CHARACTERIZATION AND EVALUATION OF ACID RAIN IN EAST CENTRAL FLORIDA FROM 1978 TO 1995

and

EVALUATION OF SOME CHROMATOGRAPHIC/SPECTROSCOPIC RESULTS FROM LEACHATE SAMPLES FROM CELSS

by

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I. CHARACTERIZATION AND EVALUATION OF ACID RAIN IN EAST CENTRAL FLORIDA FROM 1978 TO 1995

INTRODUCTION

The occurrence of acid rain has prompted extensive research and monitoring activities which began in the U.S. during the late 1970's. In the mid 1970's the National Aeronautics and Space Administration (NASA) funded an extensive environmental monitoring program which included a substantial acid rain monitoring component. Results from that study and subsequent activities have been summarized in previous reports (1,2). One site from the original network has remained in continuous operation to the present time. That site is located on the campus of the University of Central Florida (UCF) near Orlando. The site provides the longest continuous record of rainwater composition data of any site ever operated in the state of Florida. In addition several sites that operate as part of the National Atmospheric Deposition (NADP) network continue in operation. Observations from the UCF site and the NADP sites document substantial changes in rainwater composition and acid deposition.

METHODS AND PROCEDURES

Sampling Locations.

The UCF collection site is located on the roof of the Chemistry Building. The UCF campus is located at $28^{o}35'59"$ N latitude and $81^{o}12'00"$ W longitude. NADP site locations which include the NASA/KSC site designated as FL99 and start up dates are summarized in Figure 1.

Sample Collector and Collection Intervals.

Aerochem Metrics wet-dry collectors have been used exclusively for collection of rainwater samples. Collection intervals at UCF have typically been 24 hr periods ending on Tuesday through Friday and 72 hr periods ending on Monday. The NADP site sampling interval length is seven days ending on Tuesday mornings.

Sample Handling and Chemical Analysis.

The protocol for working with collected samples and methods for the measurement of the major ion chemical composition of rainwater samples as part of the UCF/KSC program and the NADP program have been described (3,4). Data quality has been evaluated by examining a number of diagnostic ratios, e.g. anion/cation ratio, measured/calculated conductivity, Cl/Na and Na/Mg on an individual sample basis (5).

NADP Network.

Data and results for rainwater collected at the five Florida NADP sites were obtained from the NADP/NTN office (6). Weekly, monthly, seasonal and annual summary data are available however only annual data were used in the development of this report. Site descriptions, locations and sample collection history are presented in Figure 1.

RESULTS AND DISCUSSION

Sample Collection History.

Collection of rainfall on the UCF campus began in July, 1977 and has continued in uninterrupted fashion. Only sample amount, pH and conductivity were measured prior to November 1977. Measurement of anion and cation concentrations began in November 1977 and have continued in uninterrupted fashion since that time. Two NADP sites FL03 and FL11 commenced operation in 1978 and 1980, respectively and four other sites including FL99 began operation in Florida in late 1983. Site FL99 is located at KSC and is approximately 50 km east of the UCF site.

General Rainfall Composition.

Composition of rainfall collected at UCF for 1995 and at FL99 for 1995 are summarized in Table 1. The general chemical composition of rainfall collected at UCF for the period 1978-1995 and for samples collected at site FL99 for the period 1984-1995 are also presented in Table 1. Weighted average composition and annual total deposition are presented. In addition, annual composition and annual total deposition summarized by year for the UCF site and for FL99 are presented in Tables 2 and 3, respectively. Volume weighted concentrations and deposition for the other four NADP sites in Florida are summarized by year for each site in Tables 4 to 7.

In typical years sulfate is the most abundant anion in rainwater collected at UCF. Because of site proximity to the ocean, chloride is typically the most abundant anion at FL99. The amount of rain that falls within Florida is characterized by extreme variability. Variability also occurs statewide and on a regional basis. In general annual rainfall amounts measured at UCF exceed corresponding amounts measured at FL99. Annual amounts of rain at four sites are compared in Figure 2. This comparison shows the substantial variations that occur from site to site and from year to year. Even greater variations are present when seasonal, monthly or weekly amounts are compared. The rainfall amounts reported based on NADP data records correspond to total rain gauge measurements, however, rain composition data correspond to samples considered valid by NADP

criteria and has varied annually from 70% to 99% of measured rain as evaluated according to NADP criterion 3 (8). Data completeness of the FL99 data set has increased dramatically during the most recent annual periods of site operation. However, the criterion 3 value of 85.3% in 1995 was the lowest since the first year of site operation. In fact, when NADP criterion 3 is used as a basis for evaluation of data completeness, valid sample analysis has been below 96% during only four of the twelve years of operation of FL99. All other NADP sites in Florida have multi-year criterion 3 percentages of less than 90% which may limit to some extent the use of these data in interpretive studies.

Rainfall Acidity.

Acidity difference(pH) and rainfall amount collectively account for the substantial differences in deposition quantities. Acidity results can be based on field measurements (UCF and NADP) or laboratory measurements (NADP). Differences between field measured acidity and laboratory measured acidity have historically been observed as part of all acid deposition measurements associated with the NADP program (7) and only recently has the cause of the differences been discovered and corrective action begun (8). Differences in annual volume weighted average acidities can be obtained from date presented in Tables 3 to 7. If appropriate quality control procedures are in place, then it is likely that the field acidity measurements will correctly represent the acidity of rain because minimal time lag between sample collection and measurement is associated with field measurements compared to lab measurements.

Amounts of deposition of acid, nitrate and excess sulfate are compared graphically for UCF (Figure 3) and for FL99 (Figure 4). The variation in annual acid deposition generally follows changes in both nitrate deposition and excess sulfate deposition.

Temporal Trend Evaluation.

