EPA/450/5-79/010

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA 450 5-79-010
September 1979

Air

EPA

Existing Visibility Levels in the United States

Isopleth Maps of Visibility in Suburban/Nonurban Areas During 1974-76

EPA-450/5-79-010

Existing Visibility Levels in the United States

Isopleth Maps of Visibility in Suburban/Nonurban Area During 1974-76

by

John Trijonis and Dawn Shapland

Technology Service Corporation
Route 3, Box 124-K
Santa Fe, New Mexico 87501

Grant No. 802815

EPA Project Officer: John Bachmann (OAQPS)
William E. Wilson and Thomas G. Ellestad (ESRL)

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

September 1979

This report has been reviewed by the Strategies and Air Standards Division of the Office of Air Quality Planning and Standards, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of EPA. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U. S. Environmental Protection Agency, Research Triangle Park, N. C. 27711, or from National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.

Publication No. EPA-450/5-79-010

ABSTRACT

Maps are prepared which illustrate median, mid-day visibility levels in suburban/nonurban locations of the continental United States. Median visibilities at 94 locations are determined from cumulative frequency distributions of quality-checked airport observations. Seven locations in the Southwest with photographic photometry or nephelometry data (which agree quite well with the airport data) are also included.

The spatial pattern of visibility is demonstrated with isopleth maps for both the annual medians and summertime medians during the years 1974 - 1976. The consistency of the spatial gradients in visibility and the agreement between neighboring locations attest to the quality of the visibility data. The isopleth maps reveal that the best visibility (70+ miles) occurs in the mountainous Southwest. Visibility is also quite good (45 - 70 miles) north and south of that region, but sharp gradients occur to the east and west of that region. Most of the area east of the Mississippi and south of the Great Lakes exhibits median visibilities of less than 15 miles annually and less than 10 miles during the summertime.

This report was submitted in partial fulfillment of Grant 802815 by Technology Service Corporation under the sponsorship of the U.S. Environmental Protection Agency. Work on this project started in May 1978 and was completed in September 1978.

CONTENTS

FIGURES

TABLE

CHAPTER 1

INTRODUCTION

A growing air quality concern in the United States is the issue of visibility or haze. In the west -- where the high mountians, rugged terrain, and exceptional visual range often produce exceptional panoramas -- there is apprehension that increased haze may deteriorate both scenic vistas and the blueness of the sky. In the east, where visibility is usually quite low, the concerns involve not only aesthetics but also hindrance of aviation (Miller et al., 1972) and possible climate modifications (Bolin and Charleson, 1976; Husar and Patterson, 1978; Trijonis and Yuan, 1978b) produced by large-scale haze. Some of these concerns are reflected in the visibility provisions of the 1977 Clean Air Act Amendments.

Because of the growing interest in the visibility issue, there is a need to address the very basic question "What are existing visibility levels throughout the United States?" Some partial answers to this question have already been provided. Trijonis and Yuan (1978a, 1978b) examined existing visibility levels and long-term visibility trends in urban and nonurban areas, but these studies only covered the Rocky Mountain Southwest and part of the Northeast. Husar et al. (1976) have constructed a very interesting isopleth map for the United States, but this map involves only summertime data (June-August in 1975), is stratified for relative humidity (thus being more concerned with air quality impacts on visibility rather than typical or average visibility), and provides no resolution above 16 miles (thus characterizing the east very well but having essentially no resolution in the west).

The purpose of this report is to prepare an isopleth map illustrating large-scale patterns in median visibility* throughout the United States.

---

*In this report, the terms "visibility" and "visual range" will be used interchangeably, both referring to the distance at which a black object can just be distinguished against the horizon sky. Actually, at many times and in many places, there are no objects within line of sight at distances as great as the prevailing visibility. The term visibility actually refers to a <u>hypothetical</u> case -- the distance at which a black object <u>would</u> just be distinguished against the horizon sky, <u>if</u> such an object were within a line of sight

Three recent years (1974-1976) of mid-day airport observations are used in order to provide a robust data set. Maps of visibility are prepared for both the yearly median and the third quarter (July-September) median. The data are quality checked and processed in a way that permits resolution of visibility from 0 to 90 miles. Only suburban/nonurban airports are included to avoid the perturbations in visibility that are sometines produced by major urban centers.

The remainder of this report is organized in two chapters. Chapter 2 discusses the data bases used and the methods of data analysis. Chapter 3 presents visibility maps and includes a brief narrative describing the nationwide patterns in visibility.

CHAPTER 2

DATA BASE ASSEMBLY AND DATA ANALYSIS METHODS

The objective of this report is to characterize existing visibility levels in suburban/nonurban locations of the continental United States. Before presenting our findings, it is worthwhile to review the data bases and statistical methods which serve as the foundation for those findings. This chapter describes the data bases used and the analysis methods applied.

SELECTION OF STUDY LOCATIONS AND ACQUISITION OF DATA

Most of the data presented in this report consists of mid-day* "prevailing visibility" observations made by airport meteorologists from 1974 through 1976. A single, near-noon hour is used each day because much of the data were obtained in hard copy, and limiting the analysis to one hour per day saved considerable work in hand-processing such data. Three years, 1974-1976, are included in order to provide a robust data set for determining existing visibility levels.

Before sites were selected for the study, telephone surveys pertaining to data quality were conducted with the meteorologists at approximately 150 suburban/nonurban airports. The purpose of these surveys was to insure that each airport had an adequate set of visibility markers for estimating visual range. In particular, we attempted to select airports that had farthest markers located at distances at least as great as the visibility levels typical of the surrounding area. Most of the airports selected do have good markers. In some cases, however, we were forced to use airports with less than optimal markers in order to attain good geographical coverage in the study; for these cases we had to extrapolate the cumulative frequency distributions in order to estimate median visual range (see discussion in next section).

*The National Climatic Center computerized data base contains observations for every third hour. We selected the 1:00 PM (Standard Time) measurement for the Eastern Time Zone, the 12:00 AM measurement for the Central Time Zone, the 11:00 AM measurement for the Mountain Time Zone, and the 1:00 PM measurement for the Pacific Time Zone.

Suburban/nonurban locations are chosen for the study because we intend to characterize large-scale patterns in visibility and to avoid the localized perturbations that are sometines produced by major metropolitan areas. Some readers may question whether a few of our study sites -- in particular Long Beach, Tucson, Oklahoma City, Memphis, Columbus, Dayton, and Charlotte -- are really suburban or nonurban. Our response to this question is as follows:

- The Long Beach airport is actually located in a major metropolitan region. We included this site so that we would have at least one location representing the large area covered by the Los Angeles basin.
- The Tucson airport is located about 9 miles south of downtown Tucson, and all of the principal visibility markers are located to the south and east of the airport. Furthermore, a previous study (Trijonis and Yuan, 1978a) demonstrated that median visibility at Tucson tends to be slightly higher than median visibility at Fort Huachuca, a nonurban location about 50 miles to the southeast of Tucson.
- The other five sites in question are all located in the eastern half of the country where nonurban visibility is low, and where even large metropolitan areas do not appear to produce great perturbations in visibility (Trijonis and Yuan, 1978b). Also, all of these airports are located several miles from the center-city and outside the urbanized area.

