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Air Ambulance Helicopter Operational Analysis

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16. Abstract

This study of visual flight rules (VFR) weather minimums and operational areas for helicopter emergency medical service operators is based on operator responses to a questionnaire. The national average VFR operational weather minimums for all respondents was determined. Also, an estimate of the percentage of time that each respondent can not fly because of ceiling and/or visibility below their VFR operating minimums was determined, as was the average percentage of time all responders can not fly. Analysis of the data indicated that on the average the operators have voluntarily adopted stricter minimums than recommended in the current FAA Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter (EMS/H)." Furthermore, the analysis indicated that on the average the operators have more restrictive daylight minimums than those in the proposed change to AC 135-14 and less restrictive night minimums than those in the proposed change. Some general observations about minimums for operations in mountainous areas are also provided.

The coverage areas reported by the operators were plotted on two maps of the United States, one for the local coverage areas and one for the cross country coverage areas. From these maps, the percentage of coverage for the conterminous United States, each FAA region, and each state were determined. The weather data were also averaged over each state and used to determine the percentage of time that coverage is available in areas where EMS/H service is provided.

The FAA is in the process of determining if there is an economic justification for the improvement of low altitude communication, navigation and surveillance services within the National Airspace System (NAS). A recent FAA study, Rotorcraft Low Altitude CNS Benefit/Cost Analysis (DOT/FAA/DS-89-11, September 1989) found that the helicopter ambulance mission is a source of significant social benefit. The results of the Air Ambulance Helicopter Operational Analysis provides data which will support further analysis of the benefits of air ambulance helicopters in an IFR environment.

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1.0 INTRODUCTION

The Federal Aviation Administration (FAA) is in the process of determining if there is an economic justification for the improvement of low altitude communication, navigation, and surveillance (CNS) services within the NAS. A recent FAA study, Rotorcraft Low Altitude CNS Benefit/Cost Analysis (DOT/FAA/DS-89-11, September 1989) found that the helicopter ambulance mission was a possible source of significant social benefit. However, the magnitude of the societal benefit could not be accurately determined in that study for two reasons: 1) there was no accurate data available on the size of each air ambulance operator's operational areas, and 2) there was no accurate data available on the operator's weather minimums. The size of each operator's operational area is needed in order to claim benefits only for areas which actually have EMS helicopter coverage. The weather minimums data is necessary because the frequency and unscheduled nature of EMS operations lead to a high probability of encountering instrument meteorological conditions. Therefore, it is necessary to know when an operator would start declining to fly missions due to weather conditions. The publication of AC 135-14, "Emergency Medical Services/Helicopter (EMS/H)" in October of 1988, recommended that each operator establish specific local and cross-country operational areas, and weather minimums for both types of areas. The establishment of these operating areas and weather minimums made available, for the first time, the data necessary for an accurate benefit/cost analysis. The information gathered in this study will be used to support future FAA analysis of the benefits of air ambulance helicopters in an IFR environment and the low altitude CNS improvements that are necessary to achieve these benefits.

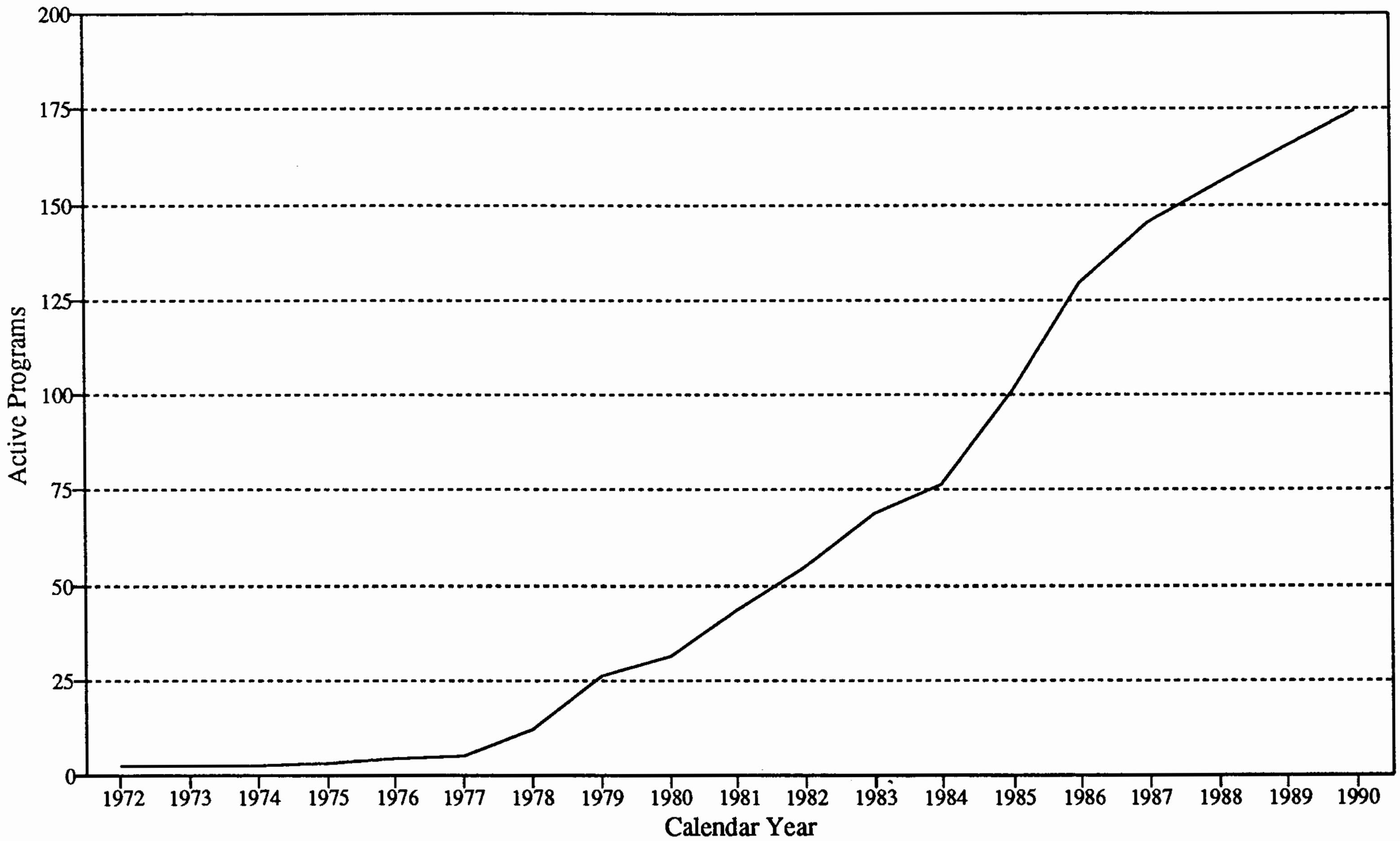
1.1 BACKGROUND

Emergency medical service helicopters are used to fly accident victims or critically ill patients to the location where they can receive the best medical treatment. EMS operations either fly established routes between contracting hospitals or pick-up victims directly at the site of the accident and fly them to a hospital. These operation scenarios are, on the average, divided on a 75 percent/25 percent ratio respectively, favoring the hospital transfers. While most EMS operations do not currently operate IFR, there is a small percentage who do and this percentage is increasing.

Emergency medical service has been the fastest growing helicopter mission of the last decade. The first two hospital-based EMS programs started in 1972. One new hospital-based operator per year started in 1975-77, then in 1978 seven hospital-based programs began and the trend kept going.

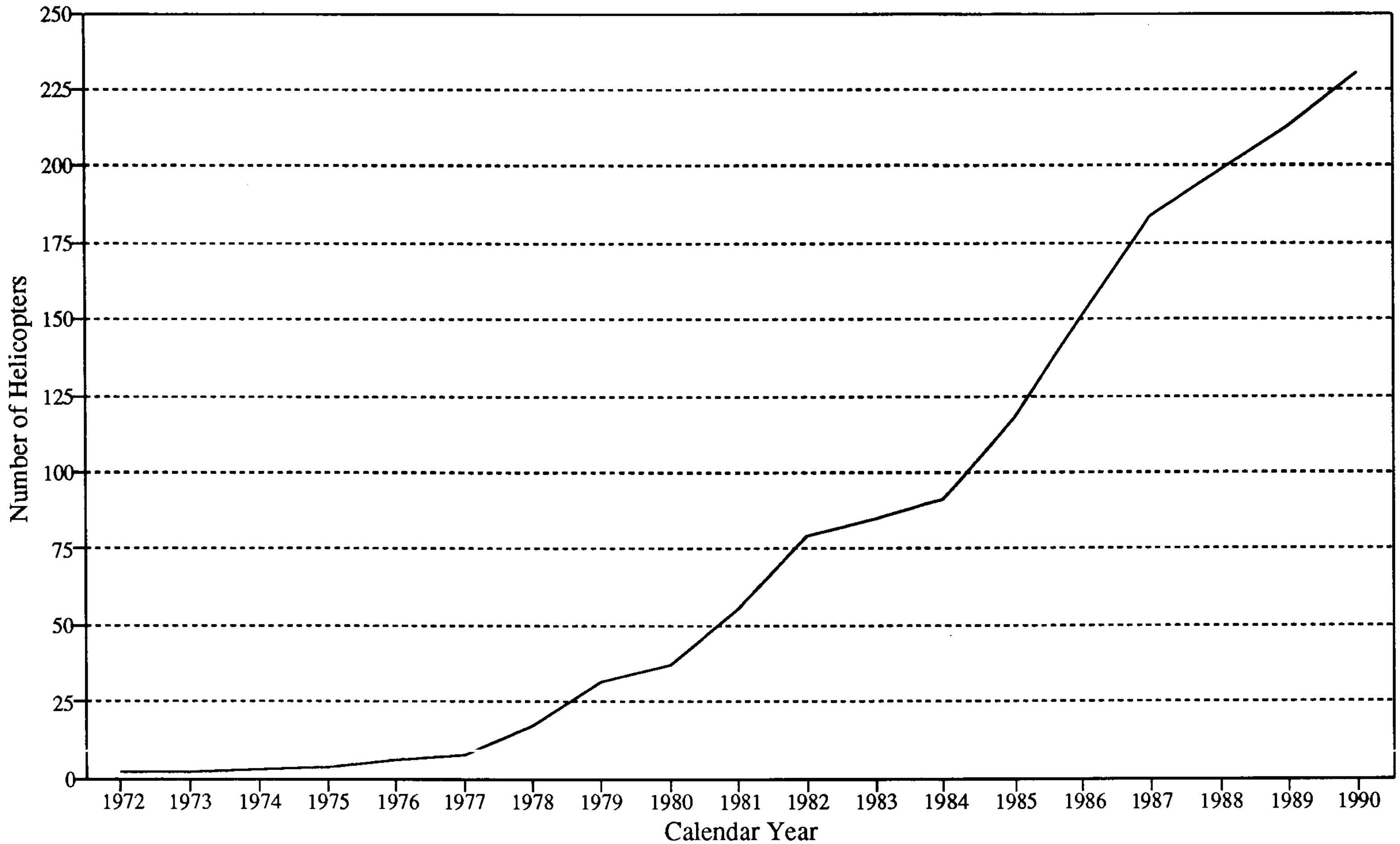
Figure 1 shows the annual increase in the number of hospital-based EMS helicopter programs and figure 2 shows the annual increase in the number of hospital-based EMS helicopters. The number of hospital-based EMS helicopter programs has been growing at a 9 percent annual rate since 1984 and the number of hospital-based helicopters used for EMS has been growing at a 10 percent annual rate since 1984.

According to The Journal of Air Medical Transport, February 1990, the four leading causes of EMS helicopter accidents from 1972 through 1989 were: adverse weather (21), obstacle strike (13), engine failure



SOURCE: "Hospital Aviation:", 1990

FIGURE 1 ACTIVE HOSPITAL-BASED EMS PROGRAMS



SOURCE: "Hospital Aviation:", 1990

NOTE: This figure does not include the many helicopters that are used primarily for other missions and are used for EMS on a part--time basis.

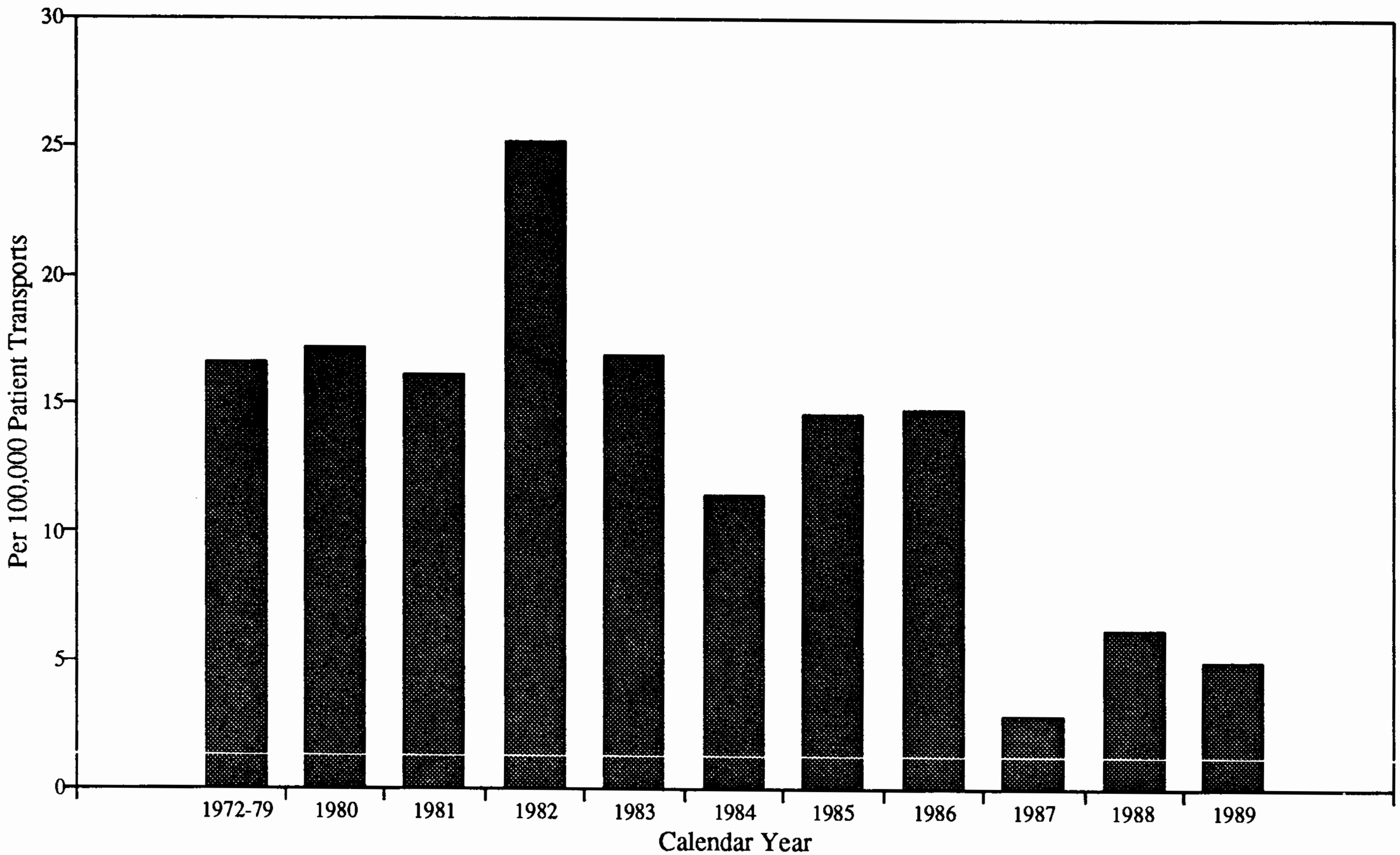
FIGURE 2 NUMBER OF HELICOPTERS IN HOSPITAL-BASED EMS

(12), and control loss (8). All other causes combined were responsible for 18 accidents. Figure 3 shows the annual air medical helicopter accident rate. Figure 4 shows the total number of air medical helicopter accidents each year. From 1972 through 1989, adverse weather accounted for 29 percent of all accidents, however, the percentage dropped to only 17 percent of the 1989 accidents. Thus it can be shown that adverse weather has historically been a significant factor in EMS helicopter accidents.

In response to the increased use of EMS helicopters and public safety concerns, the FAA issued Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter." This AC provides information and guidelines to assist EMS/H operators in the conduct of their operations. One of the suggested guidelines covers weather minimums and will be covered in detail in section 3.1 of this report.

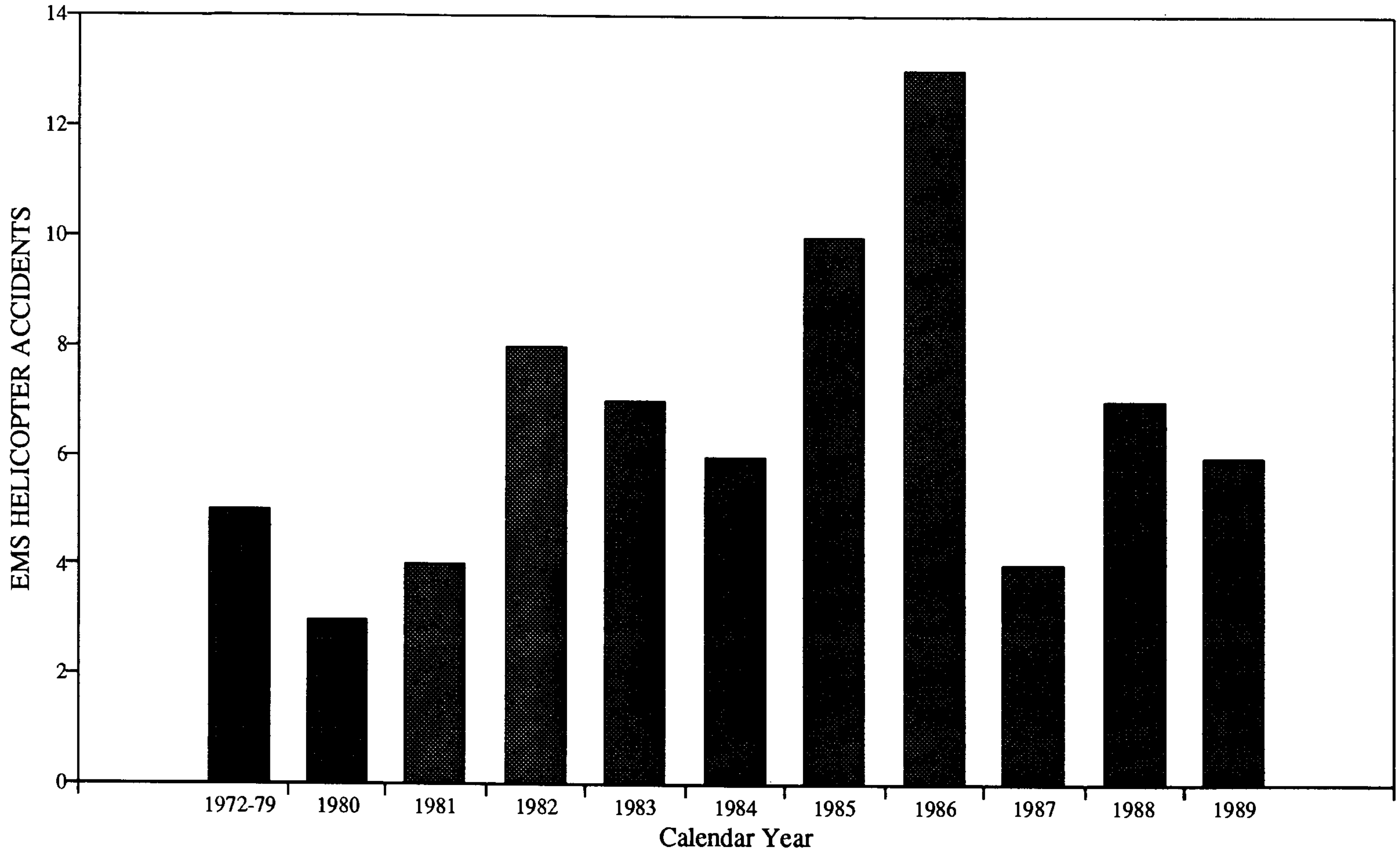
This study of visual flight rules (VFR) weather minimums and operational areas for emergency medical service/helicopter (EMS/H) operators is based on operator responses to a request for information regarding operators' weather minimums (see appendix B). The national average VFR operational weather minimums for all respondents were determined. Also, an estimate of the percentage of time that each respondent cannot fly because of ceiling and/or visibility below their VFR operating minimums was determined, as was the average percentage of time all responders cannot fly. Analysis of the data indicated that on the average that operators have voluntarily adopted stricter minimums than recommended in the current FAA Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter (EMS/H)" which was published on 20 October 1988. Furthermore, the analysis indicated that on the average the operators have more restrictive daylight minimums than those in the proposed change to AC 135-14 and less restrictive night minimums than those in the proposed change. Some general observations about minimums for operations in mountainous areas are also provided.

The coverage areas reported by the operators were plotted on two maps of the United States, one for the local coverage areas and one for the cross country coverage areas. From these maps, the percentage of coverage for the conterminous United States (CONUS), each FAA region, and each state was determined. The weather data was also averaged over each state and used to determine the percentage of time that coverage is available in areas covered by EMS/H service.



SOURCE: "The Journal of Air Medical Transport", February 1990

FIGURE 3 AIR MEDICAL HELICOPTER ACCIDENT RATE



SOURCE: "The Journal of Air Medical Transport", February 1988 and 1990

FIGURE 4 TOTAL EMS HELICOPTER ACCIDENTS PER YEAR

2.0 METHODOLOGY

In June of 1989, the Federal Aviation Administration (FAA) through the Vertical Flight Program Office (ARD-30) sent a letter requesting information to all known EMS/H operators. Each EMS/H operator's weather minimums (ceiling and visibility) were requested for both their local and cross country operating areas. The weather minimums were organized in a database and linked to weather data derived from the FAA's Airport Specific File. This linkage made it possible to analyze the effect of various weather minimums on EMS/H operations. The minimums considered in this study are: 1) the EMS/H operators' company minimums, 2) the AC 135-14 minimums, and 3) the proposed FAA change to the minimums in AC 135-14.

In addition, each operator was requested to provide a map with the boundaries of their local and cross country operating areas depicted. The size of each operating area, in square miles, was taken from the map sheets and entered into the database. Furthermore, a composite map of all the respondents' operating areas was created, one map for all of the local operating areas and one map for all of the cross-country operating areas. Individual maps of each FAA region and state (including adjacent areas) were made from the composite maps. All maps are provided in appendix A.

2.1 EMS/H OPERATOR SURVEY

The names and addresses of 179 EMS/H operators were obtained from the March 1989 edition of The Journal of Air Medical Transport. In June of 1989, a letter requesting information was sent to each operator. In December of 1989, a follow-up letter was sent to all non-respondents. A total of 153 EMS/H operators returned complete data packages, a response rate of 85.5 percent. A total of 149 respondents reported operations from a single base, and 4 public service operators reported multiple (22) bases of operation. The California Highway Patrol reported seven bases, the Maryland State Police reported seven bases, the Illinois Department of Transportation reported four bases, and the Arizona State Police reported four bases. Therefore, 171 (149 + 22) locations were entered into the database. An additional 27 operators returned incomplete data packages or answered phone inquiries that were suitable only for use in developing the maps of coverage areas, bringing the total number of locations in the database to 198.

Each operator provided information on their company VFR weather minimums for the four operating conditions recommended in AC 135-14: day/local, day/cross country, night/local and night/cross country. The data on company VFR minimums was organized in a database using database management software. In addition, a few of the operators provided comments on particular operational constraints in their areas of operation. All of these comments have been indexed and put into the database. A sample letter requesting information is provided in appendix B.

2.2 AIRPORT SPECIFIC FILE

The Airport Specific File (ASF) is a computer database, developed by the FAA Office of Policy and Plans (APO-220). It contains data describing airport facilities and equipment, weather probabilities, and aircraft ceiling and visibility requirements for 1,637 airports in the United States. For more information on the ASF, see "Development of Revised and Expanded Airport Specific File Data for the Airport Criteria Data System," Report No. FAA-APO-86-8, December 1985.

For the purposes of this study, only the weather probability data was used from the ASF. The weather data was linked to the EMS/H database by county and state. First, the county where each operator was located was identified using the operator's mailing address and a database containing all the zip codes and counties in the United States. Second, the same zip code/county database was used with a database of FAA Form 5010s, the Airport Master Record, to find the county of each heliport/airport in the United States with based helicopters. The operator's county was then matched with an airport in the same county. The airport's site identifier was found in the ASF and its weather probabilities were extracted.

The percentage of time that VFR minimums are not met at each location was calculated for all four operating conditions in AC 135-14 for 1) the company minimums, 2) the AC 135-14 minimums, and 3) the proposed change to the AC 135-14 minimums. In all, 12 different weather probability percentages were calculated for each operator's location.

One problem encountered is that the weather data in the ASF contains information on the joint (combined) probability of the weather exceeding both a ceiling and a visibility limit. However, data in the ASF is supplied for only eight combinations of ceiling and visibility limits. It is not possible to determine the unconditional (independent) probability of either the ceiling or the visibility being exceeded with this data. Nor is it possible to compute the joint probabilities for all of the various combinations of ceiling and visibility minimums used by EMS/H operators. Both of the above limitations are significant for this study. Therefore, the model of average weather probabilities for the United States, from which the data in the ASF was derived, was used to construct a second model in order to determine the specific ceiling and visibility probabilities for the areas of interest in this study. In effect, the national average weather model, corrected for each location's site specific data, was used to calculate the weather probabilities for all 171 locations. Appendix C contains an explanation of the weather models and their applications in this study.

Another problem encountered with the ASF data was that it only reports on weather during daylight hours. A second source of weather data was consulted (see appendix C) and it was found that at most locations the probabilities do not vary much from day to night. Any variation was usually on the order of 1 or 2 percent. However, there was no pattern to whether the weather was better or worse between night and day. The reader is cautioned about the application of the results of this study to individual locations during the hours of darkness. However, the averaged results are thought to be relevant. Any error introduced will be the same for all of the weather conditions examined in this report. Therefore, no bias should have been introduced to the averages discussed later in section 3.1.

3.0 RESULTS

The data was analyzed for trends in the VFR minimums reported by the operators. Estimates were calculated for the percent of time that each location was below the company minimums, below AC 135-14 minimums, and below proposed AC 135-14 minimums. In addition, the data was averaged over an entire state to determine the percentage of time that the weather is better than the operators' minimums in those areas where EMS service is provided. This statistic is termed the "weather availability."

3.1 ANALYSIS OF VFR MINIMUMS

The average ceiling, visibility, and percentage of time that VFR weather minimums are not met were calculated. The results are provided in tables 1 and 2. The data in table 1 shows that the average ceiling and visibility minimums increase in a logical manner as the operating conditions become more difficult. The minimums increase both from local to cross country and from day to night.

TABLE 1 AVERAGE EMS/H VFR OPERATING MINIMUMS
(Sample Size: 153 Operators)

Conditions	Ceiling	Visibility
Day/Local	579	1.4
Day/Cross Country	790	2.1
Night/Local	921	2.7
Night/Cross Country	1,242	3.5

TABLE 2 AVERAGE PERCENTAGE OF TIME VFR MINIMUMS NOT MET
(Sample Size: 153 Operators)

Conditions	AC 135-14		Company	Proposed AC 135-14	
Day/Local	(500/1)	2.9%	4.3%	5.3%	(800/1)
Day/Cross Country	(800/2)	6.4%	6.7%	7.8%	(1,000/2)
Night/Local	(800/2)	6.4%	8.3%	7.8%	(1,000/2)
Night/Cross Country	(1,000/3)	9.3%	11.5%	10.7%	(1,300/3)

Note: The notation (500/1) means 500 feet ceiling and 1 mile visibility minimums.

Table 2 shows the percentage of time that the weather conditions are below VFR minimums averaged across all of the operators. In addition, table 2 shows the current and proposed AC 135-14 minimums in parentheses. The reader is asked to refer back to table 1 for the average company minimums. Note that in all cases the current AC 135-14 minimums are less restrictive than the average company minimums in terms of the percentage of time that VFR operations are allowed. In other words, on average, the EMS/H operators have voluntarily adopted minimums more restrictive than the minimums recommended in AC 135-14. Also note that the proposed changes to the AC are more restrictive than the current company average minimums during the day and less restrictive than the company average minimums during the night.

It appears that the operators are more restrictive on night visibility minimums than is the proposed change to AC 135-14. The operators' average night visibility minimums for local and cross-country are 2.7 miles and 3.5 miles, respectively; the proposed AC 135-14 visibility minimums are 2.0 miles and 3.0 miles, respectively. The night ceiling minimums for both the company and the proposed change to AC 135-14 minimums are approximately equal.

The company minimums and the proposed change to AC 135-14 are much closer for the day/local and the day/cross-country conditions. In these cases, the visibility limits match closely; however, the change to the AC has slightly more restrictive ceilings, about 200 feet higher for each condition. The effects of these more restrictive minimums will be discussed later in this section.

In addition to computing the average ceiling and visibility minimums, histograms of the frequency distributions of the data were developed. Figures 5 through 12 show the frequency distributions of the data for the four operating conditions discussed above. The odd numbered figures show ceiling data and the even numbered figures show visibility data. Note that the class limits for the ceiling histograms increase in 100 feet increments from 300 to 1,000 feet and then in 500 feet increments from 1,001 feet to 2,500 feet.

The non-normal statistical distribution of the data is obvious. In many of the distributions, there are two or more spikes depicting high numbers of operators separated by large areas of low numbers of operators. This would be expected of a population encompassing such a large variation of operators and operating areas. For example, public service operators in flat areas like Arizona and conservative private operators in the mountainous areas of Colorado or Pennsylvania have greatly differing minimums. The standard deviations of the minimums were calculated and are presented in table 3. Confidence intervals were not calculated because of the non-normal data distribution.

