9	8.7	12.81	16.4	24.3
1948	1	58.46	40.60	10.03	17.2	24.7	0.00	0.0	0.0	10.03	17.2	24.7
1949	1	53.31	41.08	4.53	8.4	11.0	0.00	0.0	0.0	4.53	8.4	11.0
1950	1	45.88	33.81	9.56	20.8	28.3	0.00	0.0	0.0	9.56	20.8	28.3
1951	1	50.09	35.06	7.0	0.15	0.4	0.5	4.72	9.4	13.5	4.91	9.8	14.0
1952	1	52.82	35.91	68.0	0.00	0.0	0.0	1.57	3.0	4.4	1.57	3.0	4.4
1953	1	65.52	42.10	70.5	0.00	0.0	0.0	2.01	3.4	15.1	2.01	3.4	15.1
1954	1	57.22	34.90	61.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1955	1	42.59	29.94	69.6	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1956	1	42.68	31.44	73.7	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1957	1	62.76	35.41	56.4	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1958	1	60.28	28.50	47.3	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1959	1	73.45	48.01	65.4	3.44	4.7	7.2	7.86	10.7	16.4	11.30	15.4	23.5
1960	1	65.60	46.07	70.2	5.14	7.8	11.2	4.20	6.4	9.1	9.34	14.2	20.3
1961	1	39.44	24.00	60.8	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1962	1	51.64	38.05	73.7	0.00	0.0	0.0	0.52	1.0	1.4	0.52	1.0	1.4
1963	1	52.23	29.70	56.9	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1964	1	50.12	32.00	63.9	5.03	10.0	15.7	1.96	3.9	6.1	6.99	13.9	21.8
1965	1	50.04	37.48	74.9	1.77	3.5	4.7	0.00	0.0	0.0	1.77	3.5	4.7
1966	1	60.49	39.78	65.8	4.65	7.7	11.7	0.00	0.0	0.0	4.65	7.7	11.7
1967	1	46.61	36.50	78.3	0.00	0.0	0.0	0.36	0.8	1.0	0.36	0.8	1.0
1968	1	61.03	44.22	72.5	3.10	5.1	7.0	5.26	15.2	20.9	12.35	20.2	27.9
1969	1	65.18	42.78	65.6	0.00	0.0	0.0	2.92	4.5	6.8	2.92	4.5	6.8
1970	1	50.37	28.25	56.1	0.00	0.0	0.0	1.60	3.2	5.7	1.60	3.2	5.7
1971	1	46.21	34.08	73.7	0.00	0.0	0.0	0.96	2.1	2.8	0.96	2.1	2.8
1972	1	52.18	29.02	55.6	0.00	0.0	0.0	0.33	0.6	1.1	0.33	0.6	1.1
1973	1	52.22	34.29	65.7	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1974	1	49.62	37.75	76.1	0.00	0.0	0.0	6.94	14.0	18.4	6.94	14.0	18.4
1975	1	45.37	33.22	73.2	0.00	0.0	0.0	0.53	1.2	1.6	0.53	1.2	1.6
1976	1	47.25	28.68	60.7	0.00	0.0	0.0	2.34	5.0	8.2	2.34	5.0	8.2
1977	1	48.48	30.00	61.9	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
1978	1	52.55	31.00	59.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0