Previous studies (cf ref. 2) have suggested that temporal trends for select chemical constituents in East-Central Florida rain do exist. The evaluation presented in Figure 5 for acidity was conducted using a simplified data set that consisted of annual data from the UCF site. Linear regression was used to evaluate temporal trends. The multi-year record was used in its entirety and in addition was segmented into nine individual 10 year periods. Only the three ten year periods identified in Figure 5 suggest significant trends. A considerable decline in acidity ($P < 0.05$) is suggested for early in the multi-year record, however that decline was reversed during the later time periods. No long term trend in acidity is suggested by this treatment. The percentages that are presented in Figures 5 - 8 represent increases or decreases in concentration or deposition

from the beginning to the end of individual time periods and periods vary depending upon the length of site operation or period selected for evaluation. A similar treatment of nitrate concentrations suggests increasing levels during each period except for the ten year periods ending in 1993, 1994 and 1995 and a substantial increase over the entire period (Figure 6). Long term trends are not suggested at the NADP sites ($P > 0.05$) except during 1984-1993 at FL99. These observations are generally consistent when concentration data, log transformed concentration data (e.g. pH) and deposition data for individual species are considered (2).

When annual data are evaluated further for temporal trends using linear regression, several other trends are suggested at various sites and are presented in Figures 7 and 8. However, there is little consistency among observed trends at various sites. For example, significant trends were found only for acid deposition at FL03 and FL99, and nitrate deposition at UCF, FL99 and FL03. Evaluation of annual data for other major anions and cations in UCF rainwater and at the other three NADP sites where evaluations were performed do not reveal significant trends.

Summary

The results of monitoring the chemical composition of rain in east-central Florida have shown that the rain is moderately acid. The measured acidity of rain is less than that observed in other regions of the U. S., however, it does suggest that the level of acidity is substantial. The annual chemical composition of rain at UCF and at KSC has shown moderate variability. Extreme daily and monthly variations are observed, however these variations will not be addressed here. The total ionic composition of rain collected at FL99 is greater than that for rain collected at UCF, however this can be accounted for by site proximity to the ocean with the accompanying marine influence.

Difference in acidity data collected from the UCF and FL99 sites which are separated by 50 km may be due in part to the differences that have been observed between laboratory and field pH measurements (6,8). Trend assessment for precipitation composition requires evaluation of data that covers some minimum time period. In fact, the subdivision of the multi-year UCF record into individual 10 year records as described above can lead to the conclusion that a significant increase, a significant decrease or no trend exists for acidity depending upon the time period chosen for evaluation. Trend evaluation has also been accomplished by linear and nonlinear regression analysis using monthly volume weighted average concentrations and deposition using the UCF data set and some of the Florida NADP data set (2). These evaluations continue and will be reported in the future.

II. Chemical Analysis of Leachate Samples from CELSS

During the past three years several separate but related studies were performed to characterize the chemical composition of plant leachate samples from CELSS. The chemical characterization of some aqueous leachates (9) and of aerobically treated liquids (10) were performed as was an extension study (11). Current studies that follow up on those cited above and that provide a more detailed and systematic investigation will be reported as part of a University of Central Florida, Department of Chemistry M.S. thesis study that is expected to be completed during the spring 1997 semester.

ACKNOWLEDGMENTS

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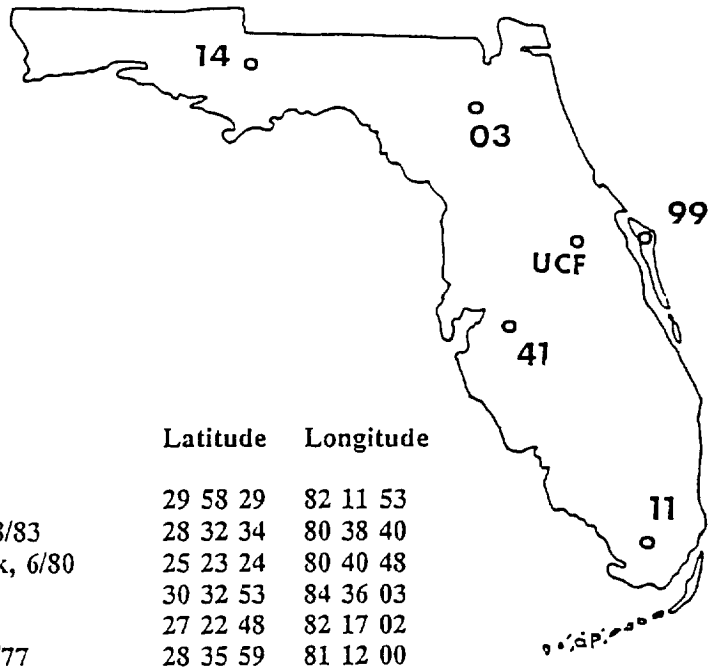

CAL No.	Station	Latitude	Longitude
FL03	Bradford Forest, 10/78	29 58 29	82 11 53
FL99	Kennedy Space Center, 8/83	28 32 34	80 38 40
FL11	Everglades National Park, 6/80	25 23 24	80 40 48
FL14	Quincy, 3/84	30 32 53	84 36 03
FL41	Verna Well Field, 8/83	27 22 48	82 17 02
UCF	Univ. Central Florida, 7/77	28 35 59	81 12 00

Figure 1. Florida Acid Deposition Sites.