TABLE 3 STANDARD DEVIATIONS OF VFR MINIMUMS
(Sample Size: 153 Operators)

Conditions	Ceiling (feet)	Visibility (miles)
Day/Local	162	0.5
Day/Cross-Country	256	0.7
Night/Local	234	0.7
Night/Cross-Country	449	1.0

For the day/local operating condition, figures 5 and 6 reveal several trends. There are two spikes in the ceiling minimums, at the 500 foot and 800 feet class limits. These spikes contain 82 percent of all the operators, with 61.4 percent using the 500 feet minimum and 21.1 percent using the 800 foot minimum. The current AC 135-14 minimum for day/local is 500 feet; the proposed change is to 800 feet. Only 5.8 percent of the operators have an altitude ceiling less than 500 feet. However, 76.6 percent of the operators have a ceiling less than 800 feet. There is no change proposed to the AC 135-14 visibility minimum; it remains at 1 mile. A predominant 62 percent of the operators use 1 mile as their visibility minimum and the rest all use higher visibility requirements. This is in agreement with the AC's recommendation, and no operations

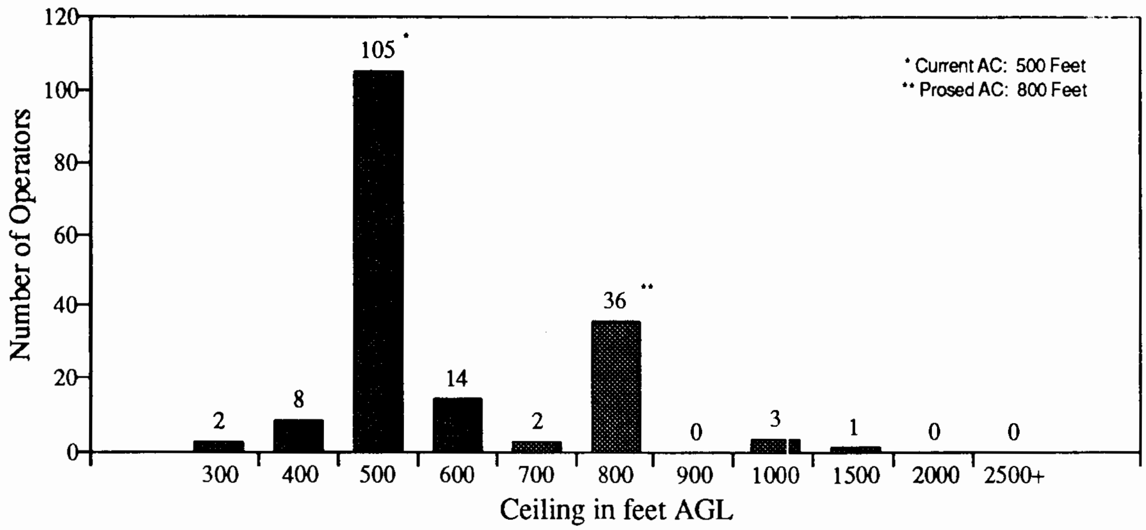