Ninety-four airports are included in the present study. To provide better coverage in the Southwest, we have also added photographic photometry and/or nephelometry data taken in special field studies at 7 nonurban locations. That the various types of data are fairly comparable (at least on the average) is evidenced by the following median noontime visibilities obtained in the vicinity of the northern Colorado-Utah border:

Airport Data:	Grand Junction, CO	84 miles
	Rock Springs, WY	76 miles
Photographic Photometry Data:	Cedar Mountain, UT. . . .	74 miles
	Piceance Creek, CO. . . .	70 miles
Nephelometry Data:	Bonanza, UT.	81 miles
	Cedar Mountain, UT	75 miles

There is a question, however, concerning the time coverage of the field study data. The photographic photometry and nephelometry data usually are taken intermittently over a one-year period. We have included special field data only if they cover at least part of 1974-1976, but there is no guarantee that these data adequately represent the entire 3-year period.

The 101 study locations are illustrated in Figure 1. The full site names are given later in the next section (Table 1). The locations of the special field studies are indicated by a superscript, "p" for photographic photometry and "n" for nephelometry.

COMPUTATION OF MEDIAN VISIBILITIES

Airport visibility measurements are most appropriately summarized by cumulative frequency distributions of the form "percent of time visibility is greater than or equal to X miles". This is because, in practice, an airport visibility observation of X miles often means that visibility is at least X miles rather than visibility is exactly X miles. It is also very important, in determining the cumulative frequency distributions, to use only those visibilities that are routinely reported by the airport observation team; otherwise, artificial "kinks" will be produced in the cumulative frequency distribution. Summarizing the data this way should also make the data consistent from airport to airport, even if the various airports have visibility markers at different distances.

Figure 2 presents examples of cumulative frequency distributions for four locations which vary widely in observed visibilities. As is the case with the four locations illustrated in Figure 2, most of the median visibilities are determined by linear interpolation of the cumulative frequency distribution. In some cases, however, the frequency distribution required extrapolation in order to reach the median visibilities. The form of these extrapolations, linear or nonlinear, was based on a comparison of the distribution for the site in question with distributions for other sites located in the same region of the country. For sites where these extrapolations involve significant uncertainties, the uncertainties are noted throughout this report by asterisks placed on the estimated median visibilities.

The visibility data reported here are based on all observations, with no sorting for meteorology. Thus, the spatial patterns in visibility are

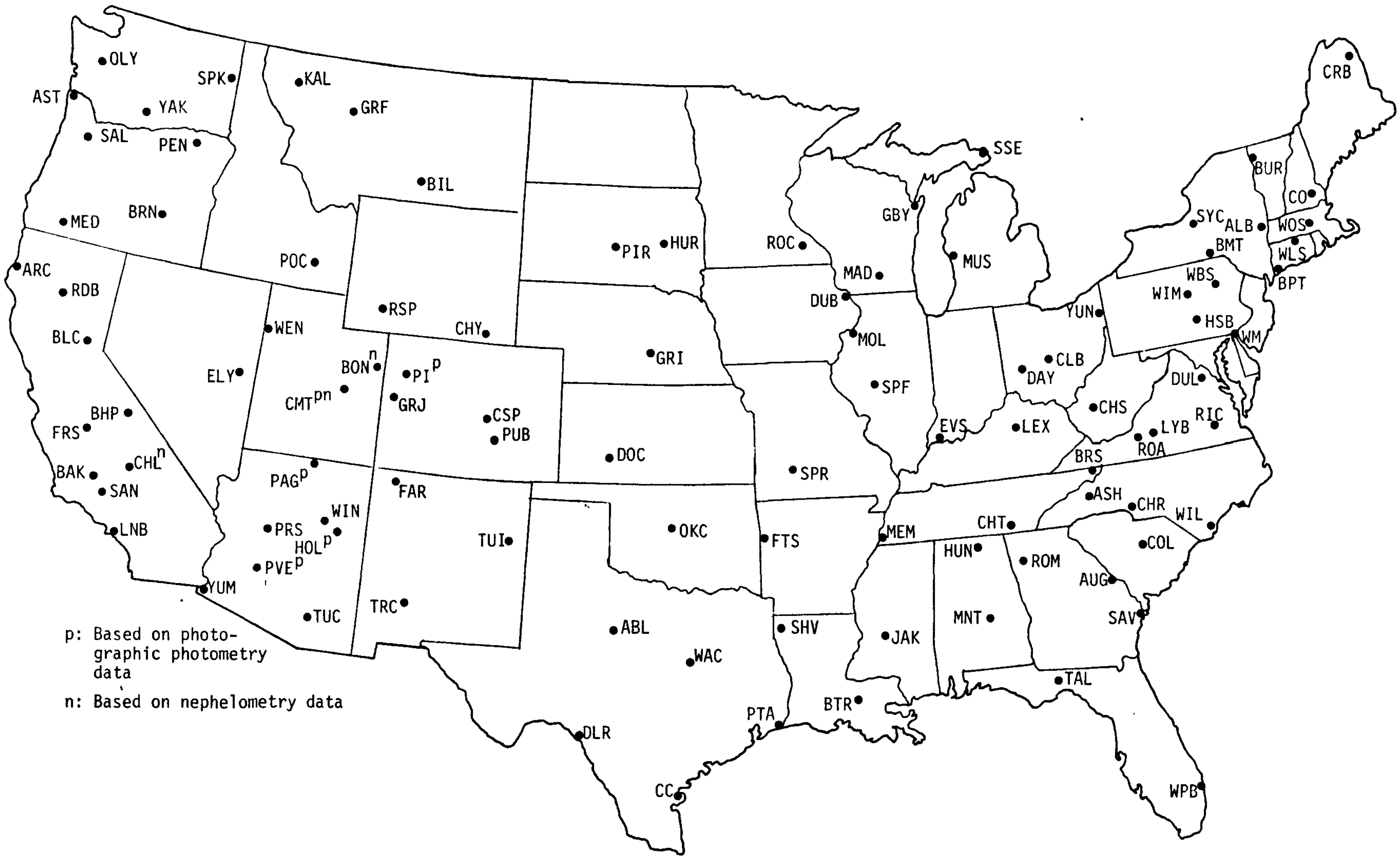

Figure 1. Locations used to characterize visibility in suburban/nonurban areas, (See Table I for full names of locations).