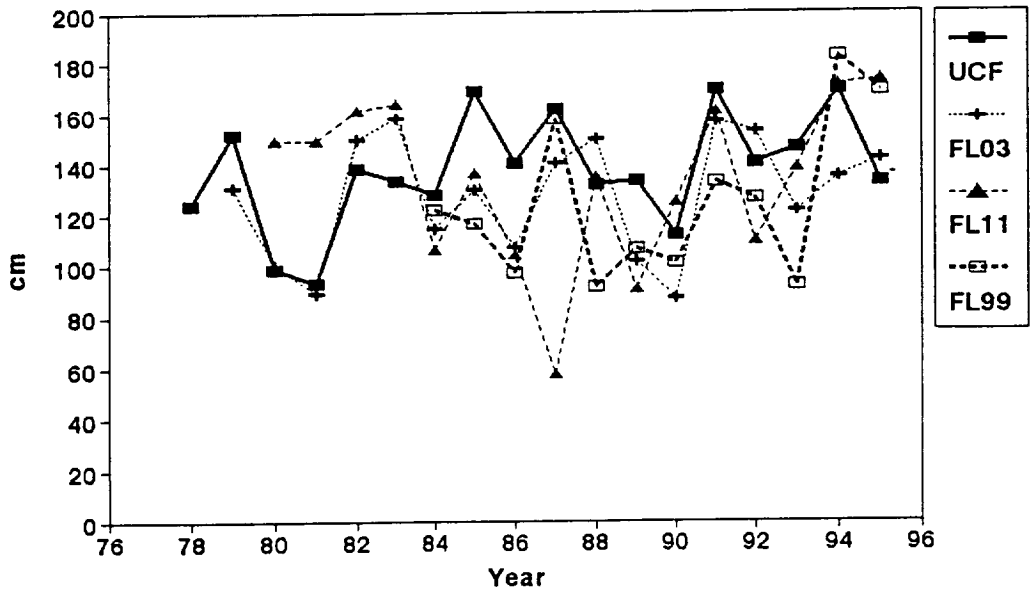

Figure 2. Annual Rainfall Amounts at UCF and Three Florida NADP Sites.

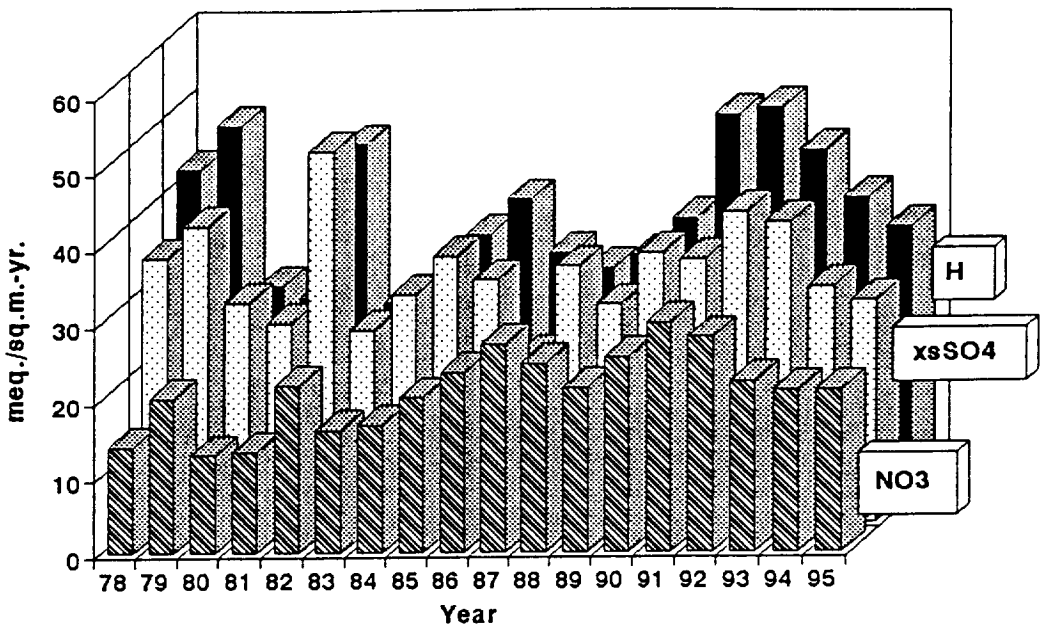

Figure 3. Annual Deposition of Acid, excess Sulfate and Nitrate at UCF.

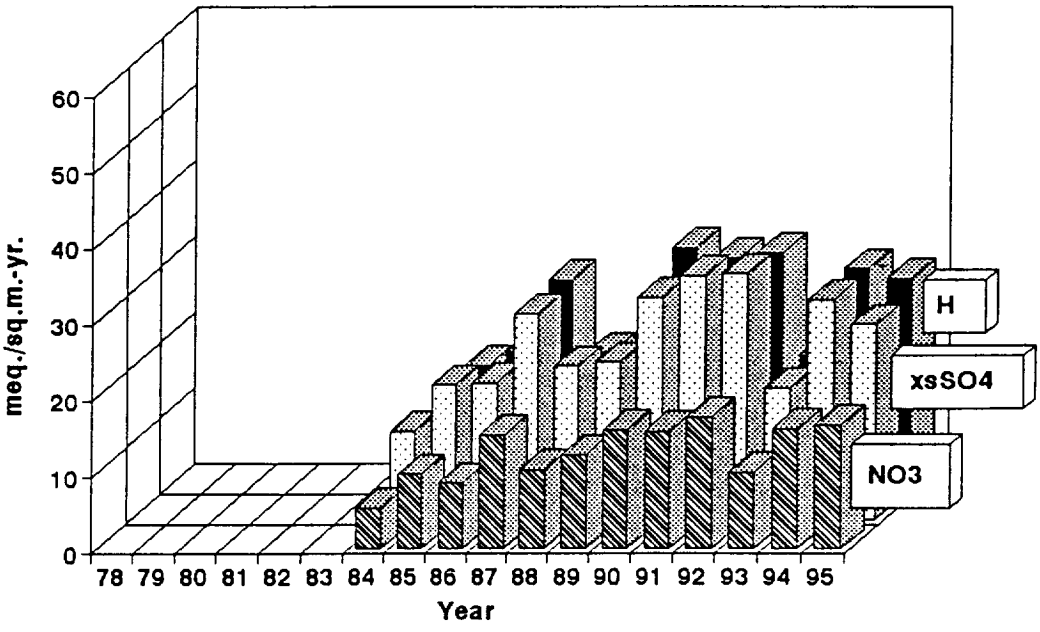

Figure 4. Annual Deposition of Acid, excess Sulfate and Nitrate at FL99(KSC).