FIGURE 5 FREQUENCY DISTRIBUTION OF COMPANY ALTITUDE CEILINGS DAY/LOCAL OPERATING AREA

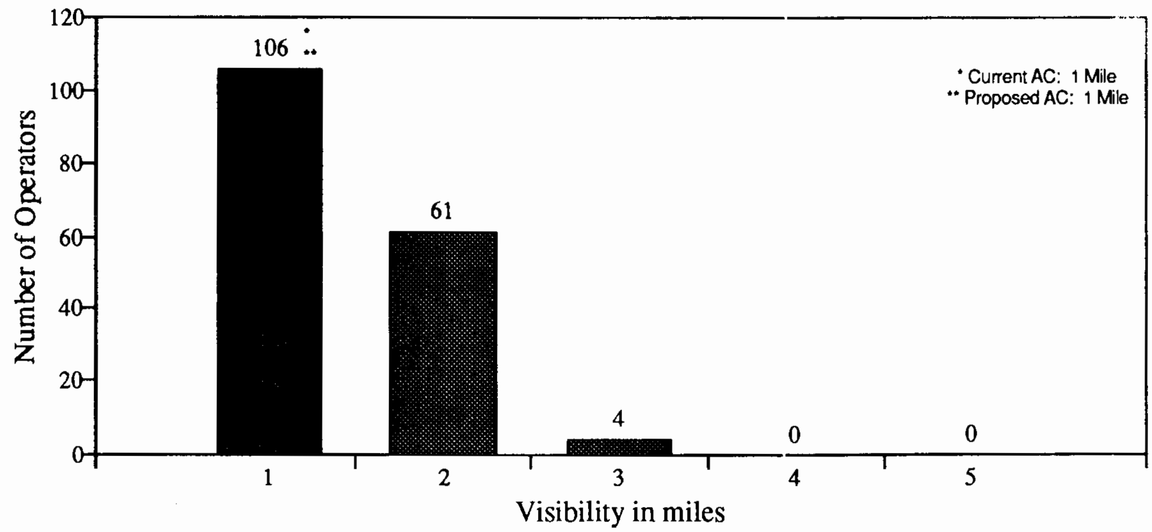


FIGURE 6 FREQUENCY DISTRIBUTION OF COMPANY VISIBILITY MINIMUMS DAY/LOCAL OPERATING AREA

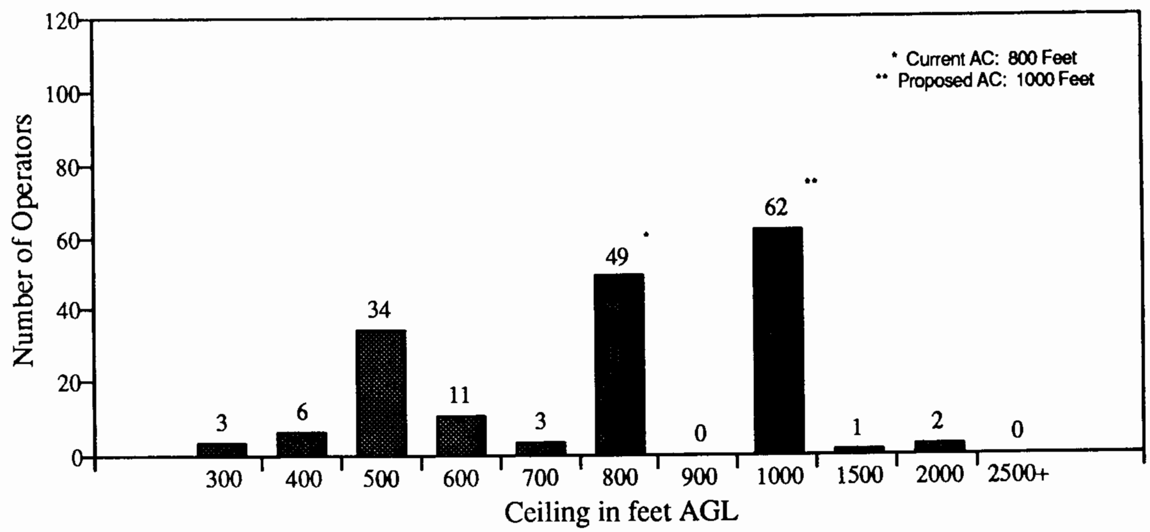


FIGURE 7 FREQUENCY DISTRIBUTION OF COMPANY ALTITUDE CEILINGS DAY/CROSS-COUNTRY OPERATING AREA

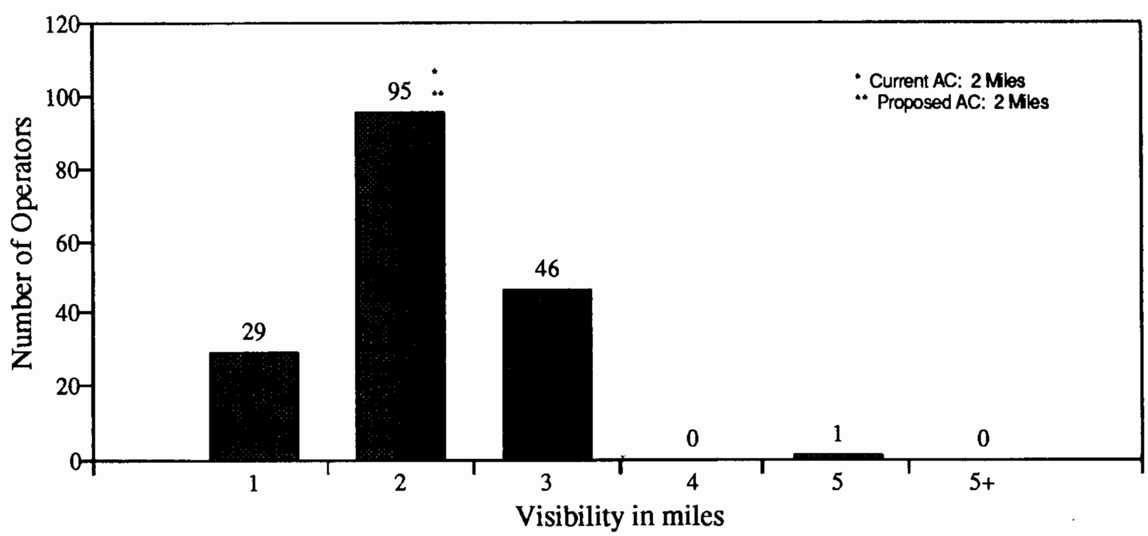


FIGURE 8 FREQUENCY DISTRIBUTION OF COMPANY VISIBILITY MINIMUMS DAY/CROSS-COUNTRY OPERATING AREA

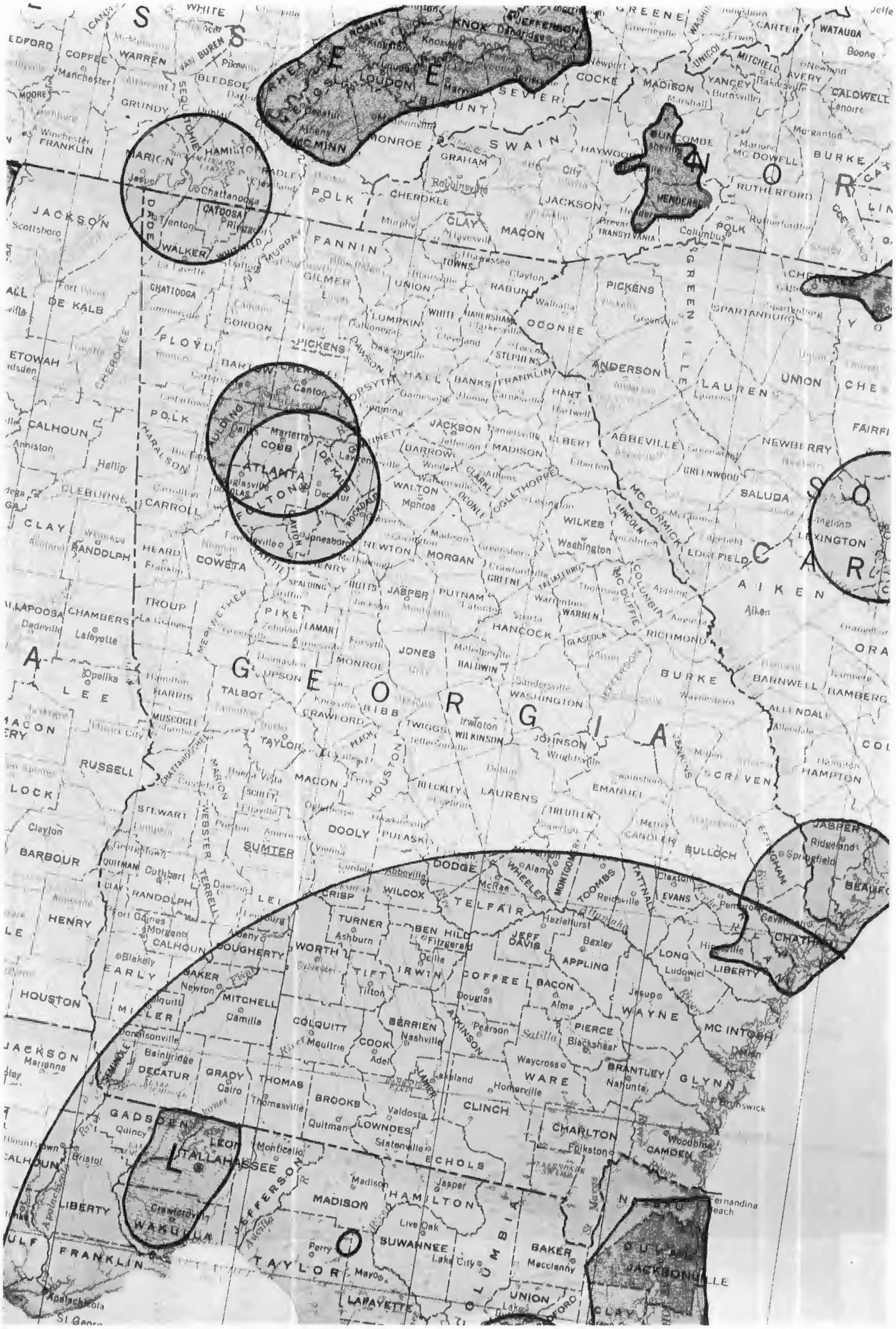


FIGURE A-21 LOCAL OPERATING AREA COVERAGE FOR GEORGIA

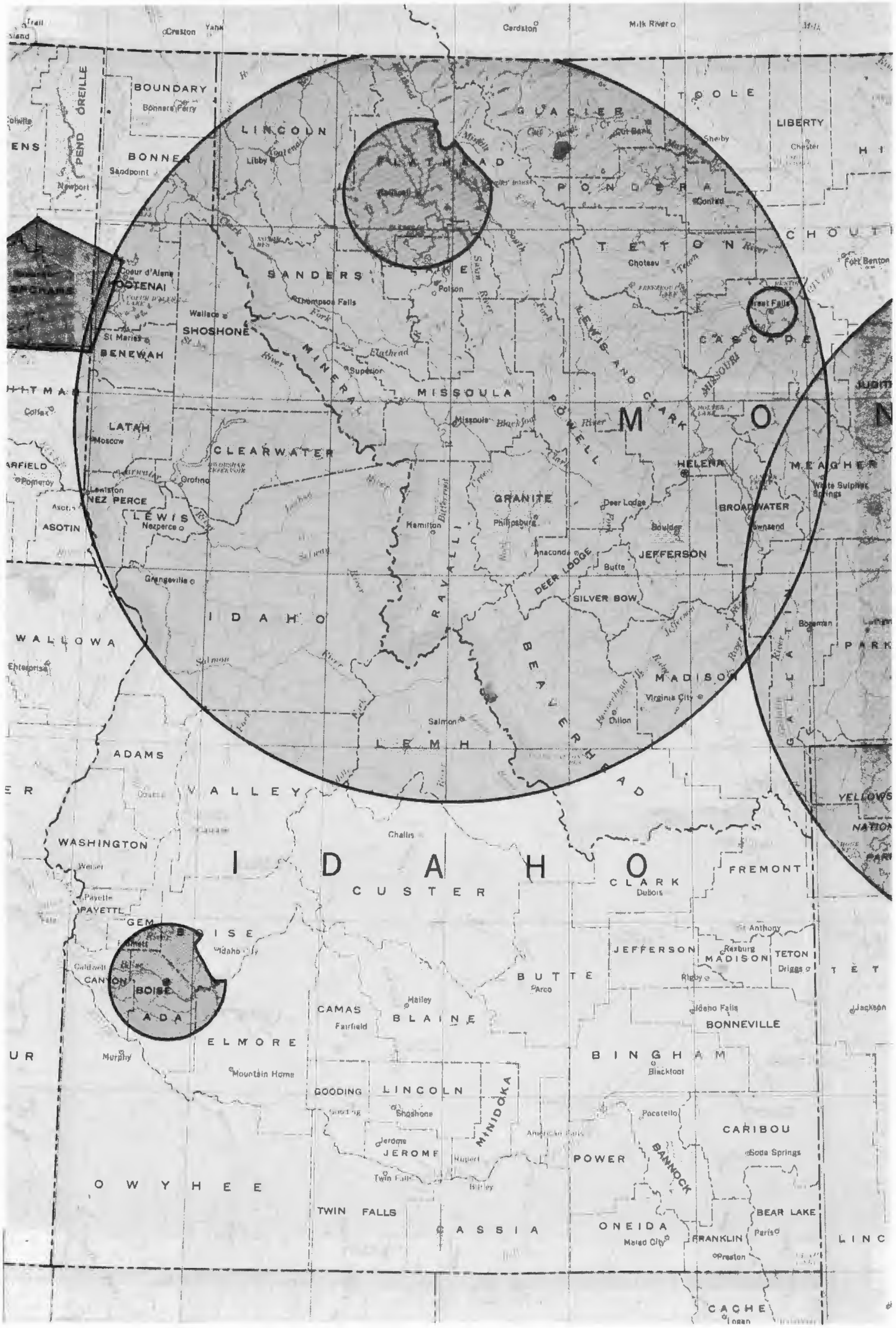


FIGURE A-22 LOCAL OPERATING AREA COVERAGE FOR IDAHO

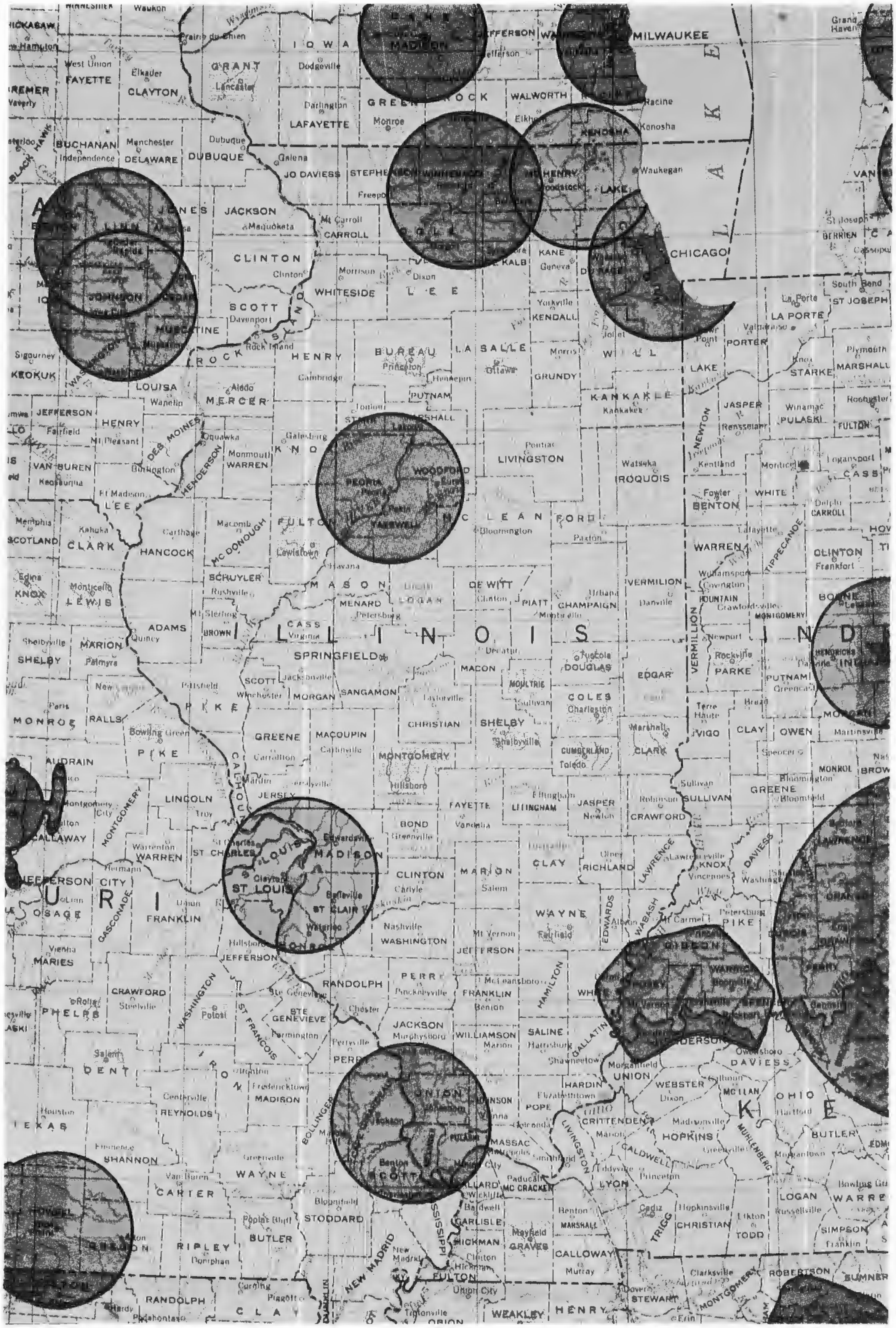


FIGURE A-23 LOCAL OPERATING AREA COVERAGE FOR ILLINOIS

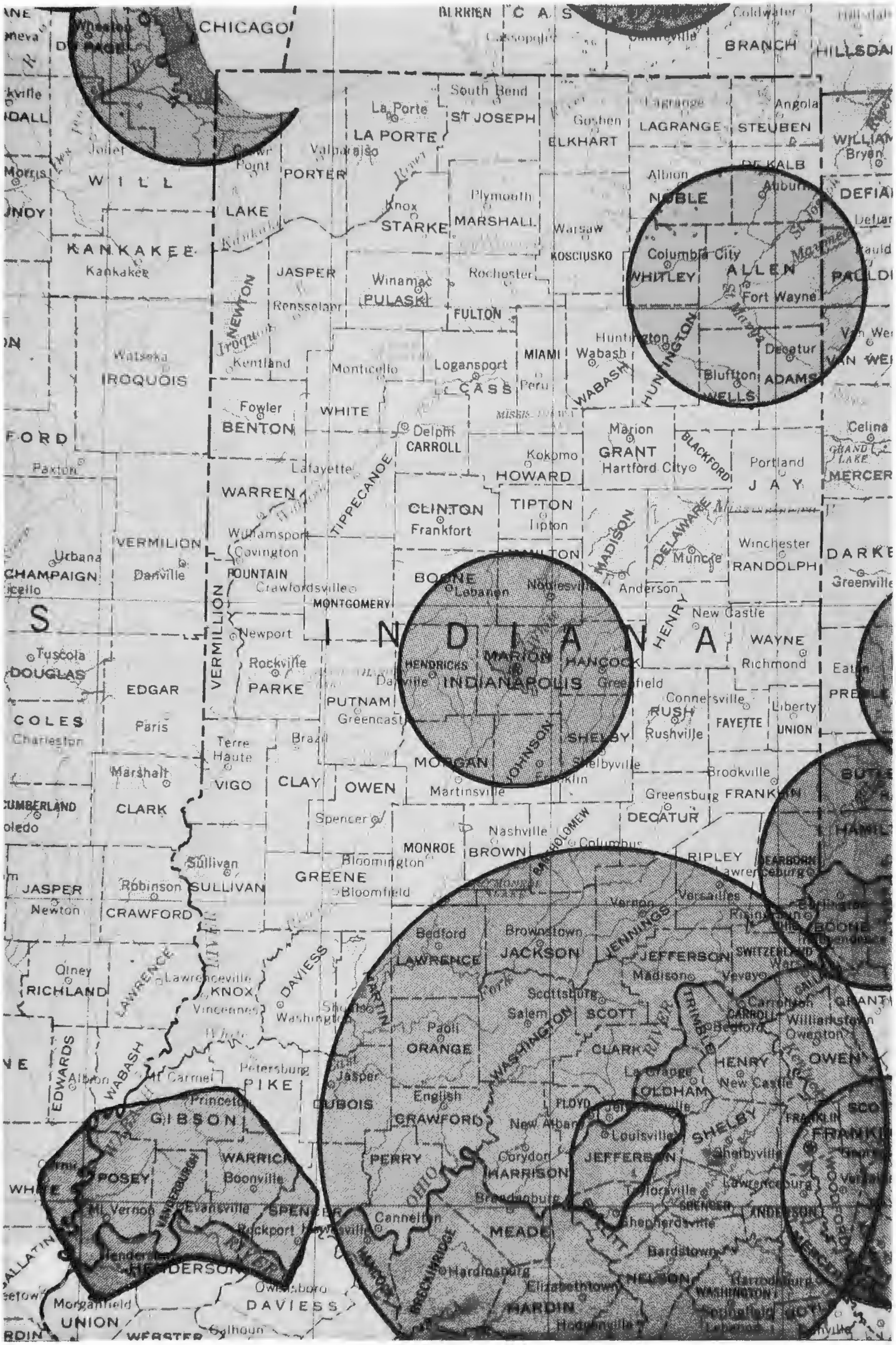


FIGURE A-24 LOCAL OPERATING AREA COVERAGE FOR INDIANA

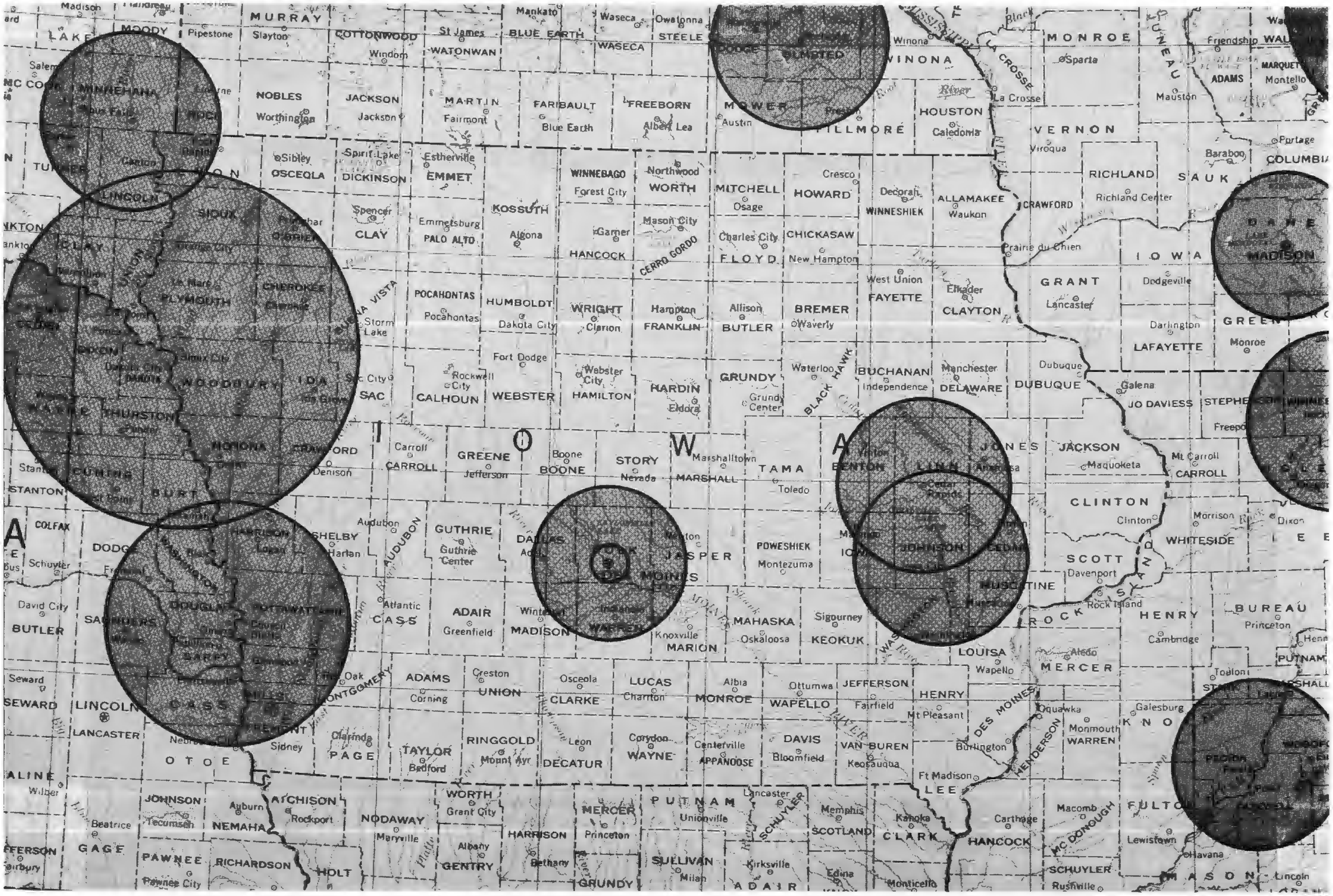


FIGURE A-25 LOCAL OPERATING AREA COVERAGE FOR IOWA

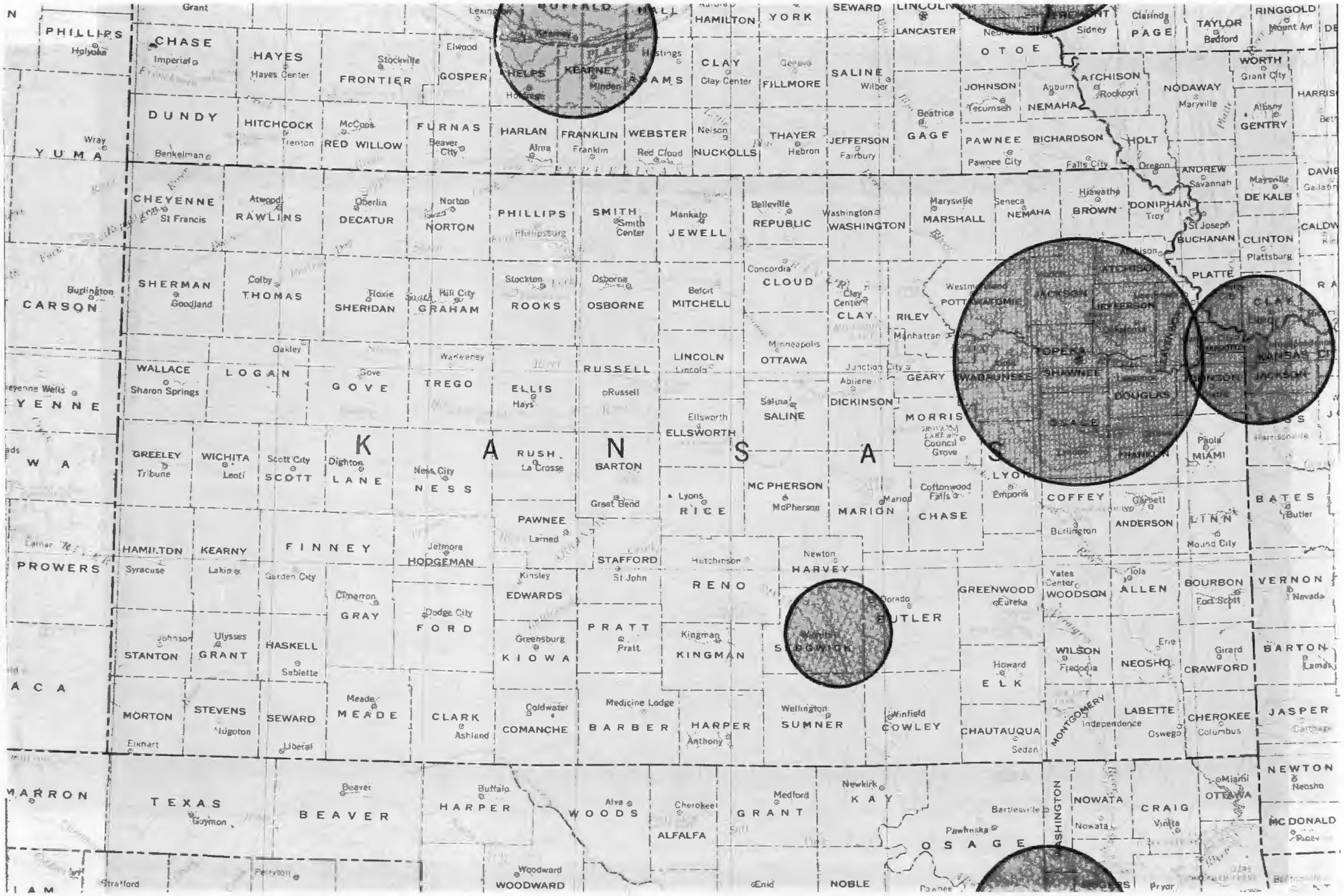


FIGURE A-26 LOCAL OPERATING AREA COVERAGE FOR KANSAS

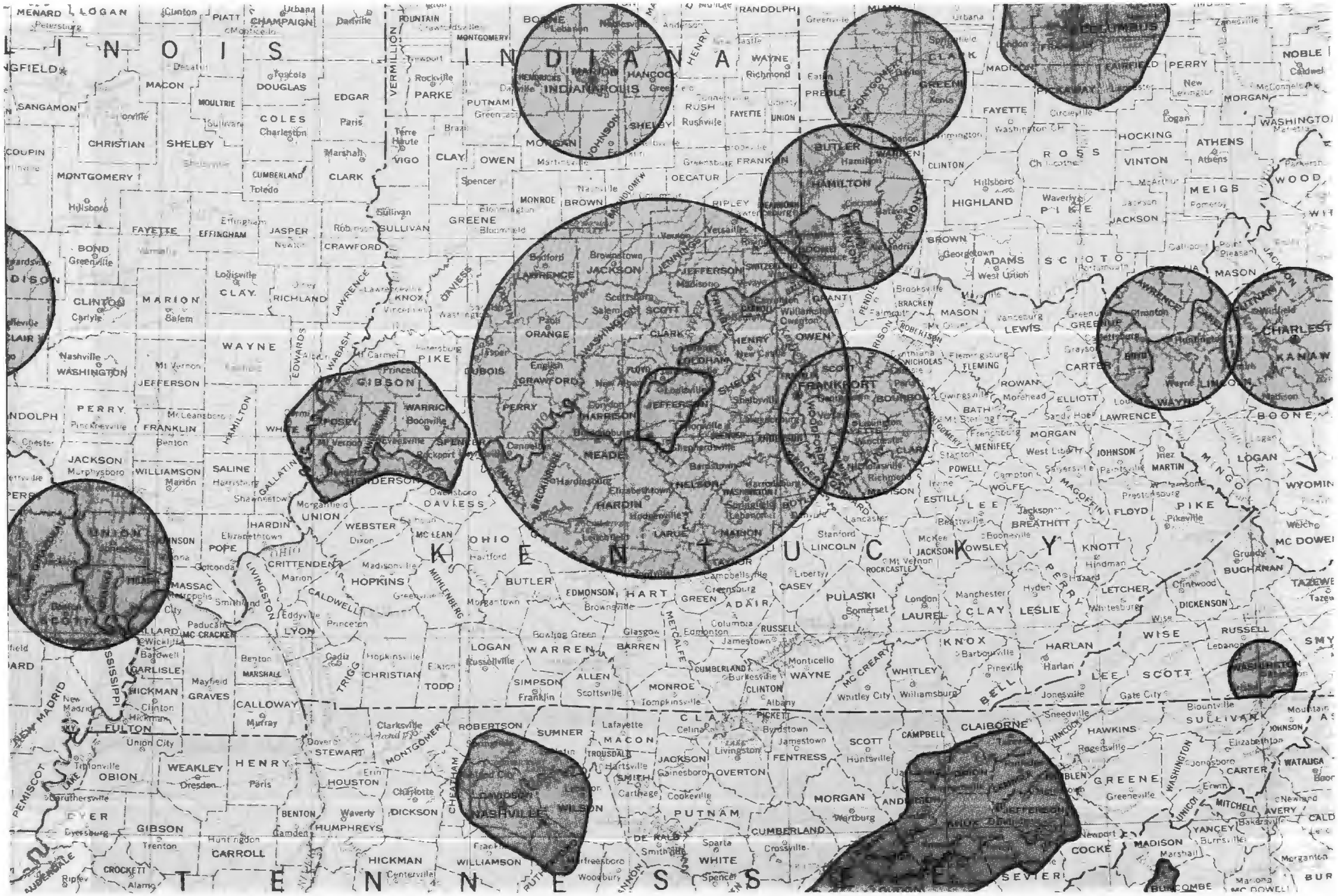