Table 3

**** INDIVIDUAL STATIONS ****
**** TROPICAL CYCLONE RAINFALL ****

CITY	DATES	NO YRS RECORD	ANNUAL MEAN RAIN	HURR. SEASON (JUNE - OCT) MEAN	HURR. SEASON (JUNE - OCT) % ANN	HURRICANE RAIN MEAN	HURRICANE RAIN % ANN	HURRICANE RAIN % SEA	TROP. STORM RAIN MEAN	TROP. STORM RAIN % ANN	TROP. STORM RAIN % SEA	HURR + TROP. ST. MEAN	HURR + TROP. ST. % ANN	HURR + TROP. ST. % SEA
ARCADIA	1919 - 48	27	52.75	35.83	67.9	2.07	3.9	5.8	1.14	2.2	3.2	3.22	6.1	9.0
	1949 - 78	30	52.28	35.55	68.0	1.12	2.1	3.1	1.60	3.1	4.5	2.72	5.2	7.7
	1919 - 78	57	52.50	35.68	68.0	1.60	3.0	4.5	1.37	2.6	3.8	2.97	5.7	8.3
AVON PARK	1919 - 48	30	54.49	36.86	67.6	2.63	4.8	7.1	1.11	2.0	3.0	3.74	6.9	10.1
	1949 - 78	30	52.55	34.77	66.2	1.28	2.4	3.7	1.70	3.2	4.9	2.98	5.7	8.6
	1919 - 78	60	53.52	35.79	66.9	1.96	3.7	5.5	1.40	2.6	3.9	3.36	6.3	9.4
BARTOW	1919 - 48	30	56.38	35.61	63.2	2.61	4.6	7.3	1.29	2.3	3.6	3.91	6.9	11.0
	1949 - 78	30	53.17	32.75	61.6	1.11	2.1	3.4	1.08	2.0	3.3	2.19	4.1	6.7
	1919 - 78	60	54.78	34.18	62.4	1.86	3.4	5.5	1.19	2.2	3.5	3.05	5.6	8.9
BELLE GLADE	1919 - 48	22	59.06	39.43	66.8	3.06	5.2	7.8	1.63	2.8	4.1	4.69	7.9	11.9
	1949 - 78	30	55.66	38.08	68.2	1.42	2.6	3.7	1.77	3.2	4.6	3.19	5.7	8.4
	1919 - 78	52	57.21	38.68	67.6	2.24	3.9	5.8	1.70	3.0	4.4	3.94	6.9	10.2
EVERGLADES CITY	1919 - 48	22	53.90	39.09	72.5	3.29	6.1	8.4	2.38	4.4	6.1	5.67	10.5	14.5
	1949 - 78	30	53.40	39.22	73.4	0.99	1.9	2.5	1.57	2.9	4.0	2.56	4.8	6.5
	1919 - 78	52	53.41	39.16	73.1	2.14	4.0	5.5	1.98	3.7	5.0	4.12	7.7	10.5
FELLSMERE	1919 - 48	30	59.26	39.95	67.4	2.97	5.0	7.4	2.01	3.4	5.0	4.98	8.4	12.5
	1949 - 78	24	51.83	34.25	66.1	1.28	2.5	3.7	2.35	4.5	6.9	3.63	7.0	10.6
	1919 - 78	54	55.96	37.25	66.6	2.12	3.8	5.7	2.18	3.9	5.9	4.30	7.7	11.6
FT. LAUDERDALE	1919 - 48	26	63.65	39.13	61.5	3.91	6.1	10.0	1.85	2.9	4.7	5.75	9.0	14.7
	1949 - 78	30	60.19	37.92	63.0	1.51	2.5	4.0	2.06	3.4	5.4	3.57	5.9	9.4
	1919 - 78	56	61.79	38.50	62.3	2.71	4.4	7.0	1.95	3.2	5.1	4.66	7.5	12.1
FT. MYERS	1919 - 48	30	53.24	38.28	71.9	2.82	5.3	7.4	2.00	3.7	5.2	4.82	9.0	12.6
	1949 - 78	30	53.01	38.51	72.6	0.95	1.8	2.5	2.37	4.5	6.2	3.32	6.3	8.6
	1919 - 78	60	53.13	38.40	72.3	1.89	3.5	4.9	2.18	4.1	5.7	4.07	7.7	10.6
FORT PIERCE	1919 - 48	30	53.19	31.83	59.9	2.76	5.2	8.7	1.94	3.6	6.1	4.70	8.8	14.8
	1949 - 78	30	52.46	33.11	63.1	1.36	2.6	4.1	1.89	3.6	5.7	3.25	6.2	9.8
	1919 - 78	60	52.82	32.47	61.5	2.06	3.9	6.3	1.92	3.6	5.9	3.97	7.5	12.2
HOMESTEAD	1919 - 48	23	64.53	44.67	69.2	3.29	5.1	7.4	1.94	3.0	4.3	5.23	8.1	11.7
	1949 - 78	30	60.41	41.86	69.3	1.35	2.2	3.2	1.66	2.8	4.0	3.01	5.0	7.2
	1919 - 78	53	62.20	43.11	69.3	2.32	3.7	5.4	1.80	2.9	4.2	4.12	6.6	9.6
ISLEWORTH	1919 - 48	25	52.28	33.66	64.4	2.33	4.5	6.9	1.12	2.1	3.3	3.45	6.6	10.2
	1949 - 78	30	51.04	31.31	61.3	1.54	3.0	4.9	1.38	2.7	4.4	2.92	5.7	9.3
	1919 - 78	55	51.60	32.42	62.8	1.93	3.7	6.0	1.25	2.4	3.9	3.18	6.2	9.8
KISSIMMEE	1919 - 48	21	50.92	31.26	61.4	2.60	5.1	8.3	1.10	2.2	3.5	3.70	7.3	11.8
	1949 - 78	30	49.23	31.45	64.3	1.34	2.7	4.2	1.58	3.2	5.0	2.93	5.9	9.2
	1919 - 78	51	49.92	31.49	63.1	1.97	4.0	6.3	1.34	2.7	4.3	3.31	6.6	10.5
LA BELLE	1919 - 48	17	50.68	35.03	69.1	2.73	5.4	7.8	1.90	3.7	5.4	4.63	9.1	13.2
	1949 - 78	30	51.74	35.25	68.1	0.80	1.5	2.3	1.82	3.5	5.2	2.62	5.1	7.4
	1919 - 78	47	51.36	35.17	68.5	1.77	3.4	5.0	1.86	3.6	5.3	3.63	7.1	10.3
MIAMI	1919 - 48	30	57.43	35.89	62.5	2.58	4.5	7.2	1.86	3.2	5.2	4.44	7.7	12.4
	1949 - 78	30	57.52	37.62	65.4	1.67	2.9	4.4	2.26	3.9	6.0	3.94	6.8	10.5
	1919 - 78	60	57.48	36.76	64.0	2.13	3.7	5.8	2.06	3.6	5.6	4.19	7.3	11.4
MOORE HAVEN	1919 - 48	28	50.62	34.41	68.0	2.27	4.5	6.6	1.51	3.0	4.4	3.78	7.5	11.0
	1949 - 78	30	49.47	33.39	67.5	1.05	2.1	3.1	1.75	3.5	5.2	2.80	5.7	8.4
	1919 - 78	58	50.02	33.88	67.7	1.66	3.3	4.9	1.63	3.3	4.8	3.29	6.6	9.7
OKEECHOBEE	1919 - 48	20	48.96	30.29	61.9	2.68	5.5	8.8	1.31	2.7	4.3	3.98	8.1	13.1
	1949 - 78	29	45.60	30.07	66.0	1.04	2.3	3.5	1.84	4.0	6.1	2.89	6.3	9.6
	1919 - 78	49	46.97	30.18	64.2	1.86	4.0	6.2	1.57	3.4	5.2	3.43	7.3	11.4
ORLANDO	1919 - 48	30	52.22	33.38	63.9	2.71	5.2	8.1	1.39	2.7	4.2	4.10	7.8	12.3
	1949 - 78	30	49.50	31.96	64.0	1.45	2.9	4.5	1.72	3.4	5.4	3.17	6.3	9.9
	1919 - 78	60	51.06	32.67	64.0	2.08	4.1	6.4	1.55	3.0	4.8	3.63	7.1	11.1
PUNTA GORDA	1919 - 48	27	52.61	36.33	69.1	2.27	4.3	6.2	1.68	3.2	4.6	3.95	7.5	10.9
	1949 - 78	29	49.59	34.36	69.3	1.05	2.2	3.2	2.03	4.1	5.9	3.12	6.3	9.1
	1919 - 78	56	51.05	35.33	69.2	1.68	3.3	4.8	1.85	3.6	5.2	3.53	6.9	10.0
WEST PALM BEACH	1919 - 48	27	63.83	37.80	59.2	4.02	6.3	10.6	1.45	2.6	4.4	5.66	8.9	15.0
	1949 - 78	30	59.34	37.12	62.5	1.29	2.2	3.5	2.14	3.6	5.8	3.43	5.8	9.2
	1919 - 78	57	61.48	37.45	60.9	2.65	4.3	7.1	1.89	3.1	5.1	4.54	7.4	12.1

Mean annual rainfall from hurricanes for the individual stations ranges from 1.60 inches (3.0 percent) at Arcadia to 2.71 inches (4.4 percent) at Fort Lauderdale. Rainfall from tropical storms ranges from 1.19 inches (2.2 percent) at Bartow to 2.18 inches (4.1 percent) at Fort Myers. Rainfall from hurricanes and tropical storms combined ranges from 2.97 inches (5.7 percent) at Arcadia and 3.05 inches (5.6 percent) at Bartow to 4.66 inches (7.5 percent) at Fort Lauderdale and 4.30 inches (7.7 percent) at Fellsmere.

Mean monthly rainfall from hurricanes and tropical storms combined ranges from 0.1 inch or 1.8 percent for July to 1.2 inches (15.8 percent) for September and 1.0 inch (19.7 percent) for October. The above figures correspond closely to the findings of Cry for this region for 1931-60.[7] The present study, however, provides more detail regarding South Florida.

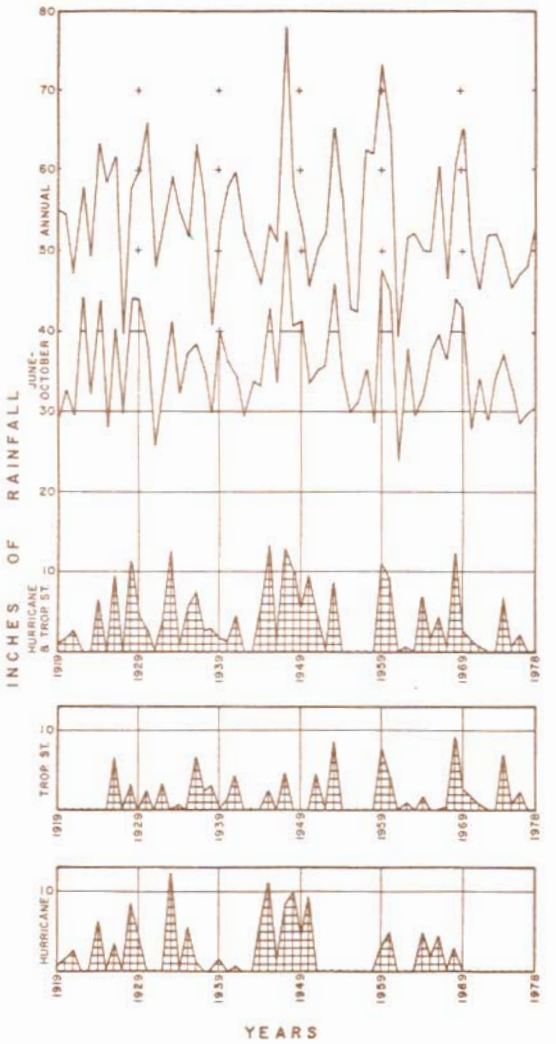


Fig. 2. Rainfall in South Florida by years.