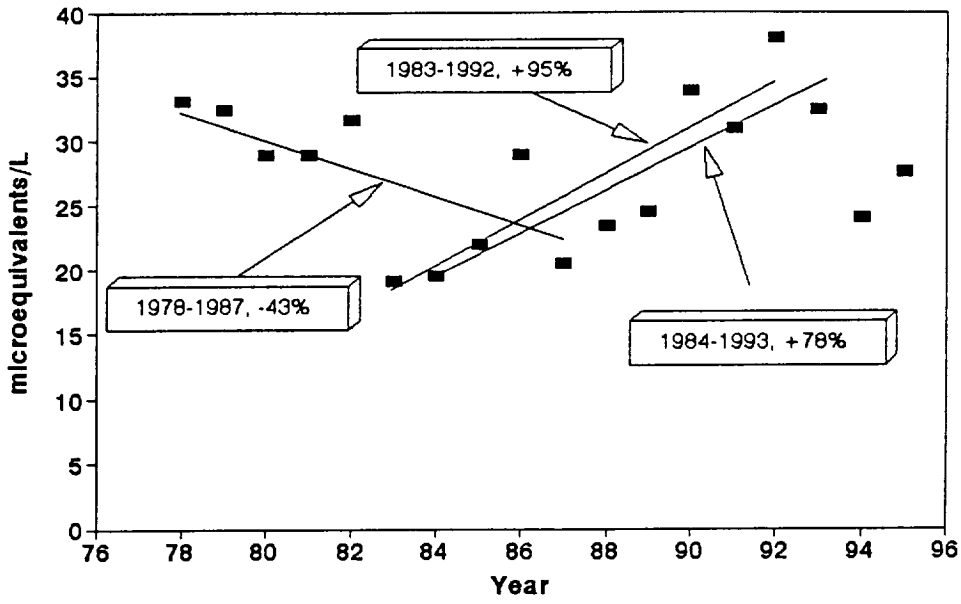

Figure 5. Acidity Trends at UCF When Ten Year Periods Are Evaluated.

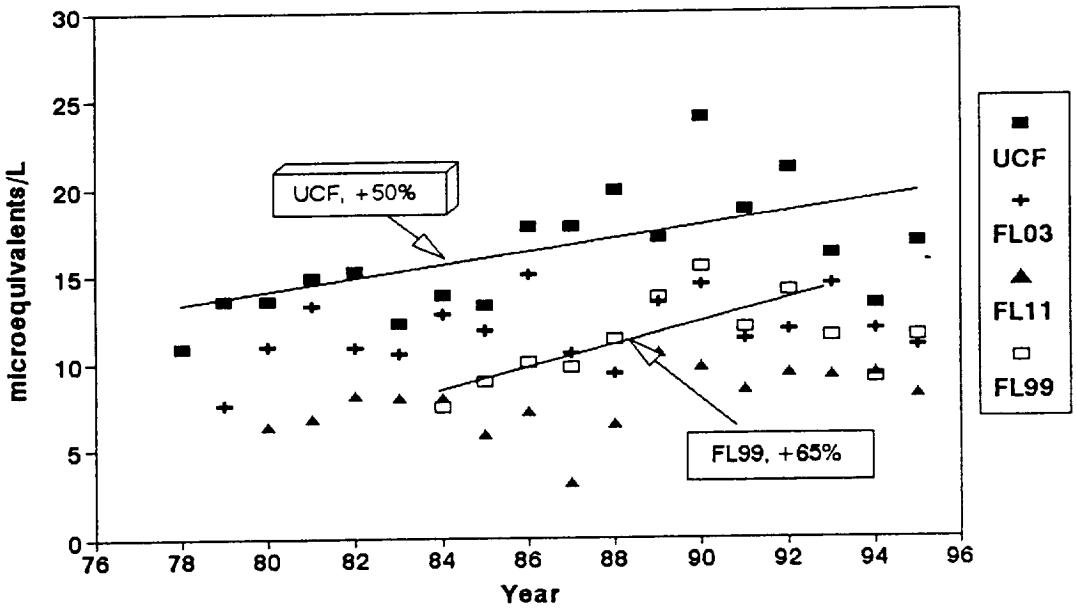

Figure 6. Trend in Nitrate Concentration (18 years) at UCF Compared To Three NADP Sites Where Only One 10 Year Trend Exists.

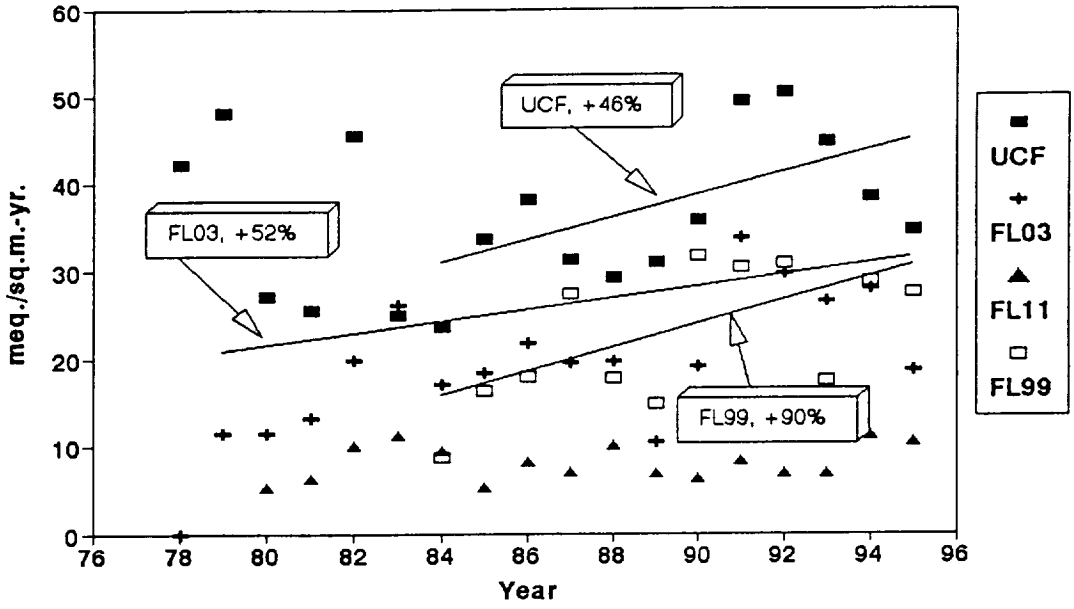

Figure 7. Trends in Hydrogen Ion Deposition at UCF, FL03 and FL99 Compared With One Site Where No Trend Exists.

