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THE NATIONAL AIR POLLUTION BACKGROUND NETWORK

FINAL PROJECT REPORT

by

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The U.S. Environmental Protection Agency, in cooperation with the U.S. Forest Service, operated a network of ozone monitoring stations from 1976 through 1983 in selected National Forests within the continental U. S. The primary objective of this project was to determine the level of ozone concentrations occurring in remote areas, especially in relation to the National Ambient Air Quality Standard for ozone. Secondary objectives included the evaluation of regional differences, the characterization of seasonal and diurnal patterns, and the assessment of long-term trends for ozone concentrations in remote areas. Annual mean ozone concentrations were found to vary from site-to-site and year-to-year within a range of 25 to 50 parts per billion (ppb). Hourly ozone concentrations in excess of 120 ppb, the current level of the National Ambient Air Quality Standard, were occasionally observed. Such events, however, were rare and generally confined to the spring and summer months at sites in the eastern half of the U.S. and during the first half of the study period. No such events were observed after 1980. Seasonal mean ozone concentrations were greatest during the spring months (April through June) and diurnal maximums occurred most frequently during the early afternoon (1-3 p.m.). While no statistically significant trends were observed in mean ozone concentrations, the frequency of exceedances of the National Ambient Air Quality Standard decreased over the course of the study.

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FOREWORD

Measurement and monitoring research efforts are designed to anticipate potential environmental problems, to support regulatory actions by developing an in-depth understanding of the nature and processes that impact health and the ecology, to provide innovative means of monitoring compliance with regulations, and to evaluate the effectiveness of health and environmental protection efforts through the monitoring of long-term trends. The Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina, has the responsibility for assessment of environmental monitoring technology and systems; implementation of agency-wide quality assurance programs for air pollution measurement systems; and supplying technical support to other groups in the Agency including the Office of Air, Noise, and Radiation, the Office of Toxic Substances, and the Office of Enforcement.

The National Air Pollution Background Network was initiated at the request of the Office of Air Quality Planning and Standards. The project was conducted jointly through an interagency agreement between the U.S. Environmental Protection Agency and the Forest Service of the U.S. Department of Agriculture. Results from the project are summarized in this report. The data are available to all interested researchers upon request to the National Aerometric Data Bank, Research Triangle Park, North Carolina.

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ABSTRACT

The U.S. Environmental Protection Agency, in cooperation with the U.S. Forest Service, operated a network of ozone monitoring stations from 1976 through 1983 in selected National Forests within the continental U. S. The primary objective of this project was to determine the level of ozone concentrations occurring in remote areas, especially in relation to the National Ambient Air Quality Standard for ozone. Secondary objectives included the evaluation of regional differences, the characterization of seasonal and diurnal patterns, and the assessment of long-term trends for ozone concentrations in remote areas.

Annual mean ozone concentrations were found to vary from site-to-site and year-to-year within a range of 25 to 50 parts per billion (ppb). Hourly ozone concentrations in excess of 120 ppb, the current level of the National Ambient Air Quality Standard, were occasionally observed. Such events, however, were rare and generally confined to the spring and summer months at sites in the eastern half of the U.S. and during the first half of the study period. No such events were observed after 1980. Seasonal mean ozone concentrations were greatest during the spring months (April through June) and diurnal maximums occurred most frequently during the early afternoon (1-3 p.m.). While no statistically significant trends were observed in mean ozone concentrations, the frequency of exceedances of the National Ambient Air Quality Standard decreased over the course of the study.

This report covers a period from January 1976 to December 1984 and work was completed as of February 1985.

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SECTION 1

INTRODUCTION

In 1971, the National Ambient Air Quality Standard (NAAQS) for ozone was established at an hourly average concentration not to exceed 80 parts per billion (ppb) more than once per year. At that time, very few ozone measurements were available from rural and remote areas, and ozone concentrations in such areas were assumed to be generally low and inconsequential relative to the standard. Furthermore, ozone from background areas was thought to be largely removed by chemical scavengers upon entry into an urban environment.

In the mid-1970's, the U.S. Environmental Protection Agency (EPA) sponsored several field studies monitoring ozone concentrations in rural areas.[1,2,3] The monitoring was conducted during summer months in small cities and agricultural areas in the eastern half of the U.S. Results suggested that rural areas experienced a greater range in ozone concentration than had been previously supposed and that ozone transported from rural to urban areas should not always be disregarded.

In 1976, in response to these and other findings, EPA began to establish a nationwide network of ozone monitoring stations located in remote areas. Originally called the National Forest Ozone Study, this project was a joint undertaking of EPA's Environmental Monitoring Systems Laboratory (EMSL), and Office of Air Quality Planning and Standards (OAQPS), both located in Research Triangle Park (RTP), North Carolina. The Forest Service of the U.S. Department of Agriculture, working under an interagency agreement, participated in the project by providing monitoring site locations within National Forest (NF) areas and by performing routine operations at the monitoring stations.

The National Air Pollution Background Network (NAPBN) eventually consisted of eight remote monitoring stations, each collecting continuous measurements of ozone by the chemiluminescence technique. Each site was located as far as was practical from any heavily used roadway and at least 100 miles from any major urban area. To ensure representative sampling, the sites were located in open and relatively elevated areas for good exposure. An effort was made to distribute the sites across the continental U.S. to cover as many regions of the country as possible. Site locations are shown in Figure 1, and station descriptions are provided in Table 1. Earlier reports describing the network and the early data were published in 1978[4] and 1983.[5]

The NAPBN was established to provide a reasonably long-term and continuous record of ozone concentrations and patterns in areas well removed from anthropogenic sources of air pollution and to make these data available to EPA and other interested researchers. The network was discontinued at the end of 1983. All valid data are on file and may be accessed through the National Aerometric Data Bank (NADB), U.S. EPA, Mail Drop 14, Research Triangle Park, North Carolina 27711.

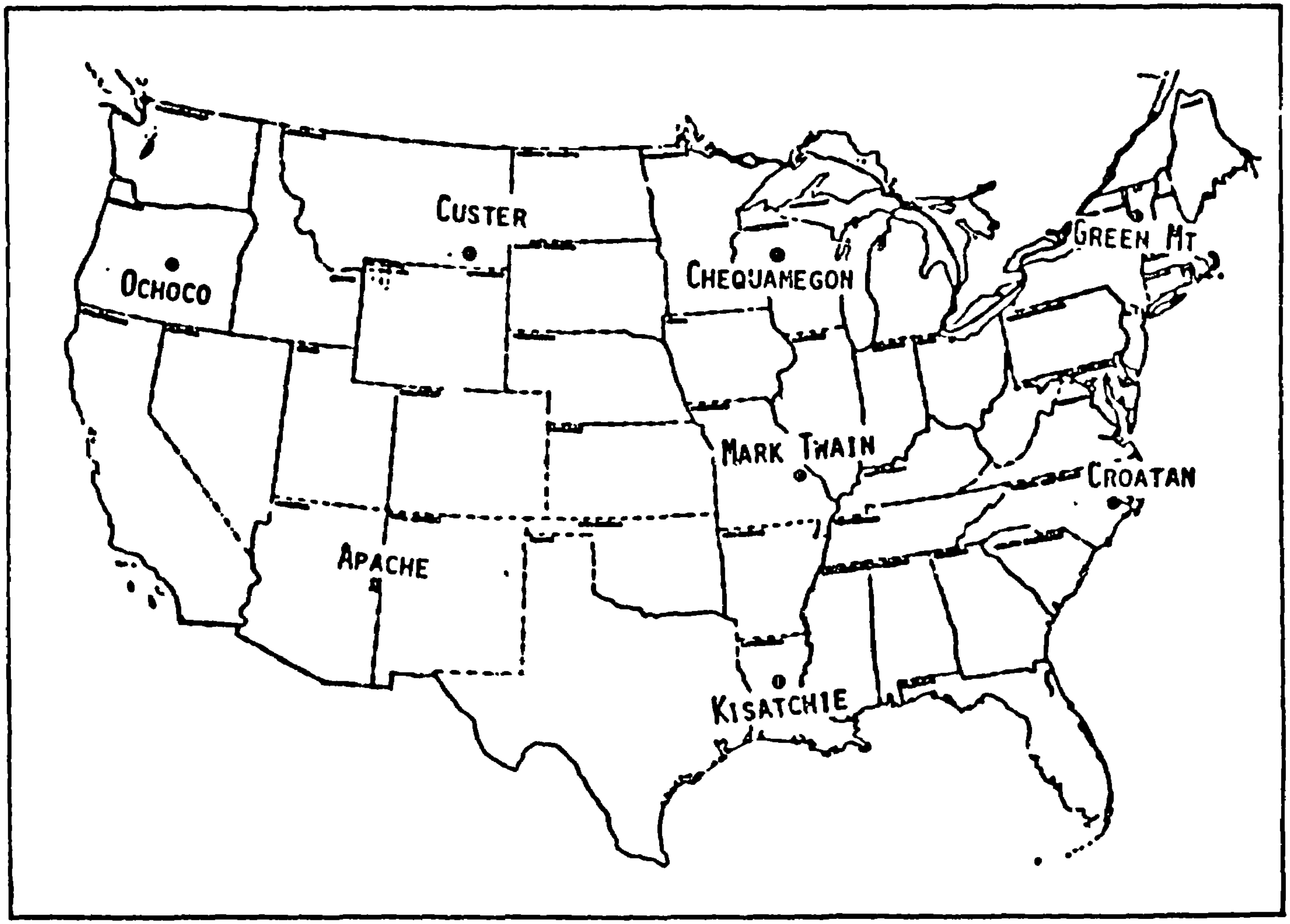

Figure 1. Location of NAPBN Monitoring Sites

TABLE 1. DESCRIPTION OF NAPBN MONITORING SITES

National Forest	State	Elevation Above MSL	Latitude/ Longitude	Start Date	End Date	SAROAD CODE
Apache	AZ	2500 M	33°45'00"N/ 109°00'00"W	9/16/79	12/31/83	030050110A08
Kisatchie	LA	65 M	31°30'00"N/ 92°28'20"W	5/26/76	9/30/82	191490101A08
Mark Twain	MO	350 M	37°28'00"N/ 90°11'00"W	12/18/78	12/31/83	262950001A08
Custer	MT	1250 M	45°14'00"N/ 106°15'00"W	6/23/76	12/22/83	270310101A08
Croatan	NC	13 M	34°59'05"N/ 77°11'24"W	3/13/78	12/31/83	340945101A08
Ochoco	OR	1350 M	44°13'30"N/ 119°42'25"W	10/04/79	12/05/83	380420111A08
Green Mountain	VT	390 M	43°56'00"N/ 73°02'00"W	10/24/76	9/28/82	470205101A08
Chequamegon	WI	440 M	45°12'00"N/ 90°37'00"W	8/10/78	9/30/82	510490001A08

SECTION 2

CONCLUSIONS

- Although exceedances of the original level (80 ppb) and the revised level (120 ppb) of the NAAQS for ozone were occasionally observed at the NAPBN remote monitoring stations, the latter were rare occurrences and observed only during spring and early summer months and at sites in the eastern half of the U.S.

- The frequency of exceedances of the 80 ppb level was less than 5 percent of valid hours for all site years, and no exceedances of the 120 ppb level were observed after 1980.

- Annual mean ozone concentrations fell within a range of 25 to 50 ppb with sites in the western U.S. recording higher mean levels, but lower variances than those in the east.

- Diurnal maximum hourly ozone concentrations occurred most frequently in the early afternoon (1 to 3 p.m.), and the maximum quarterly mean occurred in the spring (April through June).

- Although statistical tests for trend revealed no significant increases or decreases in mean ozone concentrations, there were decreases in the frequency of exceedances of the NAAQS level(s) during the course of the study.