FIGURE A-27 LOCAL OPERATING AREA COVERAGE FOR KENTUCKY

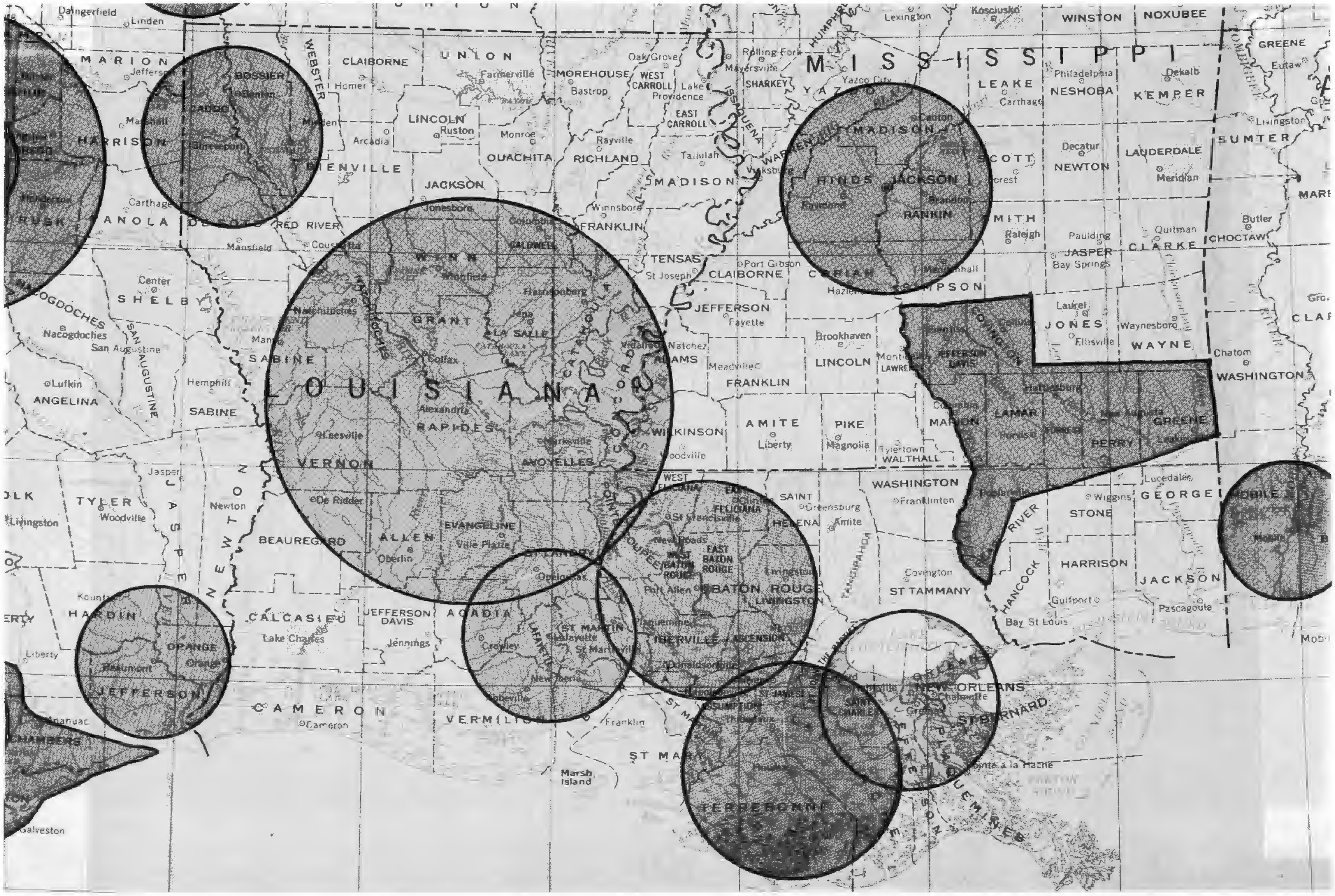


FIGURE A-28 LOCAL OPERATING AREA COVERAGE FOR LOUISIANA

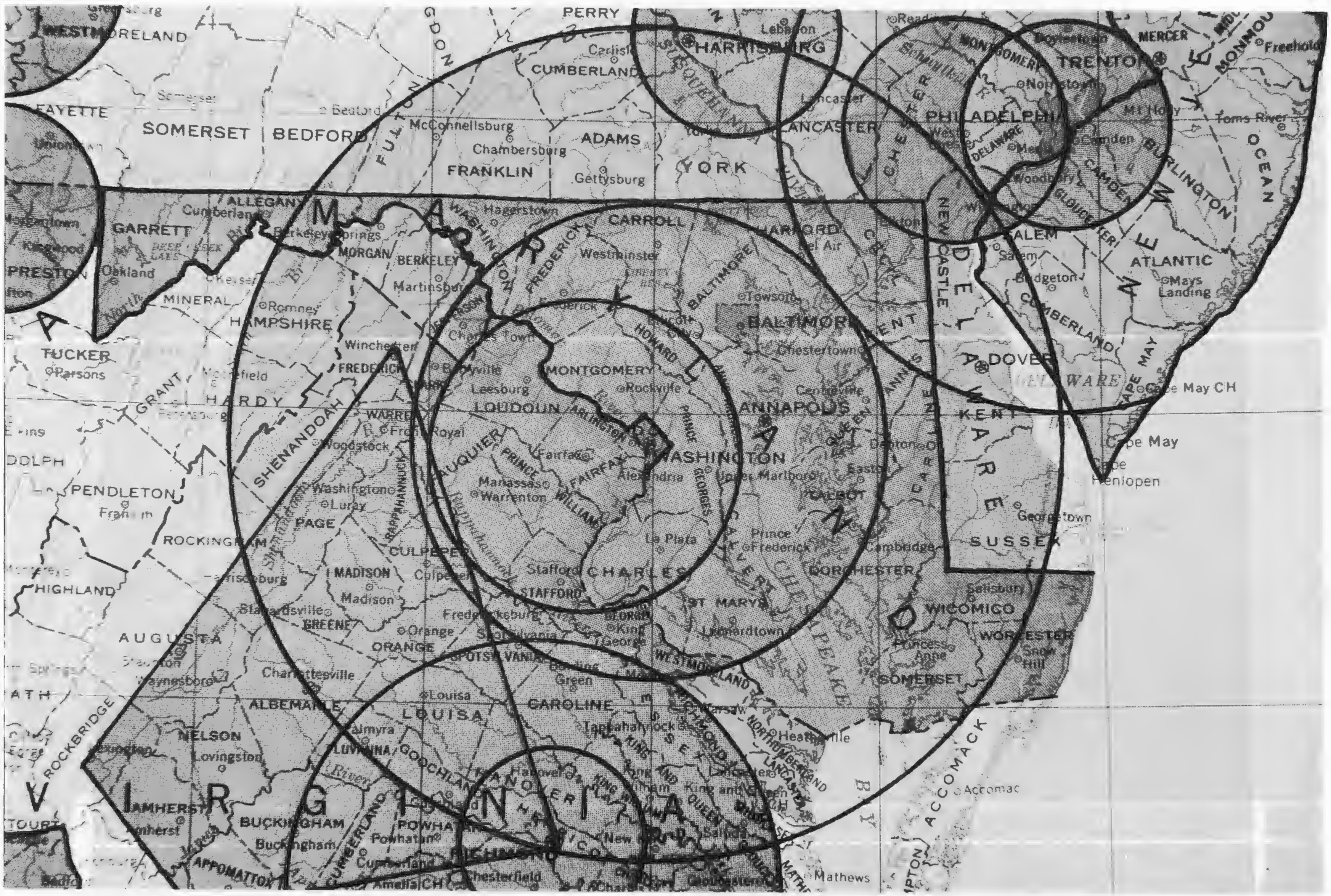


FIGURE A-29 LOCAL OPERATING AREA COVERAGE FOR MARYLAND

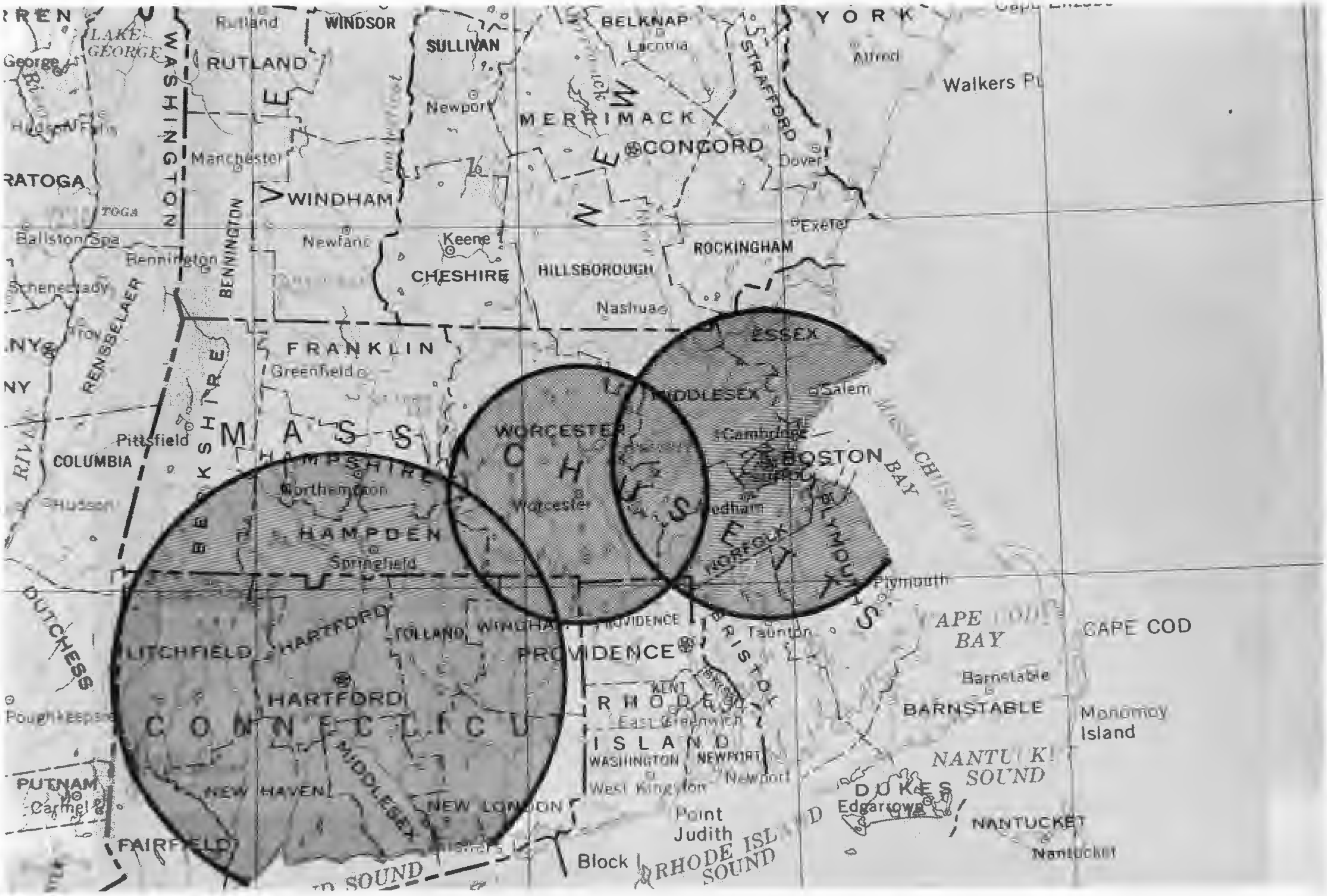


FIGURE A-30 LOCAL OPERATING AREA COVERAGE FOR MASSACHUSETTS

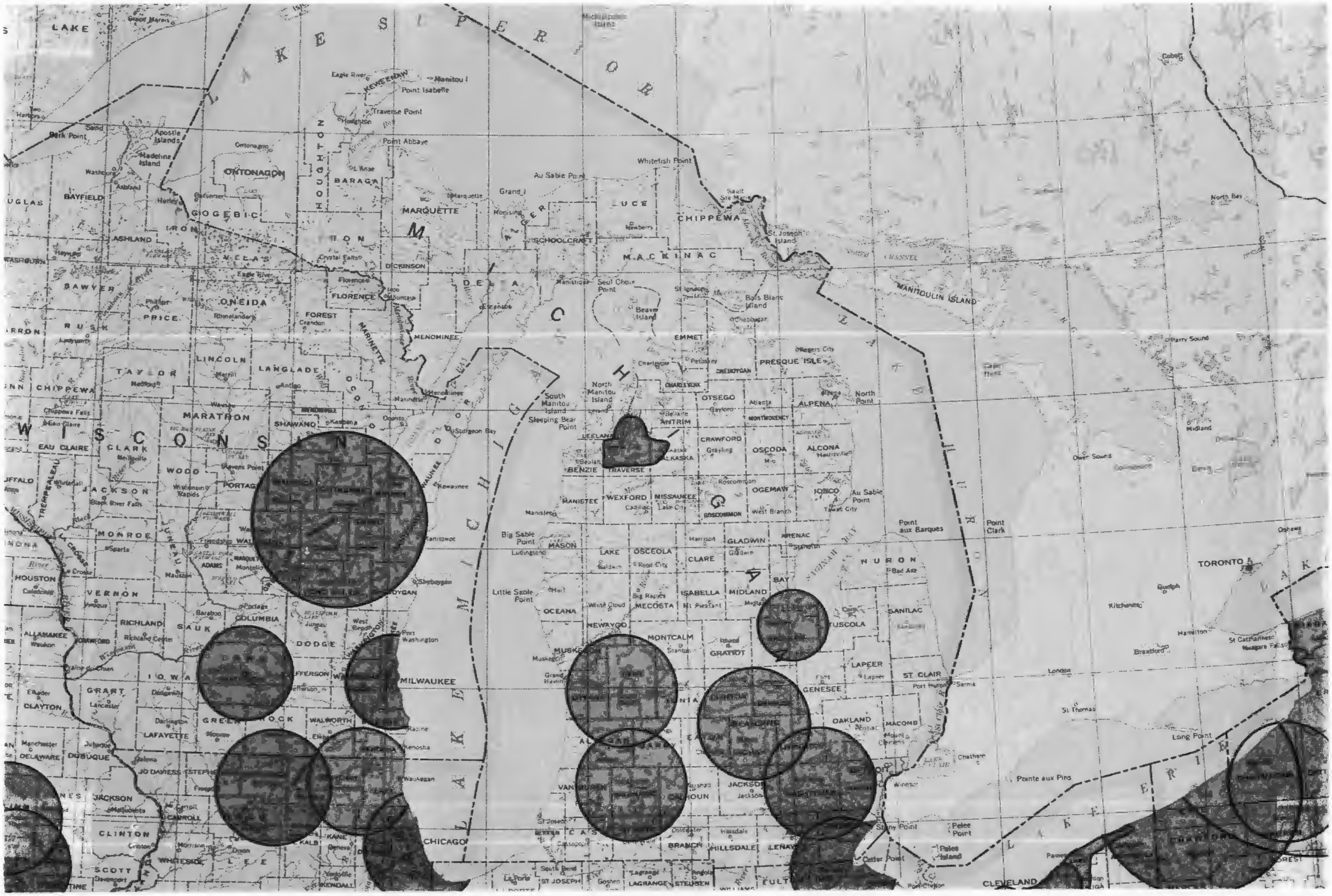


FIGURE A-31 LOCAL OPERATING AREA COVERAGE FOR MICHIGAN

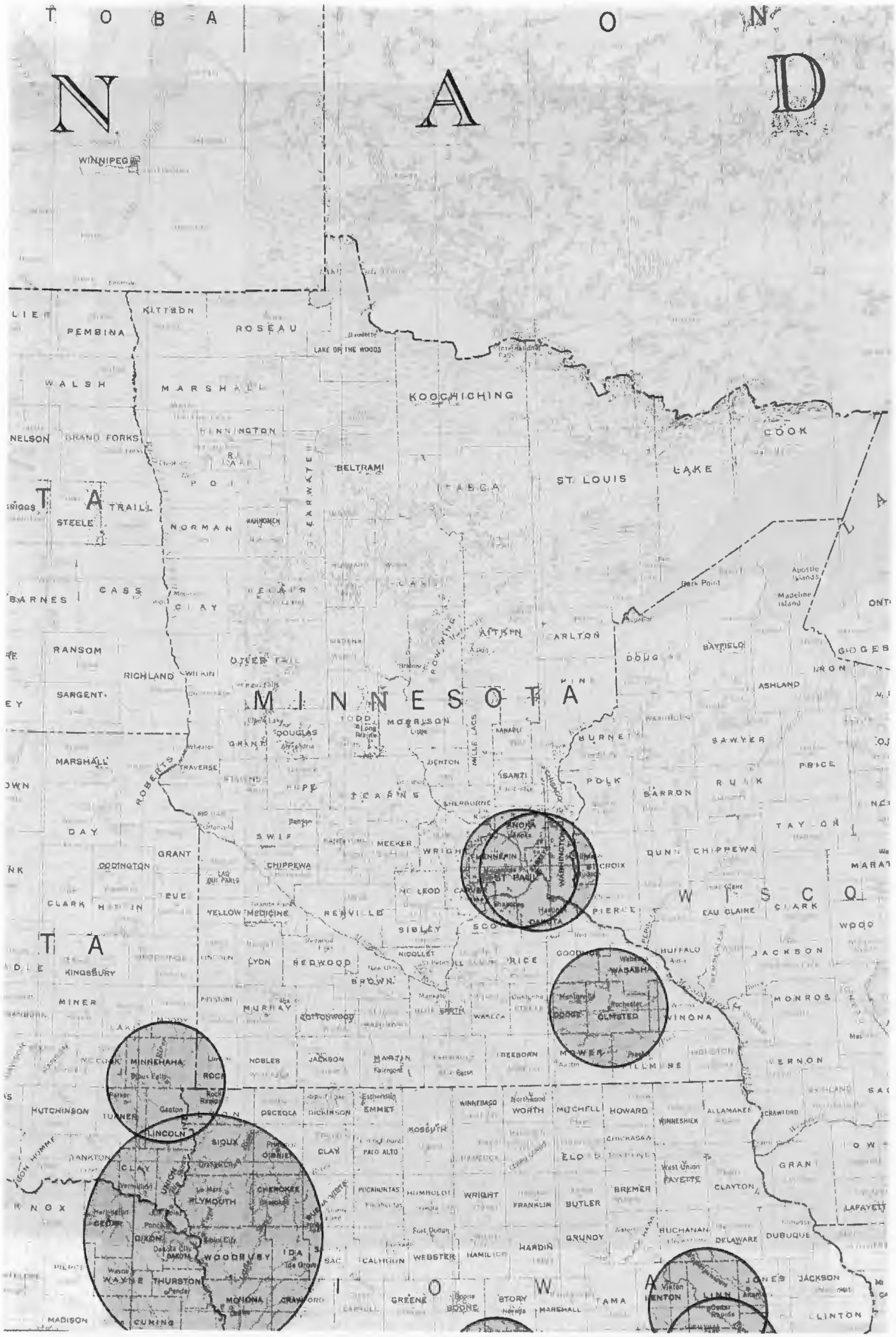


FIGURE A-32 LOCAL OPERATING AREA COVERAGE FOR MINNESOTA

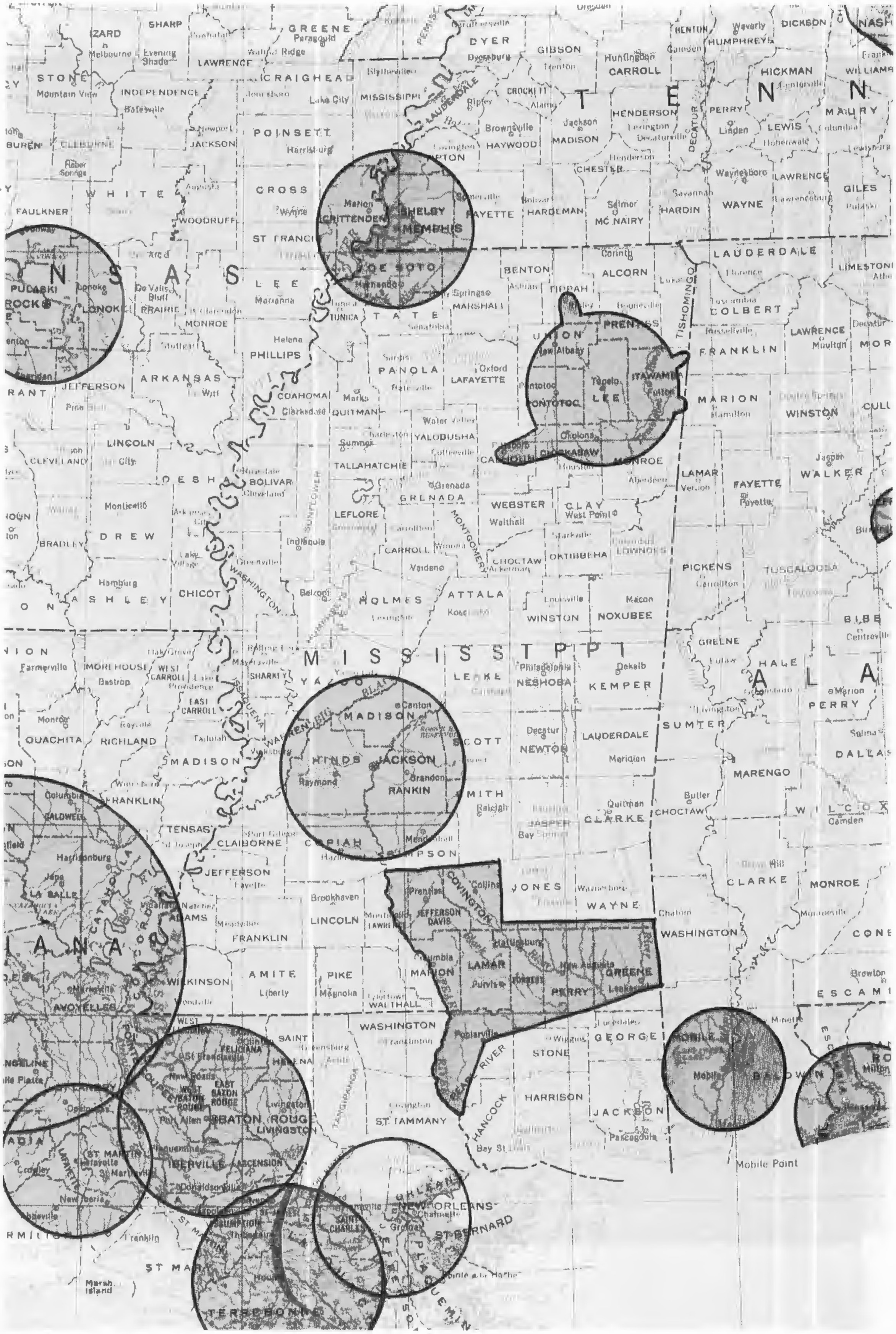


FIGURE A-33 LOCAL OPERATING AREA COVERAGE FOR MISSISSIPPI

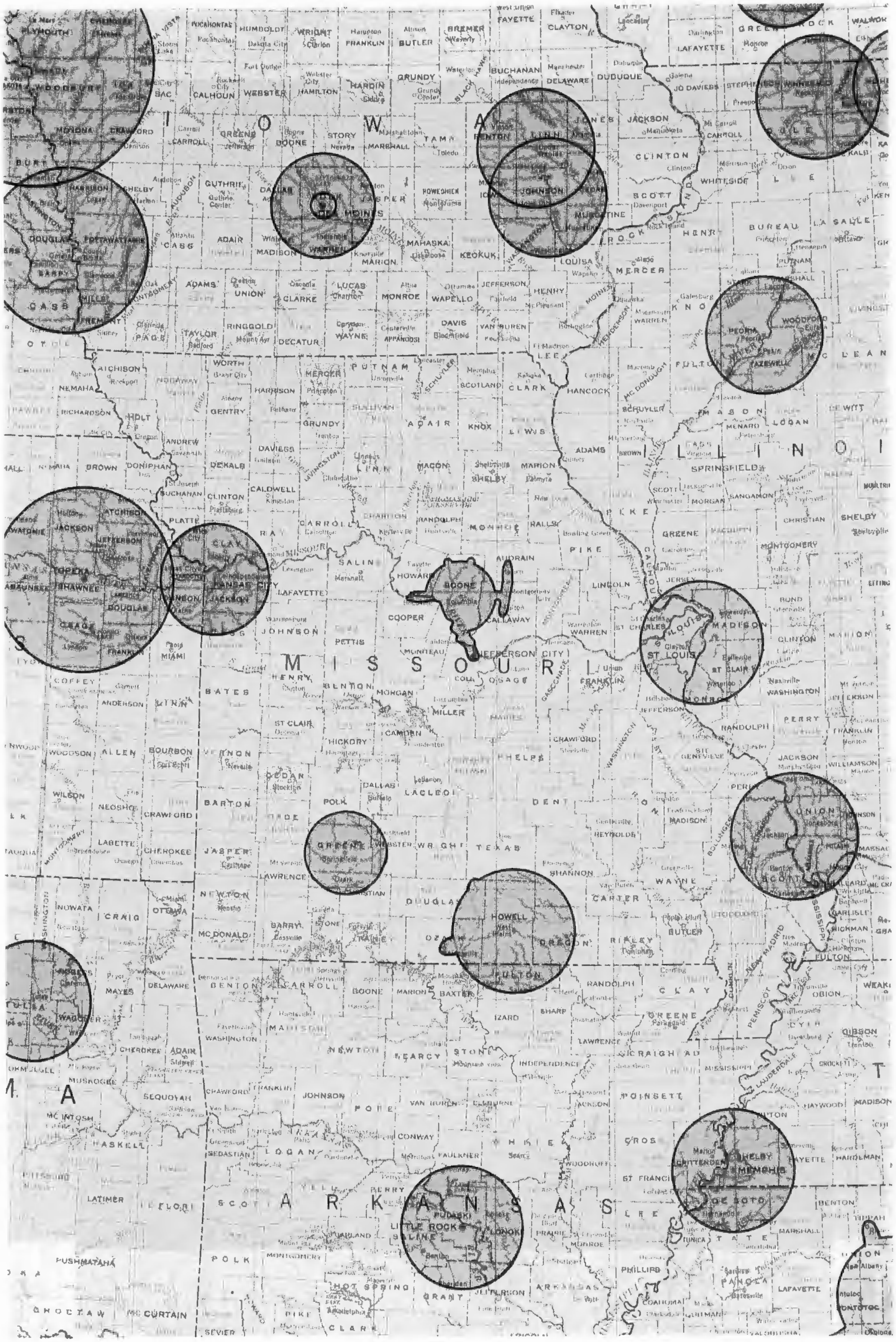


FIGURE A-34 LOCAL OPERATING AREA COVERAGE FOR MISSOURI

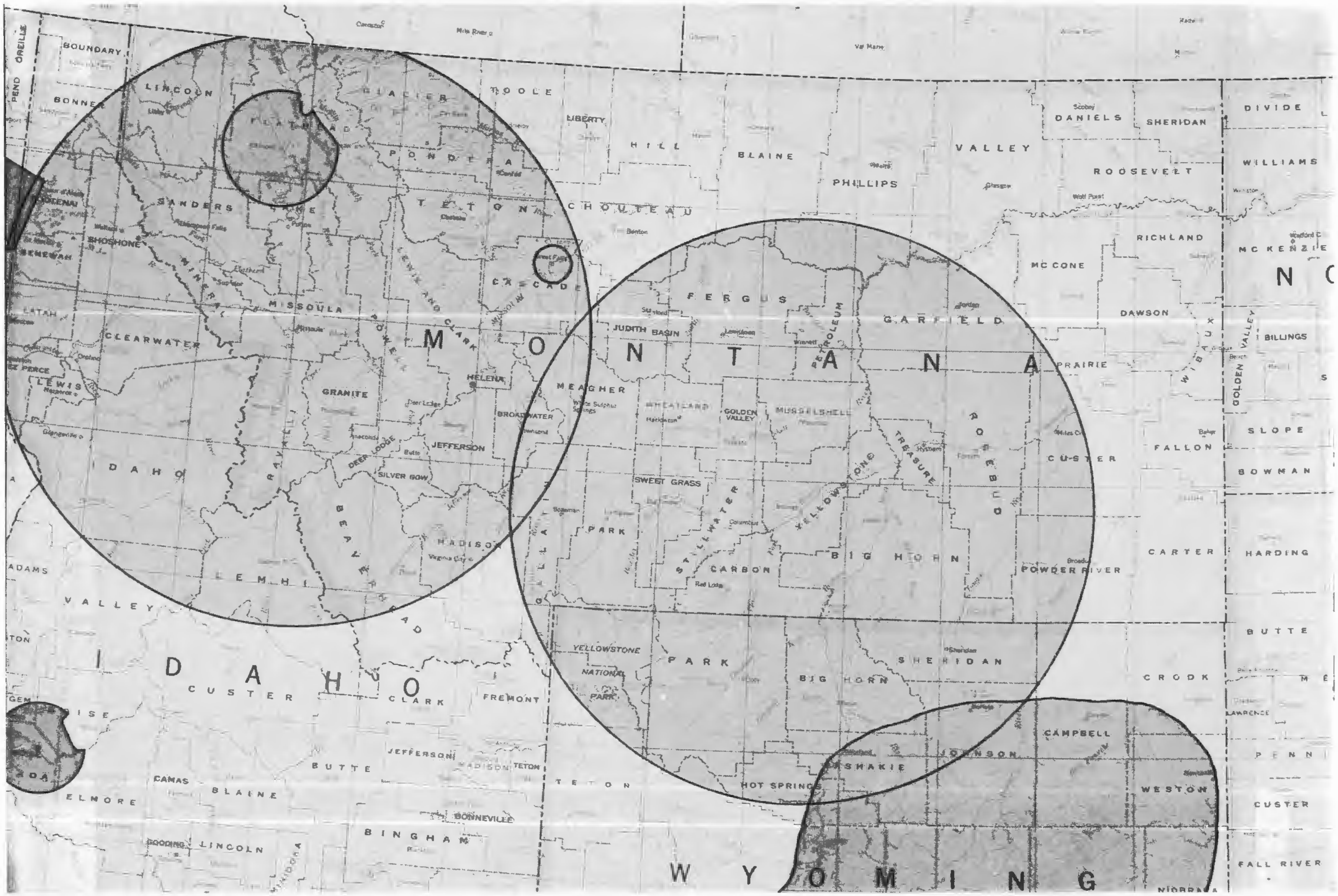


FIGURE A-35 LOCAL OPERATING AREA COVERAGE FOR MONTANA

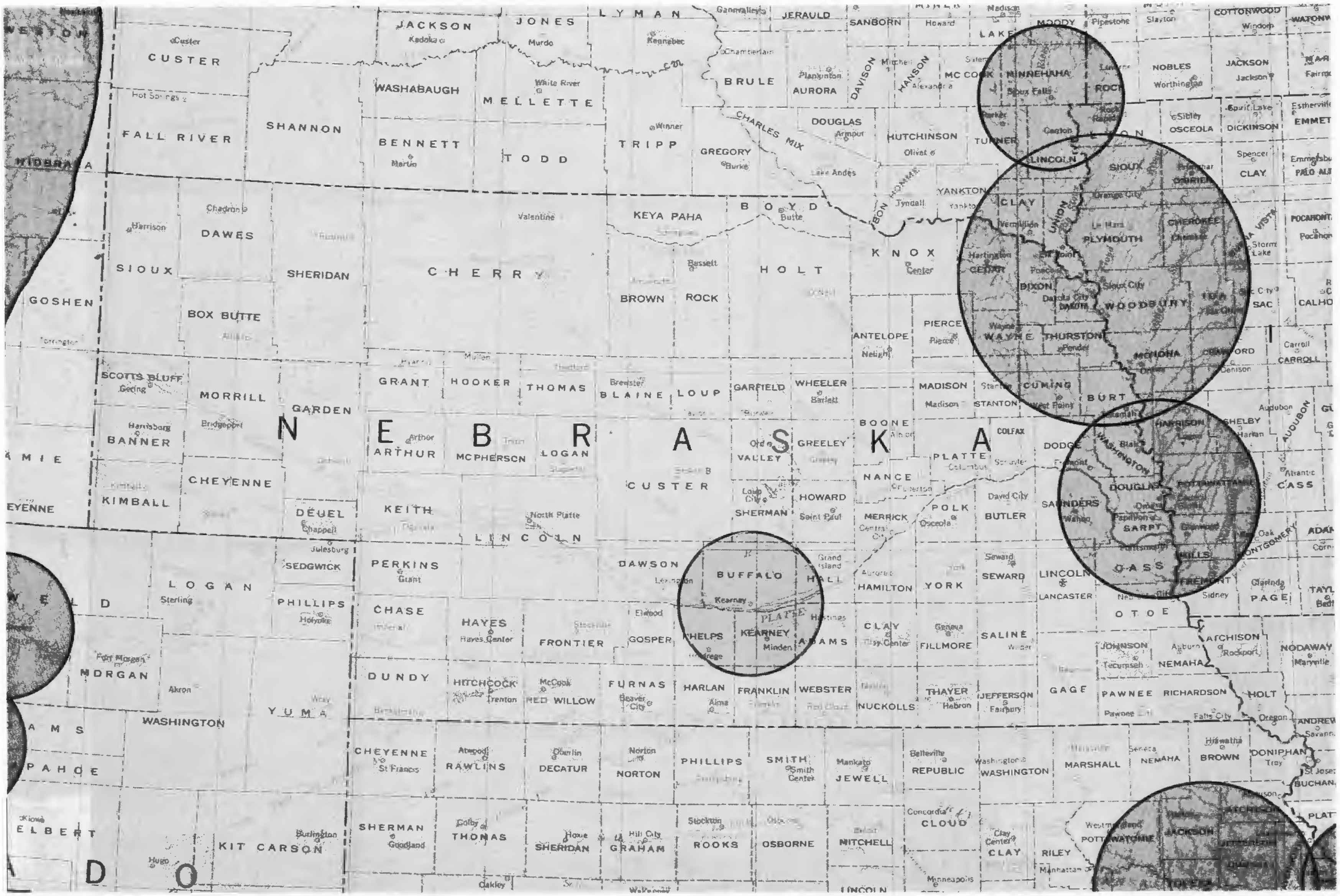


FIGURE A-36 LOCAL OPERATING AREA COVERAGE FOR NEBRASKA

FIGURE A-37 LOCAL OPERATING AREA COVERAGE FOR NEVADA

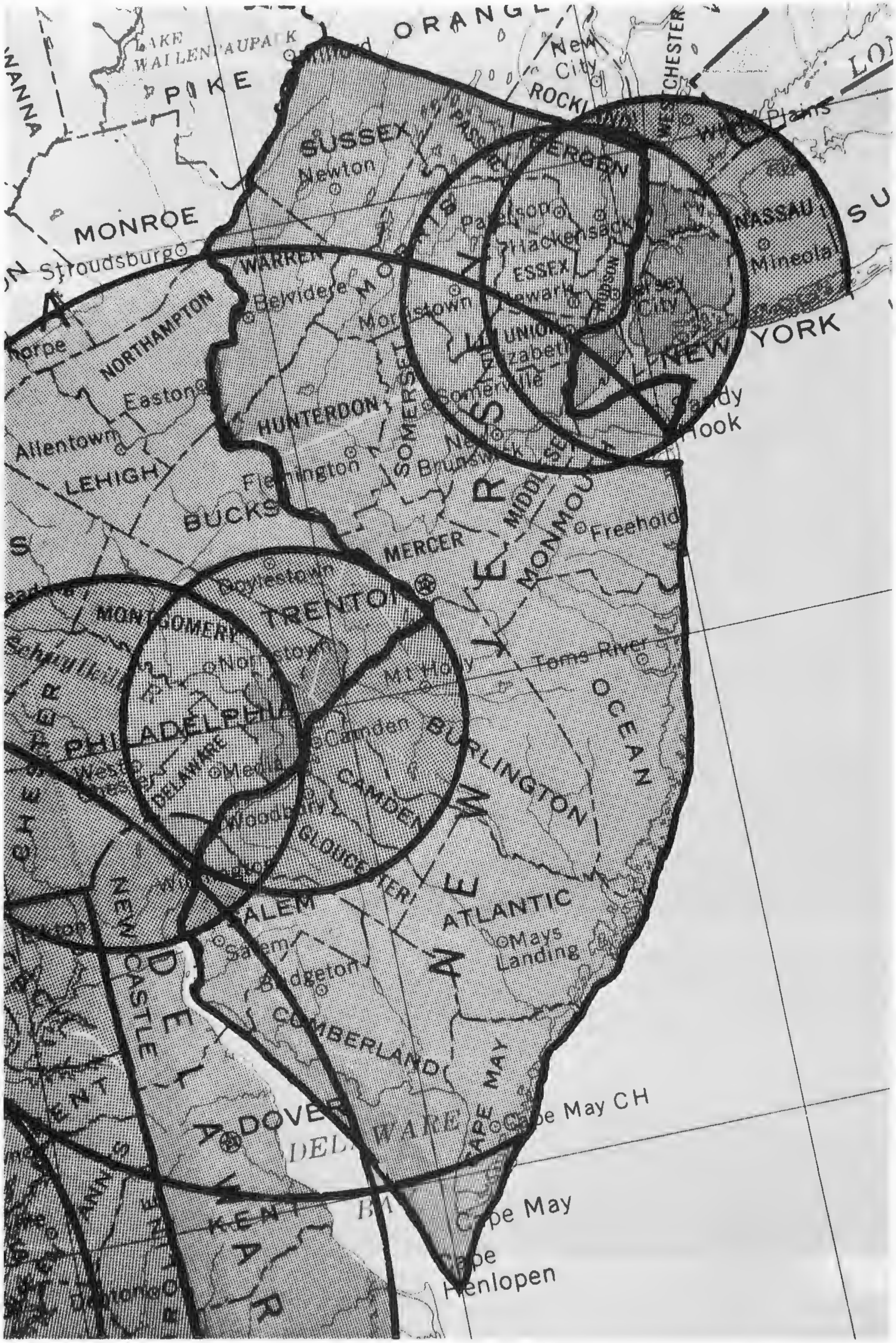


FIGURE A-38 LOCAL OPERATING AREA COVERAGE FOR NEW JERSEY