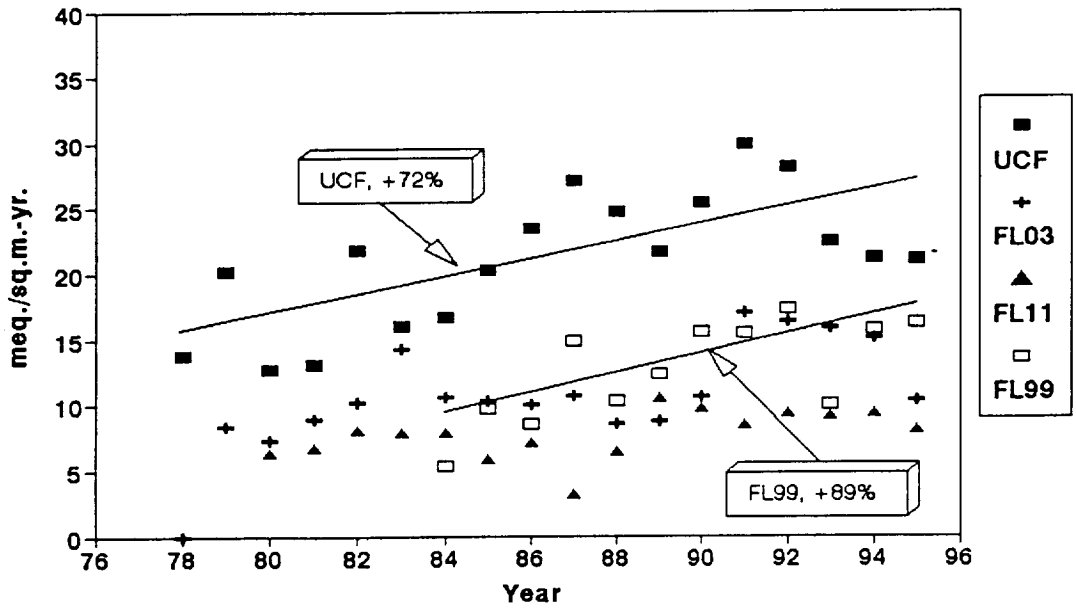

Figure 8. Trends in Nitrate Deposition at Two Sites Compared with Two Sites Where No Trends Exist.

TABLE 1. MULTIYEAR AND RECENT ANNUAL RAINFALL CHEMISTRY SUMMARIES FOR UCF AND KSC.

TIME PERIOD	1978-1995 UCF	1995 UCF	1984-1995 NADP FL99	1995[$] FL99
No. of Samples	1676	81	523	38
Rain, cm/yr	131.5[*]	125.7[**]	118.9[#]	169.3[##]
Field pH	4.56	4.56		4.72(n=34)
Lab pH			4.71	4.71(n=38)
Field Conductivity μS/cm	17.7	16.2		14.5
Lab Conductivity μS/cm			17.2	15.3
Total Deposition (meq/m^2-yr)				
Field H	36.3	34.7		26.9
Lab H			23.3	27.5
Na	25.1	19.0	47.6	43.0
NH_4	11.6	10.4	5.9	10.2
NO_3	21.0	21.1	13.1	16.2
excess SO_4	32.7	28.8	24.0	25.5
Ionic Concentrations (μeq/L)				
Field H	27.6	27.6		19.1
Lab H			19.6	19.5
Na	19.1	15.1	40.0	30.4
K	1.1	0.9	1.2	1.0
Ca	9.9	8.1	6.1	5.0
Mg	5.2	4.8	9.4	6.6
NH_4	8.8	8.3	5.0	7.2
Cl	22.1	16.1	46.6	33.0
NO_3	16.0	16.8	11.0	11.5
SO_4	27.2	24.5	24.9	21.5
excess SO_4	24.9	22.9	20.2	18.1

* Valid samples represents 99.3% of measured precipitation.

** Valid samples represent 100.0% of measured precipitation.

\# The reported precipitation represents 96.5% of recorded precipitation and corresponds to NADP criterion 3 for valid samples. The percentage for each annual period exceeds 94% except for 1984, 1989 and 1995 where values are 82.1%, 86.3% and 85.3%, respectively.

\#\# Reported precipitation corresponds to 85.3% of total measured precipitation and corresponds to NADP criterion 3 for valid samples.

TABLE 2. ANNUAL PRECIPITATION COMPOSITION SUMMARY FOR THE UNIVERSITY OF CENTRAL FLORIDA

YR	No.	cm	pH	COND μmho/cm	DEP H meq m^{-2}	Cl/Na eq/eq	AN/CA eq/eq	COND/ PCOND
1978	72	135.16	4.48	15.4	44.8	1.07	0.81	0.86
1979	84	157.81	4.49	15.4	51.1	1.18	0.86	0.81
1980	77	99.22	4.54	16.0	28.6	1.10	0.86	0.94
1981	74	93.75	4.54	18.8	27.0	1.19	0.86	0.96
1982	100	152.81	4.50	18.4	48.3	1.30	0.94	0.98
1983	95	152.34	4.72	13.7	29.0	1.22	0.93	1.00
1984	71	128.12	4.71	16.3	25.0	1.20	1.00	1.03
1985	93	165.00	4.66	16.0	36.1	1.26	0.96	1.02
1986	104	140.31	4.54	17.5	40.5	1.34	0.98	1.06
1987	101	162.19	4.69	14.8	33.1	1.09	0.91	1.07
1988	99	132.34	4.63	18.2	31.0	0.96	0.96	1.14
1989	98	133.91	4.61	18.9	32.9	1.14	0.89	1.22
1990	97	112.34	4.47	22.2	38.1	0.93	0.83	1.04
1991	108	168.44	4.51	27.4	52.1	1.13	0.87	1.48
1992	103	141.09	4.42	23.4	53.6	1.16	0.92	1.05
1993	88	146.8	4.49	17.4	47.6	1.25	0.96	0.95
1994	101	160.1	4.62	13.0	38.4	1.21	0.94	0.88
1995	81	125.79	4.56	16.2	34.7	1.07	0.89	0.86