SECTION 3

BACKGROUND

That some natural background level of ozone exists in the lower troposphere, which is primarily attributable to the exchange of air between the troposphere and the ozone-rich stratosphere, is commonly accepted. Various researchers have postulated what this concentration level might be in the absence of other sources, and how it might vary in time and space. Reiter,[6] for example, has estimated that annual mean tropospheric ozone concentrations of stratospheric origin range from 19 to 29 ppb. Mohnen[6] has concluded that a range of annual mean concentrations of 22 to 35 ppb constitutes a representative tropospheric level for ozone of stratospheric origin at mid-latitude locations. Seasonal mean concentrations as high as 50 ppb in the boundary layer are believed by Singh, et al,[7] to be the result of stratospheric ozone mixing into the lower levels of the troposphere. The peak in mean ozone concentrations at remote rural areas has been observed during the spring and early summer,[8] when stratospheric ozone concentrations over mid-latitudes of the Northern Hemisphere are at a seasonal maximum.[9]

The mechanisms that inject stratospheric ozone into the troposphere, including tropospheric folding (TF) events (associated with large-scale atmospheric disturbances) and the mean meridional circulation, have been studied by Danielsen,[10] Danielson and Mohnen,[11] Reiter,[12] and Viezee, et al.[13] Although there is still considerable debate on the relative contribution of the two mechanisms, Singh, et al,[7] estimates that TF events are responsible for the largest portion of air exchanged between the stratosphere and troposphere. According to Mohnen,[6] stratosphere-troposphere interchange processes may cause as many as 0.9% of hourly concentration values at ground level to exceed 80 ppb ozone. Although the actual occurrence of stratospheric intrusions reaching the ground has been suggested,[14] measurements aloft by Viezee, et al,[13] during intrusions associated with TF events, indicate that the channel of ozone rich air emanating from the stratosphere becomes horizontal at about 4500 m. Cases of stratospheric air being transported directly to near ground levels are considered rare,[7] and are not likely to be responsible for widespread high ozone episodes. The impact of TF events or other exchange mechanisms is probably greatest during the late winter and spring since the strong upper level eddies associated with TF events are relatively frequent and most intense in the United States during this season, and the concentration of ozone in the stratosphere is near the annual maximum.

The occurrence of high ozone events during the mid and late summer, however, may not be as closely tied to the stratospheric pool of ozone. In rural eastern U.S. areas, extensive studies[15,16,17,18] have been conducted to investigate the concentration levels and probable sources of ozone during this season. The highest ozone levels during the summer months are generally believed to arise from photochemical reactions of anthropogenic emissions which reach rural areas through the direct impact of urban ozone plumes and/or through long-range (multiday) transport of ozone within the lower troposphere.[18,19]

SECTION 4

RESULTS AND DISCUSSION

The National Air Pollution Background Network (NAPBN) became fully operational in late 1979 with the establishment of the eighth and final air monitoring station which was located within the Ochoco National Forest in Oregon. At each site, U.S. Forest Service personnel visited the monitoring station once per week to perform routine operation and maintenance procedures and to cut and label strip charts. These charts were mailed to EMSL/RTP where they were reduced to hourly average values which were keypunched and entered into EPA's mainframe computer. After validation, including statistical procedures to test for outliers, the data were entered into EPA's SAROAD data storage system. Site visits were made quarterly by either EPA or contractor personnel to audit and calibrate each ozone analyzer. Calibration was performed using a certified UV photometer.

Annual summary statistics for the ozone data collected at each NAPBN site are shown in Table 2. Statistics tabulated include the annual percent data (the number of valid hourly ozone values divided by the number of possible hours expressed as a percentage), mean, standard deviation, 50th percentile (or median), 95th percentile, maximum hourly value, and the percentage of valid hours with ozone concentrations greater than both 80 and 120 parts per billion (ppb). More complete frequency distributions by calendar quarter are included in the Appendix.

EPA established in 1971 the first National Ambient Air Quality Standard[20] for photochemical oxidants (primarily ozone) at a 1-hour average of 80 ppb which was not to be exceeded more than once in any given year. In 1979, EPA promulgated a revised standard[21] which stated that the expected number of days per calendar year with daily maximum ozone concentrations exceeding 120 ppb must be less than or equal to one. This new standard differs from the original in several important ways, including the specific designation of ozone, the emphasis on the daily maximum concentration, and the statistical interpretation of "expected exceedances."[22] The most obvious difference, however, is the change in the level of the standard from 80 to 120 ppb.

As may be seen in Table 2, exceedances of the 80 ppb level did occur during most years at the five NAPBN sites located in the eastern half of the U.S., but in all cases the frequency of such exceedances was less than 5 percent of valid hours. At four of these sites (Kisatchie, Mark Twain, Croatan, and Green Mountain), exceedances of the 120 ppb level were observed. These instances, however, were quite rare (<0.25% of valid hours) and were confined to the first half of the study period (1976 through 1980). Technically, therefore, the NAPBN sites have been in compliance with the current ozone standard since 1980.

TABLE 2. ANNUAL SUMMARY STATISTICS FOR NAPBN OZONE (ppb)

	Year	% Data	Mean	StdDev	50-%ile	95-%ile	Max	%>80	%>120
Arizona	1979	27.7	49.3	9.8	50	65	80	0	0
	1980	95.6	47.4	13.0	45	70	90	0.3	0
Apache NF	1981	94.7	35.3	7.4	35	50	65	0	0
	1982	91.1	41.2	9.2	40	55	75	0	0
	1983	89.6	37.9	9.0	35	55	70	0	0
Louisiana	1976	39.4	31.5	21.4	30	70	125	2.6	0.03
	1977	74.3	33.7	23.5	30	80	135	4.4	0.08
Kisatchie NF	1978	47.7	37.9	21.0	35	75	125	2.8	0.07
	1979	79.8	26.8	14.7	25	55	100	0.1	0
	1980	50.7	27.7	16.1	25	60	105	0.3	0
	1981	30.7	30.1	16.7	30	60	95	0.3	0
	1982	41.7	28.3	16.8	25	60	90	0.2	0
Missouri	1978	6.1	25.7	9.8	25	40	50	0	0
	1979	95.6	39.3	18.2	35	75	125	2.4	0.01
Mark Twain	1980	53.9	45.4	20.8	45	80	155	4.5	0.08
NF	1981	89.6	31.7	14.3	30	55	115	0.4	0
	1982	96.9	37.5	16.3	35	65	95	0.5	0
	1983	92.7	38.5	18.3	35	70	110	1.8	0
Montana	1977	86.8	40.2	11.1	40	60	80	0	0
	1978	51.8	41.0	8.9	40	55	75	0	0
Custer NF	1979	71.6	36.2	9.9	35	50	70	0	0
	1980	88.5	36.8	11.9	35	55	70	0	0
	1981	72.6	30.1	9.0	30	45	70	0	0
	1982	64.7	30.7	8.4	30	45	55	0	0
	1983	90.9	35.2	9.0	35	50	65	0	0
North	1978	49.1	33.2	18.8	30	65	105	0.3	0
Carolina	1979	94.3	27.8	16.8	25	60	85	0.1	0
Croatan NF	1980	87.6	28.5	18.9	25	65	150	0.9	0.07
	1981	84.2	27.4	15.4	25	55	90	0.1	0
	1982	81.0	25.2	15.6	25	55	95	0.2	0
	1983	89.6	25.2	16.1	25	55	85	0.1	0
Oregon	1979	23.9	29.2	6.7	30	40	50	0	0
	1980	88.5	38.5	9.3	40	55	80	0	0
Ochoco NF	1981	88.7	31.2	7.6	30	45	75	0	0
	1982	89.0	34.1	8.0	35	50	65	0	0
	1983	83.2	34.4	7.5	35	50	60	0	0
Vermont	1976	12.1	29.3	11.5	30	45	60	0	0
	1977	74.0	37.6	21.5	35	75	145	4.8	0.23
Green Mt. NF	1978	41.9	29.0	17.9	25	65	105	1.4	0
	1979	73.3	31.6	16.6	30	65	105	1.0	0
	1980	97.9	32.3	17.5	30	65	115	1.5	0
	1981	83.7	28.5	14.4	30	55	105	0.2	0
	1982	59.5	28.5	16.4	30	55	100	0.5	0
Wisconsin	1978	27.2	32.7	13.0	30	60	100	0.1	0
	1979	87.7	35.2	14.8	35	60	110	0.7	0
Chequamegon	1980	72.2	38.8	19.3	35	75	115	2.7	0
NF	1981	92.6	33.1	12.3	30	55	80	0	0
	1982	69.2	35.7	11.7	35	55	90	0.1	0

It is interesting to note that, with the exception of the Apache NF in Arizona, the annual mean ozone values at NAPBN sites fall within a range of 25 to 40 ppb. Remembering that Mohnen[6] has estimated that, in the absence of anthropogenic sources, annual mean tropospheric ozone concentrations of stratospheric origin would range from 22 to 35 ppb, it would appear that most (about 90%) of the ozone observed at the remote NAPBN sites may be of stratospheric origin. The higher annual mean values observed at the Apache Station may be due to the elevation (2500 meters) of that site which was by far the highest in the network. It has been reported that ozone of stratospheric origin increases in concentration with increasing altitude above mean sea level.[23]

While the sites in the western half of the U.S. (Apache, Custer, and Ochoco) tended to record slightly higher annual mean values (presumably due to relative differences in elevation), they showed much less variation (as measured by the standard deviation) and, with the exception of the Apache site in 1980, no exceedances of even the 80 ppb level.

Ozone data from each site were stratified by quarter and averaged by hour-of-day to evaluate seasonal and diurnal cyclical behavior. These diurnal plots by quarter appear for each of the NAPBN sites in Figures 2 through 9. At the Apache NF site in Arizona, depicted in Figure 2, very little diurnal structure is apparent in the data. This flat pattern is suggestive of very good atmospheric mixing and/or an absence of locally produced or transported ozone from photochemical production. Some seasonality is apparent in the data with the second quarter (April through June) clearly exhibiting the maximum mean ozone concentration. This observation is in accord with the fact that stratospheric ozone concentrations over midlatitudes of the Northern Hemisphere are at a seasonal maximum during the spring and early summer months. The remaining sites exhibit varying degrees of diurnality and seasonality, with both patterns being more pronounced at the sites in the eastern half of the U.S. Generally, maximum hourly means are seen to occur in the early afternoon (1-3 p.m.) and the pattern of elevated springtime quarterly means prevails. In no case, however, do the cyclical patterns at these remote sites resemble the well-known ozone patterns for urban locations. Concentrations there are typically negligible during the evening and early morning hours, build to a sharp peak at midday, and exhibit a seasonal maximum during the summer quarter (often termed the "photochemical season").

The daily mean ozone concentration was plotted for the duration of the project at each site (Figures 10 through 17). Also shown in the plots is each daily maximum that exceeded the 80 ppb level, the level of the original NAAQS for ozone. It is again clear from these plots that a seasonal pattern exists in remote ozone concentrations, with the maximum occurring in the spring quarter. Greater variation in ozone concentrations occurs at sites in the eastern half of the U.S., and exceedances of the 80 ppb ozone level occurred primarily at these sites. Statistical trend analysis was applied to the mean ozone values at each site, and in no case was there evidence of either an increasing or decreasing systematic pattern. However, it is clear from Figures 10 through 14 that, with the possible exception of the Mark Twain site (Figure 12), the frequency of elevated ozone episodes (hourly ozone concentrations > 80 ppb) decreased over the duration of the study period. It should be noted that although many urban sites were affected by an ozone calibration change in 1979, such was not the case for the NAPBN sites where the calibration technique was consistent throughout the study period.