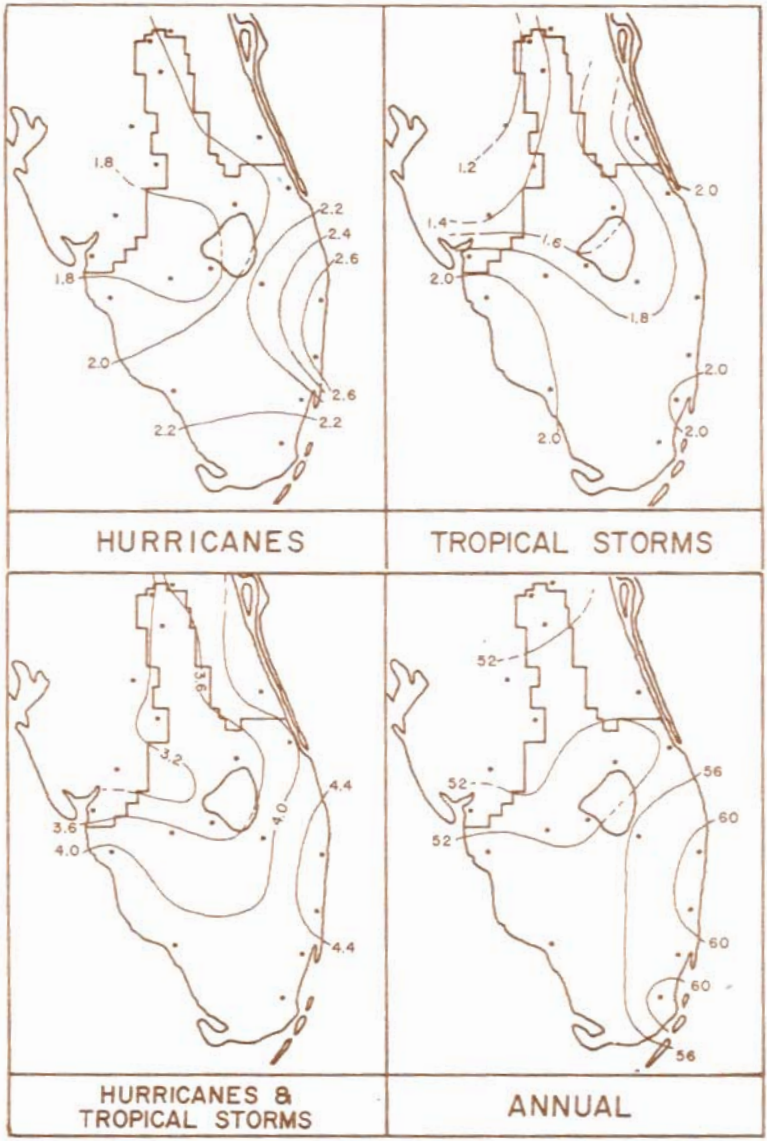


Fig. 3. Mean rainfall in inches, 1919-1978. The South Florida Water Management District.

Individual storms may at times deposit quite large amounts of rainfall, such as the 18.75 inches for the hurricane of June 14-15, 1936, at Everglades City. Incidences of such very high rainfall associated with tropical cyclones are rare however. In most years little or no rainfall attributable to tropical cyclones falls at any given station. When years of low tropical cyclone rainfall are averaged with years of very high rainfall, the resulting mean is far lower than the few high values would seem to indicate. The rainfall which resulted from the hurricane of June 14-15 1936, equaled 34.9 percent of the annual mean for that station and 28.6 percent of the total 65.52 inches which fell in that year. Both of these percentages are much higher than the 7.7 percent per year long term mean for combined hurricane and tropical storm rainfall at that location.

The average rainfall per storm is also found to be much less than is popularly expected from tropical storms and hurricanes. Conversations with employees of the South Florida Water Management District revealed that they believed rainfalls of ten to fifteen inches to be normal for severe tropical cyclones. Although such large quantities of rainfall have occurred, they are quite rare and almost never cover very large parts of the district at once. During the period 1919-78, the average hurricane dropped 3.00 inches of rainfall. The average tropical storm deposited 2.37 inches, and the mean for hurricanes and tropical storms combined was 2.63 inches.

P. J. Hebert of the National Hurricane Center in Miami observed that in the absence of tropical weather systems, other atmospheric conditions (such as a shift in upper air currents), may produce periods of rainfall which are greater than that which falls during years of tropical cyclones.[8] The present research corroborates Hebert's statement; however the fact remains that years in which tropical cyclones occur generally do tend to be wetter than years when such storms do not influence the region.

Paradoxically, although years of tropical cyclone activity tend to be wetter than years without the great storms, much of the difference in rainfall seems to be during the non-hurricane season months. Thus Hebert's observation that other causes for precipitation take the place of tropical cyclone rainfall is true during hurricane season but not necessarily true for the entire year. This finding may be a clue to evidence which could link the occurrence of tropical cyclone activity with other features of the atmosphere that may be associated with rainfall during the months of November through May.

Conclusion

The question posed by this research---how much of the total and seasonal rainfall which falls in southern Florida results from hurricanes and tropical storms?---can tentatively be answered: not all that much. Certainly not as much as was previously thought.

* * *

1. The author wishes to thank Dr. David L. Niddrie and Dr. James A. Henry of the Department of Geography, University of Florida for their guidance on this research and for their comments on an earlier draft of this paper.

2. C. J. Neumann, G. W. Cry, E. L. Caso, and B. R. Jarvinen, *Tropical Cyclones of the North Atlantic Ocean --- 1871-1977* (Ashville, N.C.: National Climatic Center, 1978).

3. I. R. Tannenhill, *Hurricanes* (Princeton: Princeton University Press, 1952).

4. P. Brunn, C. Tsao-Yi, F. Gerritsen, and W. H. Morgan, *Storm Tides in Florida as Related to Coastal Topography* (Gainesville, FL: University of Florida, Coastal Engineering Laboratory, 1962); Coastal Engineering Department, University of Florida, "Major Hurricanes, 20th Century Florida (1906-1951)" (unpublished research map, 1951); G. E. Dunn, *Florida Hurricanes*, Weather Bureau Technical Manual no. 38 (Fort Worth, Tx: U.S. Weather Bureau, 1967); W. H. Haggard and H. S. White, *North American Tropical Cyclones, 1886-1958* (Washington, D.C.: U.S. Weather Bureau, 1959); P. J. Hebert and G. Taylor, "The Deadliest Costliest, And Most Intense United States Hurricanes of the Century," NOAA Technical Memorandum NWS NHC 7 (Miami, Fl: NOAA National Hurricane Center, 1978); NOAA, *Some Devastating North American Hurricanes of the 20th Century* (Washington, D.C.: National Oceanic and Atmospheric Administration, 1973); R. W. Schoner and S. Molansky, *Rainfall Associated with Hurricanes*, National Hurricane Research Project Report No. 3 (Washington, D.C.:Weather Bureau, U.S. Department of Commerce and Corps of Engineers, 1956); R. H. Simpson, *Atlantic Hurricane Frequencies Along the U.S. Coastline* (Fort Worth, TX: U.S. Weather Bureau, 1971; A. L. Sugg, L. G. Pardue, and R. L. Carrodus, "Memorable Hurricanes of the United States since 1873," NOAA Technical memorandum NWS SR-56 (Fort Worth, TX: NOAA Southern Region, 1971): I. R. Tannehill, "The Hurricane," Misc. Paper no. 197 (Washington, D.C.: U.S. Department of Agriculture, 1939).