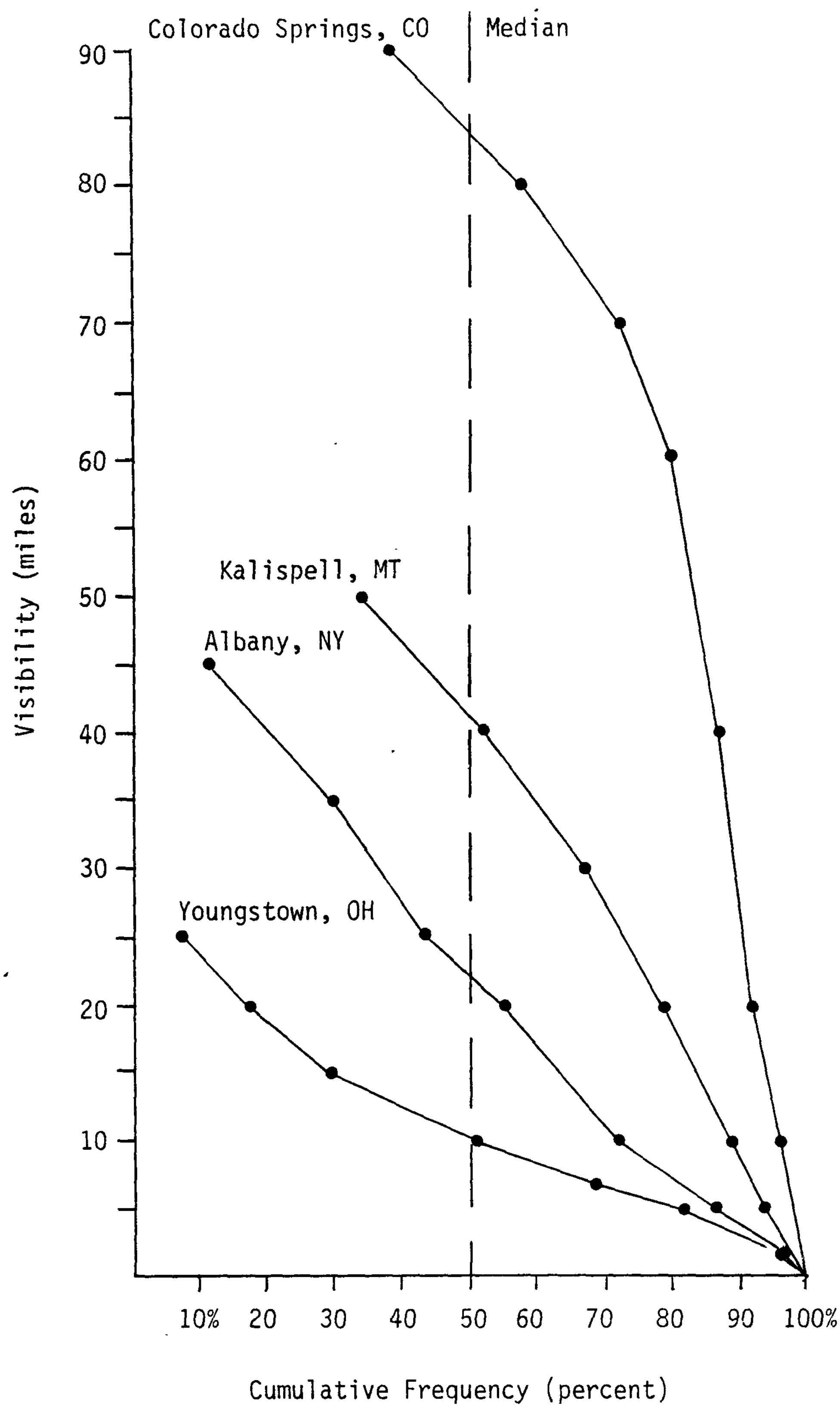

Figure 2. Examples of cumulative frequency distributions, (mid-day data, 1974 - 1976).

due to both climatological variations and air quality variations. Because a previous report (Trijonis and Yuan, 1978b) noted a substantial increase in haze within the Northeast during the summer quarter (July, August, and September), visibility maps have been prepared for the third quarter as well as for the entire year.

Table 1 lists the 101 study locations and the median visibilities for 1974-1976. Special remarks are made to note locations which involved photographic photometry data, nephelometry data, or extrapolation of the frequency distribution. The remarks also note those locations which significantly changed reporting practices during 1975 in response to the National Weather Service directive that visibility could be estimated out to a distance twice as far as the farthest marker. For those locations changing reporting practices in 1975, an overall median visibility is determined by averaging the medians for the 1974 and 1976 data.

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
ALABAMA		
Huntsville (HUN)	17	
Montgomery (MNT)	9	
ARIZONA		
Holbrook (HOL)	68[P]	Photographic photometry data for 1973-1974 provided by Arizona Public Service Company. Data are described by Roberts et al. (1975).
Page (PAG)	72[P]	Photograohic photometry data for 1974 provided by the Salt River Project.
Palo Verde (PVE)	55[P]	Photographic photometry data for 1975-1976 provided by Arizona Public Service Company. Data are described by APSC (1976).
Prescott (PRS)	80*	Based on uncertain nonlinear extrapolation of frequency distribution.
Tucson (TUC)	60	
Winslow (WIN)	80*	Based on uncertain nonlinear extrapolation of frequency distribuiton.
Yuma (YUM)	59	
ARKANSAS		
Fort Smith (FTS)	22	
CALIFORNIA		
Arcata (ARC)	15	
Bakersfield (BAK)	14	
Bishop (BHP)	90*	Involves uncertain nonlinear extrapolation of the frequency distribuiton.
Blue Canyon (BLC)	46	
China Lake (CHL)	50[N]	Nephelometry data for 1975-1976 provided by Tom Dodson of the China Lake Naval Weapons Center.

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
Fresno (FRS)	13	
Long Beach (LNB)	11	
Red Bluff (RDB)	61	
Sandberg (SAN)	49	
COLORADO		
Colorado Springs (CSP)	90	
Grand Junction (GRJ)	84	
Piceance Creek (PI)	70^{P}	Photographic photometry data for 1975-1976 provided by Occidental Shale Oil (C-b Shale Oil Venture, 1977).
Pueblo (PUB)	77	
CONNECTICUT		
Bridgeport (BPT)	15	
Windsor Locks (WLS)	19	
DELAWARE		
Wilmington (WM)	15	
FLORIDA		
Tallahassee (TAL)	12	Reporting practices change in 1975. Non-linear extrapolation of 1974 distribution yields a 13 mile median; interpolation of 1976 distribution yields an 11 mile median.
West Palm Beach (WPB)	15	Reporting practices change in 1975. Non-linear extrapolation of 1974 distribution yields a 16 mile median; interpolation of 1976 distribution yields a 15 mile median.
GEORGIA		
Augusta (AUG)	11	
Rome (ROM)	12	Reporting practices change in 1975. Interpolation of 1974 distribuiton yields an 11 mile median; interpolation of 1976 distribution yields a 14 mile median.