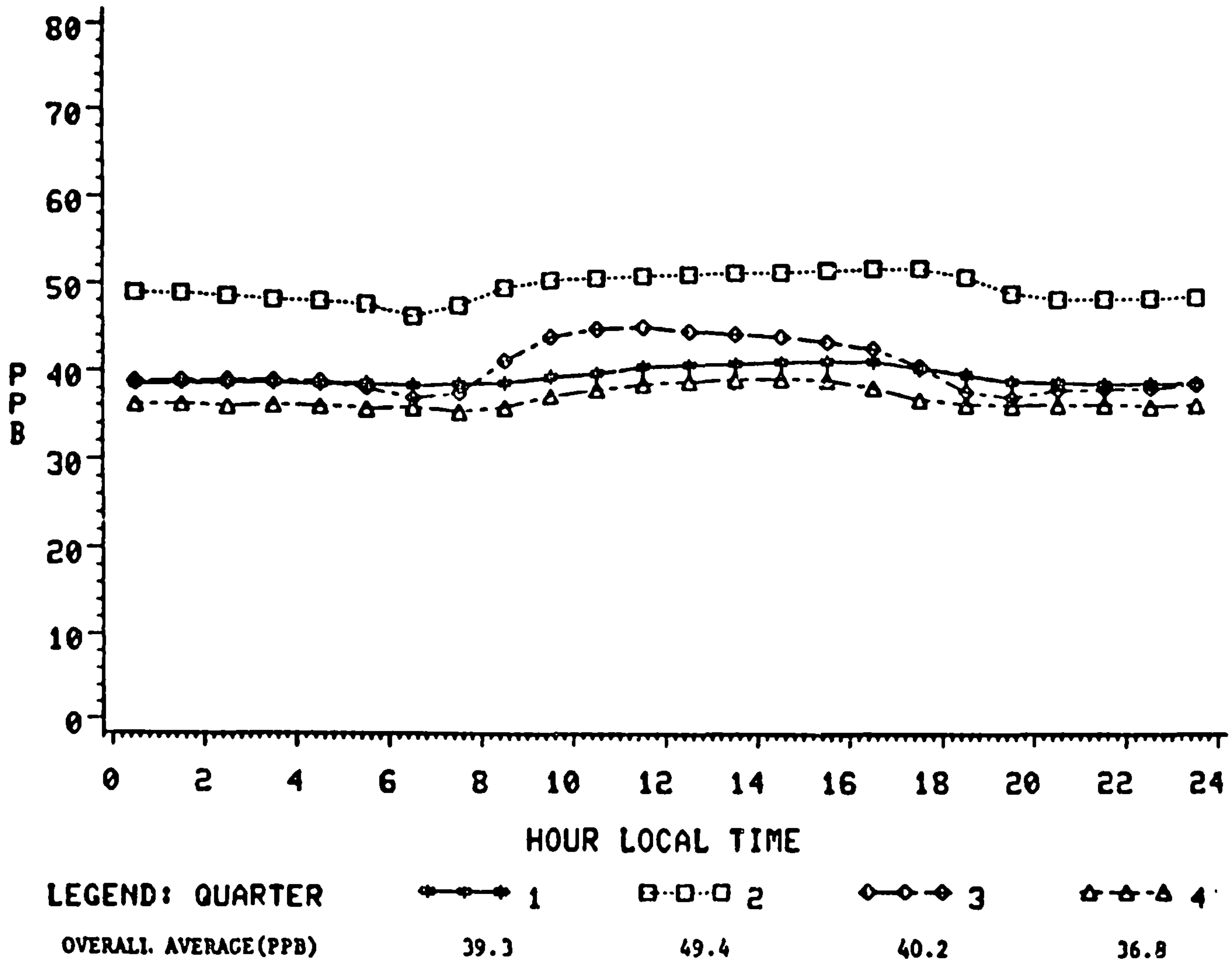

Figure 2. Hourly Mean Ozone Concentration by Quarter - Apache NF, AZ

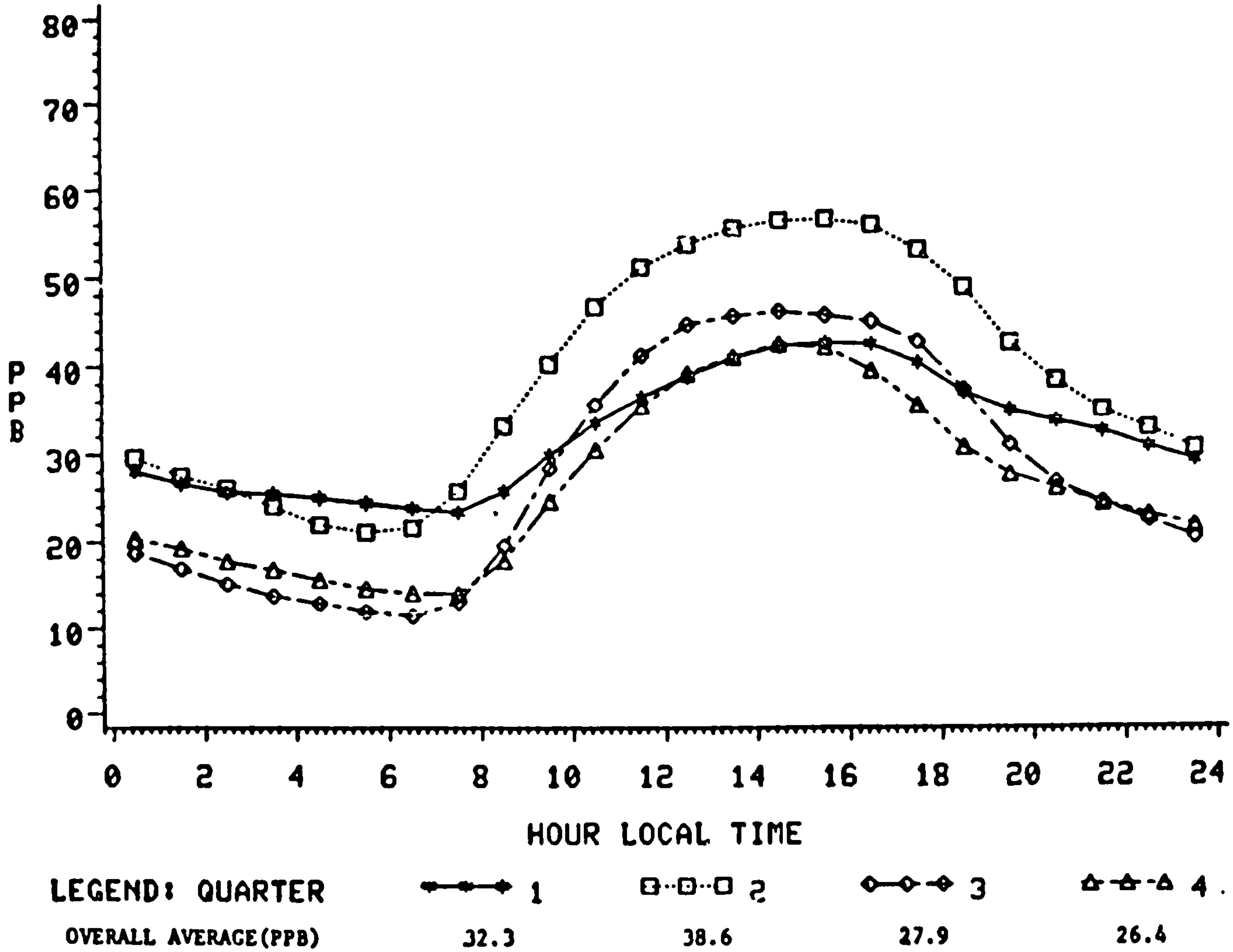

Figure 3. Hourly Mean Ozone Concentration by Quarter - Kisatchie NF, LA

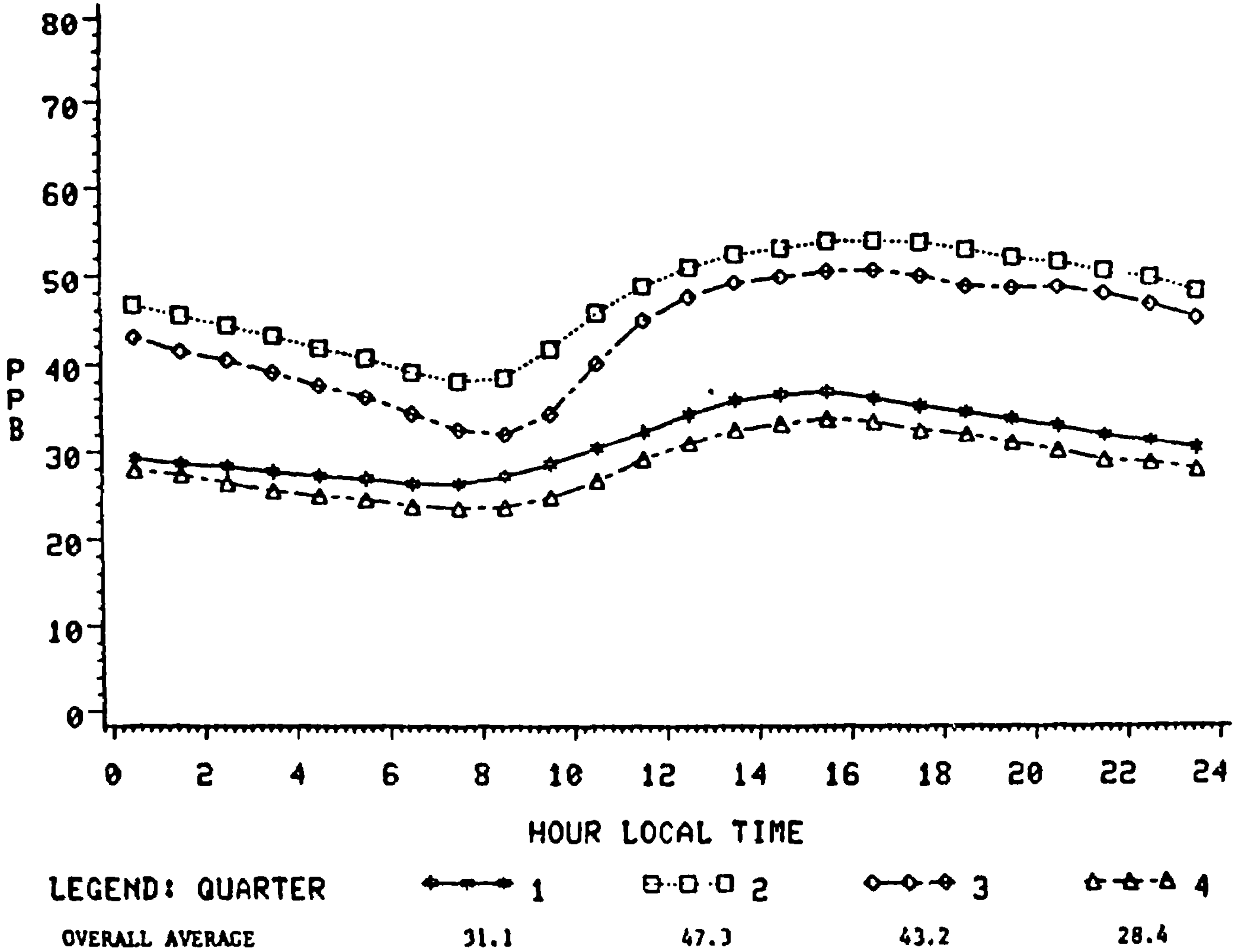

Figure 4. Hourly Mean Ozone Concentration by Quarter - Mark Twain NF, MO

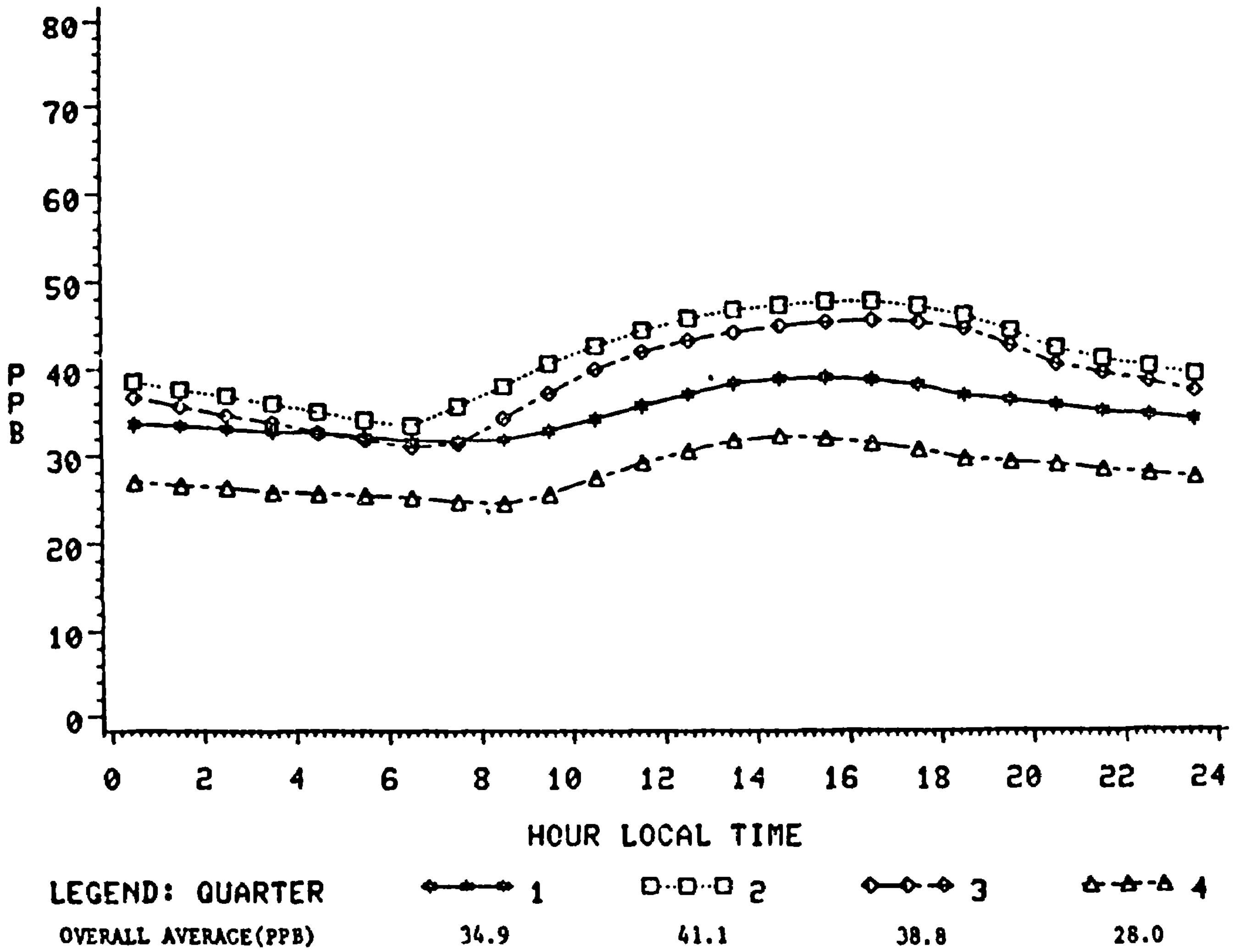

Figure 5. Hourly Mean Ozone Concentration by Quarter - Custer NF, MT