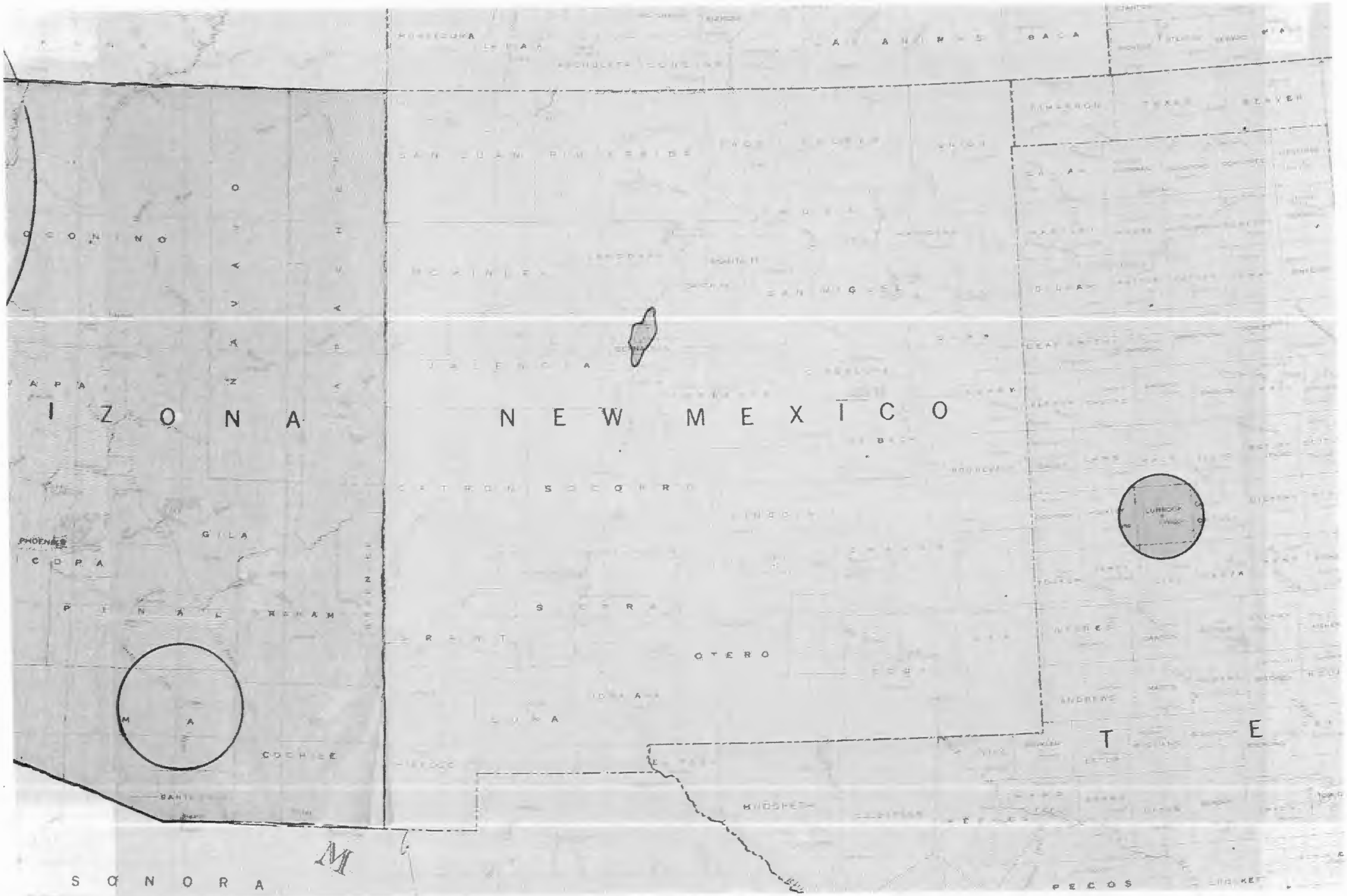


FIGURE A-39 LOCAL OPERATING AREA COVERAGE FOR NEW MEXICO

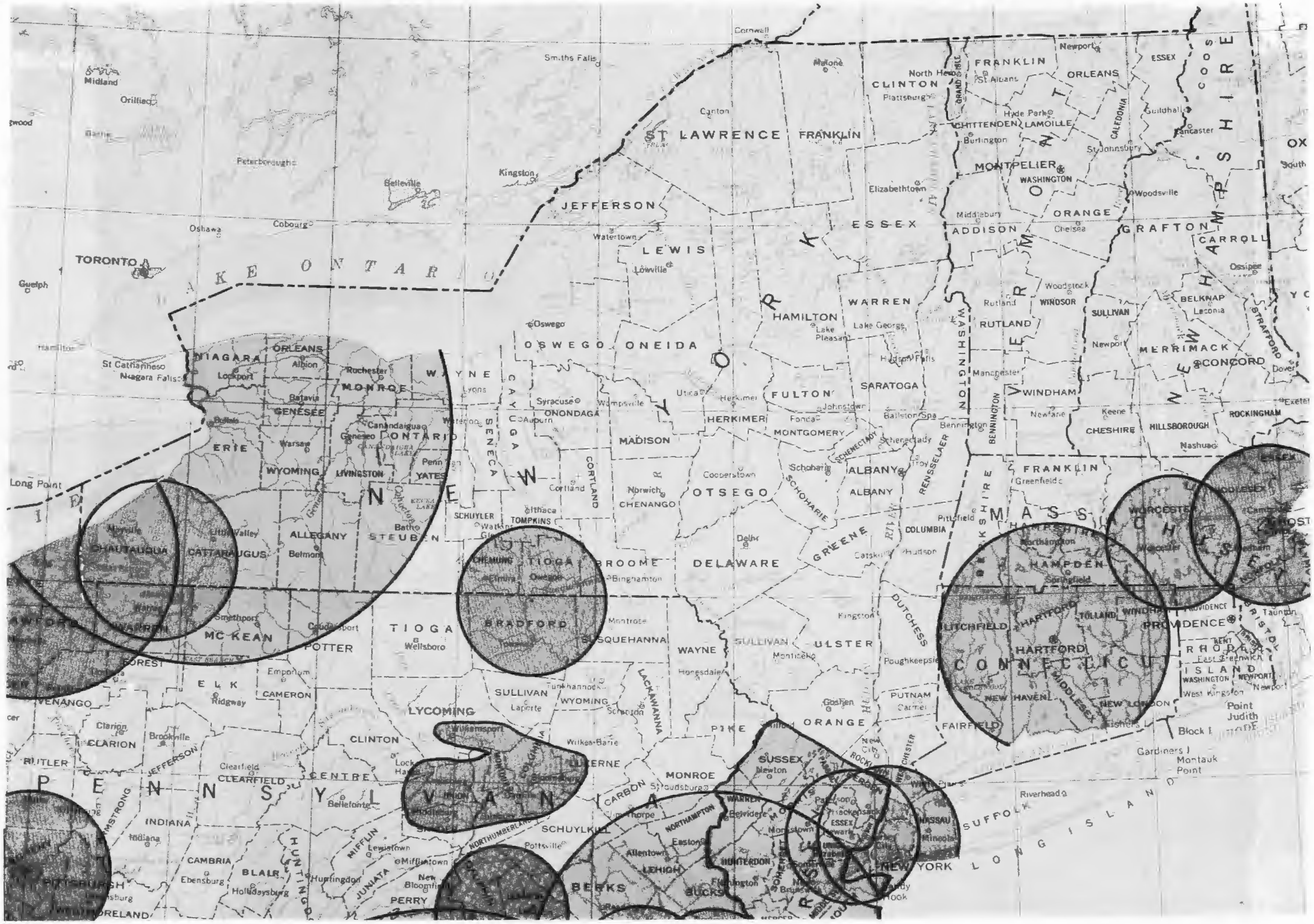


FIGURE A-40 LOCAL OPERATING AREA COVERAGE FOR NEW YORK

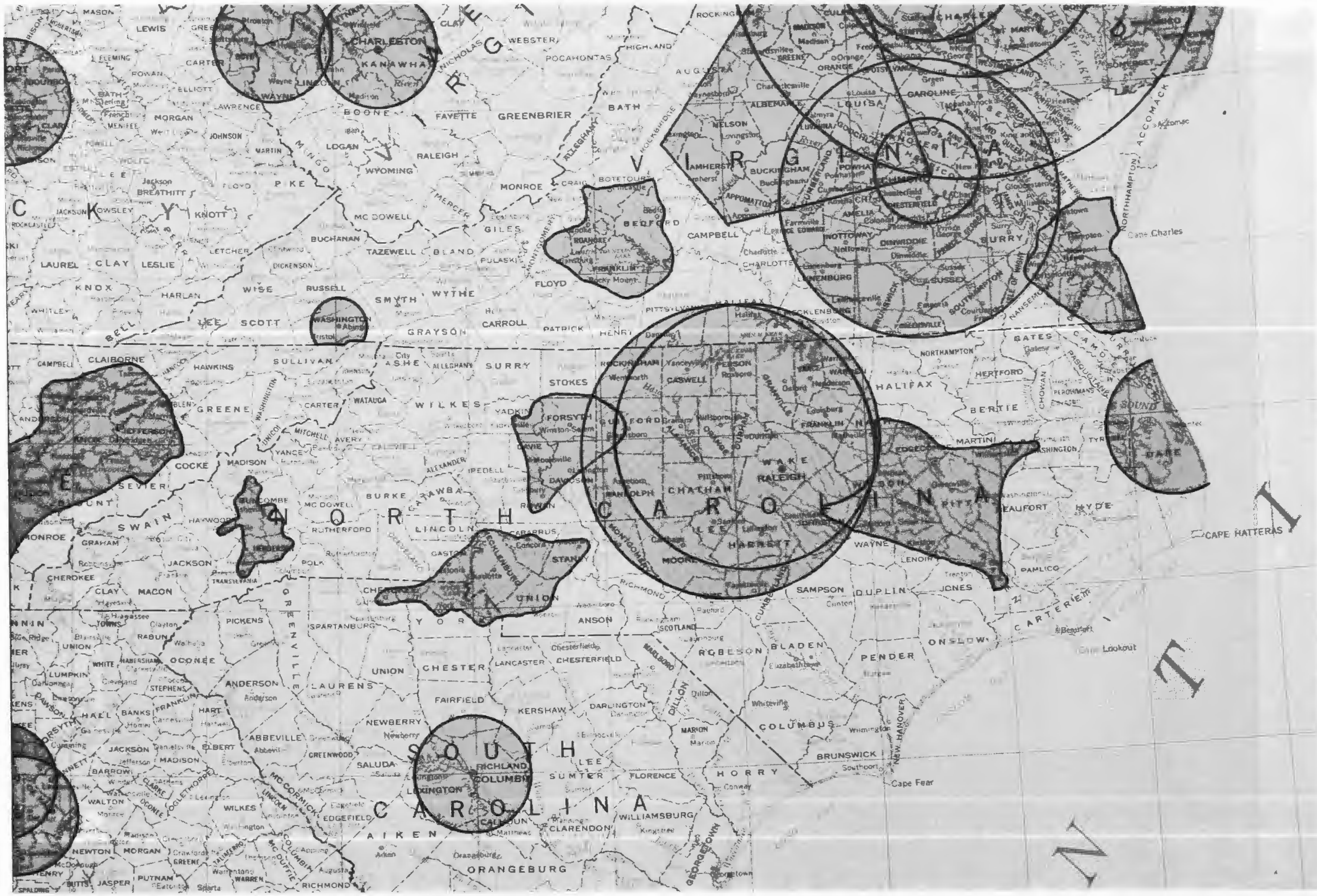


FIGURE A-41 LOCAL OPERATING AREA COVERAGE FOR NORTH CAROLINA

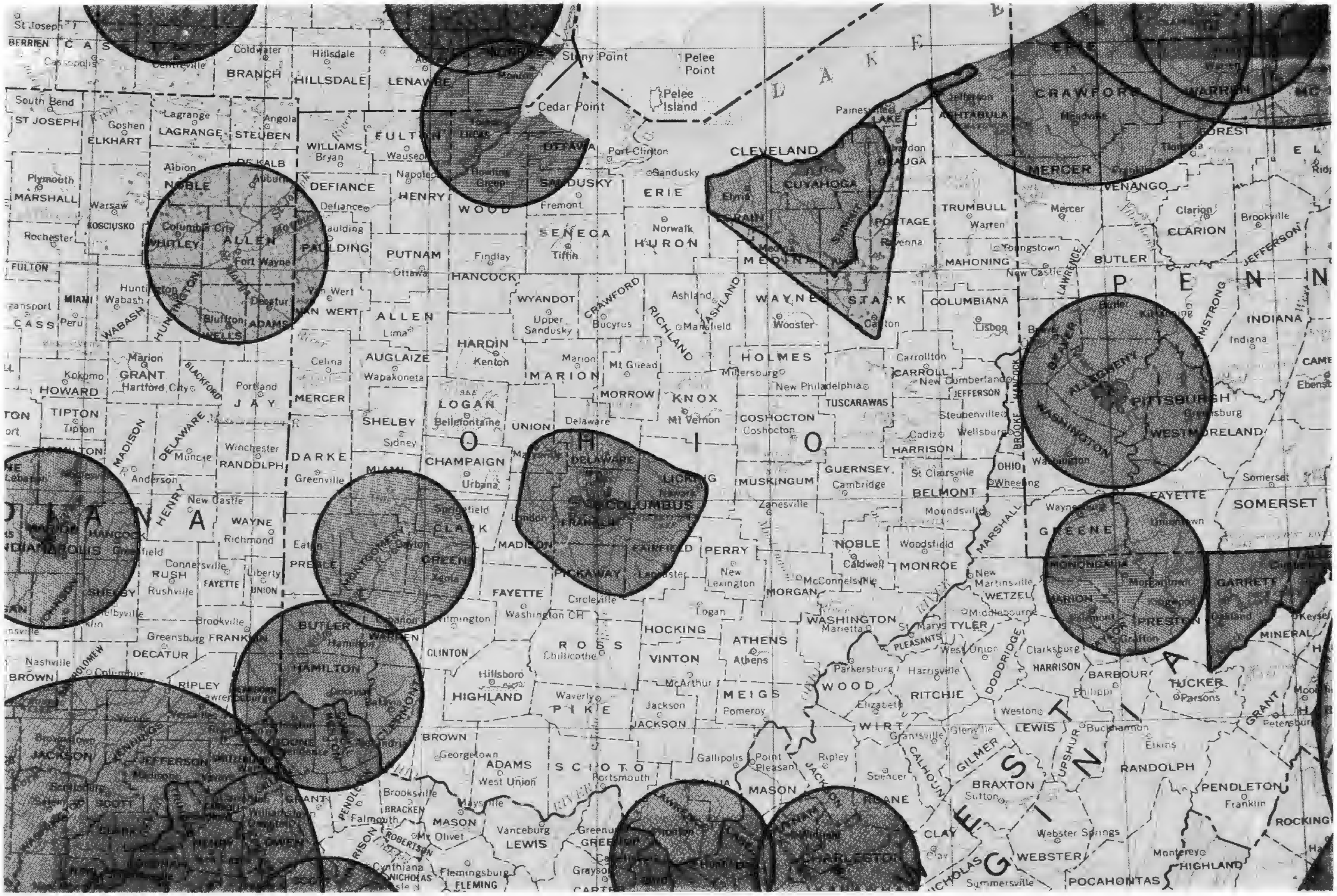


FIGURE A-42 LOCAL OPERATING AREA COVERAGE FOR OHIO

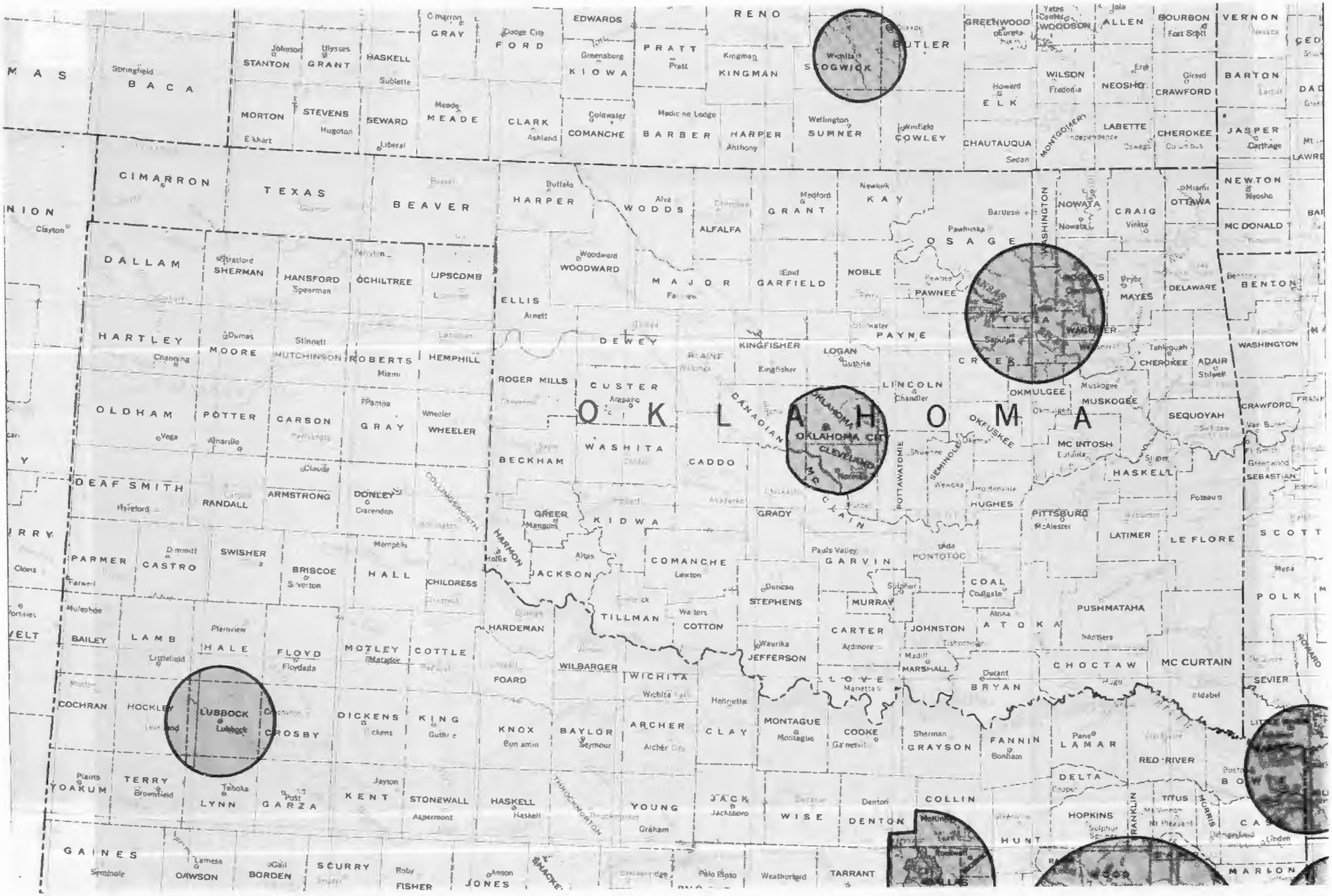


FIGURE A-43 LOCAL OPERATING AREA COVERAGE FOR OKLAHOMA

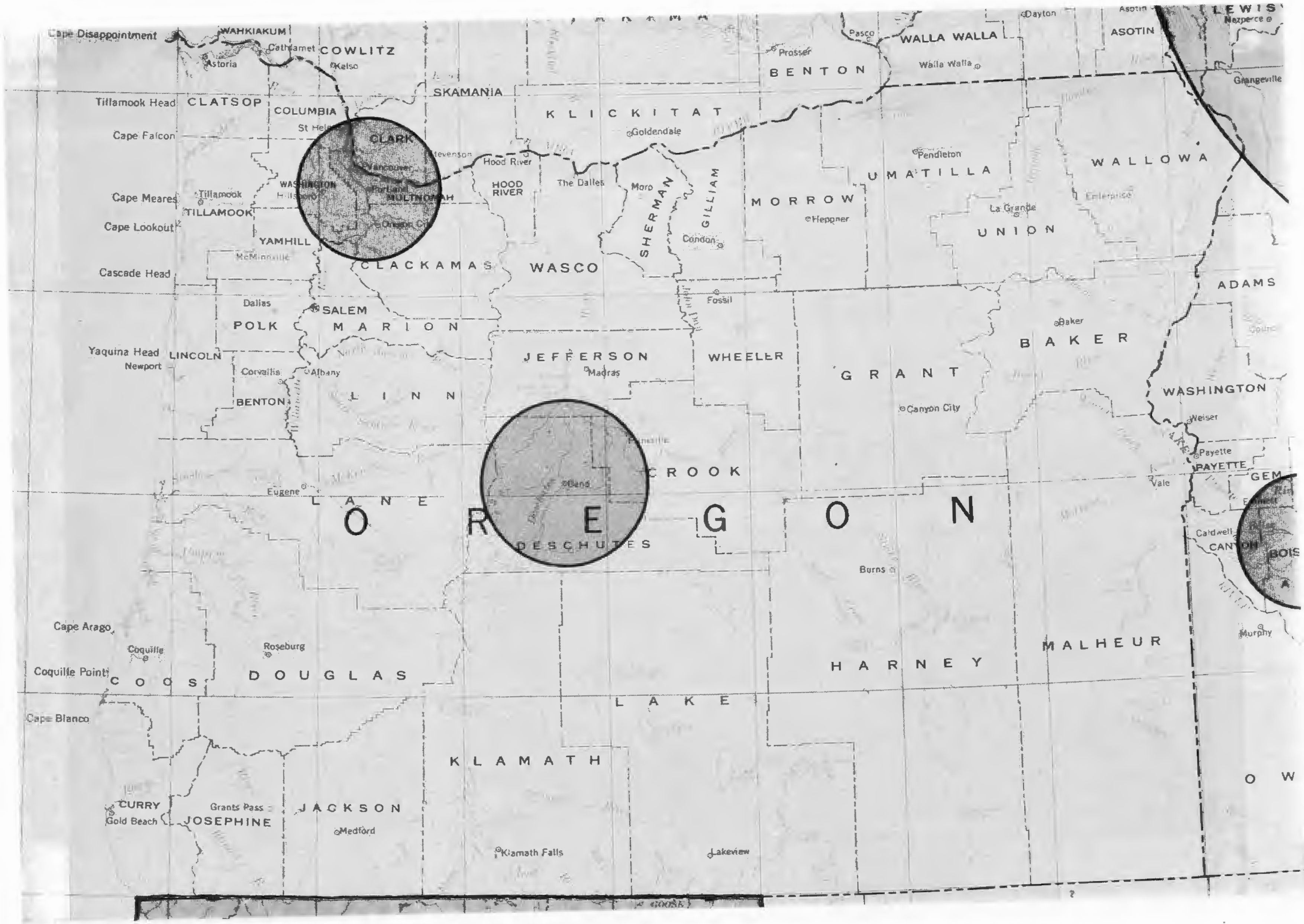


FIGURE A-44 LOCAL OPERATING AREA COVERAGE FOR OREGON

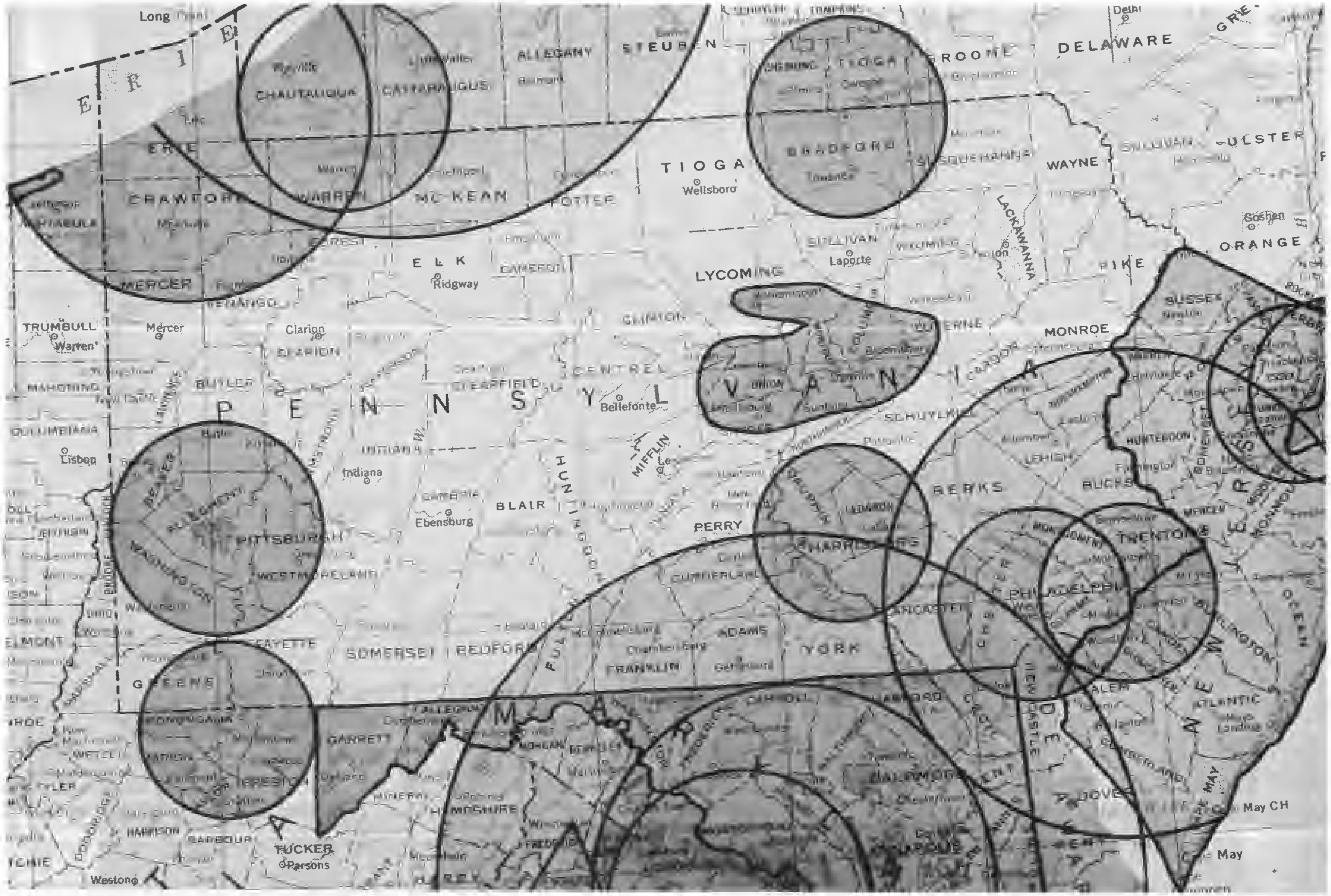


FIGURE A-45 LOCAL OPERATING AREA COVERAGE FOR PENNSYLVANIA

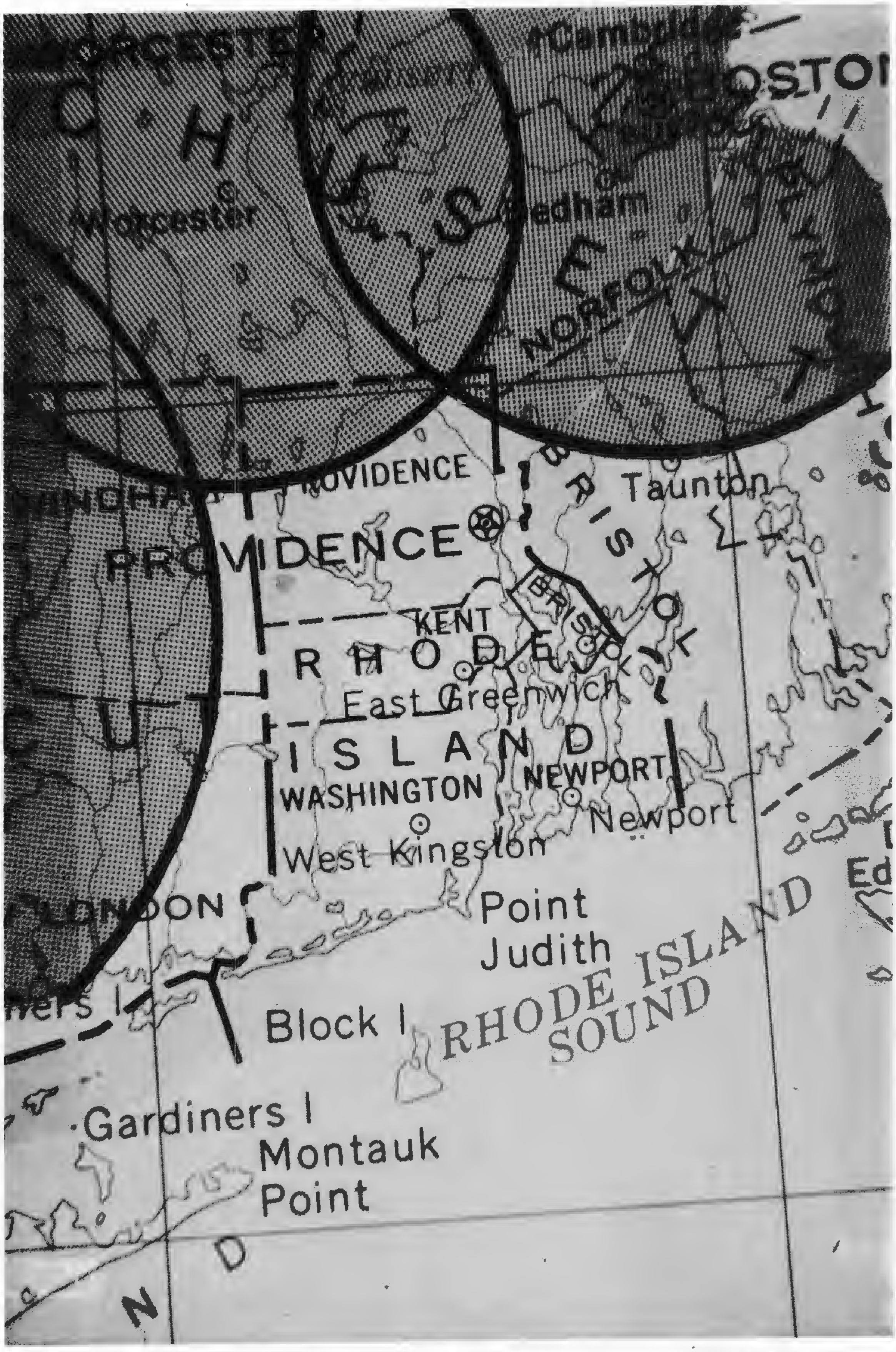


FIGURE A-46 LOCAL OPERATING AREA COVERAGE FOR RHODE ISLAND

FIGURE A-47 LOCAL OPERATING AREA COVERAGE FOR SOUTH CAROLINA

FIGURE A-48 LOCAL OPERATING AREA COVERAGE FOR SOUTH DAKOTA

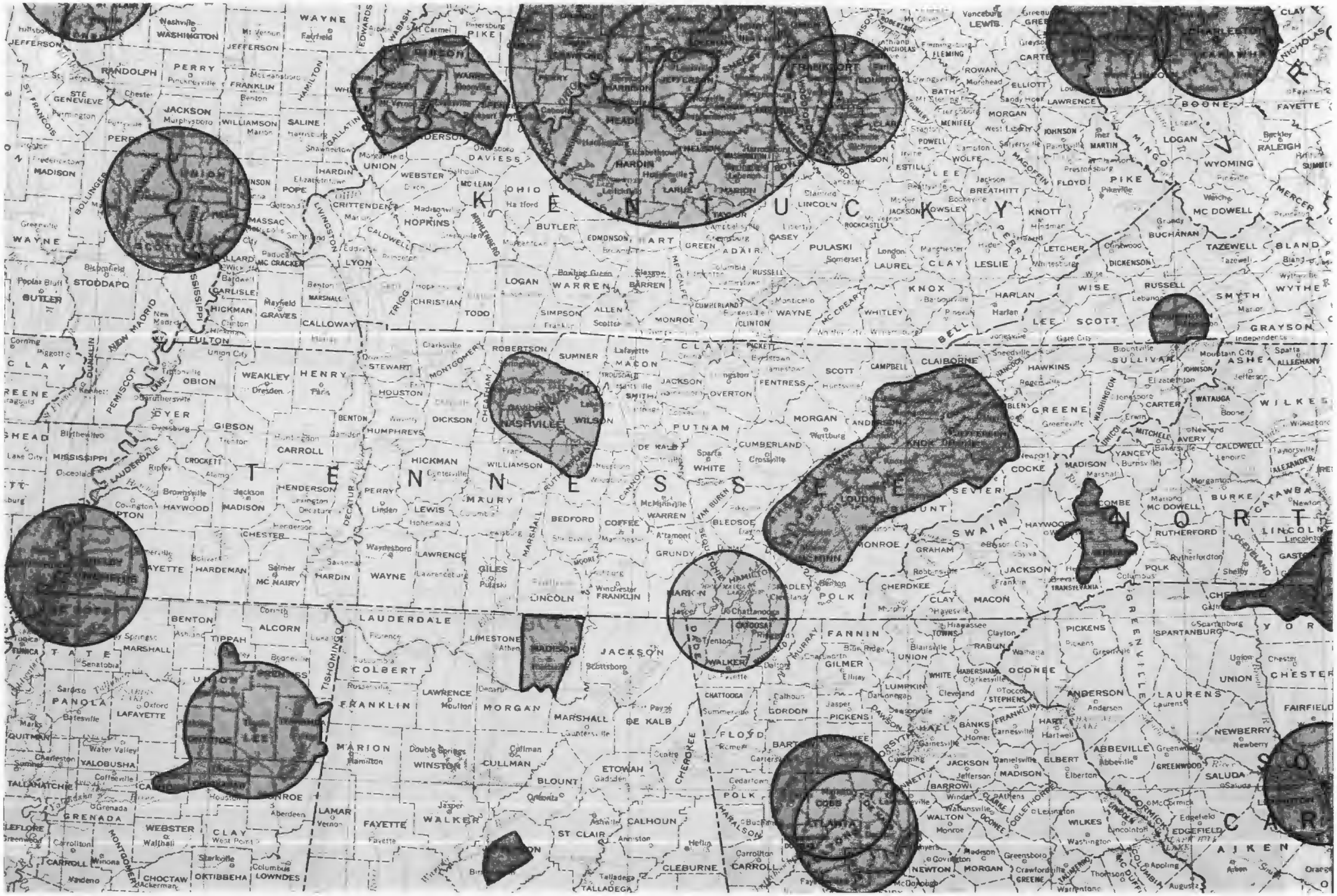


FIGURE A-49 LOCAL OPERATING AREA COVERAGE FOR TENNESSEE

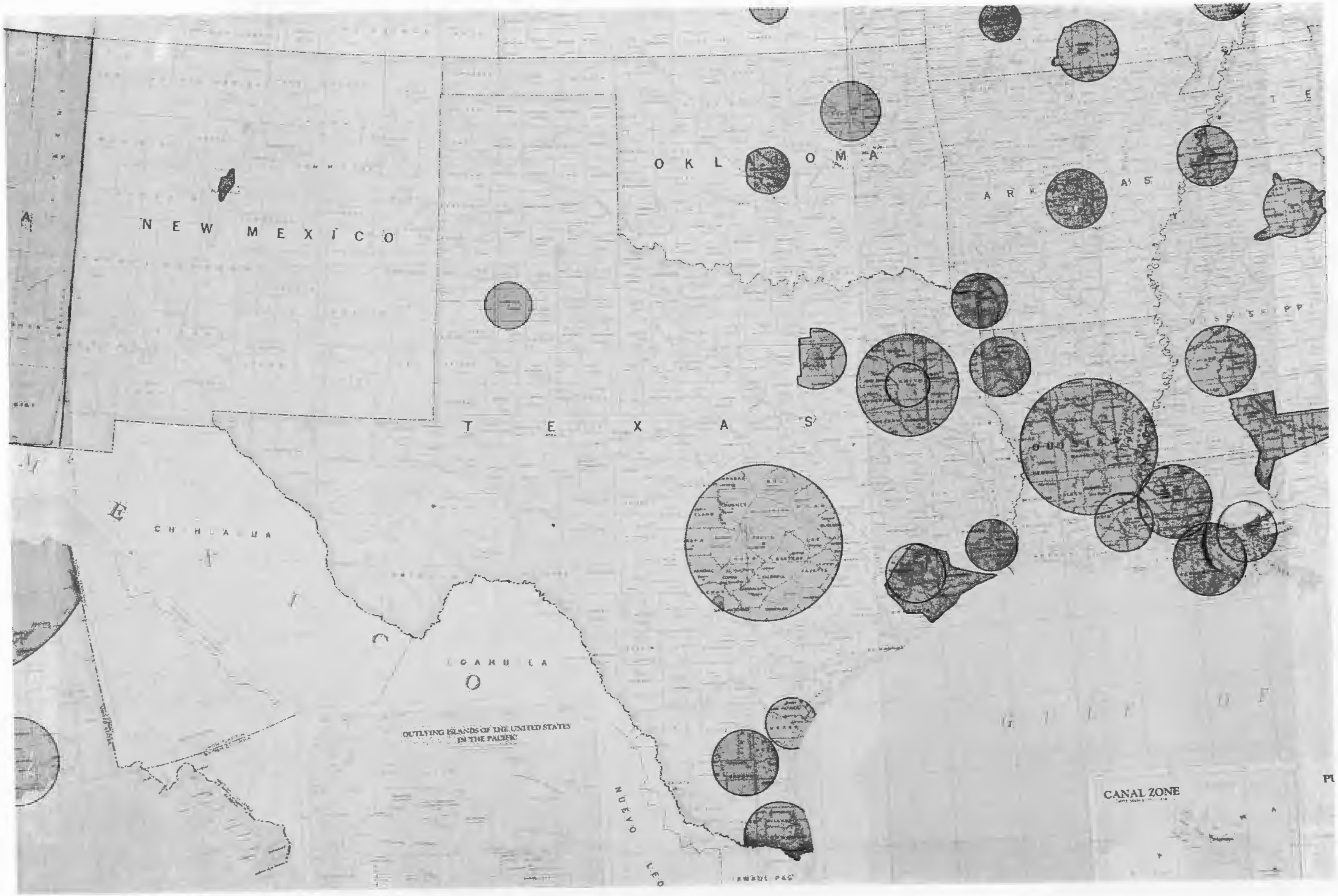