5. Although hurricane season in Florida is officially defined as lasting from June through November, only one hurricane and two tropical storms appear to have influenced rainfall in South Florida in November during the study period, so November is not included in the hurricane season for the purpose of this study.

6. Mean annual and mean monthly isohyet maps for Florida have been published previously: Jeffery A. Issacs, and Donald Brandes, "Florida Rainfall Maps," *The Florida Geographer* 15, no. 1 (1981): 12-14.

7. G. W. Cry, *Effects of Tropical Cyclone Rainfall on the Distribution of Precipitation over the Eastern and Southern United States* (Washington, D.C.: U.S. Department of Commerce, Environmental Science Services Administration, 1967).

8. P. J. Hebert, personal interview at National Hurricane Research Center, Miami, June, 1980.

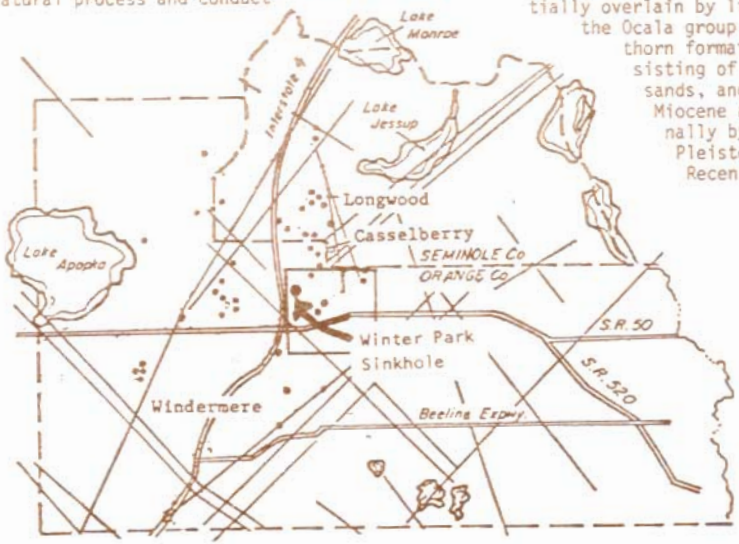
DROUGHT AND RECENT SINKHOLE OCCURRENCE IN ORANGE-SEMINOLE COUNTIES, FLORIDA

C. M. Head

During the period from January 1980 to September 1981, rainfall in Central Florida, normally 51 inches per year, declined some 16.3 inches. The result was a significant drop in water table and piezometric levels, and a notable increase in sinkhole activity. Sinks occurring in urban areas receive considerable notoriety--- the Winter Park sinkhole commanded worldwide attention when it opened in the town's business district--- but sinks in natural areas generate little interest. Geomorphologists recognize sinkhole formation as a natural process and conduct site analysis to better ascertain sink development parameters and to locate areas of potential collapse. Such analysis was undertaken in Orange and Seminole Counties (Fig. 1).

Geological Background of Orange-Seminole Counties

The basal rock underlying much of Central Florida consists primarily of Avon Park and/or Lake City limestones, both of marine origin. Neither of these formations have surface outcroppings. These formations are in turn sequentially overlain by limestones of the Ocala group, the Hawthorn formation consisting of clays, sands, and silts of Miocene age, and finally by sands of Pleistocene to Recent age. The



FRACTURE PATTERNS RECOGNIZED BY VERNON (1951)

RECORDED SINKHOLES SINCE 1962

DETAILED AREA OF FIGURE 2

0 10 miles

Fig. 1. Fractures and sinkholes of Orange and Seminole Counties. Source: Jammal and Associates, *Final Report on Winter Park Sinkhole*, 1982.

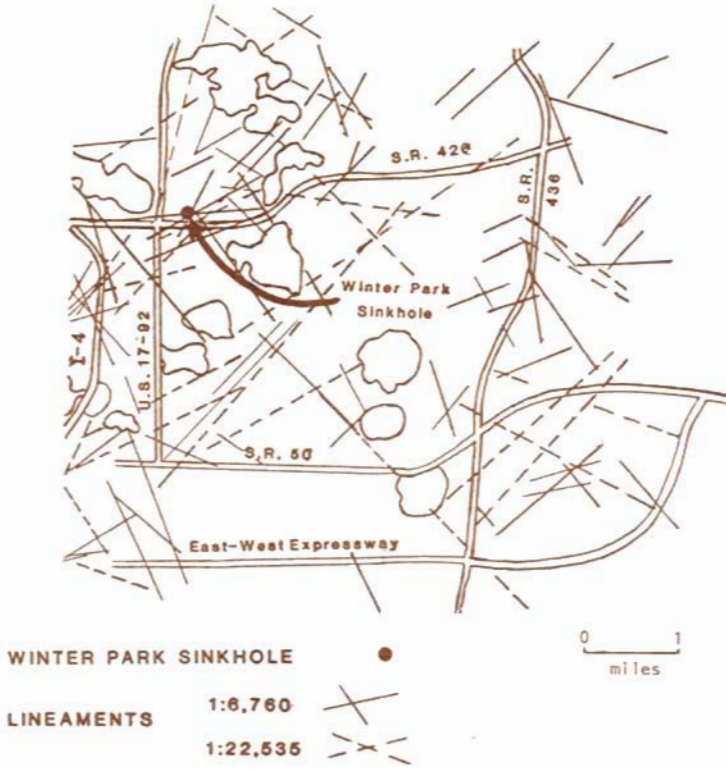


Fig. 2. Lineaments of Winter Park area. Source: Florida Department of Transportation

Ocala group consists of relatively pure limestone (containing little dolomite). It is in this layer that most solution activity occurs. The overlying Hawthorn formation provides a relatively impermeable confining bed for the limestones below. More recent sediments (many unconsolidated) overlie the Hawthorn below. Vernon indicated that the limestone formations described are apparently displaced along a series of faults which occurred during Tertiary times, probably post-Eocene and pre-Miocene in age.[1] The faults are believed to have accompanied the creation of the Ocala Uplift.

Fractures may be vertically perpetuated through the Hawthorn and surface materials due to irregularities in relief of the basal limestones or by differential compaction of the overburden. Many fractures may be attributed to the Triassic opening of the Atlantic; such fractures generally reflect a north-south trend.[2] Vernon mapped the area from air photos and recognized two general patterns through the bi-county area. The major pattern consists of a series of fractures trending generally NE-SW. A secondary system intersects the first at large angles, and trends mostly NE-SW. Recent lineament maps of the Winter Park area reveal this structure (Fig. 2).

The fracture system facilitates aquifer recharge through promotion of surface water percolation. At depth the infiltrated waters flow

more or less laterally along bedding planes. The infiltrating water is usually acidic due to acid rain, percolation through humus, stormwater runoff, and/or other causes. Thus solution activity is greatest along the routes of water entry. The solution activity follows the subsurface gradients of the fractured beds and is greatest at water table or piezometric levels. The result is the creation of cavernous or honeycomb zones within the rock or the earth materials above. Some surface expression of subsurface voids may ultimately result, either by gradual subsidence or more rapid collapse.