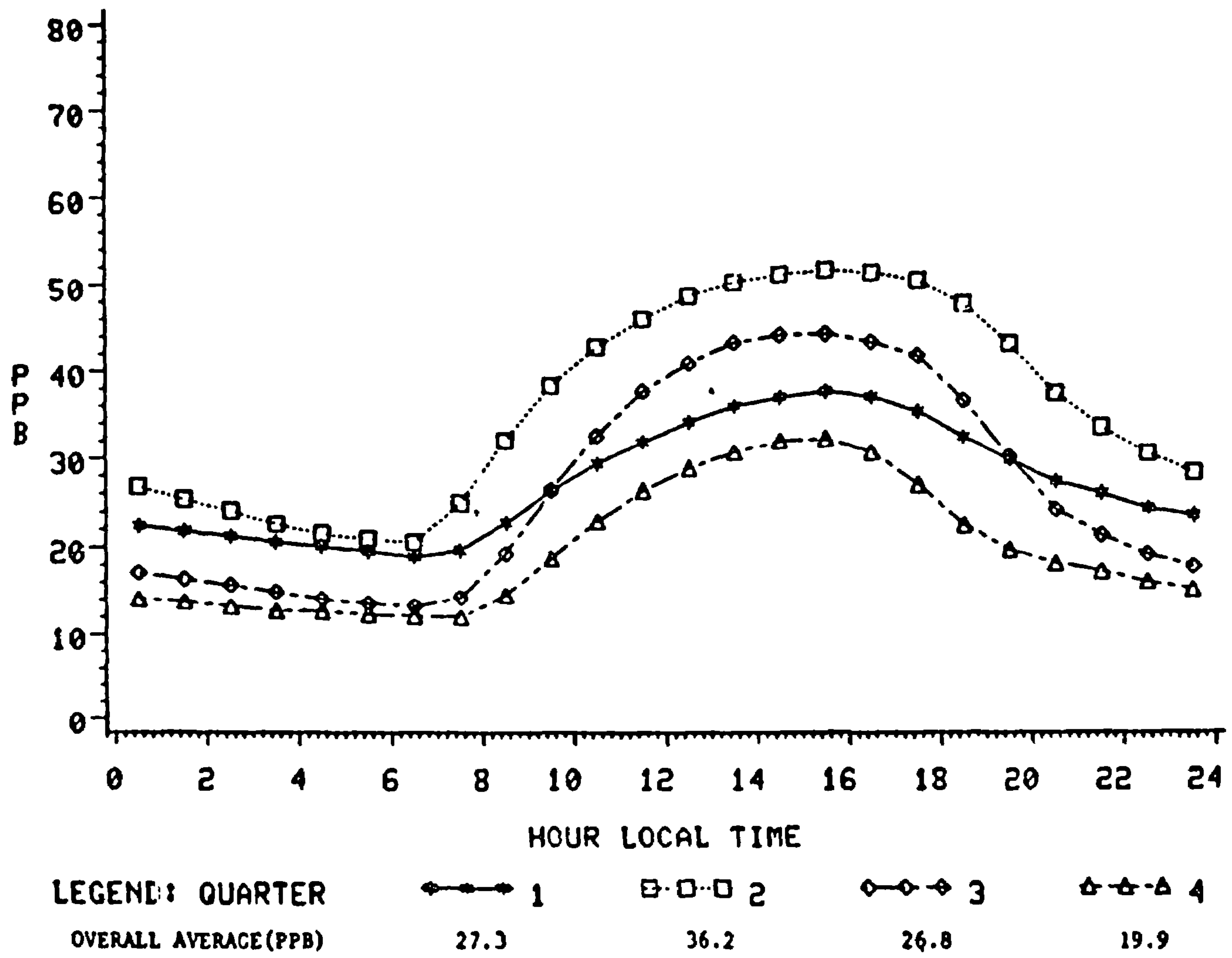

Figure 6. Hourly Mean Ozone Concentration by Quarter - Croatan NF, NC

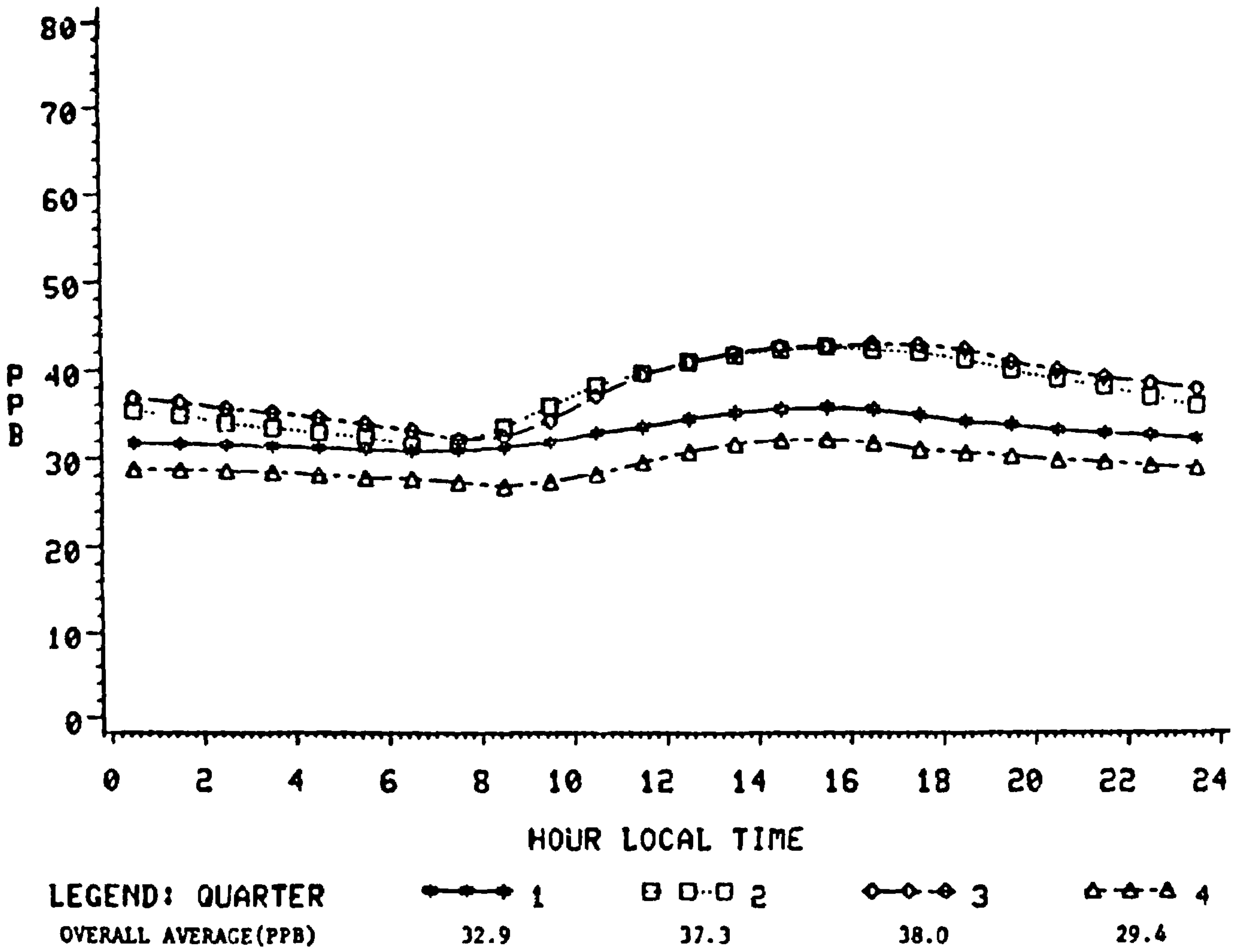

Figure 7. Hourly Mean Ozone Concentration by Quarter - Ochoco NF, OR

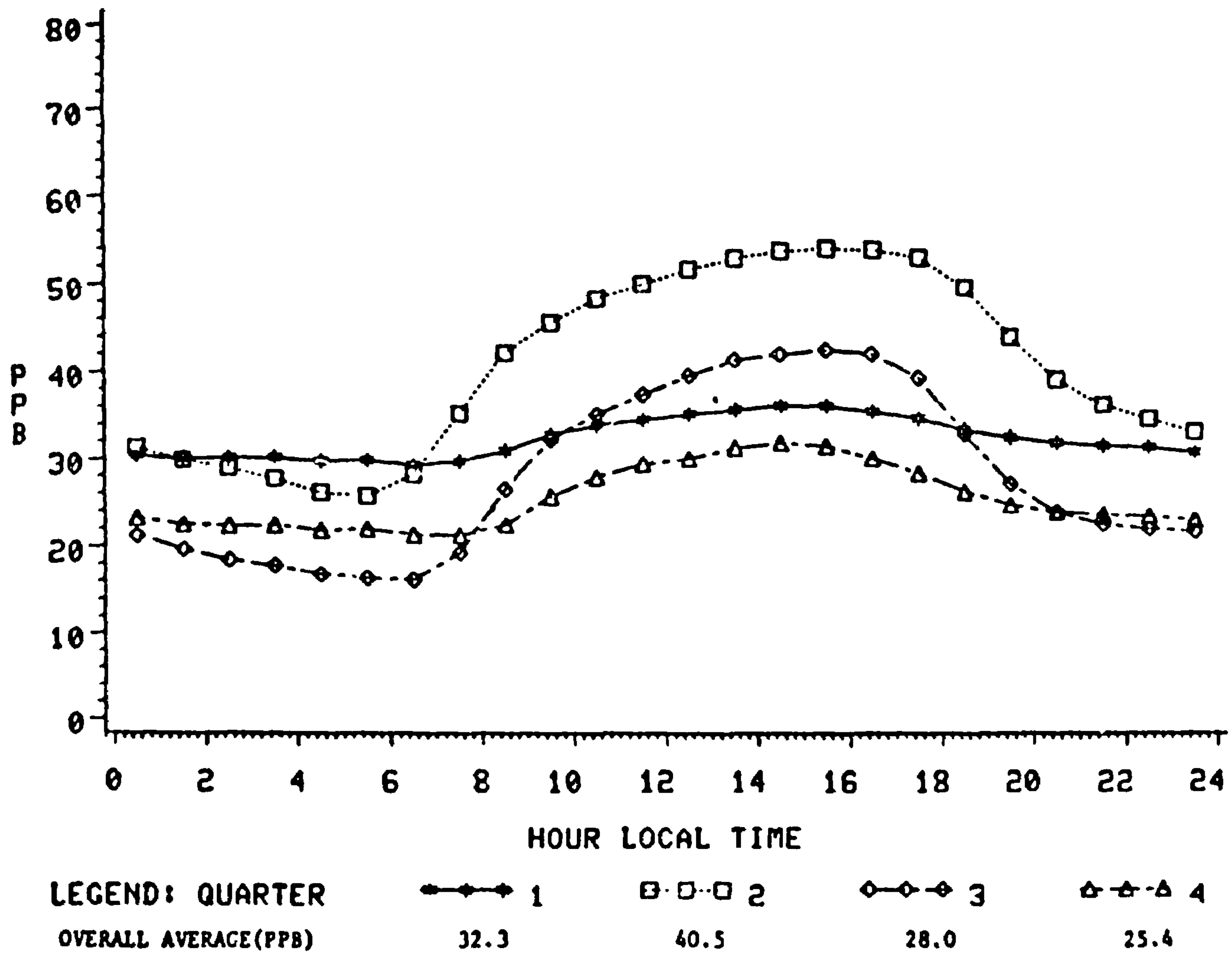

Figure 8. Hourly Mean Ozone Concentration by Quarter - Green Mountain NF, VT

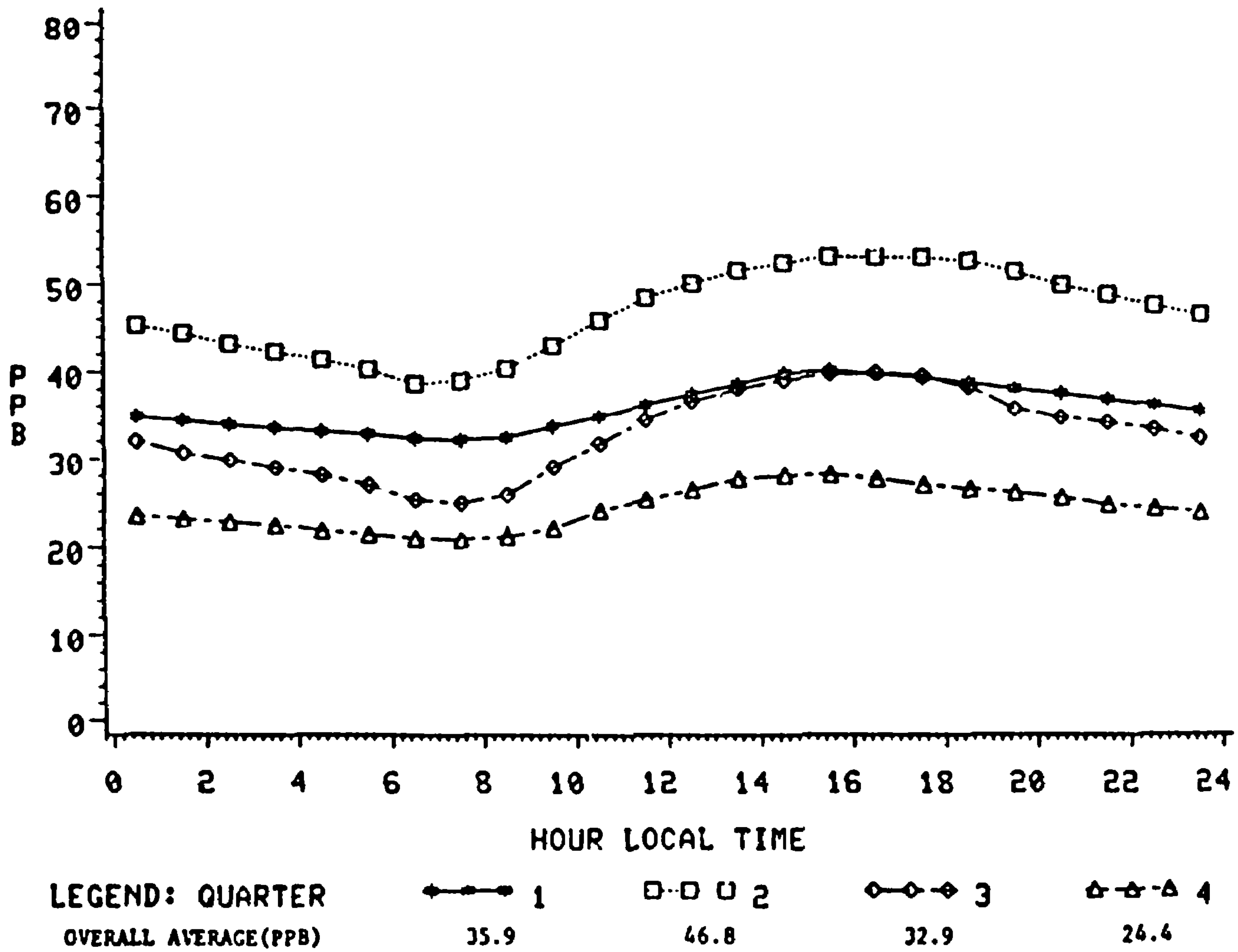