FIGURE A-50 LOCAL OPERATING AREA COVERAGE FOR TEXAS

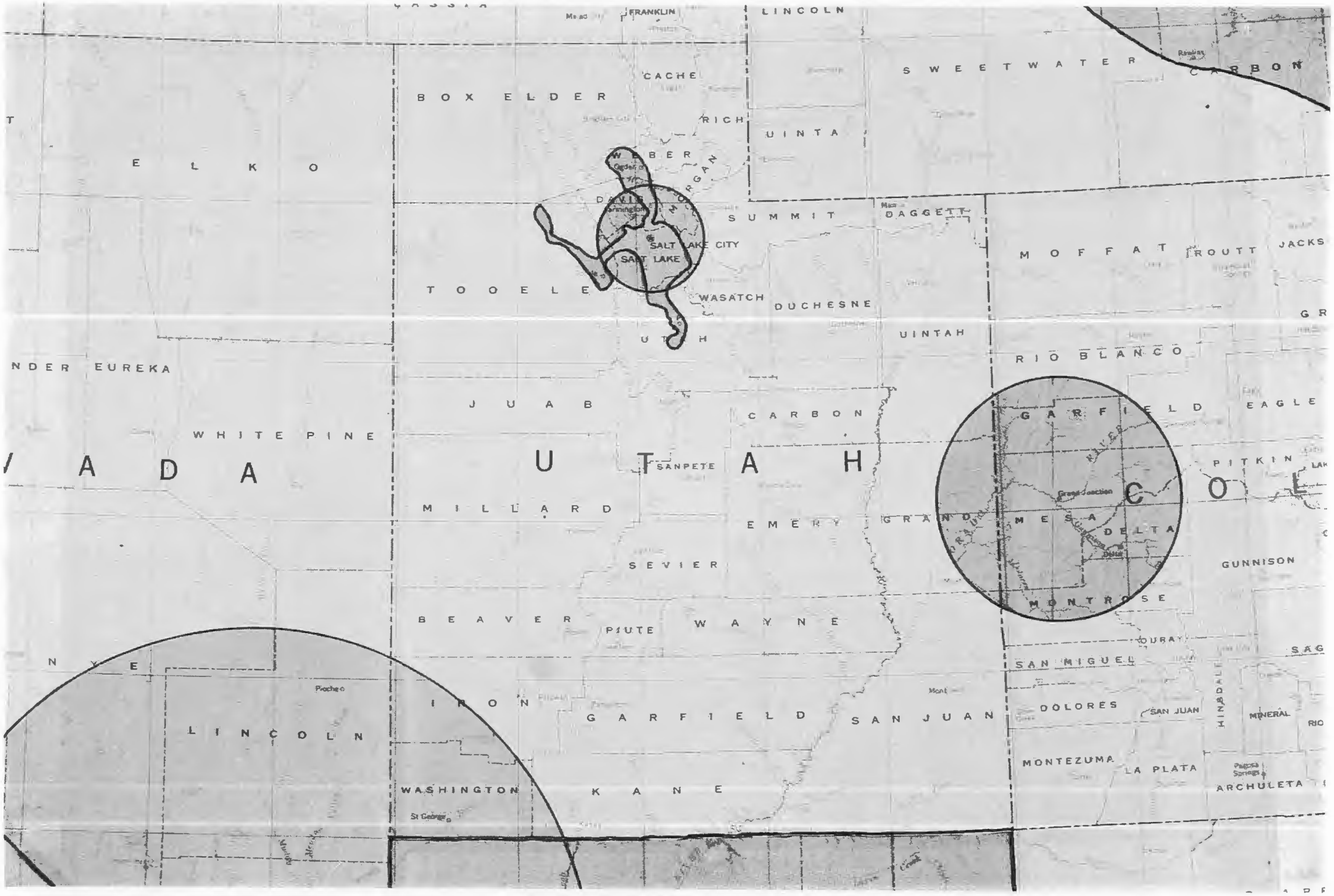


FIGURE A-51 LOCAL OPERATING AREA COVERAGE FOR UTAH

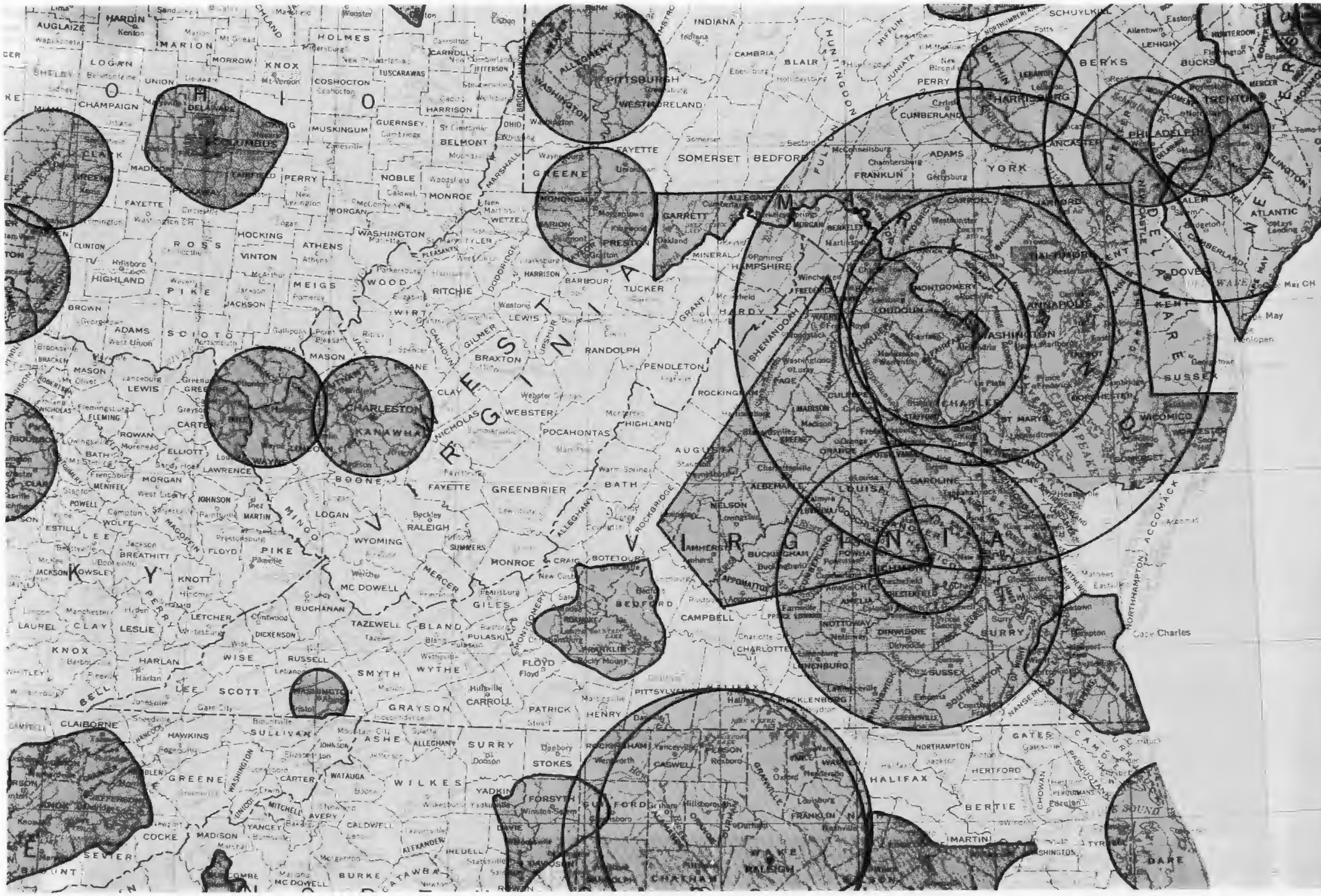


FIGURE A-52 LOCAL OPERATING AREA COVERAGE FOR VIRGINIA

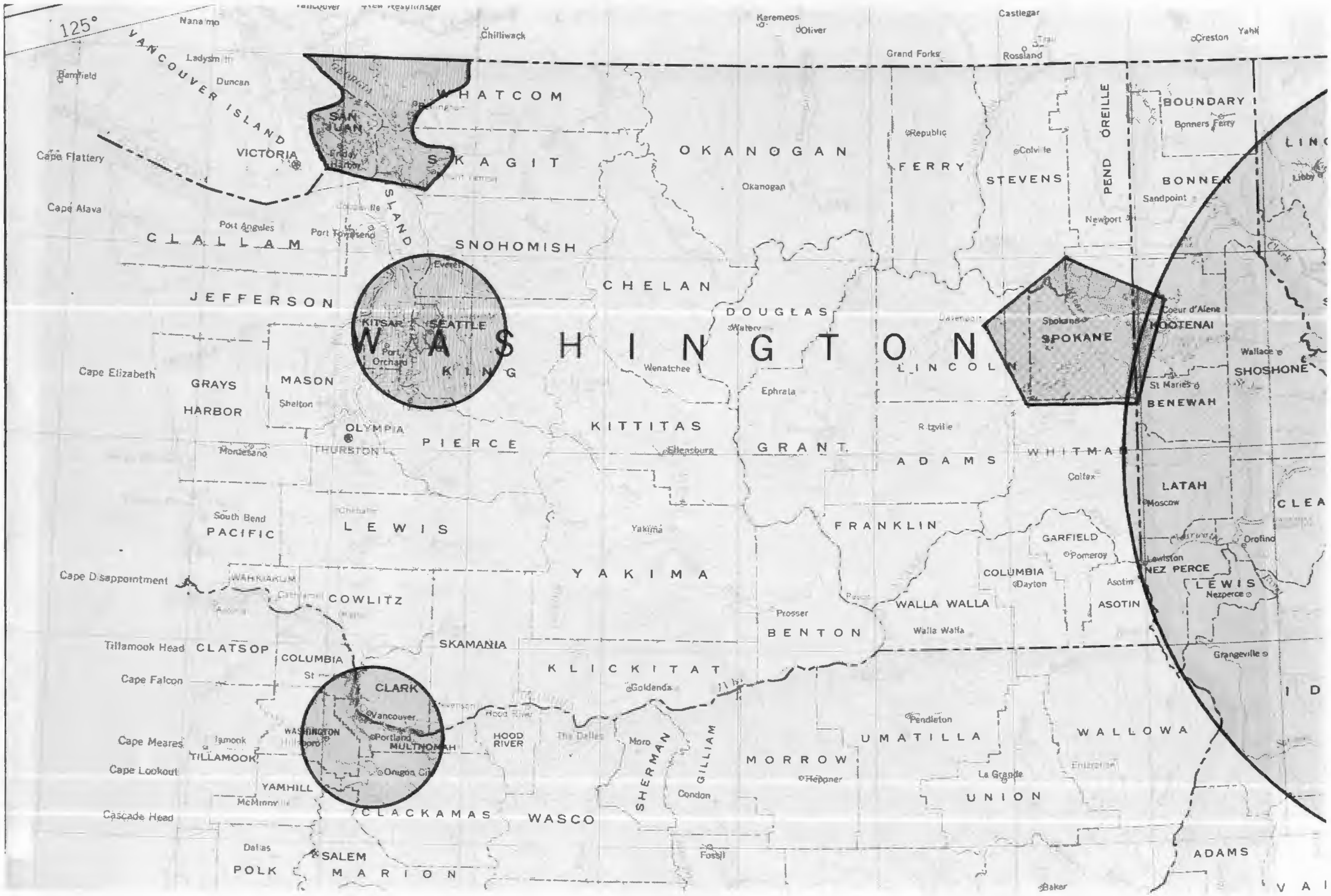


FIGURE A-53 LOCAL OPERATING AREA COVERAGE FOR WASHINGTON

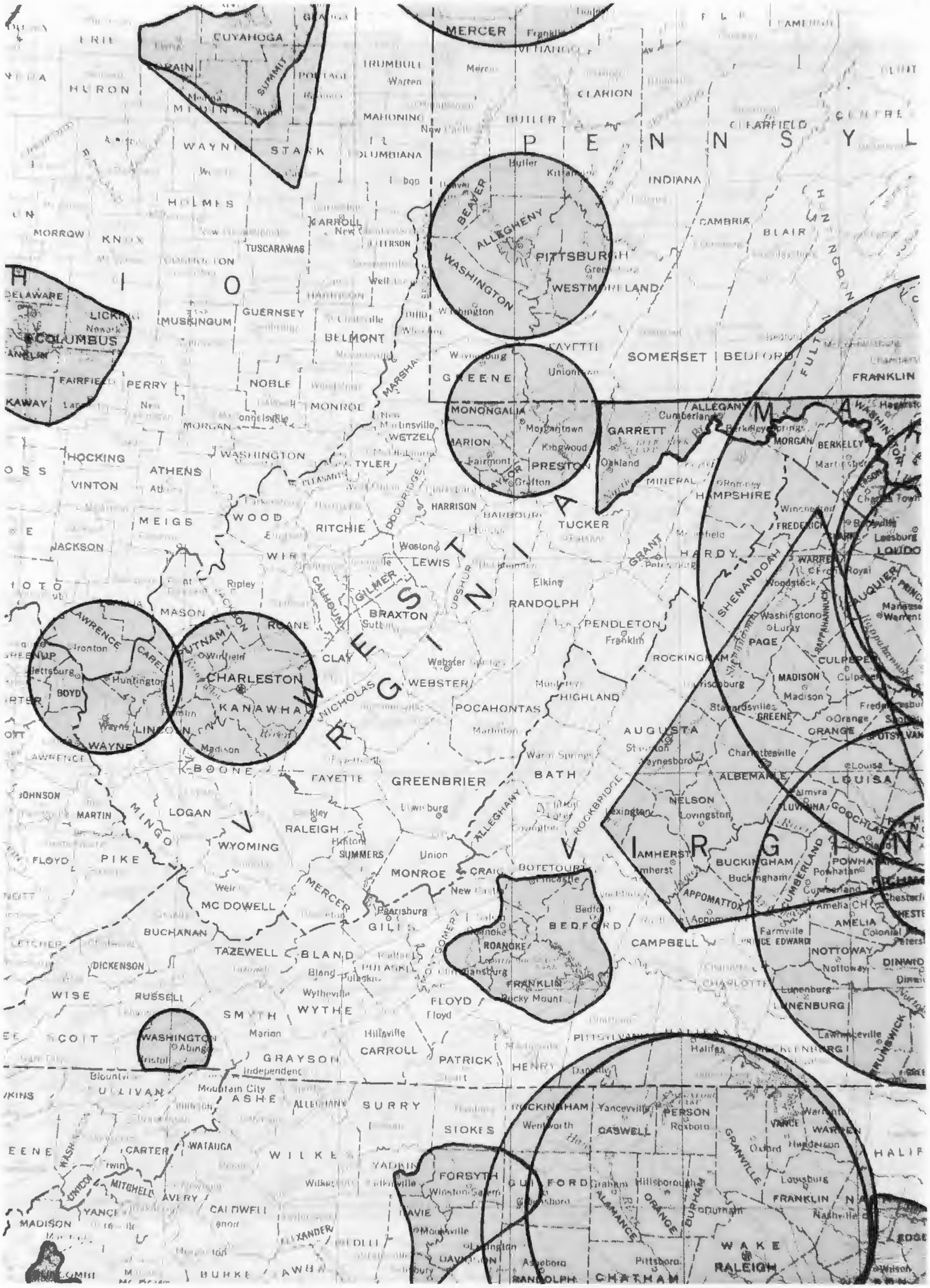


FIGURE A-54 LOCAL OPERATING AREA COVERAGE FOR WEST VIRGINIA

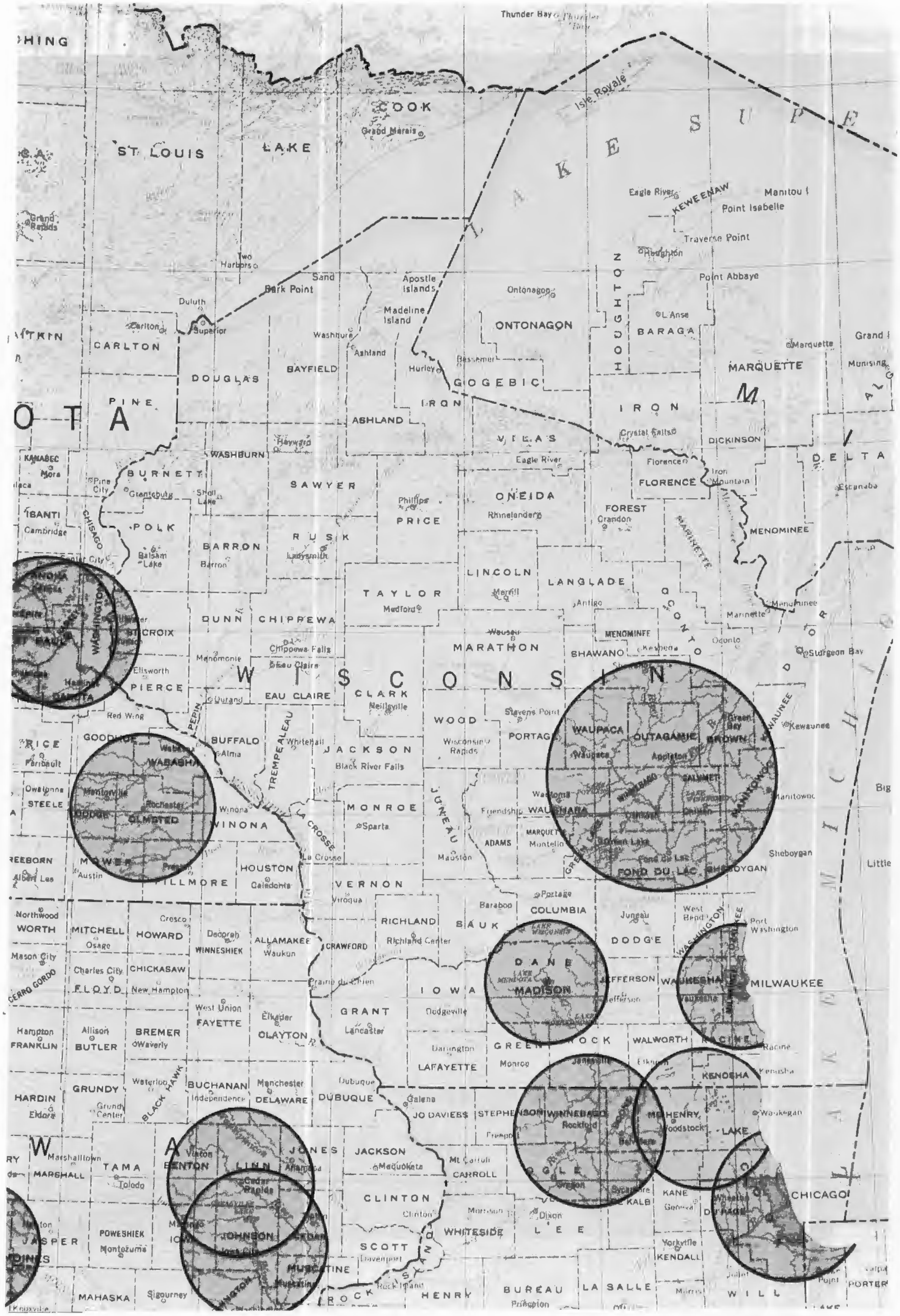


FIGURE A-55 LOCAL OPERATING AREA COVERAGE FOR WISCONSIN

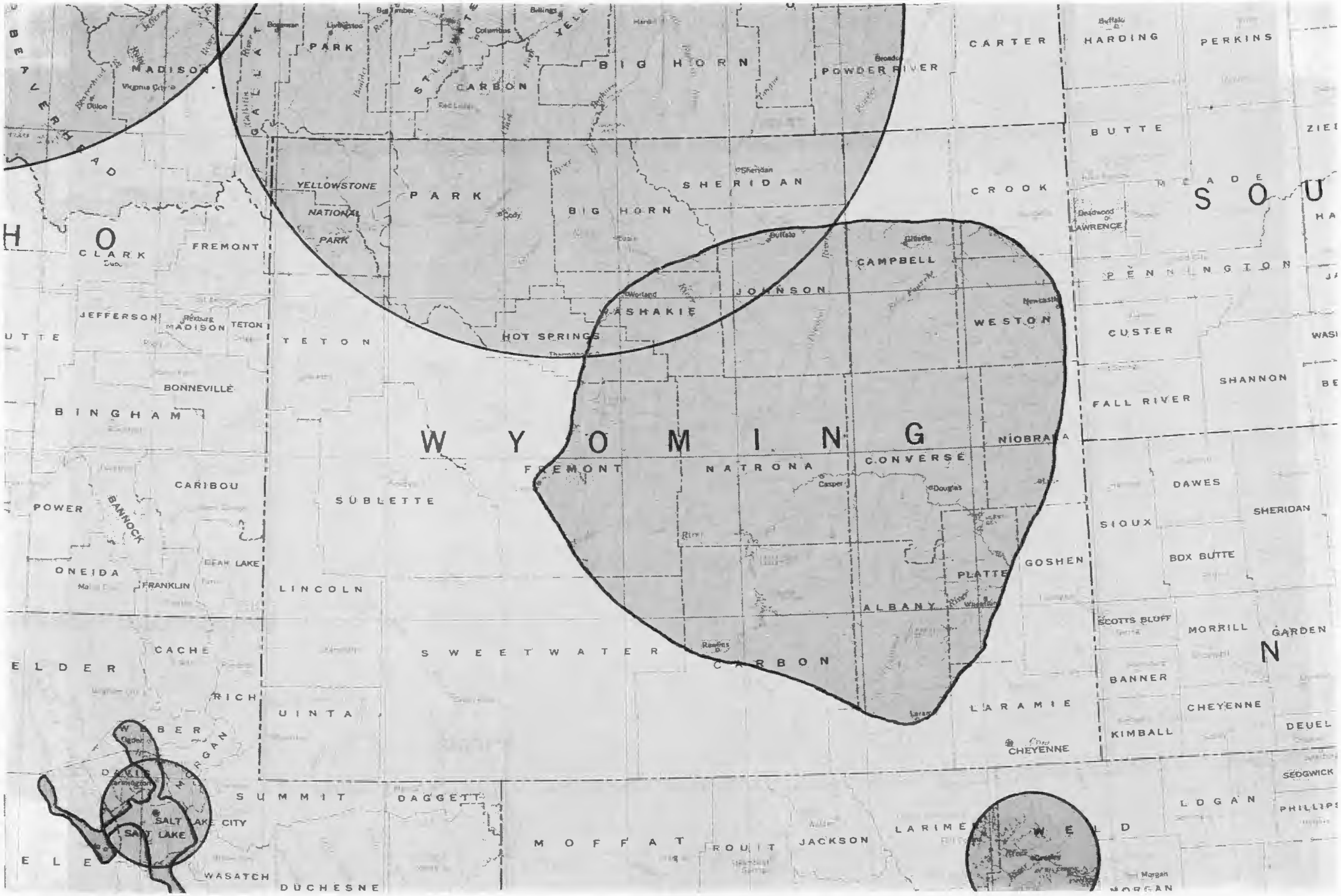


FIGURE A-56 LOCAL OPERATING AREA COVERAGE FOR WYOMING

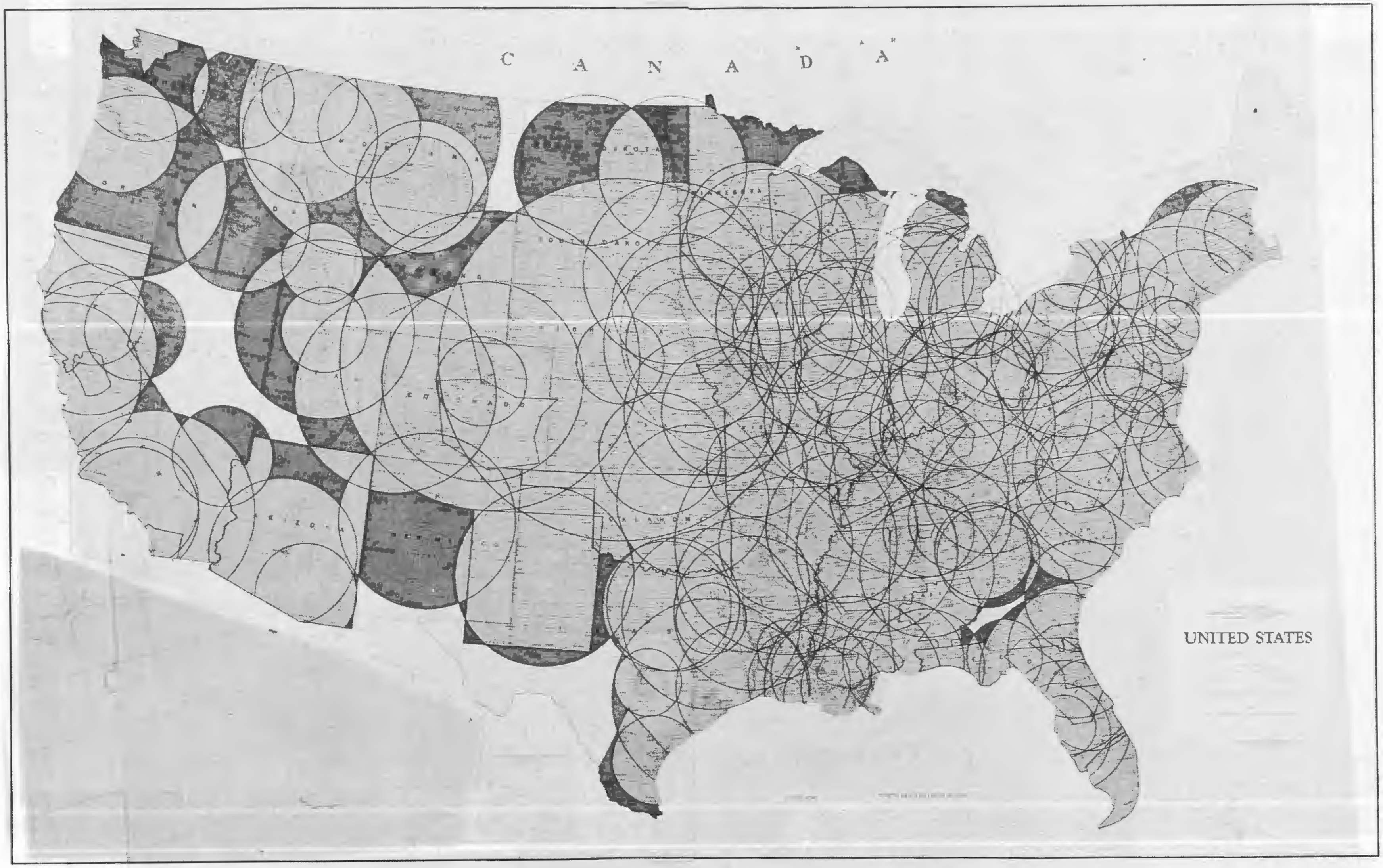


FIGURE A-57 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE CONTERMINOUS UNITED STATES

FIGURE A-58 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE NEW ENGLAND REGION

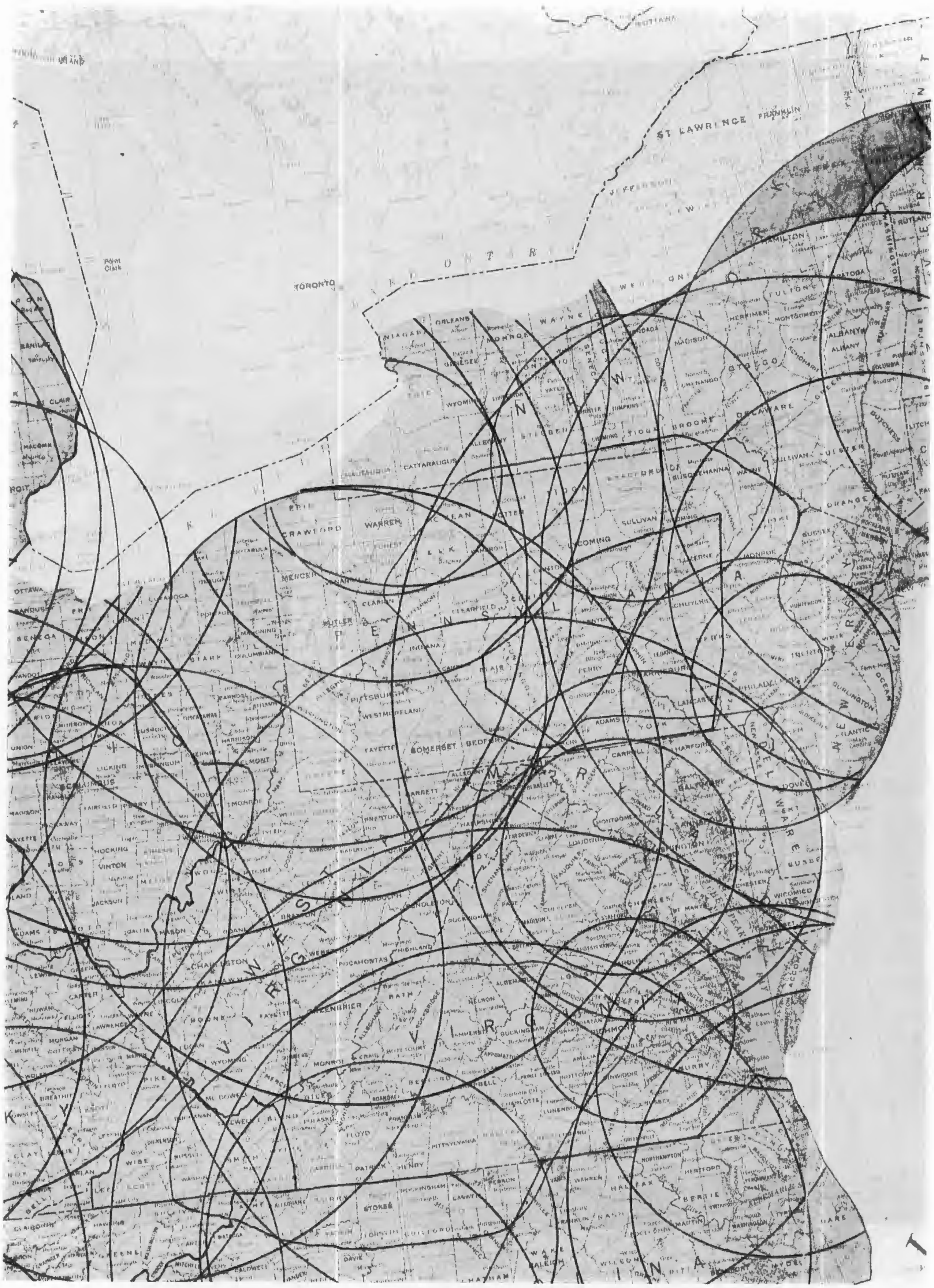


FIGURE A-59 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE EASTERN REGION

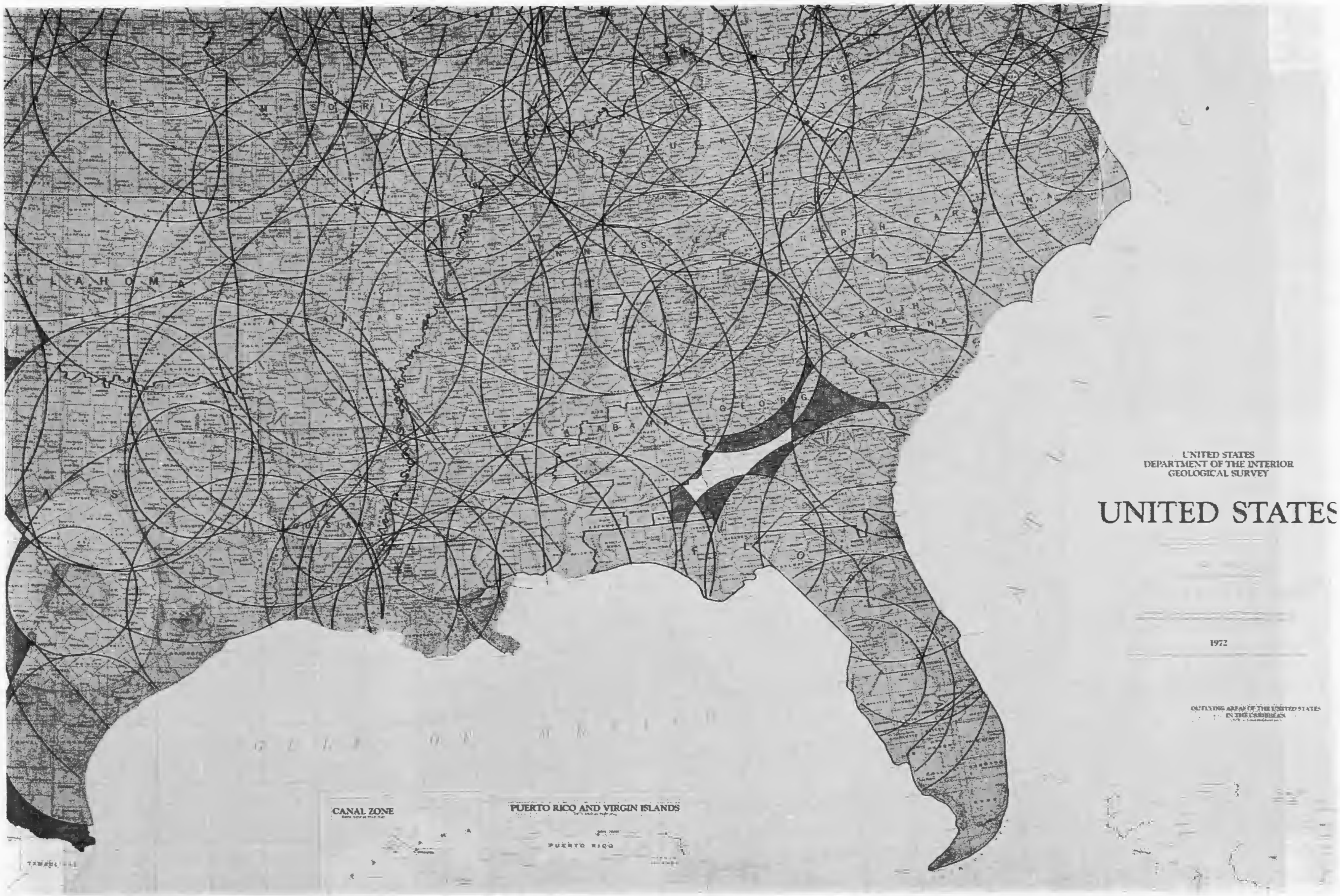


FIGURE A-60 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE SOUTHERN REGION