MICROEQUIVALENTS/LITER

YR	H	Na	K	Ca	Mg	NH_4	Cl	NO_3	SO_4	Excess SO_4
1978	33.1	14.8	1.5	7.0	3.9	8.3	15.8	10.8	28.7	27.1
1979	32.4	20.9	1.3	8.5	5.6	8.9	24.5	13.5	28.5	26.0
1980	28.8	12.6	0.8	11.5	3.2	12.2	13.8	13.5	32.1	30.6
1981	28.8	25.2	1.0	12.0	7.0	16.1	29.9	14.8	32.5	29.5
1982	31.6	14.3	0.5	12.5	3.9	10.5	18.6	15.2	35.4	33.7
1983	19.1	20.9	1.3	9.5	5.6	7.2	25.4	12.3	21.7	19.1
1984	19.5	28.3	0.8	11.5	7.5	8.3	33.8	13.9	27.9	24.5
1985	21.9	23.0	1.0	10.0	5.9	8.9	29.0	13.2	25.4	22.6
1986	28.8	12.6	0.3	8.5	3.7	7.2	16.9	17.7	25.4	23.9
1987	20.4	20.4	0.5	7.5	5.3	7.8	22.3	17.7	16.4	14.2
1988	23.4	19.1	0.8	11.5	5.3	9.4	18.3	19.8	28.7	26.8
1989	24.5	15.7	1.0	10.5	5.1	9.4	17.8	17.1	24.4	22.5
1990	33.9	21.3	1.3	22.0	5.8	10.5	19.7	24.0	35.2	33.2
1991	30.9	21.3	1.8	7.5	4.9	10.5	24.0	18.7	23.9	21.5
1992	38.0	23.0	1.8	10.0	6.9	8.9	26.8	21.1	33.3	30.6
1993	32.4	16.9	1.5	9.6	4.4	4.9	21.2	16.1	29.8	27.9
1994	24.0	18.7	1.3	6.5	4.8	5.6	22.6	13.2	21.0	18.7
1995	27.6	15.1	0.9	8.1	4.8	8.3	16.1	16.8	24.5	22.9

TABLE 3. ANNUAL PRECIPITATION COMPOSITION SUMMARY FOR NADP SITE FL99.

YR	Crit.3	cm	field pH	lab pH	DEP H,meq m^{-2} field	lab	Cl/Na eq/eq	AN/CA eq/eq	COND/ Pcond
84	82.1	122.40		4.92		14.7	1.20	1.16	
85	98.6	116.97		4.83		17.3	1.22	1.29	
86	87.0	97.08		4.68		20.3	1.19	1.35	
87	96.1	158.33	4.62	4.75	38.0	28.2	1.21	0.95	0.95
88	98.0	91.65	4.61	4.71	22.5	17.8	1.17	1.00	0.93
89	86.3	106.58	4.65	4.78	23.8	17.7	1.22	0.99	0.93
90	98.4	101.00	4.76	4.50	17.6	31.9	1.14	1.23	1.29
91	96.8	133.23	4.64	4.63	30.5	31.2	1.17	1.01	0.98
92	99.2	126.74	4.51	4.60	39.2	31.8	1.15	0.98	1.05
93	97.4	92.28	4.75	4.70	16.4	18.4	1.14	1.04	1.11
94	97.8	182.9	4.74	4.78	33.3	30.4	1.10	0.94	0.94
95	85.3	169.31	4.72	4.71	26.9	27.5	1.08	0.94	1.04

MICROEQUIVALENTS/LITER

YR	field H	lab H	Na	K	Ca	Mg	NH_4	Cl	NO_3	SO_4	Excess SO_4
84		12.0	69.6	1.8	7.5	16.6	3.9	83.8	7.4	24.2	15.8
85		14.8	32.2	1.0	8.5	8.3	2.8	39.2	8.9	19.8	15.9
86		20.9	45.7	1.3	6.5	11.2	2.2	54.1	10.0	26.2	20.8
87	24.0	17.8	31.7	0.8	4.5	7.6	4.4	38.4	9.7	21.2	17.4
88	24.5	19.5	41.3	1.0	6.5	9.5	3.9	48.5	11.3	26.9	21.9
89	22.4	16.6	42.2	1.8	8.0	10.9	9.4	51.6	13.7	27.9	22.8
90	17.4	31.6	28.7	0.8	5.5	6.7	6.1	32.7	15.5	32.3	28.9
91	22.9	23.4	35.7	2.0	6.5	8.6	6.1	41.7	11.9	28.9	24.7
92	30.9	25.1	47.4	1.5	6.0	11.1	5.5	54.4	14.0	31.6	26.0
93	17.8	20.0	34.8	1.0	5.0	7.8	5.0	39.5	11.5	23.5	19.5
94	18.2	16.6	41.3	1.0	6.0	8.9	3.9	45.4	9.0	20.4	15.7
95	19.1	19.5	30.4	1.0	5.0	6.6	7.2	33.0	11.5	21.5	18.1

TABLE 4. ANNUAL PRECIPITATION COMPOSITION SUMMARY FOR NADP SITE FL03.