Several sinkhole formation mechanisms are recognized. In Central Florida the most common method may be termed revelling. In the revelling process unconsolidated materials (i.e. clays, silts, sands) overlying the openings in the limestone move downward into the caverns or voids. Such movement is promoted by infiltrating water and its normal flushing action. Numerous instances are recorded where the flushing action has moved the loose materials significant distances from their original cavity access. As downward movement of loose overburden progresses into the limestone opening, a cavity in the overburden develops. Usually this cavity is funnel shaped, with its nozzle connected to the limestone opening. This overburden cavity enlarges progressively as downward soil movement continues. Where the thickness of the overburden is shallow (usually less than 20 feet) subsidence effects at the surface are common. The usual subsidence expression is initially a dish-shaped depression; however as it develops it may come to form the common funnel-shaped sinkhole. Where overburden thickness is greater (i.e. 25 - 500 feet) the revelling process may continue undetected until the shear strength of the overburden no longer supports the weight of material arching the cavity, and collapse occurs. A contributing factor in the revelling process is obviously ground water activity. High water tables and piezometric levels lower the shear strength of soils by increasing the effective stresses exerted from below. The effective stresses observed are actually the difference between the total stress minus the pore water pressure, and may be described in layman's terms as "bouyancy forces." It is the effective stress that provides much of the support required by revelled cavity roofs. Dropping water levels and pressures increase the soil shear strength but lower the uplift (bouyant) forces. Thus while soil strengths may increase, the unsupported cavity arch may thus collapse from excess loading in much the same fashion as does a dry sand castle on the beach. Conversely a rapid change from dry to wet conditions in the soil promotes spalling of cavity roof materials and erosion into the opening in the limestone.

In northern and western coastal Florida the prevailing sinkhole formation mechanism is one of direct collapse of the limestone cavern roof. Such failures occur where the limestone is exposed or lies less than about thirty feet below the surface. The usual surface expression in such sinks is initially a disk-shaped depression; with unconsolidated overburden filling the limestone cavity below. Where larger caverns exist, roof collapse often results in near vertical sinks, possibly with exposed rock faces. Progressive erosion and soil slippage in time may alter the sink to a more funnel shape.

The term "ponor" is often applied to deep, steep-sided sinkholes, whether dry or partially filled with water. Dismal Sink, ten miles southeast of Tallahassee is such a ponor. It is some sixty feet in diameter, 175 feet in depth, and filled with water to a depth of seventy-five feet. Solution pipes are vertical tubes dissolved or washed by downward infiltrating waters along fractures. Such tubes often breach the surface. Most are small and generally less than ten feet in diameter.

Florida's sinkhole-prone areas are characterized by (1) shallow Ocala limestones (generally with low dolomite content), (2) numerous fractures of both the limestone and overburden, (3) a piezometric level below the unconfined

water table, and (4) being located where the Florida Aquifer is relatively unsaturated.

According to Windham and Campbell, areas which are not prone to sinkhole formation are characterized by (1) incomplete salt water flushing (2) poorly developed fracture and cavern systems, (3) near surface piezometric levels, and (4) thick unconsolidated overburden.[3] Non-sinkhole prone areas include the South Florida Basin, Atlantic Coastal areas, Gulf Coastal areas south of Tampa Bay, and the western Panhandle.

Drought, Local Conditions, And Sinkhole Activity

Review of insurance claims for sinkhole related damage in Central Florida indicates that sinkholes are most common during periods of drought or high water usage. The last significant period of sinkhole related claims occurred during the drought of 1961-62. From late 1962 until 1981 not a single insurance claim related to sinkhole formation was filed for this area.

A study of the sinkhole activity in Seminole and Orange Counties indicates local subsidence is due to at least five important factors: (1) ground water table fluctuations, (2) changes in soil characteristics, (3) fault patterns, (4) surface and subsurface drainage patterns, and (5) ground water chemistry. The significance of these factors varies with site conditions.

The soils of northern Orange and southern Seminole Counties are primarily well-drained Fort Preston and Blanton sands. The soil layers range in thickness from six to forty-eight inches. Between these soils and the Hawthorn formation lie a variety of unconsolidated sedimentary materials.

During the Florida drought of 1980-81 the average water table level in shallow wells of the area fell from ten feet to eighteen feet below the surface (eighty-five to seventy feet MSL). Lowering of the water table by this amount represents an increase of soil shear strengths by some 1800 psf. Piezometric levels within the bi-county aquifer fell from sixty to forty feet with a corresponding reduction of the effective stress exerted by the confined aquifer waters. The result of these changes was a net increase in the total downward force of 1600 psf. Such forces become significant in localities where revelling processes occur. Three such localities are discussed below.

Winter Park Area

Both Vernon's suggested fracture patterns (Fig. 1) and DOT lineament map (Fig. 2) indicate that the area of the Winter Park sinkhole lies at the intersection of at least two fractures. The city of Winter Park lies in a topographically closed area in which both surface and subsurface water is directed to some low point. Figure 3 indicates that this low point coincided closely with the sinkhole site.

In a study of six wells within one mile of the large Winter Park sinkhole (and near recognized fractured areas) two cavities were encountered in the Ocala limestone and four cavities and/or honeycomb structures in the underlying Avon Park formation. All six wells encountered cavity or solution activity at depths varying from 79 to 250 feet.

Although Vernon suggested that the fractures in the Winter Park area may extend farther to the southwest, he found no surface expression of them. However five sinkholes have appeared since 1961 between Winter Park/Maitland and Highway 44 to the west. These sinkholes lie on a line representing a southwest extension of Vernon's northernmost fracture (Fig. 1).

Sinkholes do not appear linearly along the length of the areal fracture patterns for a variety of reasons. Four possible explanations are presented here: (1) Studies of topographic maps indicate that basin drainage often does not direct either surface runoff of lake infiltration (another source of water) toward the fault along its entire length. Thus sinkholes are more likely near the infiltration point;

(2) Downward moving waters along a fracture proceed to increasing depth as they flow away from their point of infiltration. Caverns formed along a fracture and at some distance from the infiltration point would thus be expected to form at greater depths and be less likely to collapse or revel; (3) Soil properties and the capacity of the soils for aquifer recharge vary along the fracture paths. The result is non-uniform infiltration, and correspondingly, differing solution rates; (4) Variation in zones of piezometric fluctuation through which the fractures pass result in varying values of effective soil stress. The preceding factors may also combine in various ways to cause failure.

The stratigraphy of the Winter Park area differs somewhat from the majority of Orange County. The exposed formation in the Winter Park area and in western Orange County consists of Fort Preston sediments. This formation consists of variegated, thinly laminated, and cross bedded sands, gray to white in color. This formation provides a principal confining bed to the Florida aquifer. The Fort Preston formation slowly absorbs water and stores it for percolation to the limestones below. This formation also promotes absorption and prevents rapid subsurface runoff. Water dispersal and subsurface runoff normally occur with fast percolating waters as they encounter the denser and less permeable Hawthorn formation below.

Beneath the Fort Preston lie the typical formations found throughout the remainder of the county. The stratigraphy of the Winter Park area shows that both the Hawthorn and Ocala formation dip toward the sinkhole in two directions (Fig. 3). Subsurface drainage, particularly along the top of the relatively impervious Hawthorn, directs percolating waters toward the sinkhole site.