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
Savannah (SAV)	16	Reporting practices change in 1975. Non-linear extrapolation of 1974 distribution yields a 13 mile median; interpolation of 1976 distribution yields a 19 mile median.
IDAHO		
Pocatello (POC)	39	
ILLINOIS		
Moline (MOL)	13	
Springfield (SPF)	11	Reporting practices change in 1975. Linear extrapolation of 1974 distribuiton yields a 9 mile median; interpolation of 1976 distribution yields a 13 mile median.
INDIANA		
Evansville (EVS)	10	
IOWA		
Dubuque (DUB)	19	
KANSAS		
Dodge City (DOC)	29*	Involves uncertain linear extrapolation of frequency distribution.
KENTUCKY		
Lexington (LEX)	11	Data available only for 1975 and 1976.
LOUISIANA		
Baton Rouge (BTR)	9	
Shreveport (SHV)	11	Reporting practices change in 1975. Interpolation of 1974 distribution yields an 11 mile median; interpolation of 1976 distribution yields a 12 mile median.
MAINE		
Caribou (CRB)	33	Involves linear extrapolation of frequency distribution.

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
MASSACHUSETTS		
Worchester (WOS)	18	
MICHIGAN		
Muskegeon (MUS)	11	Reporting practices change in 1975. Linear extrapolation of 1974 distribution and interpolation of 1976 distribution both yield 11 mile medians.
Sault St. Marie (SSE)	17	Reporting practices change in 1975. Interpolations of 1974 and 1976 distributions both yield 17 mile medians.
MINNESOTA		
Rochester (ROC)	16	Reporting practices change in 1975. Linear extrapoation of 1974 distribution yields a 16 mile median; interpolation of 1976 distribution yields a 17 mile median.
MISSISSIPPI		
Jackson (JAK)	13	
MISSOURI		
Springfiled (SPR)	17	Involves linear extrapolation of frequency distribution.
MONTANA		
Billings (BIL)	60	
Great Falls (GRF)	65	Reporting practices change in 1975. Interpolation of 1974 distribution yields a 64 mile median; interpolation of 1976 distribution yields a 67 mile median.
Kalispell (KAL)	41	
NEBRASKA		
Grand Island (GRI)	22	Reporting practices change in 1975. Linear extrapolation of 1974 distribution yields a 24 mile median; interpolation of 1976 distribution yields a 21 mile median.

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
NEVADA		
Ely (ELY)	65*	Based on uncertain nonlinear extrapolation of frequency distribuiton.
NEW HAMPSHIRE		
Concord (CO)	37	Involves linear extrapolation of frequency distribution.
NEW MEXICO		
Farmington (FAR)	80	Involves nonlinear extrapolation of frequency distribution.
Truth or Consequences (TRC)	70*	Involves uncertain nonlinear extrapolation of frequency distribution.
Tucumcari (TUI)	45*	Involves uncertain linear extrapolation of frequency distribution.
NEW YORK		
Albany (ALB)	22	
Binghampton (BMT)	17	
Syracuse (SYC)	13	
NORTH CAROLINA		
Asheville (ASH)	18	Reporting practices change in 1975. Interpolation of 1974 distribution yields a 17 mile median; interpolation of 1976 distribution yields a 20 mile median.
Charlotte (CHR)	12	
Wilmingotn (WIL)	10	Reporting practices change in 1975. Interpolations of 1974 and 1976 distributions both yield 10 mile medians.
OHIO		
Columbus (CLB)	11	Reporting practices change in 1975. Interpolation of 1974 distribution yields a 10 mile median; interpolation of 1976 distribution yields a 12 mile median,

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
Dayton (DAY)	10	Reporting practices change in 1975. Linear extrapolation of 1974 distribution yields a 9 mile median; interpolation of 1976 distribution yields a 12 mile median.
Youngstown (YUN)	10	
OKLAHOMA		
Oklahoma City (OKC)	17	Reporting practices change in 1975. Linear extrapolation of 1974 distribution and interpolation of 1976 both yield 17 mile medians.
OREGON		
Astoria (AST)	17	
Burns (BRN)	65	Based on linear extrapolation of frequency distribution.
Medford (MED)	25	
Pendleton (PEN)	29	
Salem (SAL)	23	
PENNSYLVANIA		
Harrisburg (HSB)	13	
Wilkes-Barre (WBS)	19	
Williamsport (WIM)	17	Reporting practices change in 1975. Interpolation of 1974 distribution yields a 17 mile median; interpolation of 1976 distribution yields a 16 mile median.
SOUTH CAROLINA		
Columbia (COL)	14	
SOUTH DAKOTA		
Huron (HUR)	20	
Pierre (PIR)	45*	Reporting practices change in 1975. Uncertain nonlinear extrapolations of 1974 and 1976 distributions yield 40 and 50 mile medians, respectively.

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
TENNESSEE		
Bristol (BRS)	14	
Chattanooga (CHT)	13	
Memphis (MEM)	11	Reporting practices change in 1975. Interpolation of 1974 distribution yields a 10 mile median; interpolation of 1976 distribution yields a 12 mile median.
TEXAS		
Abilene (ABL)	36	Reporting practices change in 1975. Interpolation of 1974 distribution and linear extrapolation of 1976 distribution both yield 36 mile medians.
Corpus Christi (CC)	15	
Del Rio (DLR)	34	Reporting practices change at end of 1975. Interpolation of 1974/1975 distribution yields a 35 mile median; interpolation of 1976 distribution yields a 33 mile median.
Port Arthur (PTA)	18	
Waco (WAC)	16	
UTAH		
Bonanza (BON)	81^{N}	Nephelometry data for 1975-1976 provided by Aerovironment Inc. Data are described by Tombach and Chan (1977).
Cedar Mountain (CMT)	74^{PN}	Photographic photometry and nephelometry data for 1976-1977 provided by NOAA Environmental Research Laboratories (Allee et al. 1978). The photographic photometry data yield a 74 mile median; the nephelometry data yield a 75 mile median.
Wendover (WEN)	80^{*}	Involves uncertain nonlinear extrapolation of frequency distribution; data are available only for 1974 and 1975.
VERMONT		
Burlington (BUR)	23	

TABLE I. LIST OF STUDY SITES AND MEDIAN YEARLY VISIBILITIES (Cont'd)

STATE, Site	Median Mid-Day Visibility (miles)	REMARKS
VIRGINIA		
Dulles (DUL)	17	
Lynchburg (LYB)	21	
Richmond (RIC)	10	Reporting practices change in 1975. Interpolation of 1974 distribution yields a 10 mile median; interpolation of 1976 distribution yields an 11 mile median.
Roanoke (ROA)	31	
WASHINGTON		
Olympia	29	
Spokane (SPK)	36	Involves linear extrapolation of frequency distribution.
Yakima (YAK)	47	
WEST VIRGINIA		
Charleston (CHS)	10	Reproting practices change in 1975. Interpolation of 1974 distribution yields a 9 mile median; interpolation of 1976 distribution yields a 10 mile median.
WISCONSIN		
Green Bay (GBY)	16	
Madison (MAD)	16	
WYOMING		
Cheyenne (CHY)	64	
Rock Springs (RSP)	76	

CHAPTER 3

VISIBILITY ISOPLETH MAPS

This chapter presents maps which illustrate the nationwide patterns in yearly and summertime visibility. Three types of map are presented: maps indicating median visibilities at individual locations, maps illustrating isopleths drawn to these data, and shaded isopleth maps. This chapter also provides a brief analysis of the maps; this analysis, however, is only of a descriptive nature. To perform a causal analysis explaining the visibility patterns would require considerably more work, such as examination of spatial emission patterns, scrutiny of climatological patterns, study of nonurban air quality data, and stratification of the visibility data into fixed meteorological classes.