Figure 9. Hourly Mean Ozone Concentration by Quarter - Chequamegon NF, WI

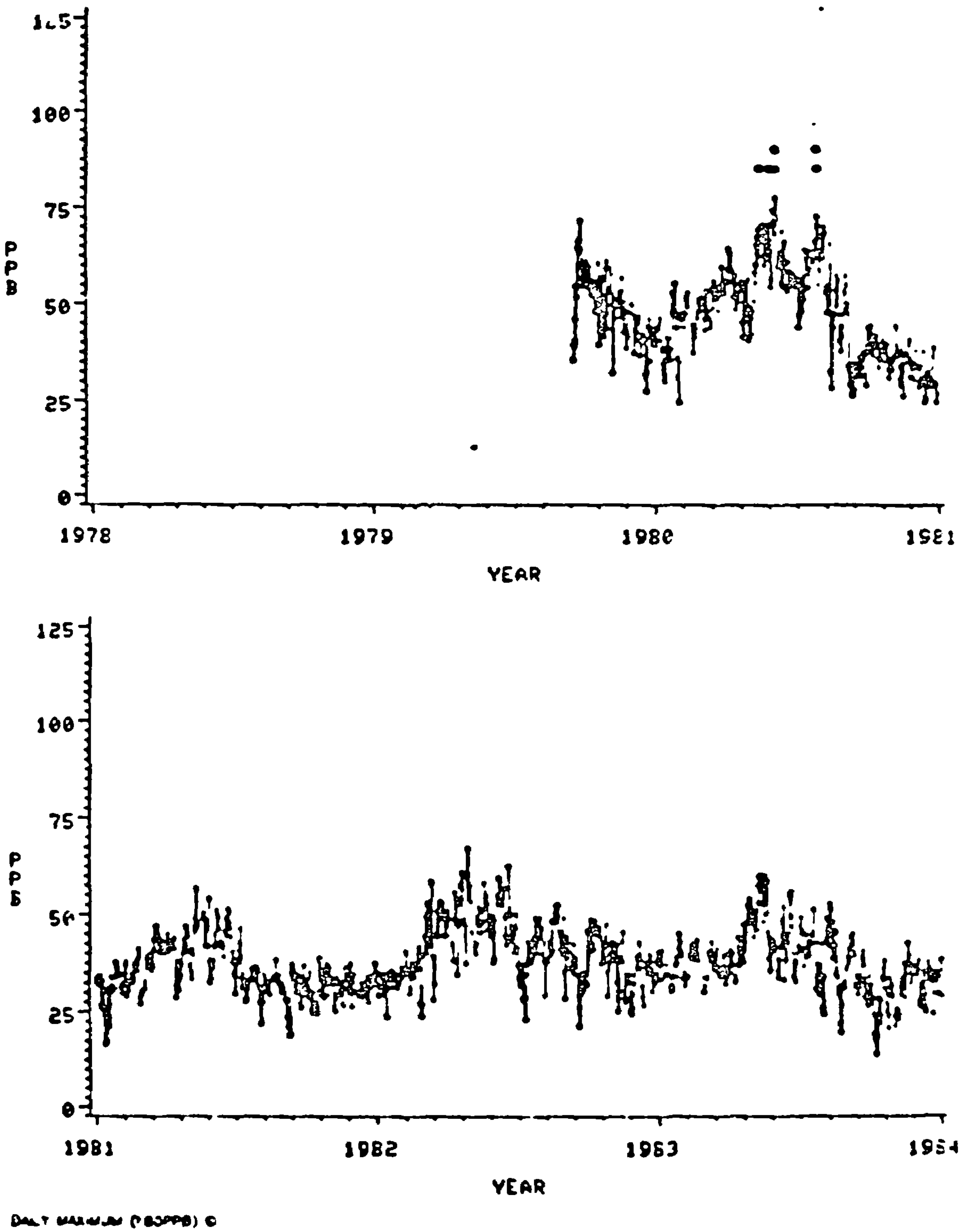

Figure 10. Daily Mean and Maximum (>80ppb) Ozone Concentration - Apache NF, AZ

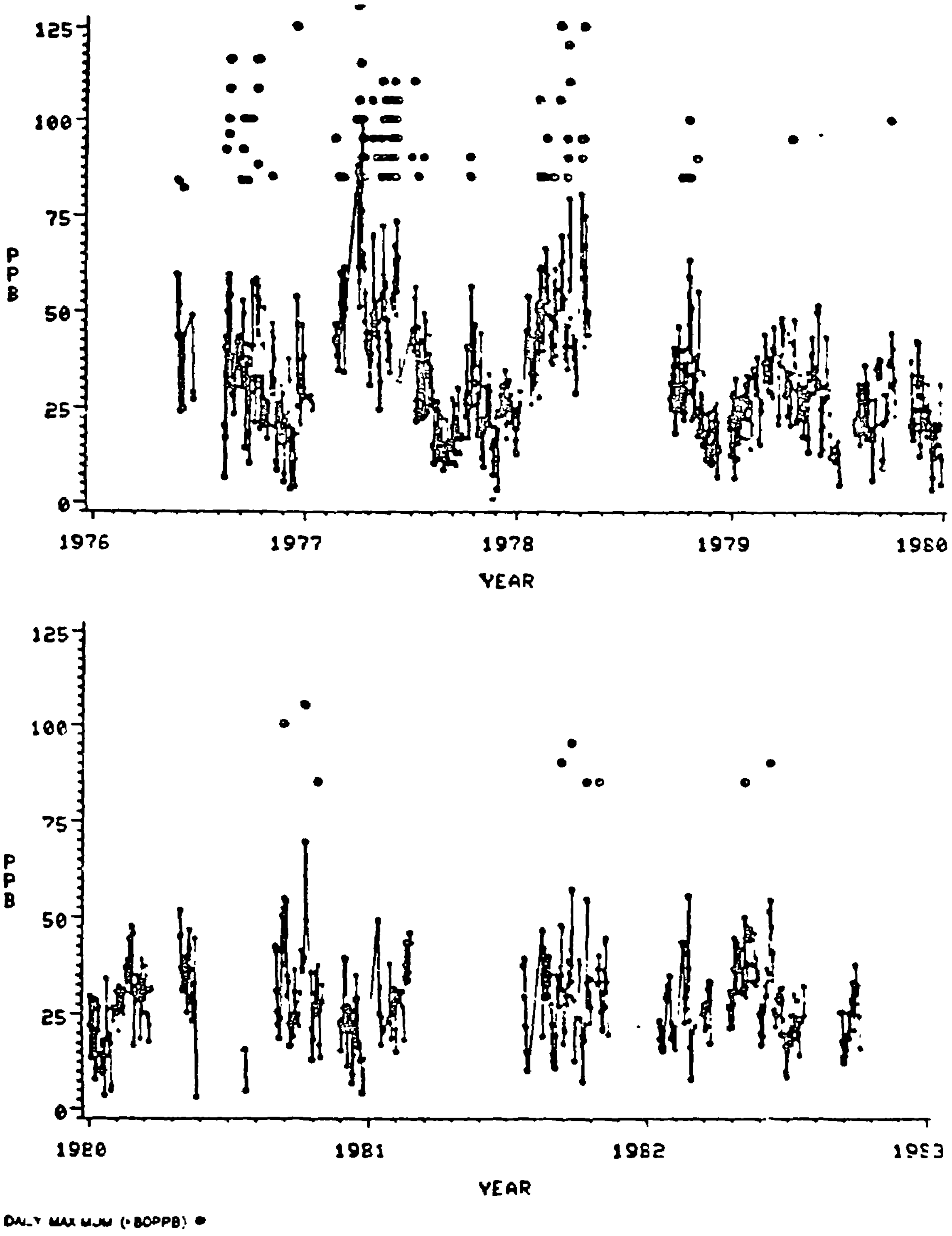

Figure 11. Daily Mean and Maximum (>80ppb) Ozone Concentration - Kisatchie NF, LA

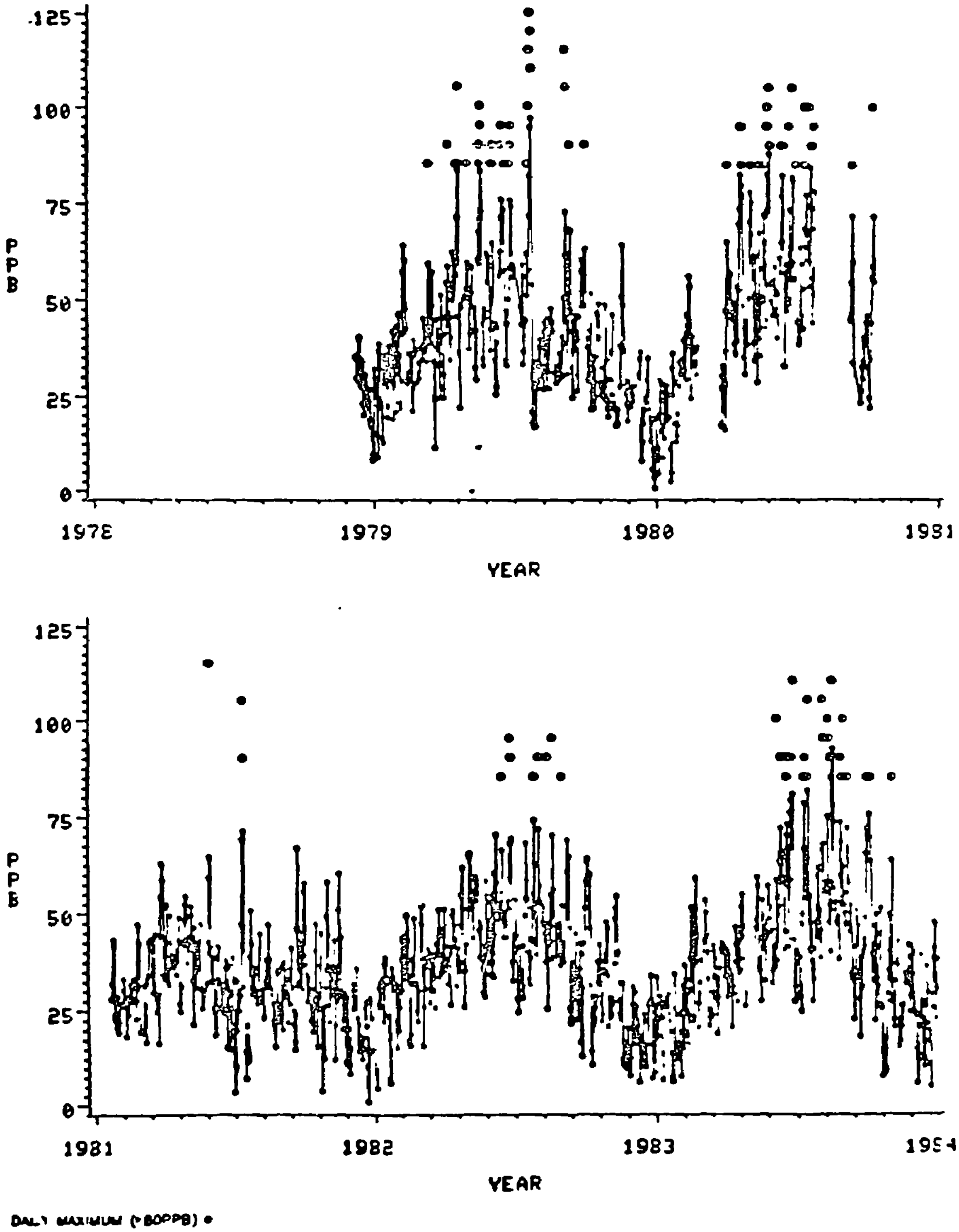

Figure 12. Daily Mean and Maximum (>80ppb) Ozone Concentration - Mark Twain NF, MO