Investigation immediately following the sinkhole collapse revealed the presence of a severe depression cone in the water table surrounding the sink. The presence of the depression cone implies the existance of a groundwater drainage conduit (probably the fracture intersection shown in Figs. 1 and 2). Under described circumstances solution activity and erosion could be significant along and adjacent to the fracture intersection. Areal infiltrating waters were found to have a PH of 6.2 (acidic), which would also contribute to limestone solution. Additionally water hardness was found to increase down the subsurface slope east and south of the Winter Park basin (FDNR, MS #21) in the direction of the dip.

The Winter Park sinkhole occurred on May 18, 1981. Review of water usage suggests high usage occurred during April and May. One may thus assume that the combination of drought and water usage produced a significant lowering of both areal piezometric surfaces and aquifer levels. These combinations produced an increase in effective soil stress,and ultimately collapse of the Winter Park revell cavity. This correlates well with formation of Lake County sinkholes which normally occur during January and February when water usage by the fern industry is highest.

The Winter Park sinkhole averages some 320 feet in diameter and is 100 feet in depth (Fig. 4). The hole began as a vertical tube or pipe on the evening of May 8. It expanded to its present size through a series of side failures in a period of eighteen hours. The southern slope of the sink has nearly reached its stable repose angle of 33°. The other sides still contain vertical sections around the lip of the crater. Slow but continued growth of the sink, until all sides reach a stable angle, will increase the diameter by some sixty additional feet. Water flow entering the pit from both east and west may contribute to additional side failures. Bottom stability is currently questionable, as a series of large fluctuations in lake level within the sink have occurred since its formation. However, should the bottom reach stability, the water level in the sink should conform to that of the surrounding lakes (eight to ten feet below the lip).

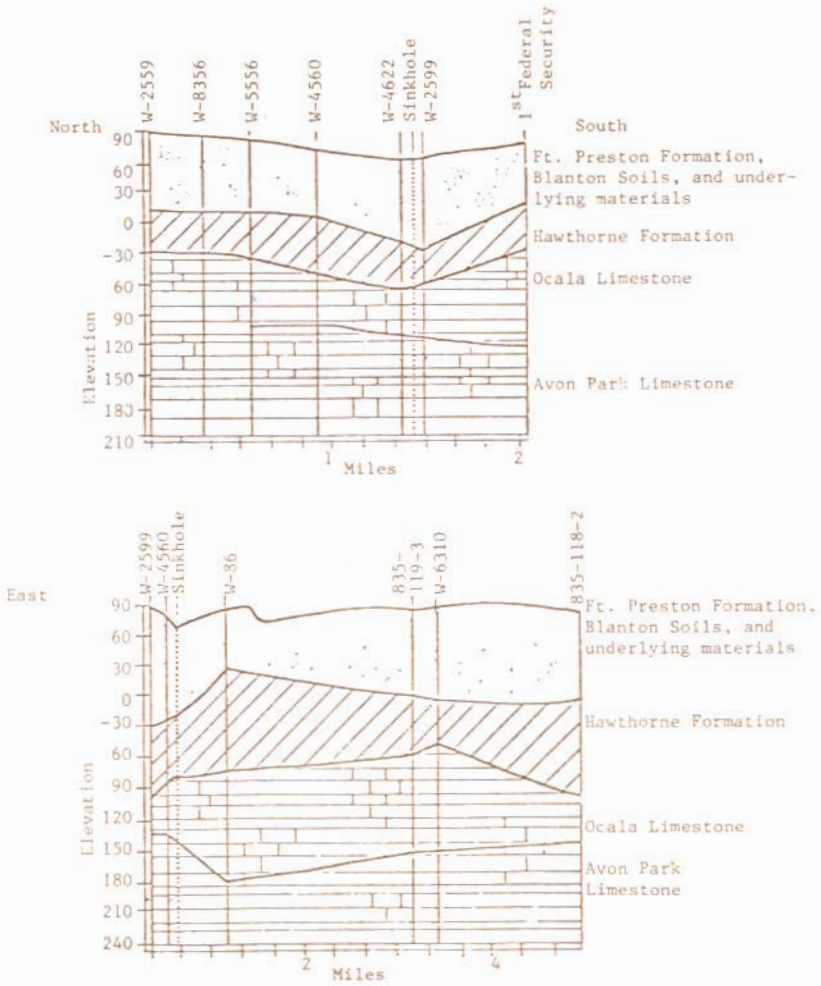


Fig. 3. Stratigraphy of the Winter Park area.

Windermere

Windermere is a small community lying essentially on a peninsula surrounded by Lakes Bessie, Down, and Butler. Five sinkholes have occurred in this area since 1964, two of them in 1981.

Windermere lies in an area which is geologically and hydrologically similar to that of Winter Park. A long fault passes beside Lake Bessie. The area is also topographically closed, though the basin is larger than the Winter Park basin. Like Winter Park, the basin contains several large lakes. In addition to those mentioned, Lakes Tibet, Speer, Sheen, and Mabel lie within the basin. These lakes are so positioned as to provide seepage into the fault. Surface and subsurface drainage is toward the central lakes and the fault.

Windermere's position between the lakes and the number of sinkholes occurring in the last seventeen years, provide strong evidence for cavities beneath the community. In light of the previous Winter Park discussion and the apparent presence of cavities of the area, more sinkholes can be expected with continued piezometric level declines.

Longwood, Altamonte Springs, And Casselberry

Longwood and Altamonte Springs lie astride and adjacent to two of Vernon's fractures. The faults both originate near Pine Hills (another sinkhole area) and extend northeastward to Lake Monroe. With the exception of surface drainage characteristics, the hydrology and geology of these two towns are similar to the Winter Park environment. Sinkholes are more numerous but none matches the size or scale of the Winter Park hole.

The Casselberry area has no recognized fractures, unlike the areas previously discussed. Casselberry contains the Cranes Roost, Palm Springs, and Grace Lake basin sinks. The three basins comprise an aggregate area of 8.43 square miles and three distinct (closed) systems of lakes and sinks. Barraclough indicated that throughout most of the area the Hawthorn Formation is overlain by ten to sixty feet of clay.[4] However, in the western parts of Cranes Roost and Palm Springs sink basins, and in the northern part of Grace Lake sink basin, sandy deposits overlie the Hawthorn. The underlying limestone formation beneath the sandy areas has a greater permeability.[5] The sands and permeable limestone combine to promote more rapid infiltration in such areas, and increasing solution rates. The effect is somewhat analogous to a faulted or fractured basin.

Conclusions

The preceeding study suggests that potential sinkhole areas and their times of occurrence reflect a variety of common features. Periods of drought or high water usage can significantly lower ground water levels.

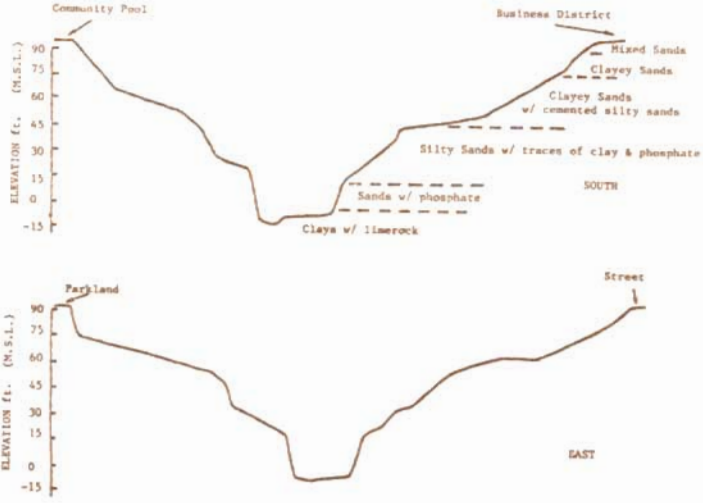


Fig. 4. Profile of Winter Park sinkhole. Source: after Jammal and Associates, *Final Report on Winter Park Sinkhole*, 1982.