MEDIAN YEARLY VISIBILITIES, 1974 - 1976

Figure 3 presents the median yearly visibilities for the 101 study sites, plotted at the locations of those sites. Figure 4 illustrates isopleths drawn to the data, and Figure 5 provides a shaded isopleth map.

The quality of the visibility data is evidenced in Figures 3 and 4 by the monotonic trends that often exist in passing from areas of poor visibility to areas of good visibility, and by the consistency of the readings at many neighboring stations even at distances of a few hundred miles. As prime examples of monotonic spatial trends, we note the following: on a straight line from Concord, NH to Charleston, WV, one encounters a sequence of data points of 37 miles, 22 miles, 19 miles, 12 miles, and 10 miles; continuing on another straight line from Charleston, WV to Rock Springs, WY, the sequence of data points proceeds as 10 miles, 11 miles, 22 miles, 64 miles, and 76 miles. As examples of consistency, we note that the 8 stations within 300 miles of the central Indiana/Ohio border all record visibilities of 10 or 11 miles, and that the 8 stations within 200 miles of Grand Junction, CO all record visibilities of 70 to 84 miles. There are some sites where visibility appears to be anomalous compared to the general patterns, but these sites are few in number, and the aberrations are usually minor.

Figure 3. Median yearly visibilities at suburban/nonurban locations.

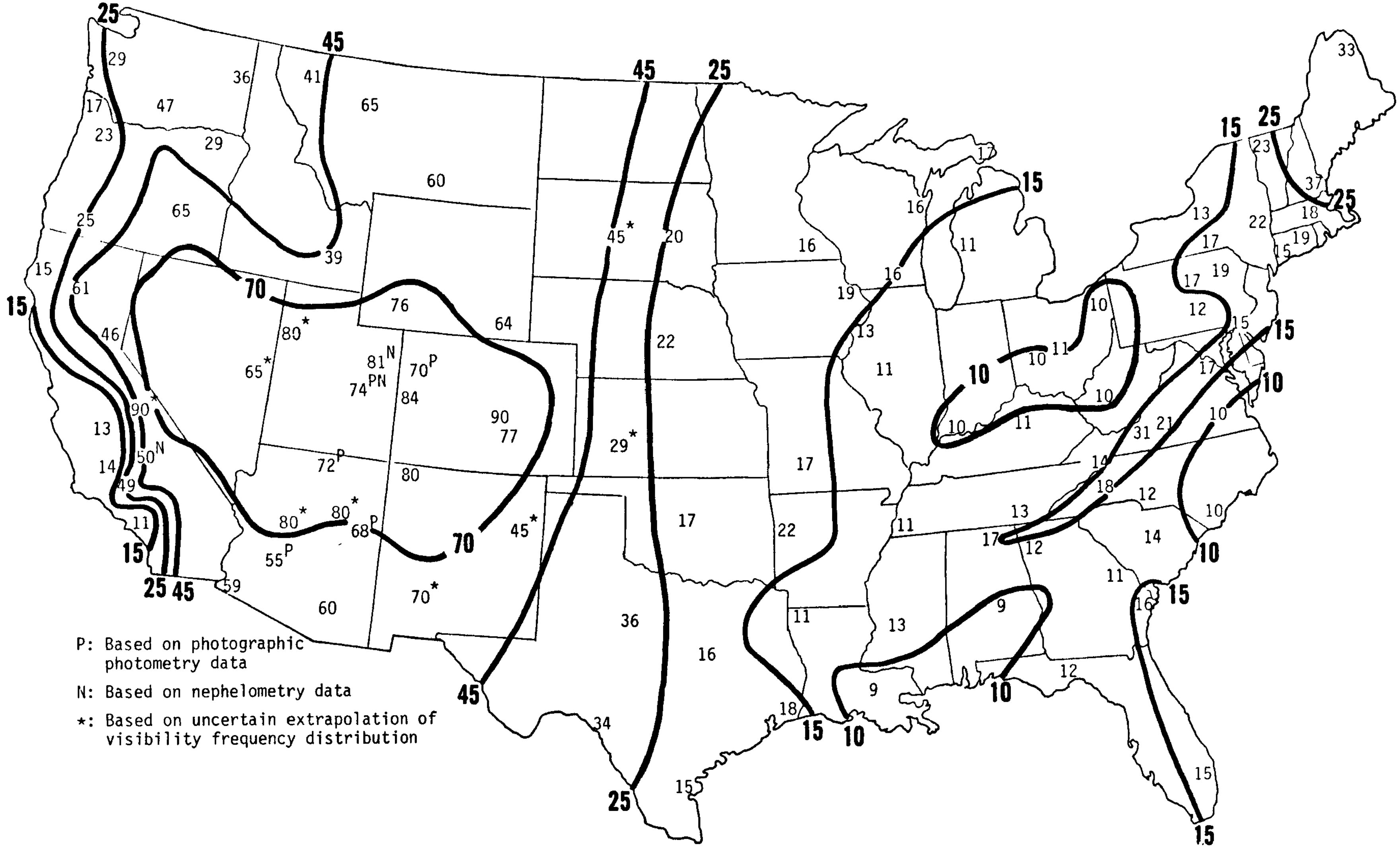

Figure 4. Median yearly visibilities and visibility isopleths for suburban/nonurban areas.