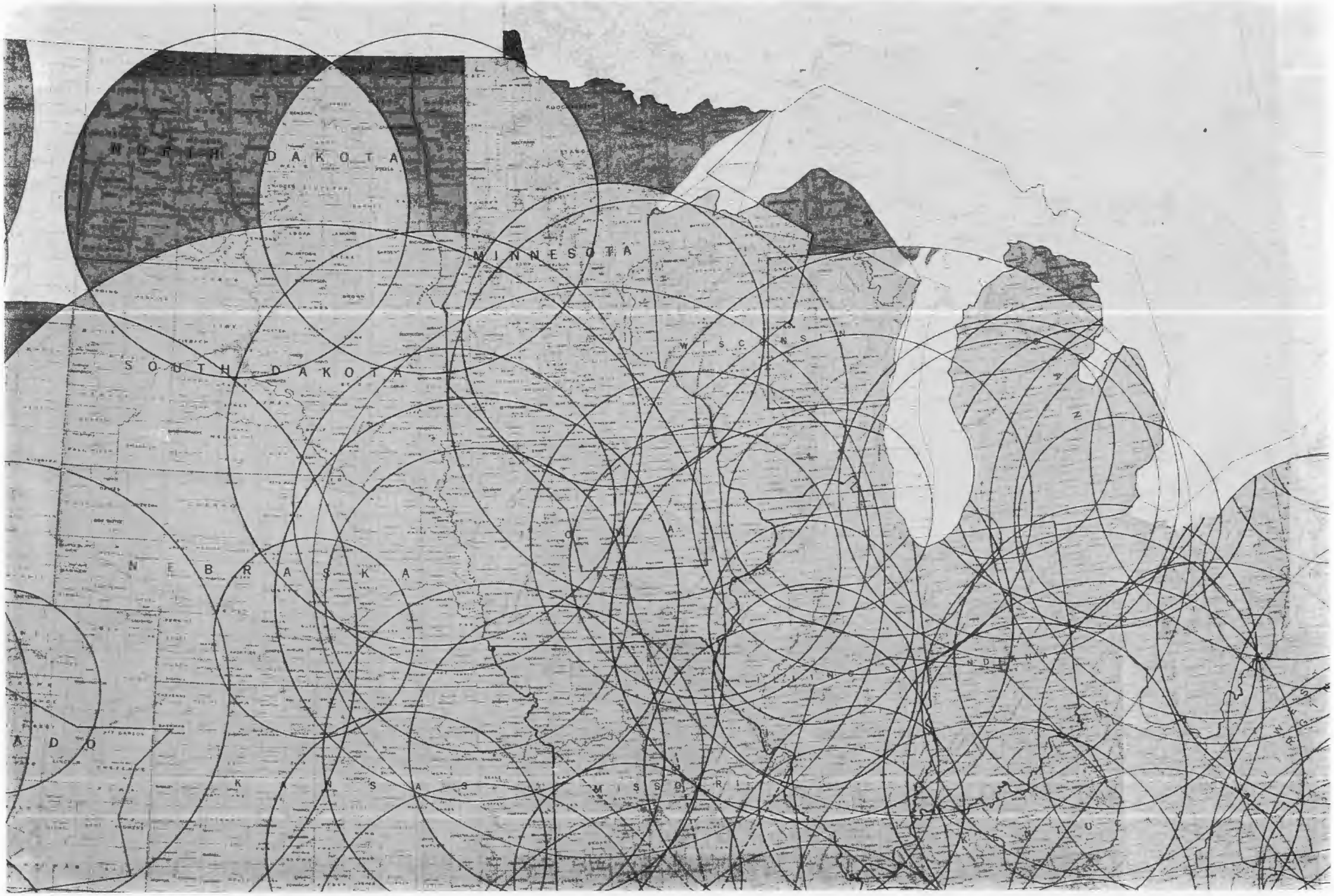


FIGURE A-61 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE GREAT LAKES REGION

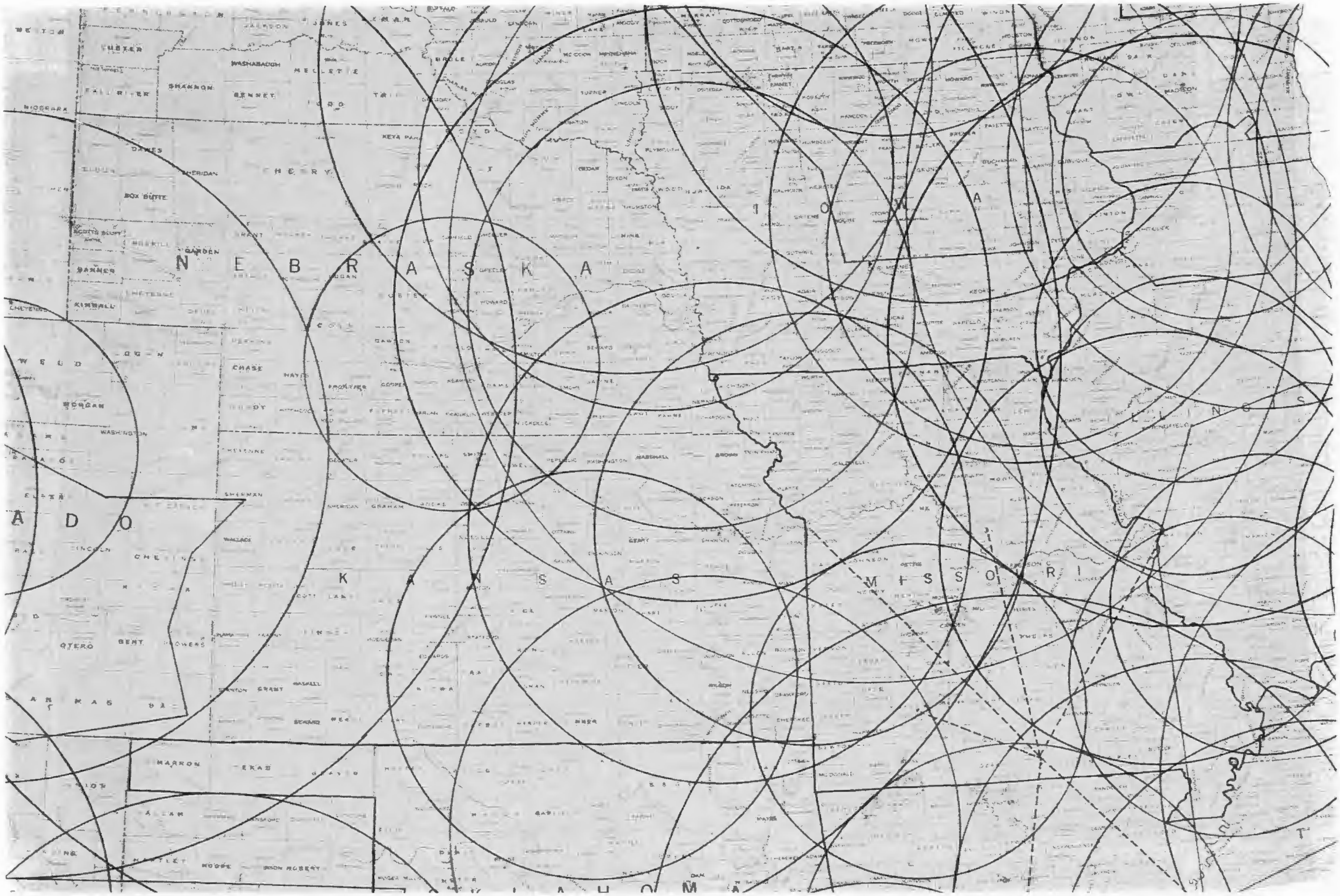


FIGURE A-62 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE CENTRAL REGIOl

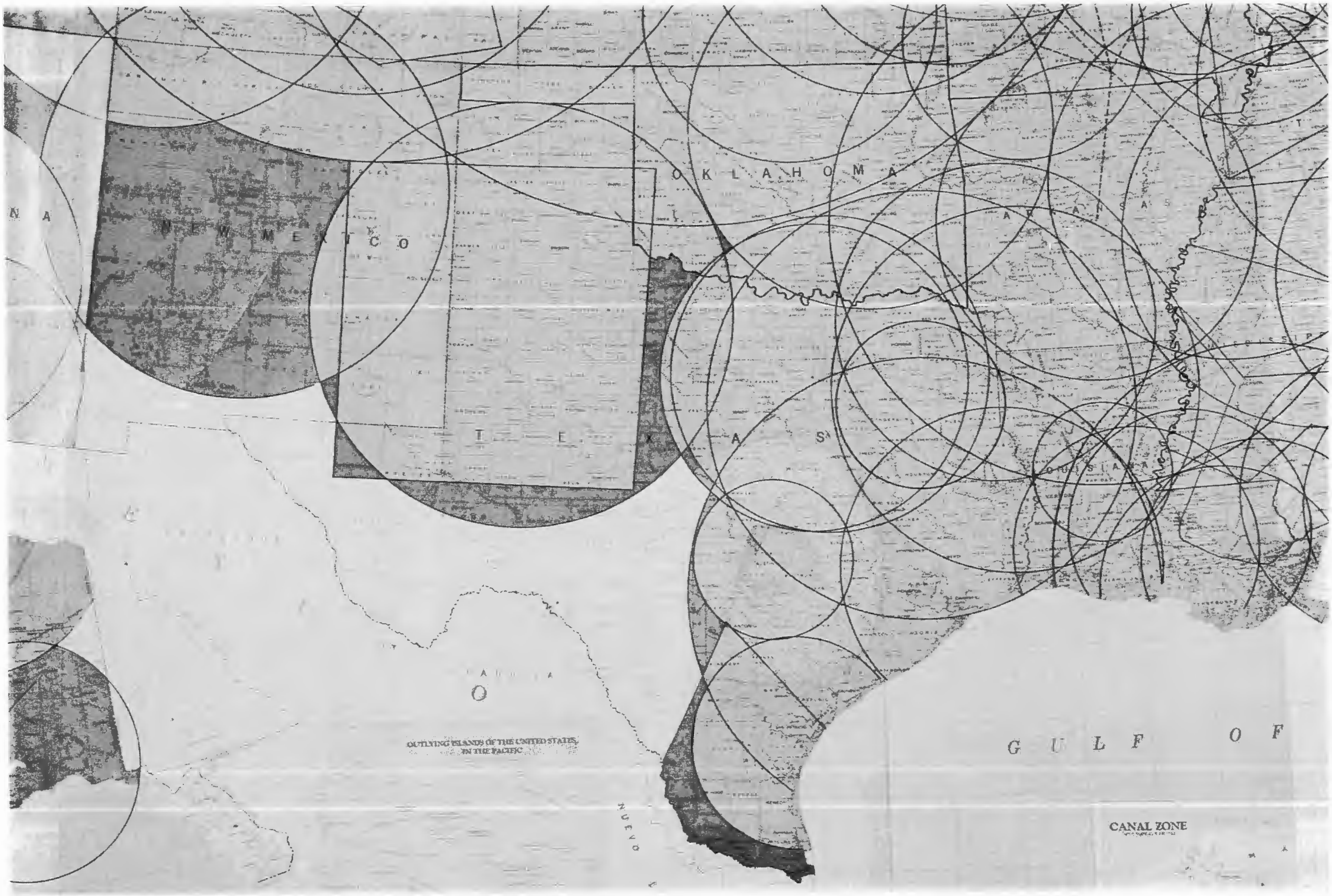


FIGURE A-63 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE SOUTHWEST REGION

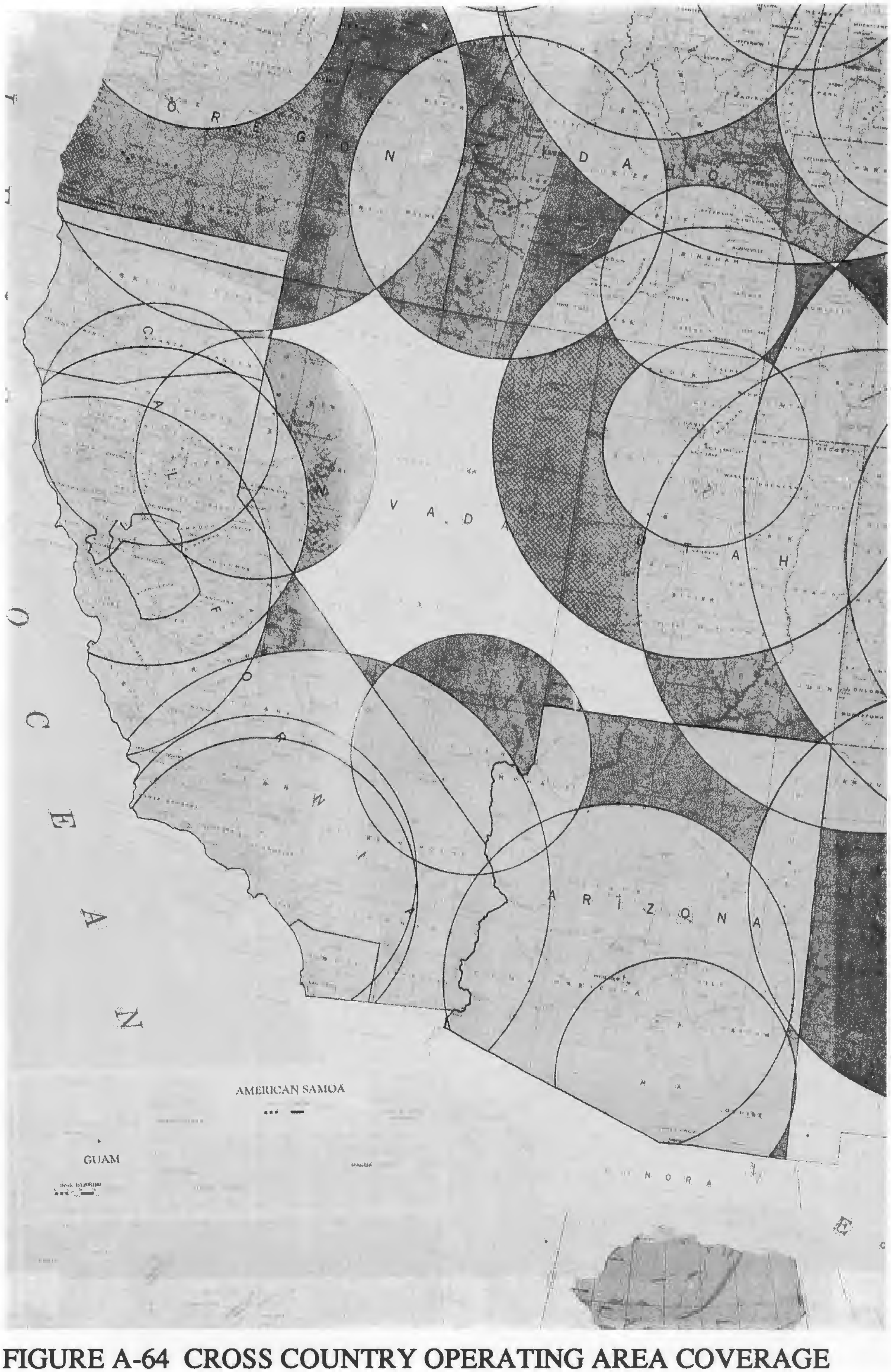


FIGURE A-64 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE WESTERN PACIFIC REGION

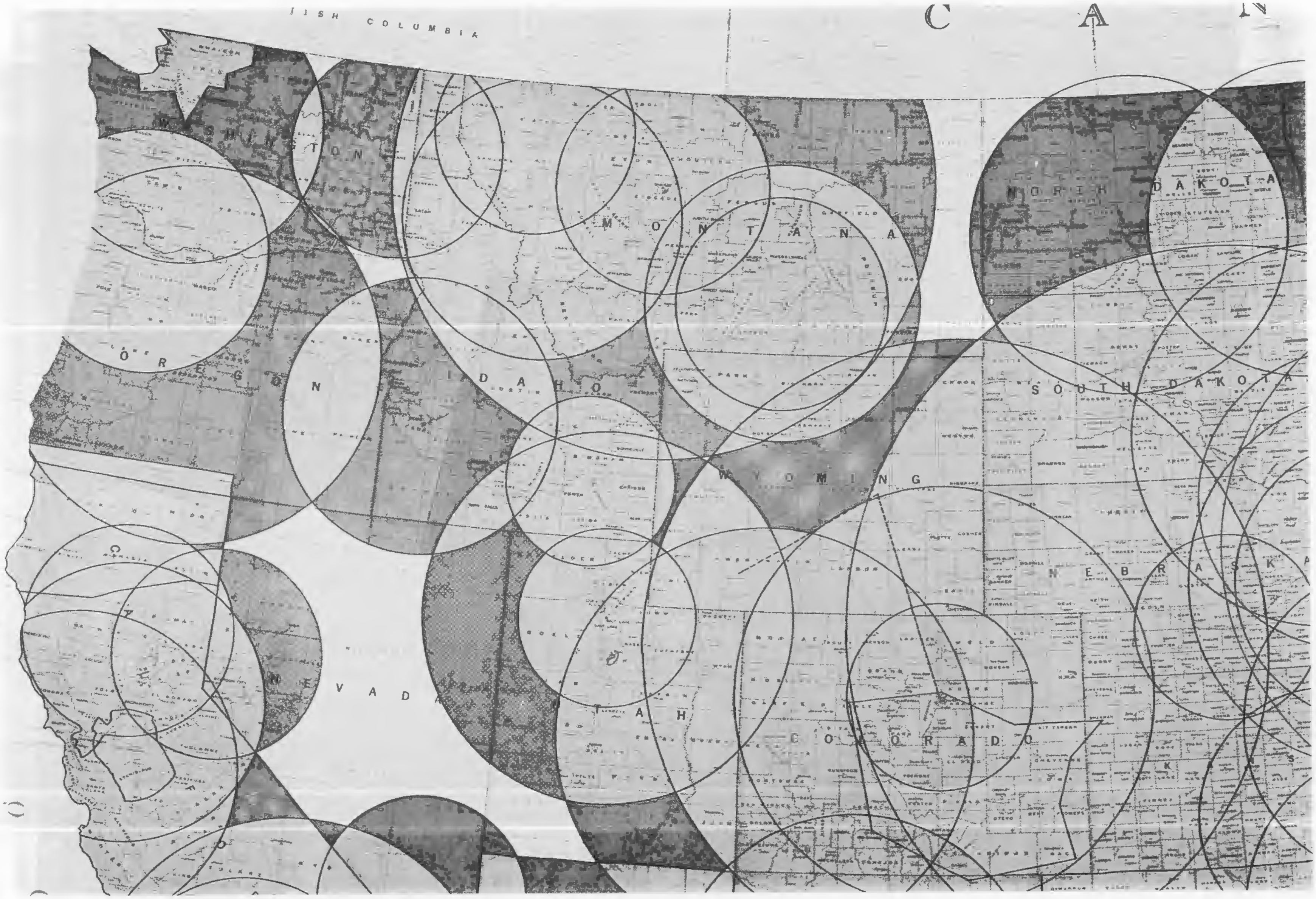


FIGURE A-65 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE NORTHWEST MOUNTAIN REGION