Reduction of water table and piezometric surfaces contribute to an increase in effective soil stress and promote collapse of revell cavity ceilings. Sinkholes are unlikely without wide fluctuation of ground water levels.

This investigation suggests that revell sinkholes are likely to occur in either topographically closed or psuedo-basin areas where surface and/or sub-surface drainage concentrate infiltrating waters into fractured or permeable limestones. Those fractures or features which divert groundwater into the Floridan Aquifer apparently create a cone of depression in the surrounding water table. The presence of such depression cones may offer a means of potential sinkhole forecasting.

* * *

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Millard H. Wafle's article "Location of Shoplifters in Boca Raton, Florida," which appeared in the previous number of *The Florida Geographer* (vol. 15, no. 1, April 1981), was reprinted in *The Florida Police Chief* (vol. 7, no. 3, 1981). Congratulations, Mil.

STEAMBOATS AND REGIONAL DEVELOPMENT: THE OCKLAWAHA AND ST. JOHNS RIVERS IN THE NINETEENTH CENTURY

Storm L. Richards and Jeanne Fillman-Richards

The interior of Florida remained undeveloped until late in the nineteenth century primarily because of a lack of reliable transportation systems in North-central Florida. Railroads had been built along much of the Atlantic Coast but did not exist in the interior of Florida with the exception of the Fernandina to Cedar Key line, and the West India Transfer Railroad (Fig. 1). Wagon roads between major cities were poor and did little to stimulate commercial activity in urban areas. As a result, the principal means of transportation which evolved in the area was steamboats used for passenger and commercial traffic on the navigable tributaries of the St. Johns River.

This paper focuses on the twenty-year period from 1880 to 1900 to show how a particular mode of transport changed the economics, land use, and geography of North-central Florida. Information comes from contemporary writings about the growth of the areas from Palatka to Silver Springs and Ocala before the turn of the century.

Rise of Steamboats

The importance of steamboat transport in the late 1880s was recorded in De Berard's *Steamboats in the Hyacinths*, an early account of Jacksonville's development. One of her informants recalled that "Before the coming of the steamboats to the river, the only communication between Jacksonville and the south side of the city was by rowboat, but after the 1880s, a hundred stern and side wheelers ran on the St. Johns" (Fig. 2)[1]

The Ocklawaha, a tributary of the St. Johns, was featured in the 1876 *Harpers New Monthly Magazine*, in which it was described as follows:

Fig. 1. En route for St. Augustine, 1874. Source: footnote 6, p. 7.

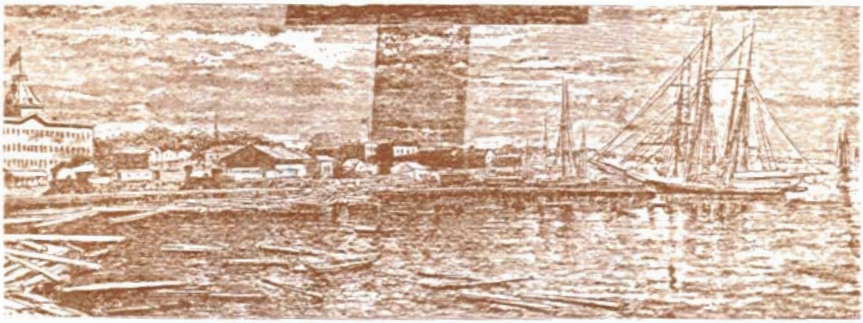

Fig. 2. Jacksonville, 1874. Source: footnote 6, p. 2.

> we passed the landings here and there, swampways where rafts of cypress logs were waiting, towed aside to give us a channel, and at last we came to the fair waters of which we heard. Silver Springs, beautiful enchanted pool, who can describe thee! About one hundred miles from the mouth of the Ocklawaha, a silvery stream enters the river; we turn out of our chocolate-colored tide, and sail up this crystal channel, which carries us along between open prairies and,savannas covered with flowers.[2]

A letter from E. N. Spinney in the winter of 1892 stated that "Prior to the coming of the railroads in the 1880s, the Oklawaha was busy with commercial traffic, almost all goods entering or leaving the area [were] by water."[3]

The development of dependable transport increased the population of Marion County and of Ocala, the early terminus of the St. Johns River route. The population of the county seat tripled in three years and the business aggregate went up 600 percent between the years 1888 and 1891. The changes are shown in Table 1.

The most prestigious and long-lived steamboat line was that of the H. L. Hart Company which had its beginnings in the 1860s (Fig. 3). The first River steamer was the *James Burt*, but little is known about her. Bradford Mitchell, writing about the Hart lines, noted that:

> The majority of early steamers had to depend for verbal description on shipbuilders, travelogues or adventurers, all of whom are likely to suffer from one defect of expression or another. But the Hart vessels of the early seventies had the hon-

Table 1

"Phenomenal Growth of Ocala since 1880"

Year	Resident Population	Aggregate Business*
1880	500	.5
1882	800	.7
1884	1,200	1.0
1886	1,500	1.5
1888	2,000	2.0
1890	5,000	7.0
1891	6,500	14.0

*Millions of dollars.

Source: footnote 12, p. 15.

Fig. 3. The *Marion* lying at Silver Springs, Florida, 1874. Source: footnote 6, p. 21.

> or of being described by two authors of some renown--a dubious honor, admittedly, since neither writer could find anything very complimentary to say.[4]

These writers were Harriet Beecher Stowe and William Cullen Bryant.[5]

The geographic and economic impact of the Hart steamboat line on St. Johns and Ocklawaha Rivers was considerable. This is documented in the literature of the late nineteenth century. Hart was but one of many entrepreneurs who used the St. Johns River to open central Florida to agricultural exploitation and set the pattern for development for the next half century.

Hart's experiments with citrus production near Palatka marked the beginnings of what was to become a twentieth-century agricultural phenomenon which relied on river transportation for its initial success. His groves were a source of encouragement to other land owners in the area because of the profits he derived from the small, seven hundred tree farm. For instance, in 1874 his annual gross income was projected in excess of $15,000, based on citrus production from his grove. A popular writer visiting his area noted that "an adjacent nursery to Hart's small farm had 100,000 young trees awaiting transplanting and budding."[6] Sites along the St. Johns and Ocklawaha Rivers thus became core areas for citrus production, and more than one million seedlings were planted by 1874 with a density of one hundred trees per acre (Figs. 4, 5 and 6).