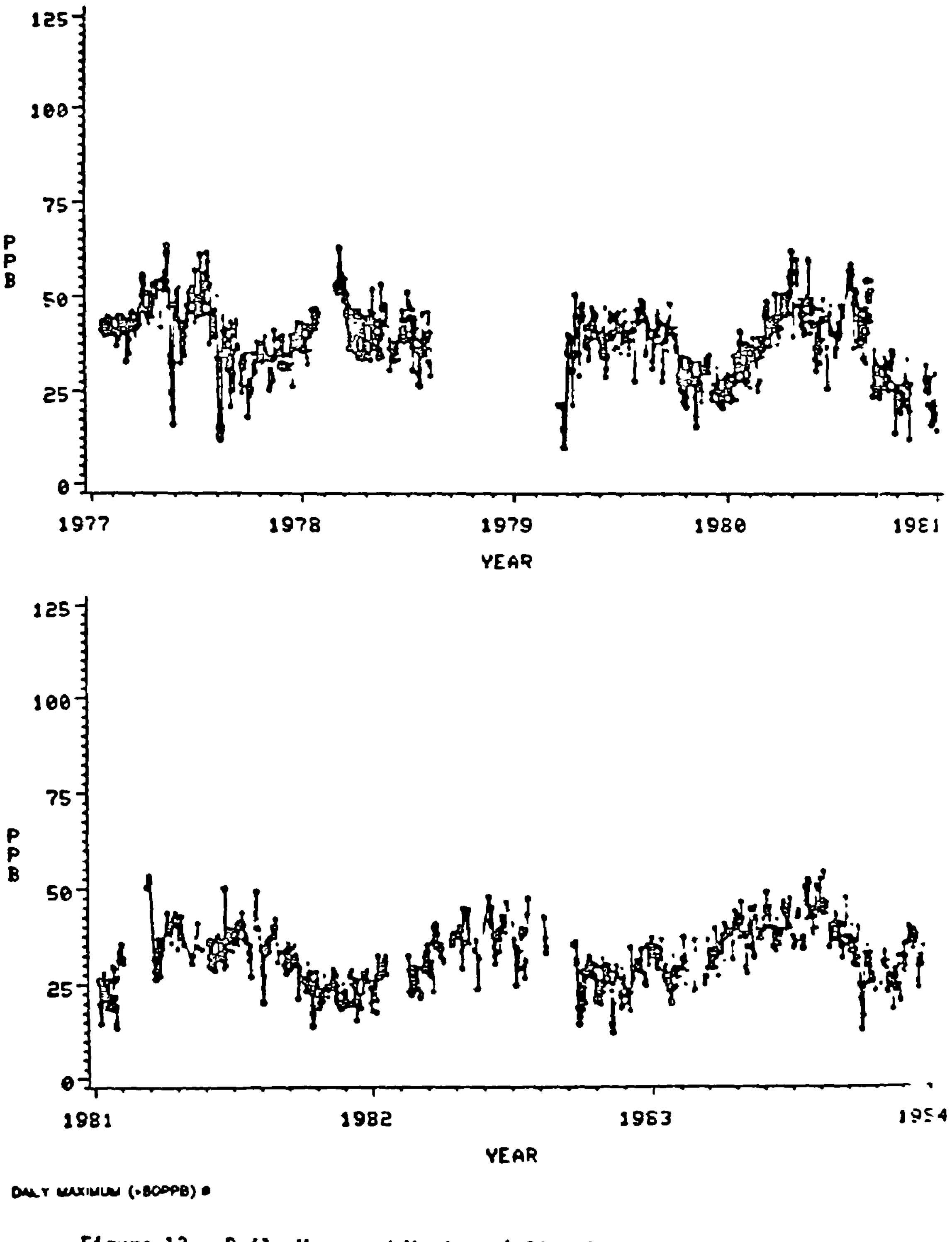

Figure 13. Daily Mean and Maximum (>80ppb) Ozone Concentration - Custer NF, MT

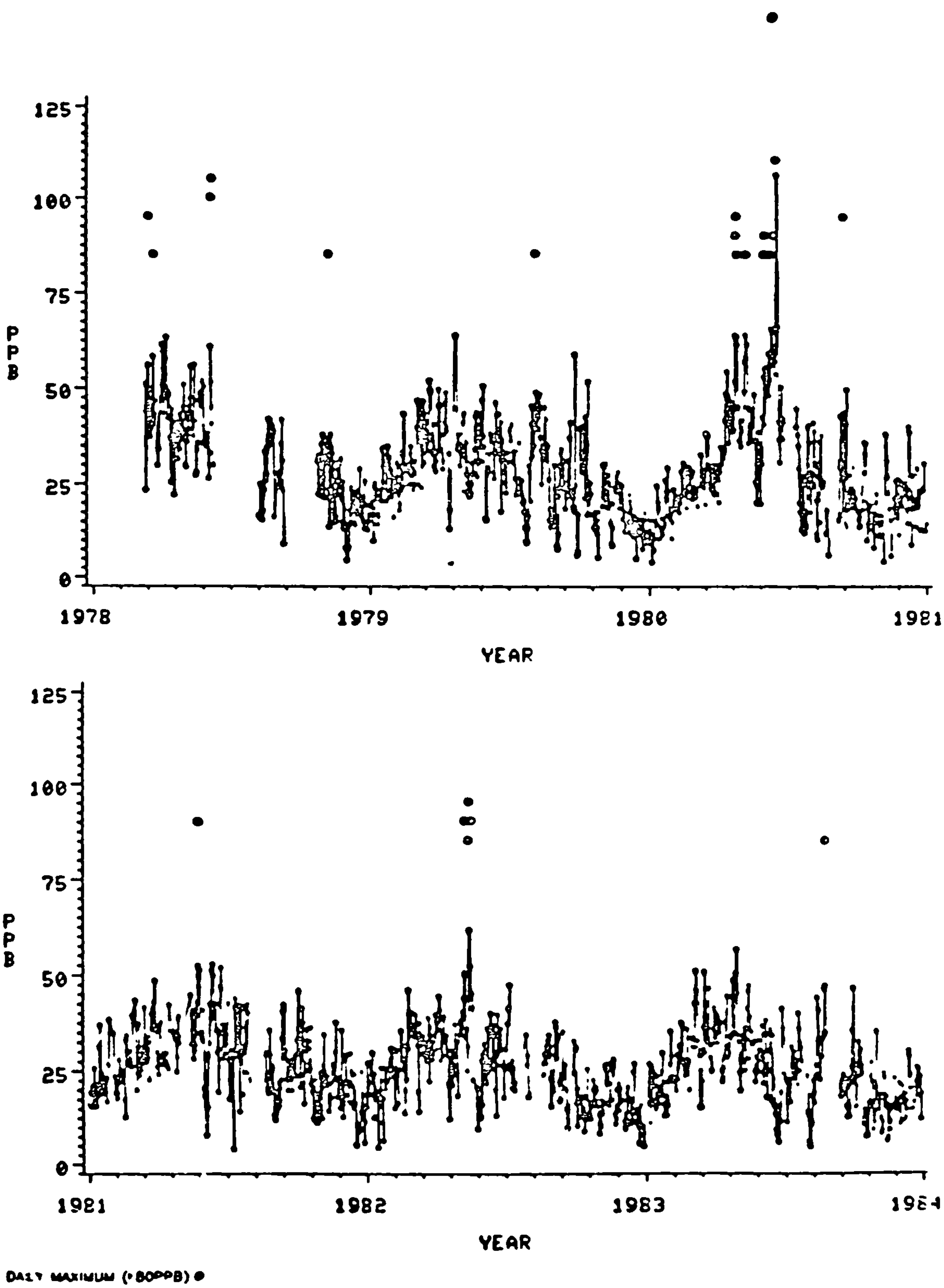

Figure 14. Daily Mean and Maximum (>80ppb) Ozone Concentration - Croatan NF, NC

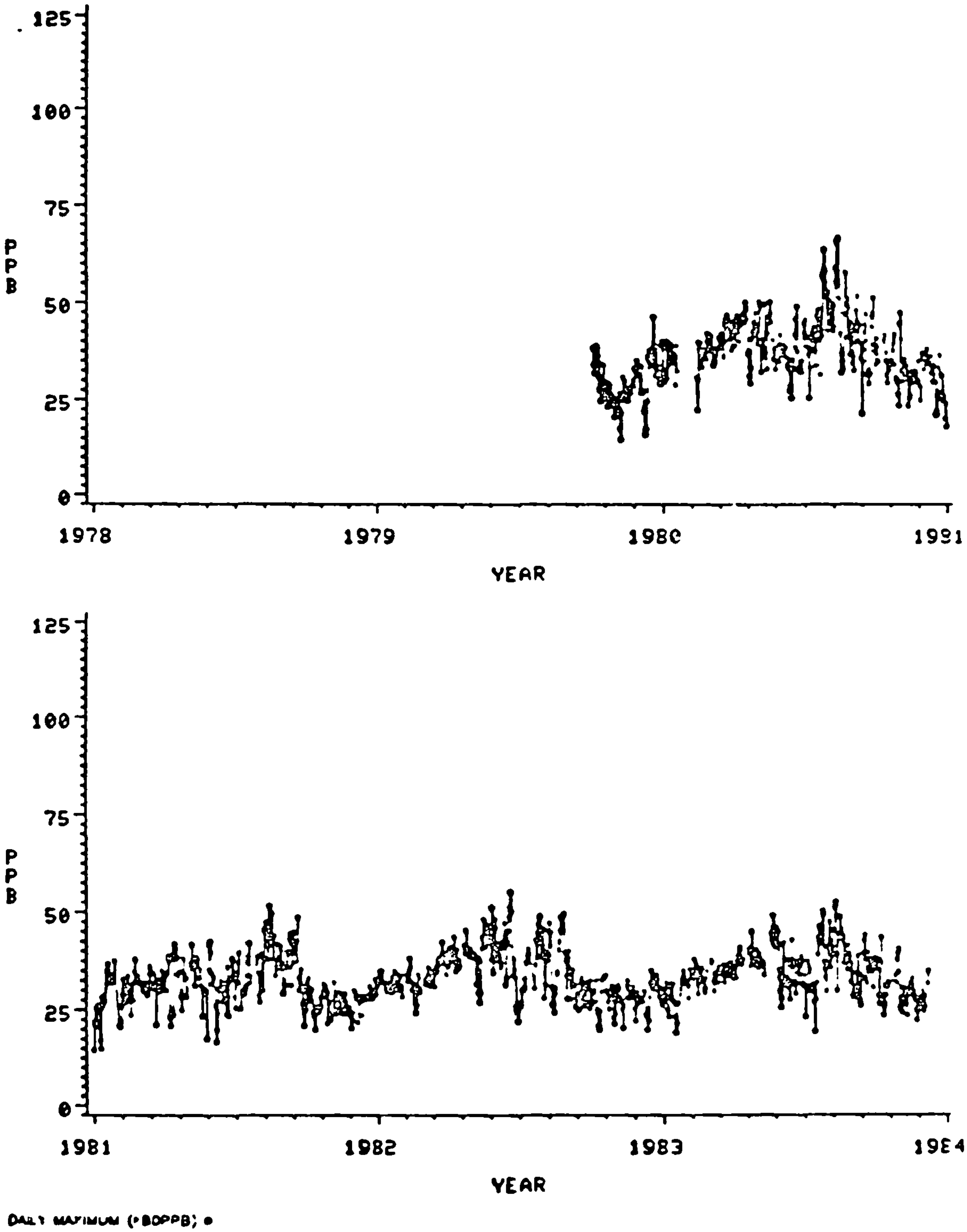