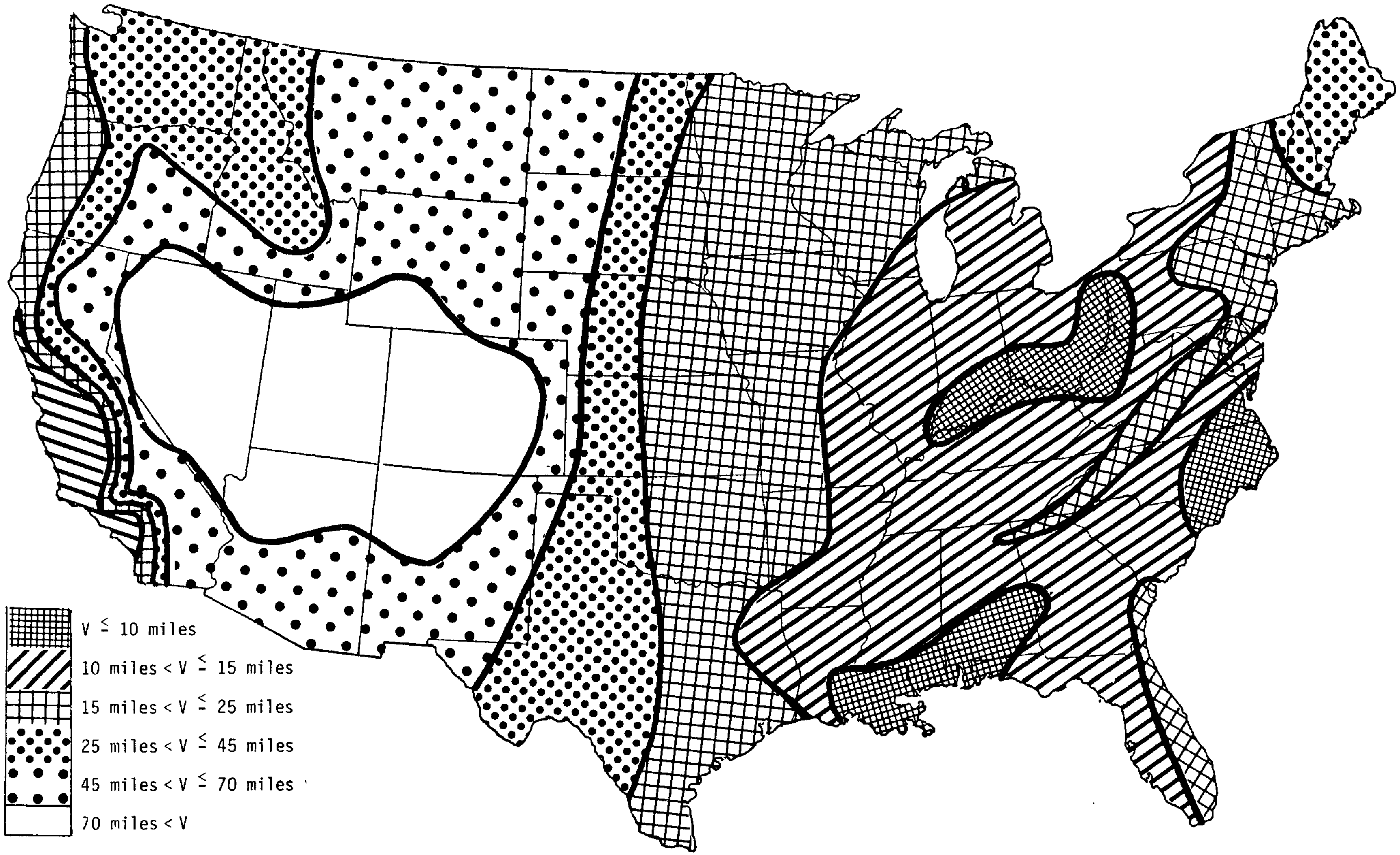

Figure 5. Shaded isopleth map of yearly visibilities, for suburban/nonurban areas.

The isopleths in Figures 4 and 5 have been drawn to distinguish six basic ranges in median visibility: greater than 70 miles, 45-70 miles, 25-45 miles, 15-25 miles, 10-15 miles, and less than or equal to 10 miles. The best visibility (70^+ miles) in the country occurs in the mountainous Southwest -- an area comprised of Utah, Colorado, Nevada, northern Arizona, northern New Mexico, and Southwestern Wyoming. Visibility is also quite good to the north and south of this region. Passing westward or eastward, fairly sharp gradients occur. Median visibility falls to less than 25 miles in a narrow band along the northern Pacific coast, to less than 15 miles in the central valley of California and the Los Angeles basin, and to less than 15 miles at the Mississippi.

Most of the area east of the Mississippi has a median visibility of 15 miles or less. In fact, three areas -- the Ohio River Valley, the Louisiana/Mississippi/Alabama Gulf coast, and the North Carolina/Virginia coast -- exhibit visibility of 10 miles or less. Visibility improves toward the northern Atlantic States, exceeding 15 miles in eastern Pennsylvania and eastern New York, and exceeding 30 miles in New Hampshire and Maine. A long, narrow region of 15^+ miles visibility also extends down the entire eastern slopes of the Appalachian Mountains.

MEDIAN THIRD-QUARTER VISIBILITIES, 1974 - 1976

Figures 6, 7, and 8 are similar to Figures 3, 4, and 5, except they represent median <u>summertime</u> (third quarter) visibilities. Again, the quality of the data is evidenced in Figures 6 and 7 by the monotonic trends appearing in many of the spatial patterns, and by the good agreement that often exists between nearby locations. In fact, there is one continuous region -- the Ohio Valley and areas to the south and east of the Ohio Valley -- that includes 22 stations, <u>all</u> of which exhibit median visibilities of 8 to 10 miles.

Comparing Figure 7 to Figure 4, or Figure 8 to Figure 5, it is obvious that summertime visibility is significantly lower than yearly visibility in the entire area east of the Mississippi and south of the Great Lakes. This phenomenon is also apparent, but to a lesser degree, in the south-central states (i.e. Texas, Arkansas, and Louisiana). Most of the western United