By 1880 citrus had been accepted as a major export crop of North-central Florida. In that year Silvia Sunshine, a well-known writer, described the development in the area: "Civilization has commenced making its mark on the Ocklawaha," she said, "and the march of improvement, which never tires in its efforts, is leaving footprints here. These new developments are visible from the various landings which the steamer makes, as it advances through the rapid current."[7] Yet a scant ten years earlier T. B. Thorpe had written that "the mouth of the Ocklawaha River looked scarcely wide enough to admit a skiff, much less a steamboat" (Fig. 7).[8]

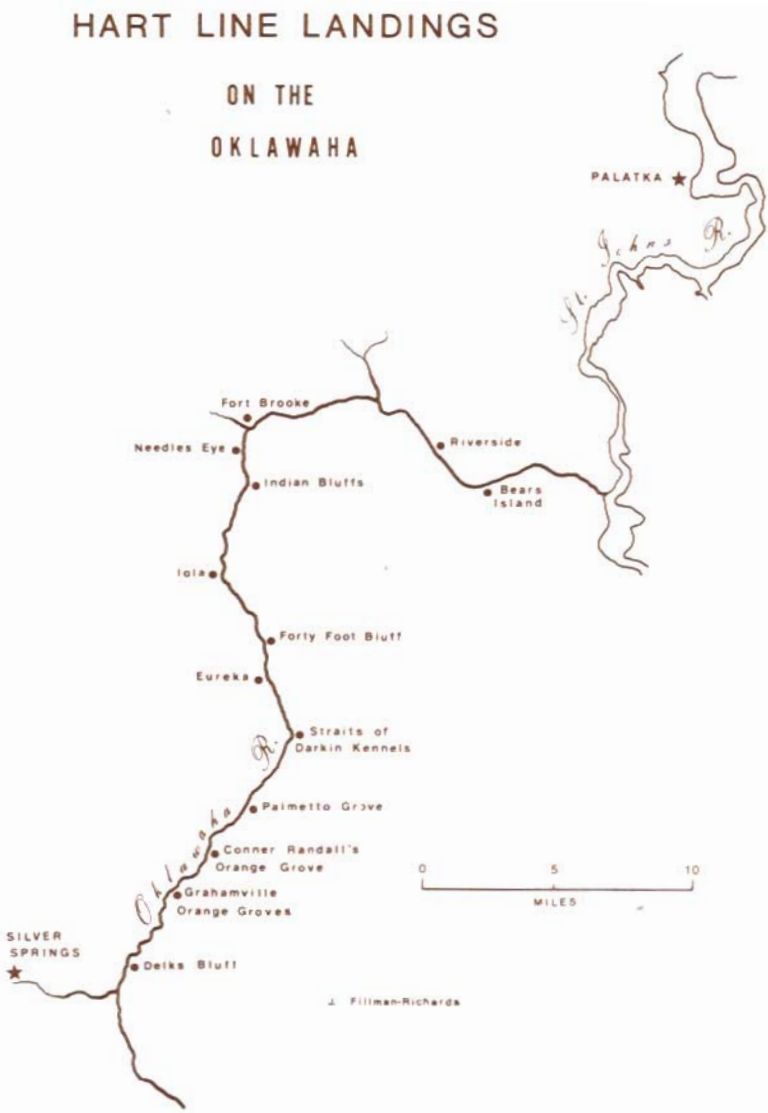
HART LINE LANDINGS
ON THE
OKLAWAHA
PALATKA
St. Johns R.
Fort Brooke
Needles Eye
Indian Bluffs
Riverside
Bears Island
Iola
Forty Foot Bluff
Eureka
Straits of Darkin Kennels
Oklawaha R.
Palmetto Grove
Conner Randall's Orange Grove
Grahamville Orange Groves
SILVER SPRINGS
Delks Bluff
0
5
10
MILES
J. Fillman-Richards

Fig. 4

Fig. 5. Entrance to Col. Hart's grove near Palatka, Florida. Source: footnote 6, p. 18.

The Hart boats were designed for the narrow and winding river system on which they operated. A promotional pamphlet published in 1897 advertised that the boats were "recess stern wheel of original and unique design invented by the founder of the line for the peculiarities of this river."[9] The *Okahumkee*, for example, was 86 feet in length, 25 feet wide, and consisted of upper and lower saloon decks with 25 to 30 staterooms which housed 50 to 60 first-class passengers (Fig. 8).[10]

The Hart line reached its zenith between 1885 and 1888, when such craft as the *Ocklawaha*, *Marion*, *Seminole*, *Okahumkee*, *Osceola*, *Tuskawilla*, *Astatula*, *Forester*, *Lake Dolly*, *Dispatch*, *Wekiva*, *Lake Dora*, *Lake Apopka*, *J. Y. Speer*, *Griffin* and the *Eureka*, ran on the Ocklawaha.[11]

Steamboat Decline

By the early 1890s, the steamboat had been replaced as a commercial carrier. Railroads now formed an impressive network throughout the state. An 1892 publication, *Ocala and Silver Springs Company*, by George S. Mayo, mentioned the once-famed Ocklawaha steamer company in passing and misrepresented its utility, stating that "these steamers were built expressly for tourist travel."[12]

Several factors helped to bring about the demise of the small steamboat transportation system before the turn of the twentieth century. While it was true that the shallow draft of the small boats allowed passage in areas otherwise inaccessible by larger vessels, the dredging of the St.Johns Bar in 1885 caused Jacksonville to replace Palatka as port of registry for Ocklawaha steamers. This undoubtedly was a major factor in changing the emphasis of the lines to accommodate tourists instead of cargo. In fact, the next year several of the boats were equipped with additional stairways for easier movement from bow to cabin deck.[13]

The winter of 1894-95 also hastened the decline of the steamboat lines for transporting citrus cheaply to Jacksonville. On December 29, 1894 the temperature dropped to 14°F in central Florida and another freeze on February 7,

Fig. 6. Fruit and flowers in "the Oklawaha," 1876. Source: footnote 2, p. 176.

1895 destroyed forever the commercial citrus groves of North-central Florida. The damage to citrus and other crops is estimated to have been $100,000,000.[14]

The changing function of the steamboat was in large part a consequence of a shift from water to rail transport, freezes which destroyed the major agricultural crop, changes in ports and harbors resulting from a shift in economic activities toward the east coast, and the introduction of large coastal steamships after the turn of the century. Early changes in transportation modes are documented directly or indirectly in the literature. For example, Spinney's letter of 1892 and De Berard's interviews both cited the steamboat as a means of commercial transportation for moving goods entering or leaving the area. Yet by the 1890s the function of the steamboat had shifted exclusively to the tourist trade.

Steamboat transport as a means to carry cargo was short lived in North-central Florida, but the population changes and land use developments stimulated by the steamboat traffic became set irreversibly.

Fig. 7. Palmetto thicket, 1876. Source: footnote 2, p. 168.

Fig. 8. The *Okahumkee*, 1876. Source: footnote 2, p. 162.

* * *

1. Ella Teague De Berard, *Steamboats in the Hyacinths* (Daytona Beach: College Publishing Co., 1956), p. 11.

2. C. F. Woolson, "The Oklawaha," *Harper's New Monthly Magazine* 52, no. 308 (January, 1876): p. 171.

3. E. N. Spinney, Reprint of letter of Winter, 1892.

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9. Hart Line Route Map of the Ocklawaha River, Palatka, Florida, 1897.

10. Ibid.

11. De Berard, *Steamboats in the Hyacinths*, p. 54.

12. George Mayo, *Ocala and Silver Springs Company* (Ocala, Florida: Ocala and Silver Springs Co., 1892), p. 22.

13. De Berard, *Steamboats in the Hyacinths*, p. 58.

14. Leeila Copeland, and J. E. Dovell, *La Florida: Its Lands and People* (Austin, Texas: The Steck Company Publishers, 1957).

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