YR	Crit.3	cm	field pH	lab pH	DEP H,meq m^{-2} field	lab	Cl/Na eq/eq	AN/CA eq/eq	COND/ Pcond
79	91.0	131.13		4.98		13.7	0.66	1.28	
80	72.7	100.34		4.76		17.4	1.56		
81	83.7	89.50		4.71		17.5	0.87	1.36	
82	94.9	150.41		4.68		31.4	1.27	1.89	
83	92.4	158.75		4.72		30.2	1.16	1.71	
84	87.1	114.79		4.69		23.4	1.14	1.56	
85	87.1	130.21		4.68		27.2	1.23	1.68	
86	77.9	107.32		4.49		34.7	1.15	2.86	
87	89.7	140.38	4.54	4.72	40.5	26.7	1.18	0.86	0.94
88	84.5	150.28	4.59	4.67	38.6	32.1	1.12	0.97	2.04
89	63.7	101.69	4.82	4.79	15.4	16.5	1.15	1.05	0.88
90	85.7	86.98	4.53	4.59	25.6	22.3	1.14	0.95	1.01
91	98.8	157.03	4.58	4.65	41.3	35.1	1.14	0.97	1.11
92	97.0	153.11	4.56	4.67	42.2	32.7	1.14	0.93	0.93
93	97.7	121.50	4.52	4.62	36.7	29.1	1.10	0.96	0.99
94	94.5	134.80	4.59	4.66	36.8	29.5	1.10	0.89	0.91
95	90.3	142.25	4.66	4.71	20.9	18.6	1.08	0.93	1.06

MICROEQUIVALENTS/LITER

YR	field H	lab H	Na	K	Ca	Mg	NH_4	Cl	NO_3	SO_4	Excess SO_4
79		10.5	20.0	0.8	6.0	3.6	3.3	13.3	7.6	22.3	20.9
80		17.4	17.0	1.0	7.0	3.5	6.7	14.9	11.0	28.9	27.4
81		19.5	23.9	1.0	11.5	6.7	10.5	20.9	13.2	38.7	36.6
82		20.9	10.0	1.3	6.0	3.5	5.5	12.7	10.8	26.2	25.0
83		19.1	12.2	1.3	5.5	3.9	5.5	14.1	10.5	23.9	22.5
84		20.4	16.5	1.0	8.5	5.0	7.8	18.9	12.7	28.9	27.0
85		20.9	16.5	0.8	7.0	4.9	3.9	20.3	11.8	23.5	21.5
86		32.4	7.8	0.5	5.0	2.3	4.4	9.0	15.0	33.3	32.4
87	28.8	19.1	10.0	0.5	4.0	2.7	5.5	11.8	10.5	22.1	20.9
88	25.7	21.4	11.3	0.3	5.0	2.9	2.8	12.7	9.4	24.4	23.1
89	15.1	16.2	13.9	0.5	6.5	3.5	14.4	16.1	13.4	26.9	25.2
90	29.5	25.7	12.6	0.5	7.5	3.4	8.9	14.4	14.4	30.6	29.1
91	26.3	22.4	13.9	0.5	4.0	3.4	4.4	15.8	11.3	23.7	22.1
92	27.5	21.4	10.4	0.3	3.0	2.6	5.0	11.8	11.8	21.9	20.6
93	30.2	24.0	12.6	0.5	5.5	3.0	6.1	13.8	14.4	27.3	25.9
94	25.7	21.9	11.3	0.3	4.5	2.7	4.4	12.4	11.8	19.4	18.1
95	21.9	19.5	11.7	0.5	3.5	2.6	7.8	12.7	10.8	19.0	17.7

TABLE 5. ANNUAL PRECIPITATION COMPOSITION SUMMARY FOR NADP SITE FL11.

YR	Crit.3	cm	field pH	lab pH	DEP H,meq m^{-2} field	lab	Cl/Na eq/eq	AN/CA eq/eq	COND/ Pcond
81	53.3	149.78		5.20		9.4	1.17	0.95	
82	97.3	161.73		5.00		16.2	1.19	1.14	
83	72.7	163.88		4.95		18.4	1.16	1.23	
84	97.6	106.24		5.02		10.1	1.15	1.24	
85	76.8	136.91		5.28		7.2	1.21	0.96	
86	63.2	104.43		5.09		8.5	1.21	1.17	
87	99.0	57.39	5.07	5.15	4.9	4.1	1.21	1.01	1.04
88	98.2	135.34	4.90	5.00	17.0	13.5	1.16	0.99	1.09
89	91.6	90.43	4.85	5.17	12.8	6.1	1.15	0.88	0.89
90	76.9	125.18	5.20	5.20	7.9	7.9	1.15	0.94	1.14
91	99.3	161.16	5.09	5.08	13.1	13.4	1.16	0.96	1.25
92	82.8	109.71	5.03	5.16	10.2	7.6	1.09	0.97	1.19
93	73.8	138.50	5.13	5.17	10.3	9.4	1.11	0.95	1.13
94	78.2	171.90	5.07	4.95	14.6	19.2	1.13	0.99	1.22
95	83.3	173.61	5.06	4.98	12.7	15.2	1.10	0.89	1.09

MICROEQUIVALENTS/LITER

YR	field H	lab H	Na	K	Ca	Mg	NH_4	Cl	NO_3	SO_4	Excess SO_4
81		6.3	38.3	2.3	12.5	11.5	12.8	44.8	6.8	21.7	17.1
82		10.0	22.6	1.5	8.5	6.5	3.9	26.8	8.1	14.2	11.4
83		11.2	23.0	1.0	6.5	6.1	4.4	26.8	7.9	16.0	13.3
84		9.6	20.4	0.8	7.5	5.8	2.8	23.4	7.9	14.8	12.4
85		5.2	26.1	2.0	10.5	7.2	7.2	31.6	5.8	13.7	10.6
86		8.1	33.5	2.8	7.5	8.9	5.0	40.6	7.1	19.6	15.6
87	8.5	7.1	37.0	0.8	4.0	8.5	1.7	44.6	3.1	13.3	8.9
88	12.6	10.0	20.9	0.8	6.0	4.9	1.7	24.3	6.5	15.4	12.9
89	14.1	6.8	20.9	1.8	6.5	5.1	8.9	24.0	10.5	16.0	13.6
90	6.3	6.3	23.5	3.1	8.5	6.3	7.8	27.1	9.7	15.2	12.4
91	8.1	8.3	20.9	3.1	8.0	5.8	2.8	24.3	8.4	13.9	11.5
92	9.3	6.9	18.7	2.0	5.0	4.4	5.0	20.3	9.4	13.3	11.2
93	7.4	6.8	22.6	2.0	7.5	6.6	5.5	25.1	9.2	15.0	12.4
94	8.5	11.2	23.0	2.0	5.0	5.6	7.2	26.0	9.4	15.5	12.8
95	8.7	10.5	20.4	3.3	5.0	5.3	6.1	22.6	8.1	14.4	12.1

TABLE 6. ANNUAL PRECIPITATION COMPOSITION SUMMARY FOR NADP SITE FL14.