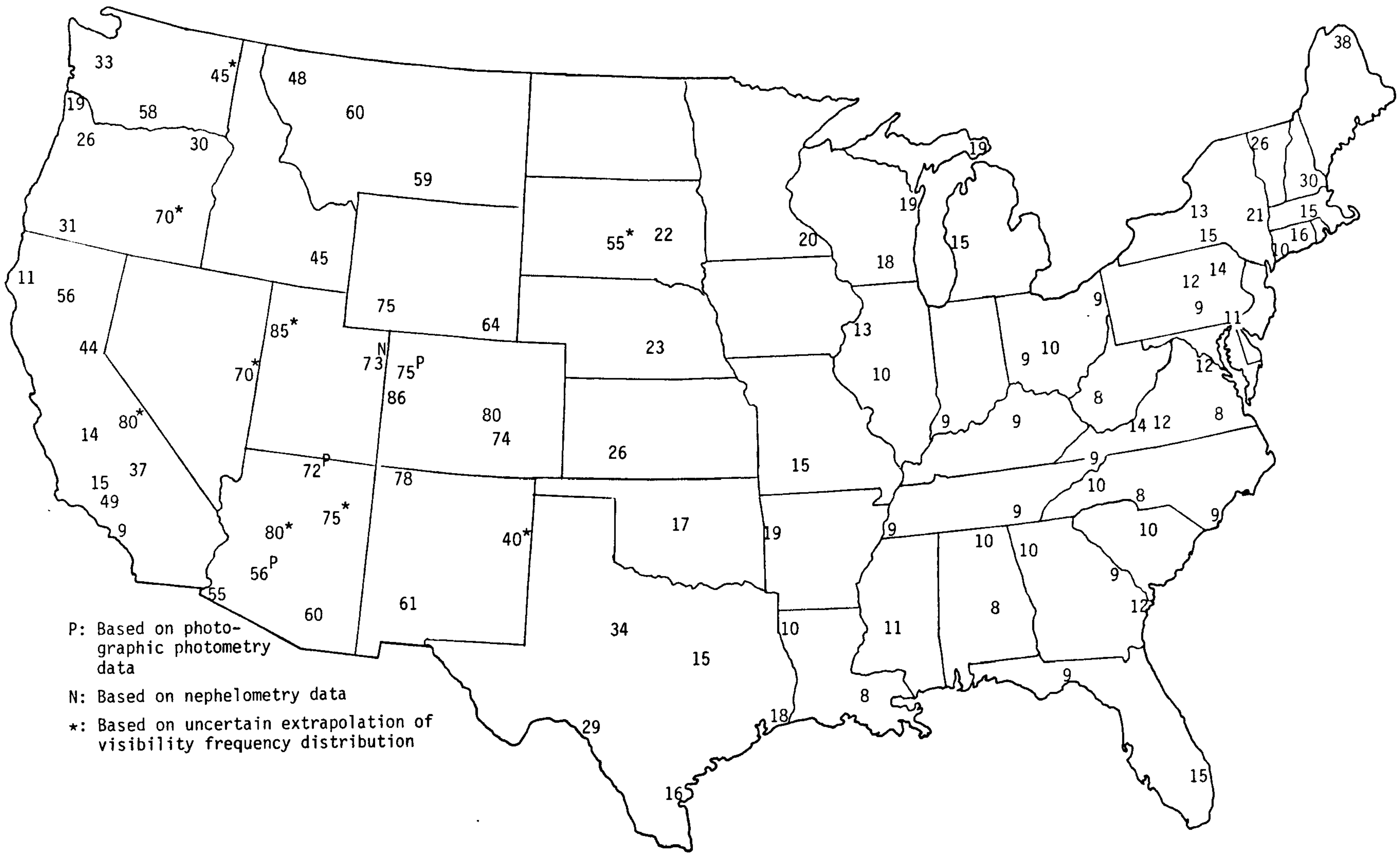

Figure 6. Median summer visibilities at suburban/nonurban locations.

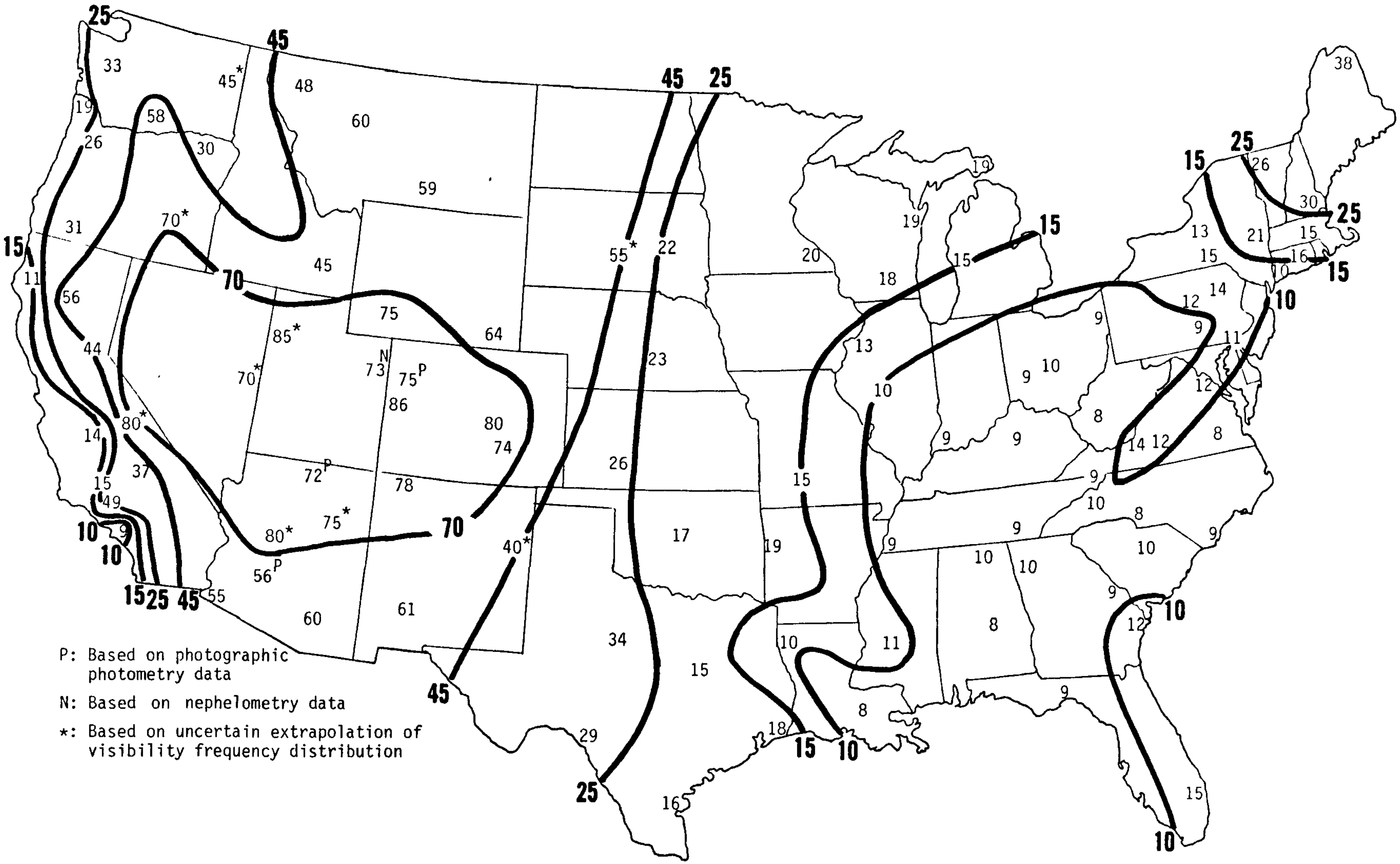

Figure 7. Median summer visibilities and visibility isopleths for suburban/nonurban areas.