Figure 15. Daily Mean and Maximum (>80ppb) Ozone Concentration - Ochoco NF, OR

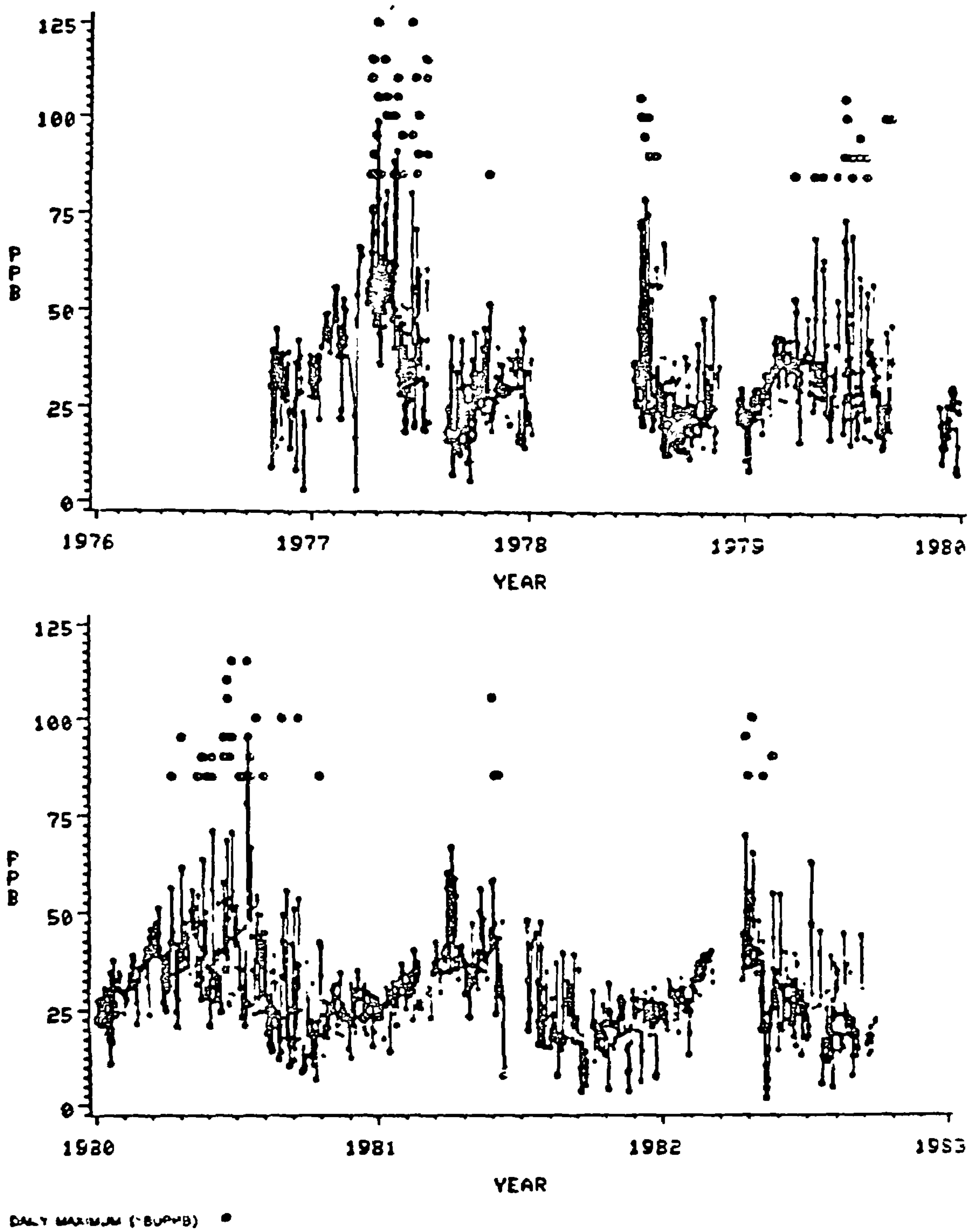

Figure 16. Daily Mean and Maximum (>80ppb) Ozone Concentration - Green Mountain NF, VT

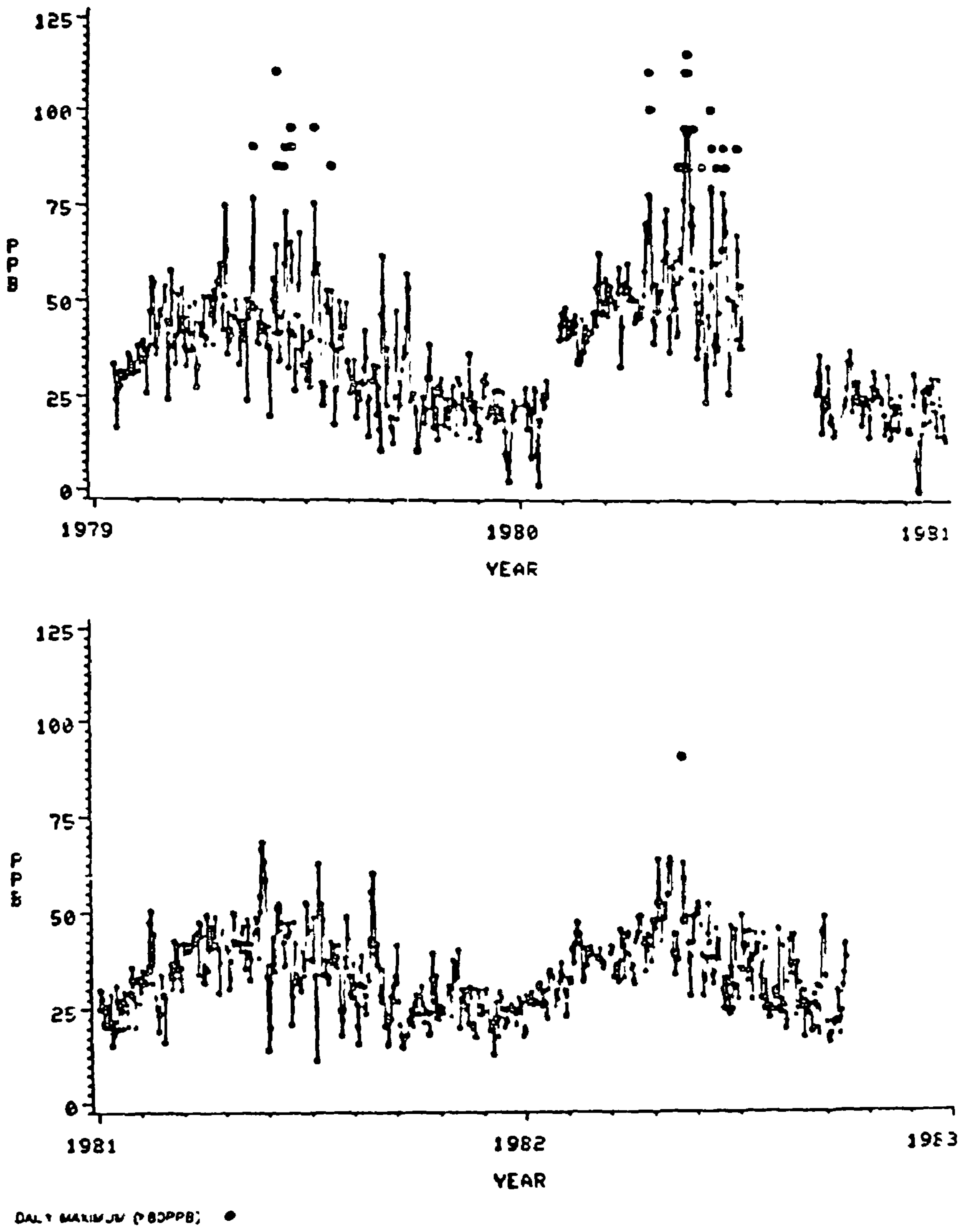

Figure 17. Daily Mean and Maximum (>80ppb) Ozone Concentration - Chequamegon NF, WI