YR	Crit.3	cm	field pH	lab pH	DEP H,meq m^{-2} field	lab	Cl/Na eq/eq	AN/CA eq/eq	COND/ Pcond
84	64.2	111.70		4.62		16.9			
85	87.5	135.72		4.86		18.7	1.19	1.51	
86	76.3	147.75		4.78		24.5	1.17	2.10	
87	97.2	113.64	4.70	4.76	22.7	19.7	1.16	0.98	0.99
88	61.6	118.62	4.51	4.56	36.7	32.7	1.14	1.08	1.11
89	95.5	153.31	4.70	4.81	30.6	23.7	1.15	0.94	0.96
90	86.6	93.10	4.50	4.62	29.4	22.3	1.14	0.88	1.02
91	86.0	202.11	4.76	4.76	35.1	35.1	1.13	1.05	1.11
92	99.2	149.69	4.71	4.84	28.8	21.3	1.12	0.93	1.03
93	87.1	142.05	4.59	4.69	36.1	29.0	1.10	0.94	1.04
94	85.7	210.4	4.78	4.83	34.9	31.1	1.14	0.93	1.01
95	78.5	141.35	4.75	4.83	19.2	15.9	1.12	0.94	1.06

MICROEQUIVALENTS/LITER

YR	field H	lab H	Na	K	Ca	Mg	NH_4	Cl	NO_3	SO_4	Excess SO_4
84		24.0	11.7	0.8	7.0	3.9	6.6	13.3	10.0	25.4	24.0
85		13.8	13.0	0.8	4.0	3.9	3.9	15.5	6.6	16.4	14.9
86		16.6	10.9	0.5	2.5	2.9	2.2	12.7	8.2	18.9	17.6
87	20.0	17.4	10.0	0.5	3.0	2.7	4.4	11.6	8.9	19.2	18.0
88	30.9	27.5	10.9	0.3	4.0	2.8	3.3	12.4	12.1	31.9	30.6
89	20.0	15.5	13.5	1.0	4.5	3.5	7.8	15.5	10.3	21.7	20.1
90	31.6	24.0	12.2	0.8	4.0	3.8	8.3	13.8	11.8	27.7	26.3
91	17.4	17.4	8.3	0.3	2.5	2.0	3.9	9.3	8.7	17.9	16.9
92	19.5	14.5	10.9	0.3	2.5	2.7	3.9	12.1	8.7	16.0	14.8
93	25.7	20.4	11.3	0.5	4.0	3.0	6.1	12.4	11.5	23.7	22.5
94	16.6	14.8	7.4	0.8	2.0	2.0	3.3	8.5	7.4	13.9	13.0
95	17.8	14.8	16.1	0.8	4.0	3.9	9.4	18.1	9.8	17.9	16.1

TABLE 7. ANNUAL PRECIPITATION COMPOSITION SUMMARY FOR NADP SITE FL41.

YR	Crit.3	cm	field pH	lab pH	DEP H,meq m^{-2} field	lab	Cl/Na eq/eq	AN/CA eq/eq	COND/ Pcond
84	94.1	89.41		4.81		13.8	1.15	1.49	
85	69.0	126.76		4.74		23.1	1.22	1.50	
86	98.4	132.15		4.80		20.9	1.22	1.68	
87	69.3	128.21	4.87	4.99	17.3	13.1	1.19	1.00	0.96
88	94.1	147.37	4.60	4.69	37.0	30.1	1.21	0.96	0.91
89	92.3	99.28	4.46	4.56	34.4	27.2	1.27	0.92	0.92
90	99.2	101.23	4.68	4.80	21.1	16.0	1.15	0.90	0.89
91	62.9	157.62	4.75	4.85	28.0	22.3	1.11	0.92	0.97
92	90.8	154.49	4.81	4.92	23.9	18.6	1.13	0.88	0.97
93	93.4	144.81	4.64	4.62	33.2	34.7	1.13	1.06	1.08
94	92.0	132.5	4.83	4.62	19.6	31.8	1.14	1.20	0.98
95	89.0	157.52	4.76	4.73	25.0	26.8	1.07	0.94	1.07

MICROEQUIVALENTS/LITER

YR	field H	lab H	Na	K	Ca	Mg	NH_4	Cl	NO_3	SO_4	Excess SO_4
84		15.5	14.8	1.3	9.0	5.2	6.1	16.9	12.7	24.4	22.6
85		18.2	17.8	1.0	9.0	5.5	3.3	21.7	9.5	23.7	21.6
86		15.8	13.9	0.8	6.0	3.9	3.9	16.9	11.3	19.8	18.1
87	13.5	10.2	15.2	0.8	6.5	4.4	5.5	18.0	10.8	16.9	15.0
88	25.1	20.4	16.1	1.3	6.0	4.5	3.3	19.5	10.3	24.4	22.4
89	34.7	27.5	11.7	0.8	6.0	3.5	7.8	14.9	14.2	30.2	28.8
90	20.9	15.8	15.2	0.8	8.5	4.3	7.8	17.5	13.5	20.4	18.6
91	17.8	14.1	16.5	1.3	7.5	4.4	6.7	18.3	11.9	19.4	17.5
92	15.5	12.0	18.7	0.8	4.0	4.4	8.3	21.1	8.9	15.6	13.4
93	22.9	24.0	11.7	0.5	6.5	3.2	6.7	13.3	15.5	25.6	24.2
94	14.8	24.0	17.2	0.5	5.5	3.0	5.6	13.8	13.9	22.2	20.8
95	17.4	18.6	13.5	0.8	4.0	3.2	6.1	14.4	10.8	18.3	16.9