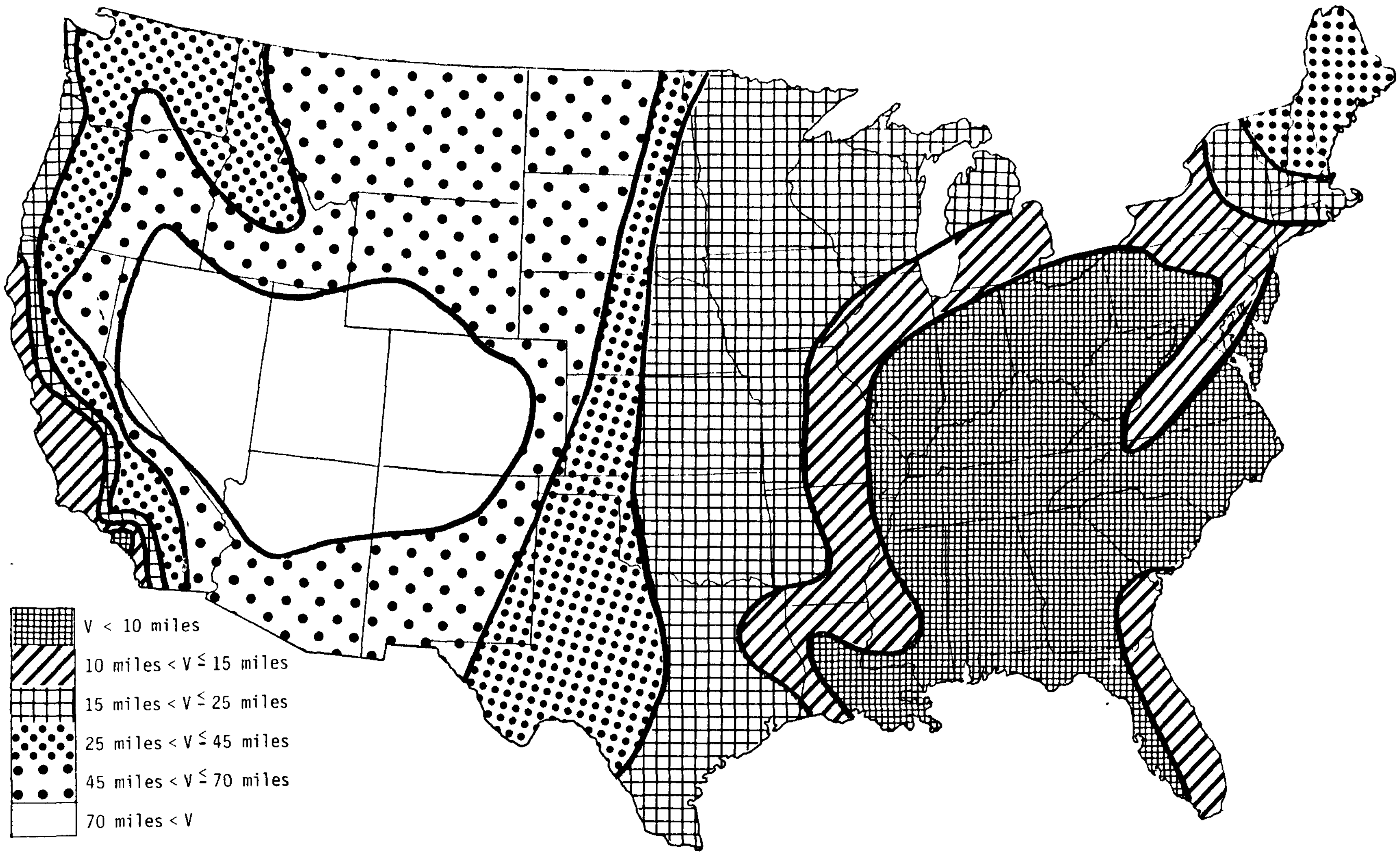

Figure 8. Shaded isopleth map of summer visibilities for suburban/nonurban areas.

States show little change in the summer, with some stations increasing slightly and other stations decreasing slightly compared to the yearly medians. The only exception in the West is the Pacific Northwest, where visibility increases significantly during the summer.

The nationwide spatial gradients in visibility during the summer are fairly similar to those during the entire year. As shown in Figures 7 and 8, the same large region in the mountainous Southwest still experiences median visibilities of 70^+ miles. Visibility also remains good north and south of this region, and strong gradients again exist toward the west and east of this region. Visibility falls to less than 25 miles along a narrow strip on the northern Pacific coast, to less than 15 miles in California's central valley and coastline, and to less than 10 miles in the Los Angeles basin. Visibility also falls to less than 10 miles as one moves east across the southern half of the Mississippi River.

A very large area east of the Mississippi and south of the Great Lakes exhibits summertime visibilities of less than 10 miles. The spatial trend is such that visibility becomes better than 10 miles in central Pennsylvania, western New York, and a narrow strip on the eastern slopes of the Appalachians. Summertime visibility exceeds 15 miles in eastern New York and southern New England and 25 miles in northern New England.

REFERENCES

Allee, P.A., et al., "Air Quality Studies in Carbon and Emery Counties, Utah, December 1976 - July 1977", Draft Report by NOAA Environmental Research Laboratories, 1978.

APSC (Arizona Public Service Company), "Visibility and Particle Analysis for the Palo Verde Nuclear Generating Station", Reports for July 1975 - March 1976, 1976.

Bolin, B. and R.J. Charlson, "On the Role of the Tropospheric Sulfur Cycle in the Shortwave Radiative Climate of the Earth", Ambio, Vol. 5, No. 2, 1976.

Husar, R.B., et al., "A Study of Long Range Transport from Visibility Observations, Trajectory Analysis and Local Air Pollution Monitoring Data", Presented at the 7th International Technical Meeting on Air Pollution Modeling and its Application, NATO/CCMS, Airlie, Virginia, September 7 - 10 1976.

Husar, R. and D. Patterson, Report in preparation for EPA Office of Research and Development under Grant No. 802815, Washington University, St. Louis, Missouri, 1978.

Miller, M.E., et al., "Visibility Changes in Ohio, Kentucky, and Tennessee from 1962 to 1969", Monthly Weather Review, Vol. 100, No. 1, pp. 67 - 71, January 1972.

Roberts, F.M., et al., "Visibility Measurements in the Painted Desert", Paper No. 75-26.1, Presented at the 68th Annual Meeting of the Air Pollution Control Association, June 1975.

Tombach, I.H. and M.W. Chan, "Physical, Chemical, and Radiological Characterization of Background Particulate Matter in Northeastern Utah", Paper No. 77-48.6, Presented at the 70th Annual Meeting of the Air Pollution Control Association, June 1977.

Trijonis, J. and K. Yuan, "Visibility in the Southwest, An Exploration of the Historical Data Base", EPA-600/3-78-039, April 1978.

Trijonis, J. and K. Yuan, "Visibility in the Northeast", Prepared at Technology Service Corporation under Grant No. 802815 for EPA Office of Research and Development, 1978.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/5-79-010	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Existing Visibility Levels in the United States		5. REPORT DATE September 1979 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) John Trijonis and Dawn Shapland		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Technology Service Corporation Route 3, Box 124-K Santa Fe, New Mexico 87501		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. Grant No. 802815
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency Research Triangle Park, N. C. 27711		13. TYPE OF REPORT AND PERIOD COVERED Interim May-Sept. 1978 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Maps are prepared which illustrate median, mid-day visibility levels in suburban/ nonurban locations of the continental United States. Median visibilities at 94 locations are determined from cumulative frequency distributions of quality-checked airport observations. Seven locations in the Southwest with photographic photometry or nephelometry data (which agree quite well with the airport data) are also included.

The spatial pattern of visibility is demonstrated with isopleth maps for both the annual medians and summertime medians during the years 1974-1976. The consistency of the spatial gradients in visibility and the agreement between neighboring locations attest to the quality of the visibility data. The isopleth maps reveal that the best visibility (70+ miles) occurs in the mountainous Southwest. Visibility is also quite good (45 - 70 miles) north and south of that region, but sharp gradients occur to the east and west of that region. Most of the area east of the Mississippi and south of the Great Lakes exhibits median visibilities of less than 15 miles annually and less than 10 miles during the summertime.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution Visibility Haze	United States	

18 DISTRIBUTION STATEMENT Release to public	19. SECURITY CLASS *(This Report)* Unclassified 20 SECURITY CLASS *(This page)*	21. NO. OF PAGES 35 22. PRICE

EPA Form 2220-1 (9-73)