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APPENDIX

TABLE A-1. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
APACHE,AZ NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	99%	Mean	Std.
79	3	338	40	60	65	70	75	80	56	12
	4	2059	35	50	55	60	60	65	48	9
80	1	1994	35	45	55	55	55	60	46	8
	2	2159	50	60	65	70	75	80	59	10
	3	2092	30	50	60	65	70	75	49	14
	4	2129	30	35	40	40	45	45	35	5
81	1	2030	30	35	40	45	45	50	35	7
	2	1960	35	45	50	50	55	60	43	7
	3	2108	25	35	35	40	40	45	32	6
	4	2200	25	30	35	35	40	45	32	5
82	1	1917	30	35	45	50	55	55	38	6
	2	1825	40	50	55	60	65	65	50	6
	3	2152	30	40	45	50	55	60	40	9
	4	2083	30	40	45	45	50	50	38	7
83	1	1646	35	40	40	45	45	50	38	4
	2	2027	35	45	55	55	60	65	45	9
	3	2055	25	35	45	50	50	60	37	9
	4	2125	25	35	35	40	40	45	32	6

TABLE A-2. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
KISATCHIE, LA NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	99%	Mean	Std
76	2	341	10	38	59	70	74	82	40	21
	3	981	12	32	56	68	84	100	37	24
	4	2126	5	25	40	52	64	91	28	19
77	1	479	25	40	60	80	85	100	45	20
	2	1680	20	50	75	90	95	110	53	25
	3	2138	5	20	45	55	65	80	26	20
	4	2208	5	20	35	45	50	75	25	15
78	1	1716	25	45	60	70	80	95	45	18
	2	488	25	50	70	80	90	116	57	22
	3	245	10	30	49	55	55	60	30	16
	4	1726	10	25	40	55	65	85	28	18
79	1	1991	15	30	35	45	50	60	28	12
	2	2003	10	30	40	50	55	65	29	15
	3	1409	5	20	40	50	55	60	25	16
	4	1590	10	20	35	45	50	70	24	14
80	1	1997	10	25	35	45	50	65	26	14
	2	492	15	35	50	55	65	80	35	16
	3	680	10	30	45	60	75	80	31	19
	4	1269	10	25	40	50	60	80	26	17
81	1	781	15	30	40	45	55	65	30	13
	3	1140	10	30	50	55	60	80	31	18
	4	770	10	25	45	55	65	80	30	18
82	1	910	10	25	35	45	50	65	26	12
	2	1670	10	30	50	55	65	76	33	18
	3	990	5	20	35	45	50	60	22	16
	4	79	5	25	40	50	55	55	27	16

TABLE A-3. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
MARK TWAIN,MO NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	97%	Mean	Std
78	4	536	15	25	35	35	40	45	26	10
79	1	2152	15	35	45	50	55	70	34	13
	2	2173	30	50	65	75	80	[illegible]	51	17
	3	2021	20	40	55	65	80	110	43	19
	4	2025	15	25	40	45	55	70	29	14
80	1	1474	10	30	40	45	50	60	27	13
	2	2174	35	55	70	80	85	95	55	17
	3	848	30	50	70	80	85	100	53	19
	4	226	20	45	58	65	75	97	44	18
81	1	1636	20	30	40	50	55	65	32	12
	2	2030	20	35	45	55	55	68	37	14
	3	2092	15	30	40	50	60	80	31	16
	4	2092	10	25	35	40	55	70	27	14
82	1	2079	15	35	40	45	50	60	34	12
	2	2115	30	45	60	65	70	80	47	14
	3	2136	25	45	55	65	70	85	44	16
	4	2162	10	25	35	45	55	70	27	14
83	1	2143	10	30	40	45	50	60	29	13
	2	1802	30	45	60	65	75	90	46	15
	3	2059	30	50	65	75	85	97	51	18
	4	2119	10	30	40	50	60	75	30	16

TABLE A-4. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
CUSTER,MT NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	99%	Mean	Std.
78	1	1457	35	45	50	55	60	65	45	8
	2	2095	30	40	50	50	55	60	40	9
	3	980	25	40	50	55	55	55	39	10
79	1	68	10	15	25	25	30	30	17	7
	2	2029	30	40	45	50	55	60	40	9
	3	2118	30	40	50	50	55	60	41	8
	4	2057	20	30	35	35	40	45	29	7
80	1	2159	25	35	40	45	50	55	35	8
	2	1873	35	45	55	55	60	70	46	10
	3	1959	25	40	50	55	60	65	40	12
	4	1763	15	25	30	35	35	40	25	7
81	1	1142	15	30	35	40	40	55	28	9
	2	1299	25	35	40	45	50	55	37	8
	3	1742	25	35	40	45	45	50	35	7
	4	2180	15	25	30	30	30	35	24	5
82	1	1416	20	30	35	40	40	45	29	6
	2	1279	25	40	45	50	50	55	38	8
	3	788	20	35	40	45	45	51	33	9
	4	2189	20	30	30	35	35	40	27	6
83	1	1890	25	35	35	35	40	45	30	6
	2	2166	30	40	45	50	50	55	39	8
	3	2144	30	40	50	50	55	60	40	9
	4	1767	20	30	35	40	40	40	30	7

TABLE A-5. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
CROATAN, NC NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	99%	Mean	Std
78	1	517	20	45	55	65	70	85	43	17
	2	1610	15	45	60	65	70	75	42	18
	3	565	5	25	50	60	70	75	30	20
	4	1611	5	20	30	40	40	55	22	13
79	1	2145	10	30	40	45	55	65	30	14
	2	1959	10	35	50	60	60	70	34	17
	3	2097	5	25	45	55	60	75	27	18
	4	2061	5	15	30	40	50	65	20	15
80	1	2034	10	20	30	35	40	50	22	11
	2	2046	20	45	60	70	80	100	45	21
	3	1614	5	20	40	55	60	75	26	18
	4	1950	5	20	30	35	40	55	20	12
81	1	1978	10	25	35	45	50	60	27	12
	2	1672	15	35	50	55	65	75	35	17
	3	1541	5	25	45	50	60	70	28	17
	4	2180	5	20	30	40	45	55	22	13
82	1	1904	10	25	35	45	50	55	27	13
	2	2034	10	30	45	55	60	80	31	16
	3	1102	5	25	40	50	55	60	28	16
	4	2055	5	15	25	30	35	45	17	11
83	1	2062	10	25	40	45	50	67	27	14
	2	2170	5	30	45	55	60	70	31	18
	3	1468	5	20	40	50	60	75	25	18
	4	2149	0	20	30	35	37	50	18	12

TABLE A-6. **Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)**
OCHOCO,OR NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	99%	Mean	Std.
79	4	2096	20	30	35	40	40	45	29	7
80	1	1555	30	40	45	45	50	50	39	6
	2	2115	30	40	50	50	55	55	40	8
	3	2079	30	45	50	55	60	70	43	11
	4	2007	25	35	35	40	45	50	32	7
81	1	1873	20	30	35	35	40	40	30	6
	2	1892	20	35	40	40	45	50	32	8
	3	1879	25	35	45	45	50	55	36	8
	4	2124	20	30	30	30	35	35	27	4
82	1	1779	30	35	35	40	40	45	33	4
	2	2069	30	40	45	50	55	55	39	8
	3	1985	25	35	45	45	50	55	35	9
	4	1960	20	30	30	35	35	35	28	5
83	1	2029	25	35	35	40	40	40	32	5
	2	1785	30	35	45	45	50	55	37	7
	3	2098	25	35	45	50	50	55	37	9
	4	1376	25	30	35	40	40	45	30	6

TABLE A-7. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
GREEN MT.,VT NATIONAL FOREST

		N	10%	50%	80%	90%	95%	99%	Mean	Std.
Year	QUARTER									
76	4	1058	14	30	40	40	45	50	29	12
77	1	968	25	40	50	55	65	70	40	13
	2	2031	20	55	70	85	100	120	51	26
	3	1297	5	25	40	50	60	85	27	19
	4	2187	15	30	40	45	50	65	30	13
78	1	104	25	35	40	40	45	45	34	7
	2	32	20	35	45	45	45	45	34	10
	3	2099	5	25	45	60	70	95	31	21
	4	1436	10	25	30	40	50	65	26	12
79	1	2159	20	30	40	45	45	55	31	10
	2	1932	15	35	50	65	75	85	37	19
	3	1533	5	30	45	60	70	85	31	20
	4	799	10	20	30	30	35	35	21	8
80	1	2172	20	30	40	45	45	60	32	10
	2	2156	15	40	60	65	80	90	41	21
	3	2117	5	30	50	60	70	95	32	22
	4	2129	10	25	30	35	35	50	24	10
81	1	1984	20	30	40	40	45	65	32	9
	2	1601	20	40	50	60	65	75	39	16
	3	1590	5	20	35	45	50	65	23	16
	4	2161	10	20	30	30	35	45	21	9
82	1	1466	20	30	35	40	40	45	30	7
	2	1869	5	35	45	55	65	85	32	19
	3	1875	5	20	35	50	55	70	24	17

TABLE A-8. Cumulative Frequency Distribution Table of NAPBN Ozone Data (PPB)
CHEQUAMEGON,WI NATIONAL FOREST

Year	QUARTER	N	10%	50%	80%	90%	95%	99%	Mean	Std.
78	3	1154	20	35	50	60	65	77	37	16
	4	1225	20	30	35	35	40	55	29	8
79	1	1665	25	35	45	55	60	70	38	11
	2	2027	30	45	55	65	75	90	47	14
	3	2079	15	30	45	55	60	75	34	14
	4	1913	15	25	30	30	30	40	22	7
80	1	1788	20	45	50	55	60	65	39	14
	2	2005	35	50	70	80	90	105	56	17
	3	523	15	30	45	55	65	90	33	16
	4	2011	15	25	30	30	35	40	23	8
81	1	2095	20	30	40	45	50	60	32	10
	2	2053	30	40	50	60	60	70	42	12
	3	1975	15	30	45	50	55	70	32	13
	4	1985	15	25	30	35	40	50	26	8
82	1	1921	25	35	40	45	45	50	34	8
	2	1987	30	40	50	60	65	70	43	12
	3	2154	15	30	40	45	50	60	31	12