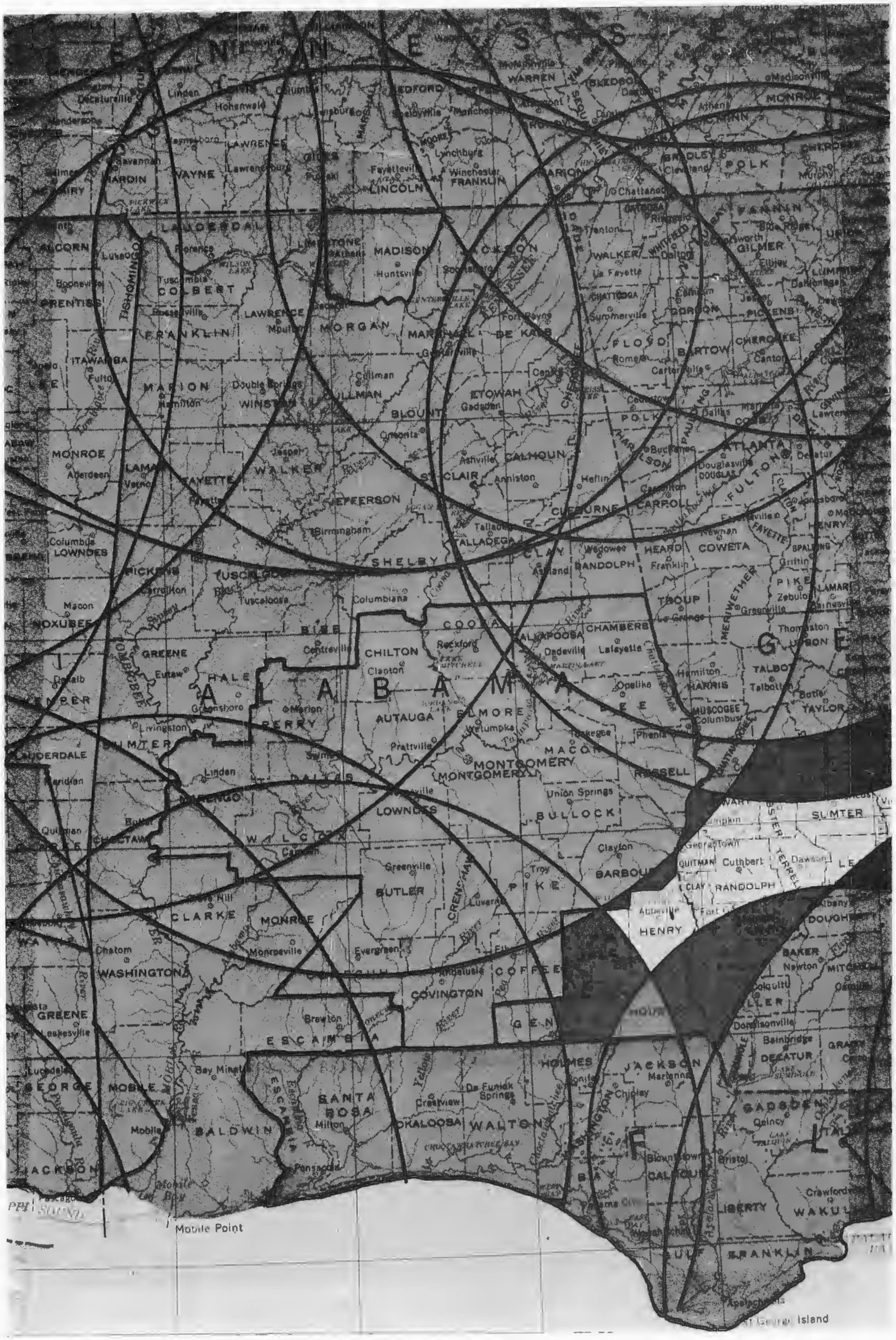


FIGURE A-66 CROSS COUNTRY OPERATING AREA COVERAGE FOR ALABAMA

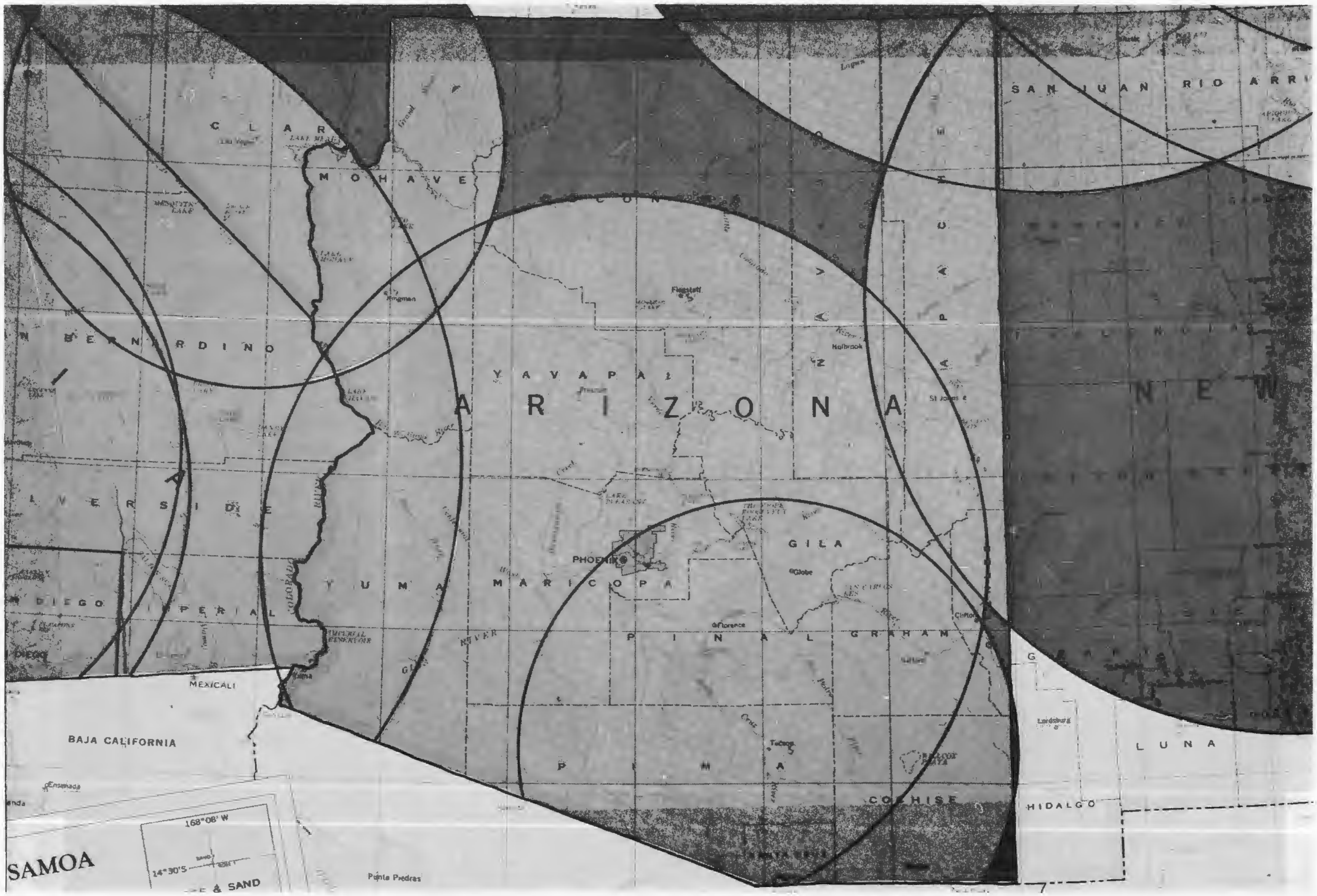


FIGURE A-67 CROSS COUNTRY OPERATING AREA COVERAGE FOR ARIZONA

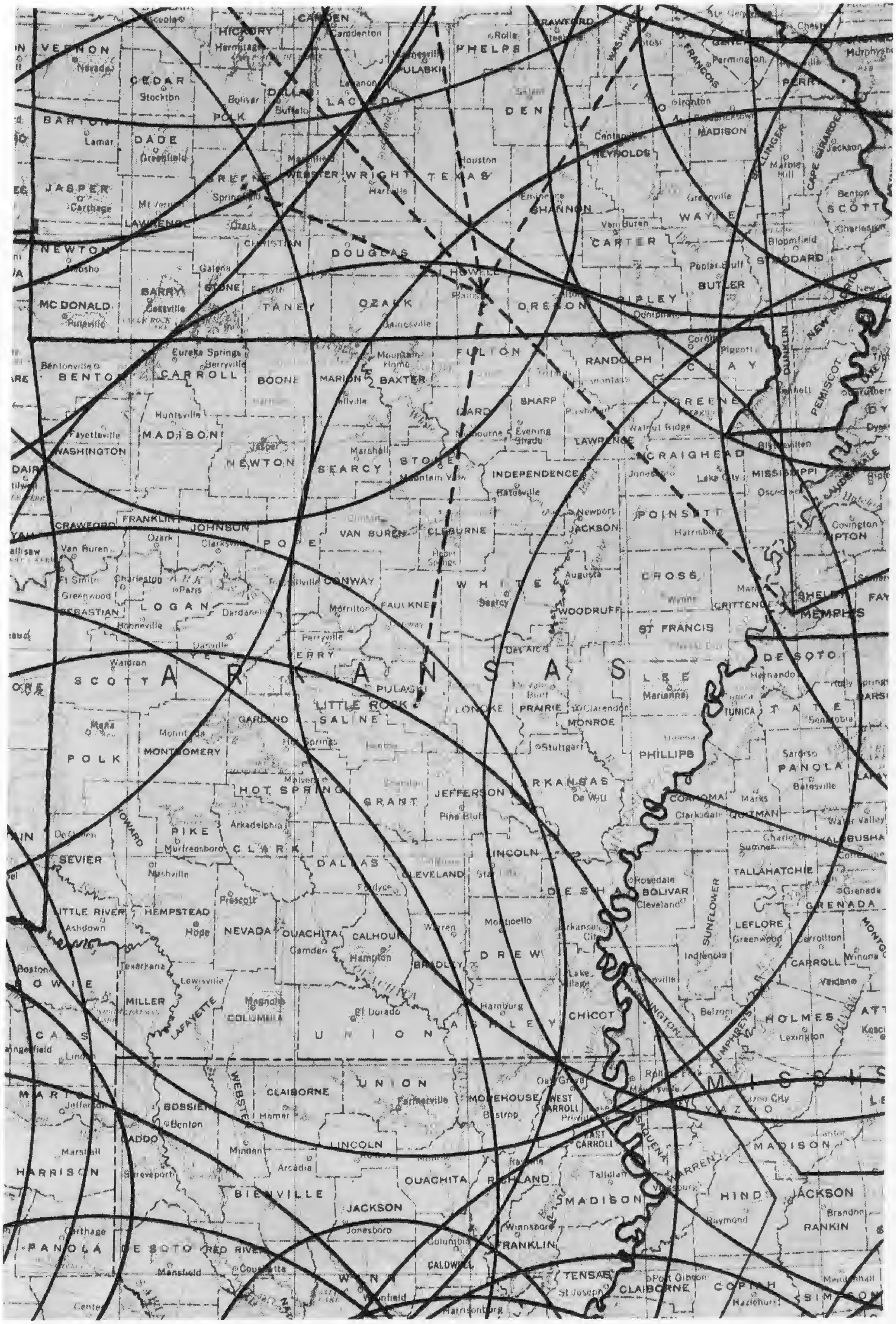


FIGURE A-68 CROSS COUNTRY OPERATING AREA COVERAGE FOR ARKANSAS

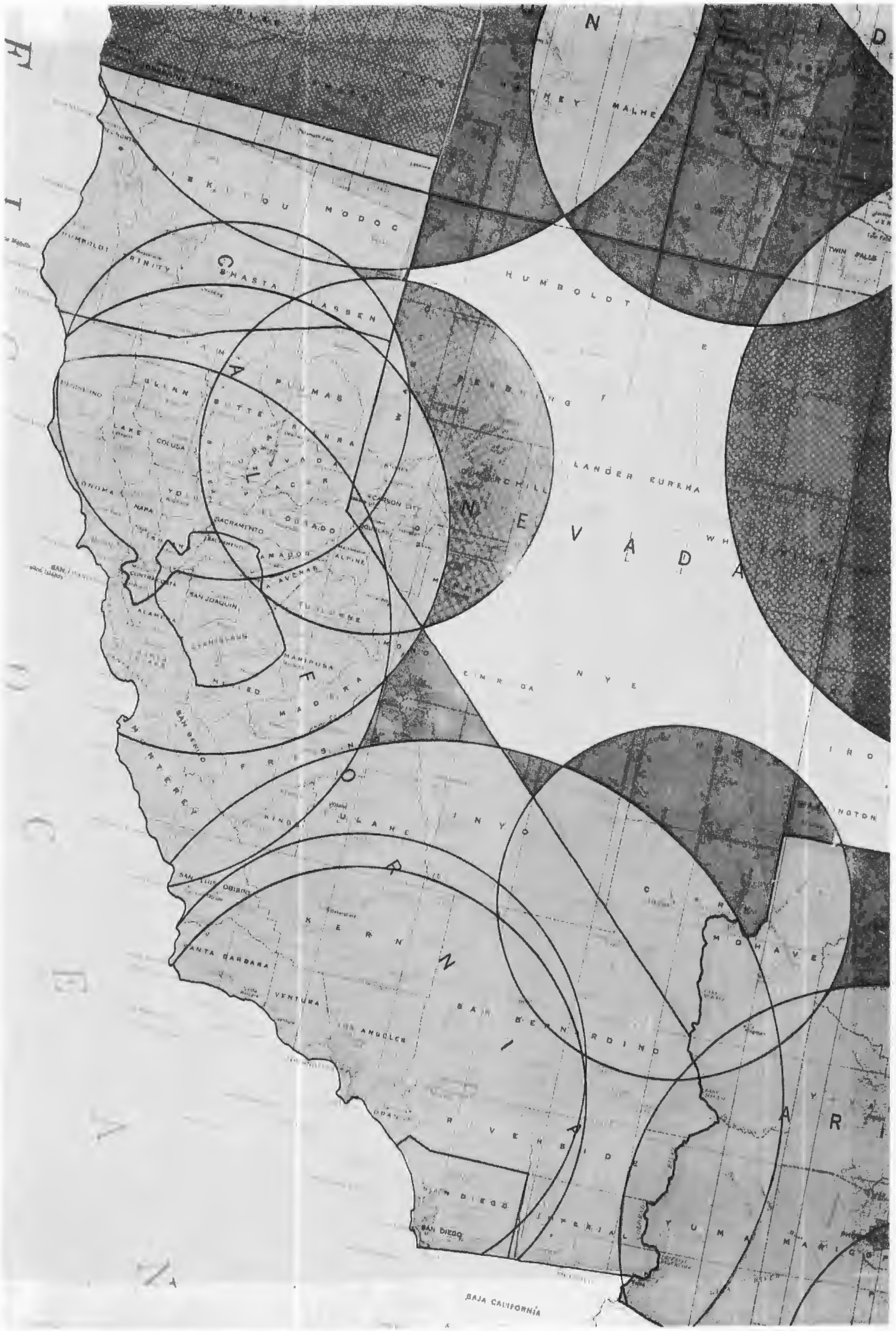


FIGURE A-69 CROSS COUNTRY OPERATING AREA COVERAGE FOR CALIFORNIA

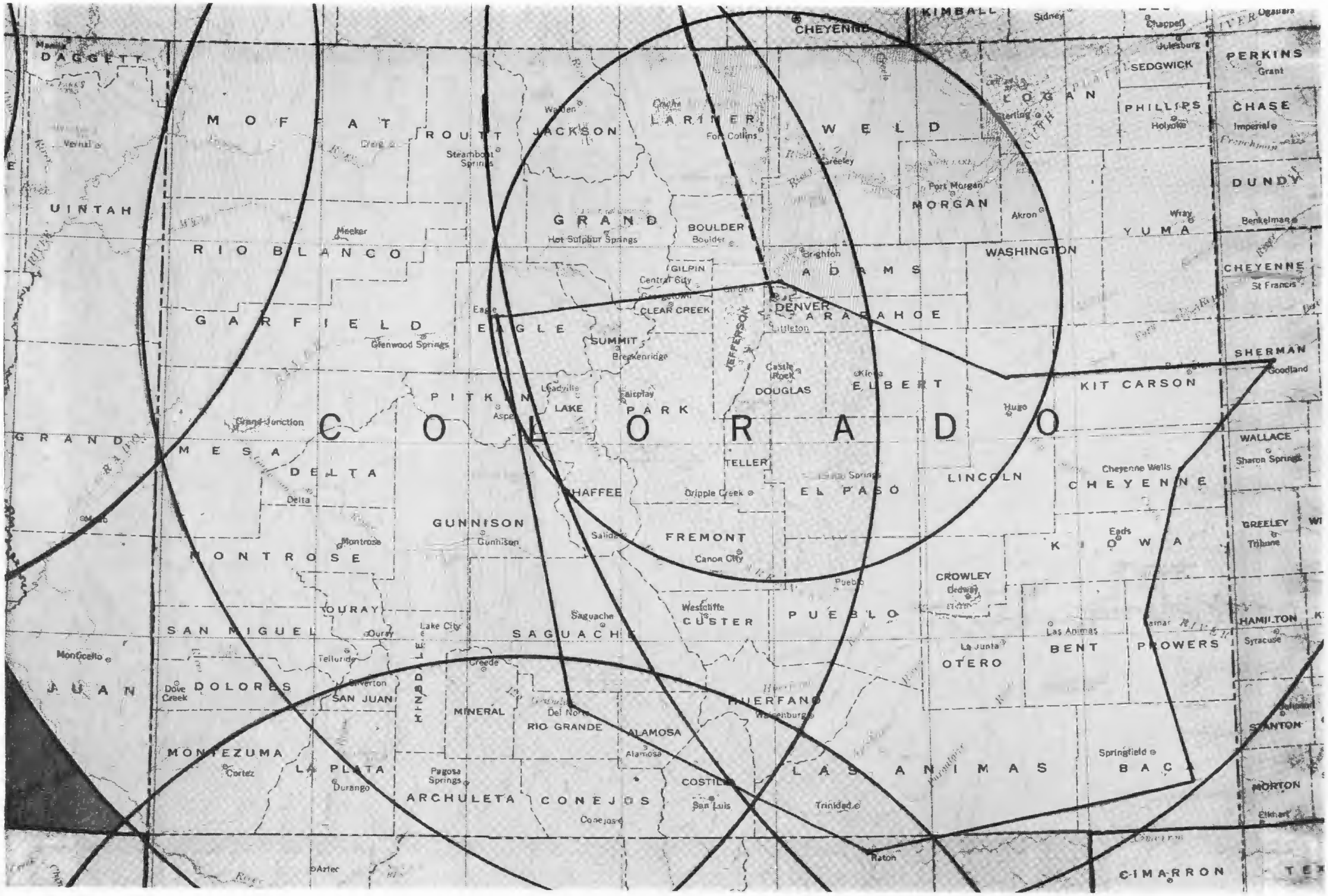


FIGURE A-70 CROSS COUNTRY OPERATING AREA COVERAGE FOR COLORADO

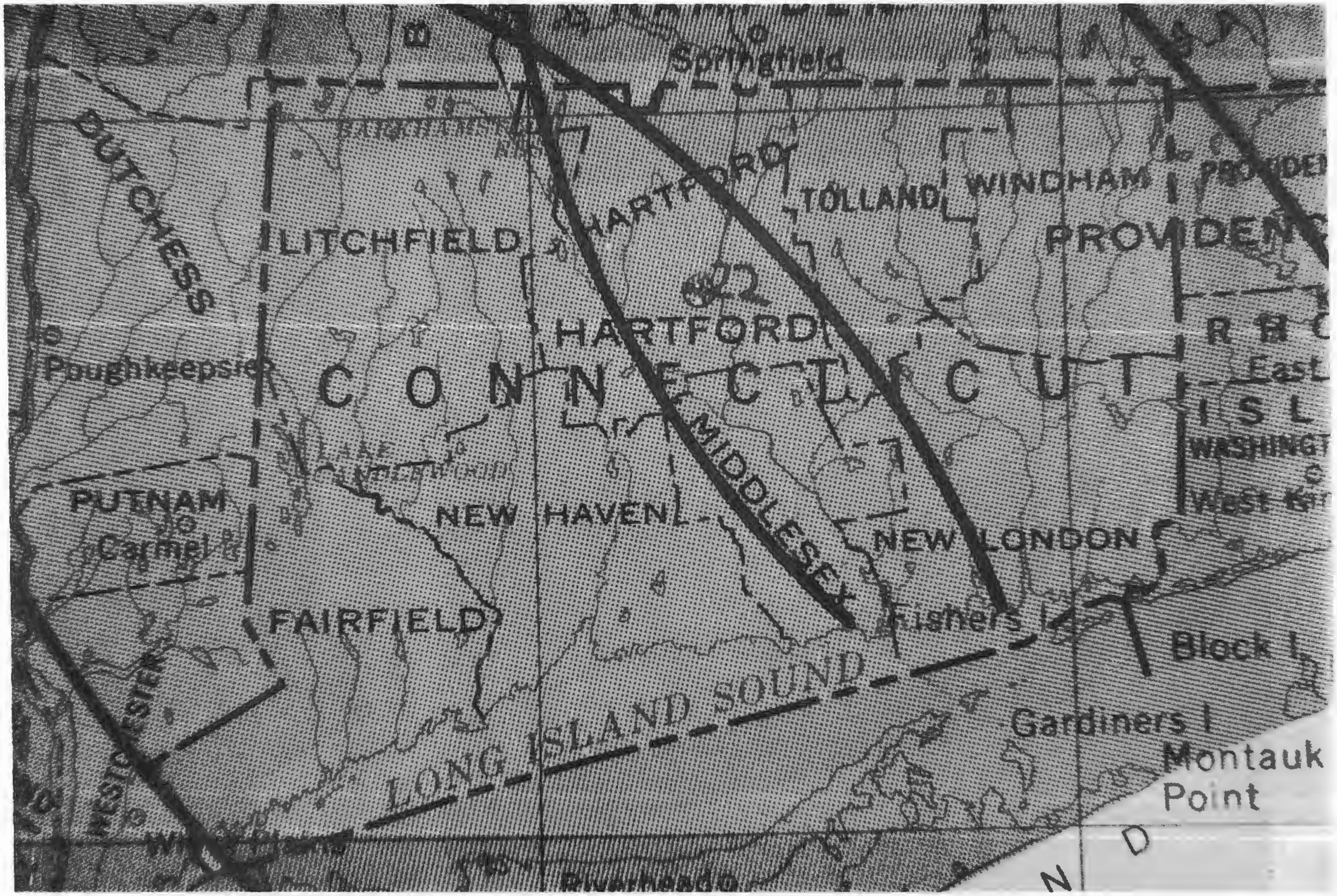


FIGURE A-71 CROSS COUNTRY OPERATING AREA COVERAGE FOR CONNECTICUT

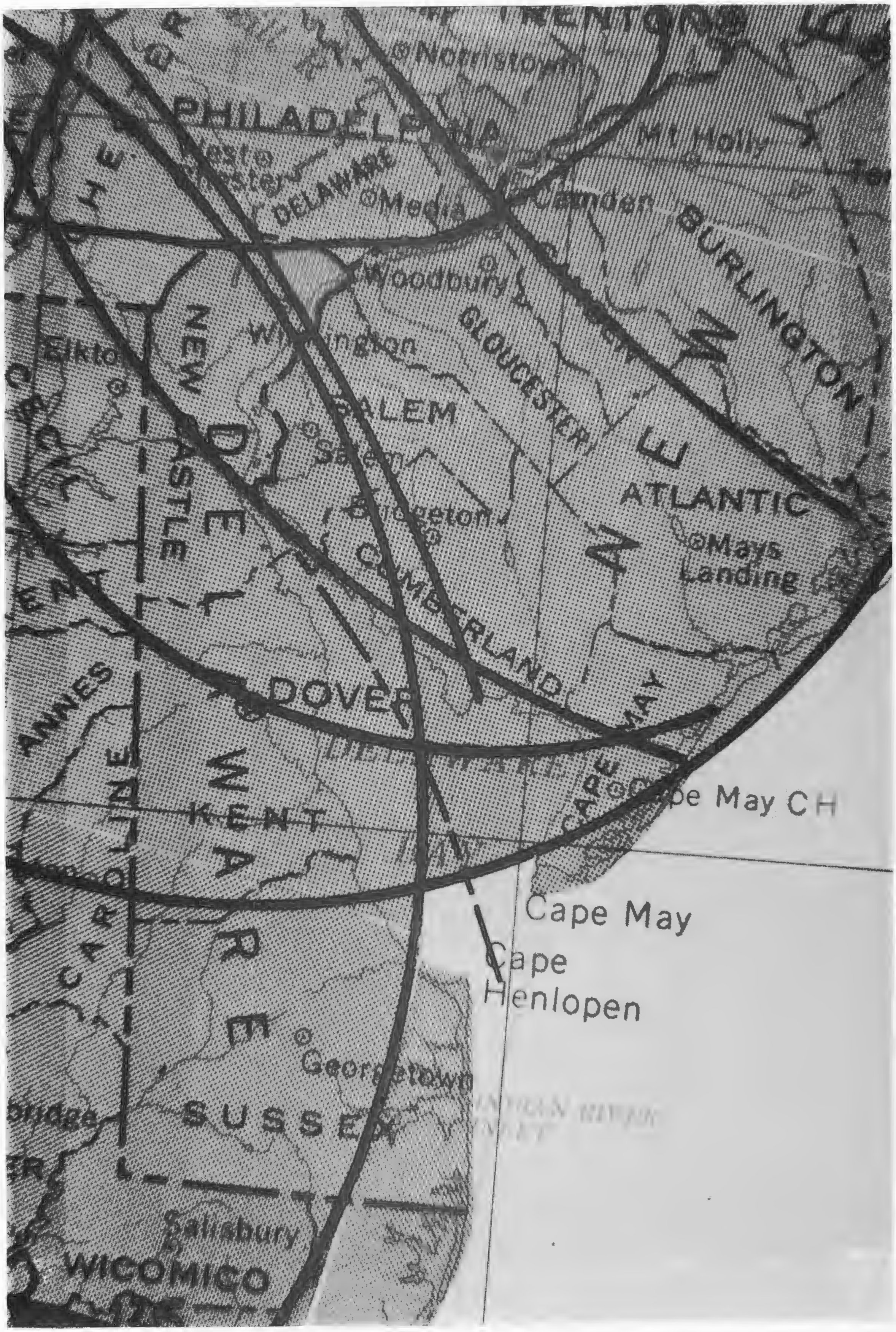


FIGURE A-72 CROSS COUNTRY OPERATING AREA COVERAGE FOR DELAWARE

FIGURE A-73 CROSS COUNTRY OPERATING AREA COVERAGE FOR FLORIDA

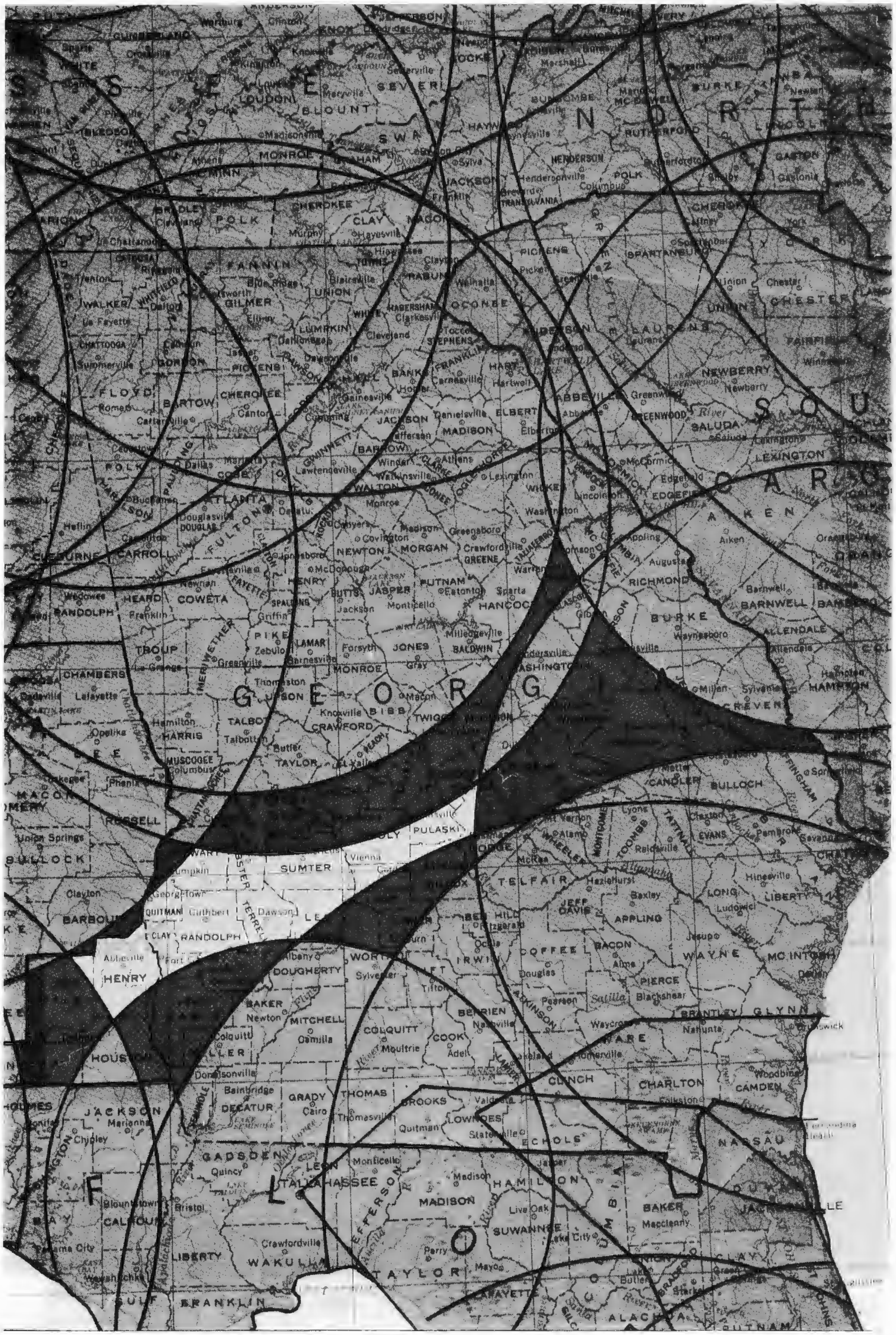


FIGURE A-74 CROSS COUNTRY OPERATING AREA COVERAGE FOR GEORGIA

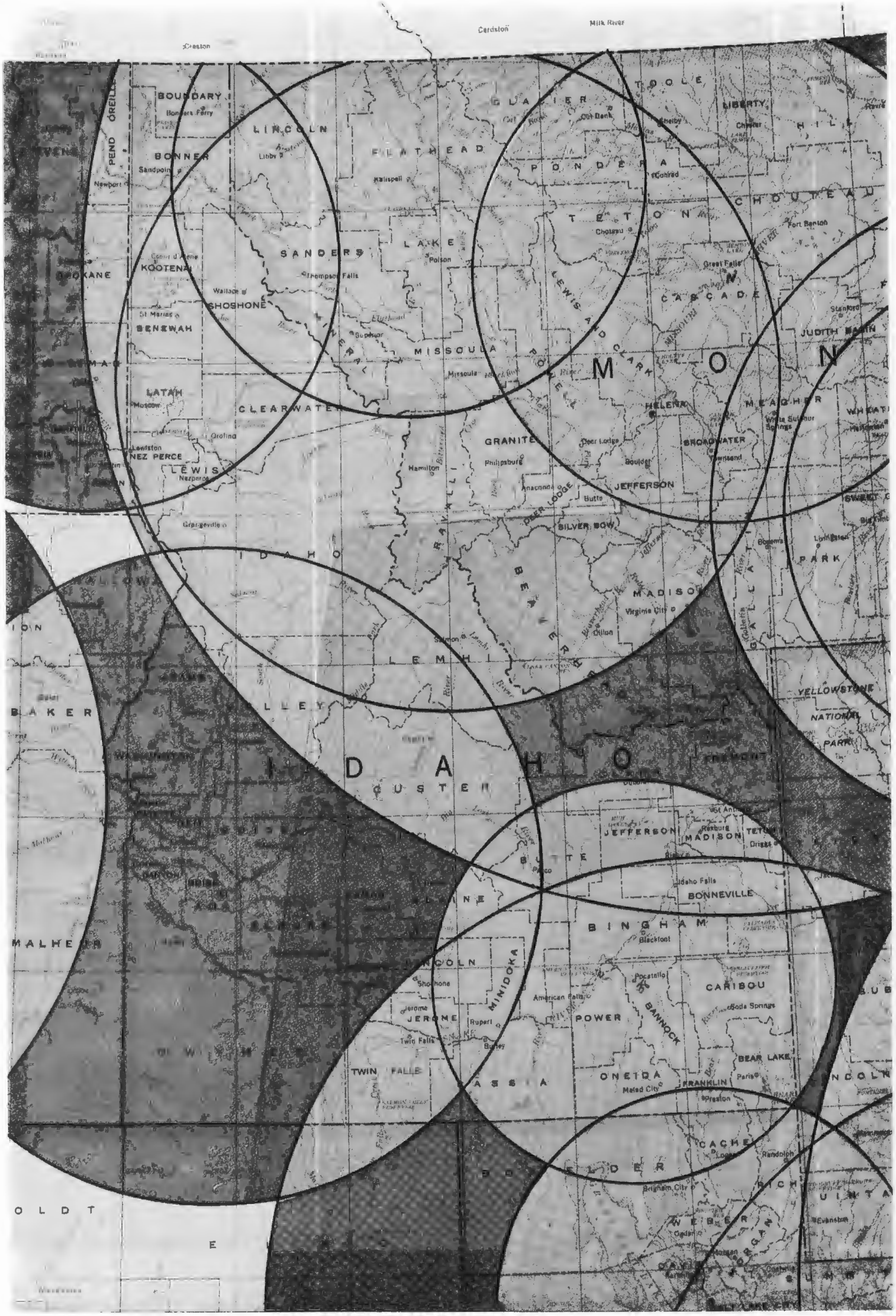


FIGURE A-75 CROSS COUNTRY OPERATING AREA COVERAGE FOR IDAHO

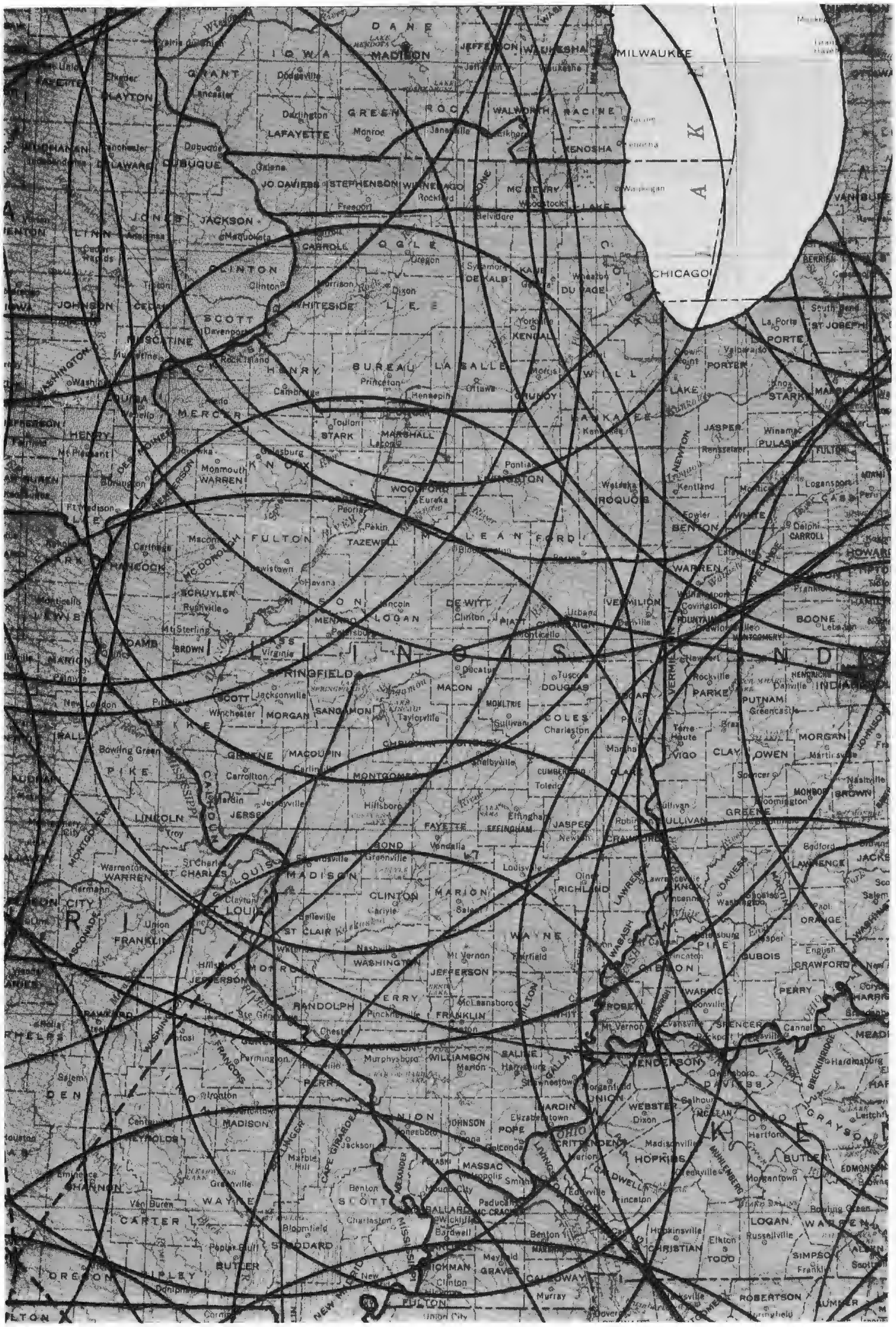


FIGURE A-76 CROSS COUNTRY OPERATING AREA COVERAGE FOR ILLINOIS

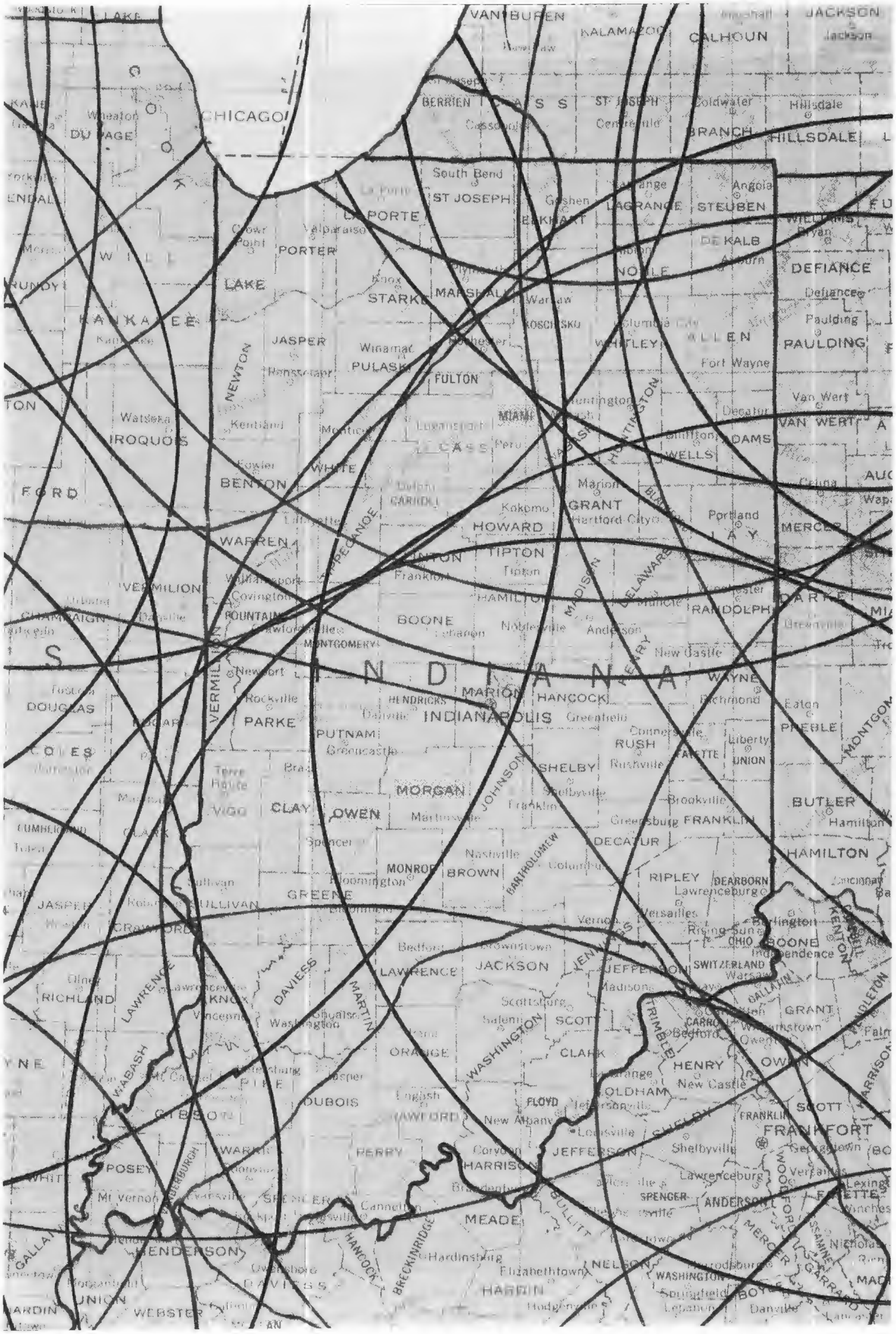


FIGURE A-77 CROSS COUNTRY OPERATING AREA COVERAGE FOR INDIANA

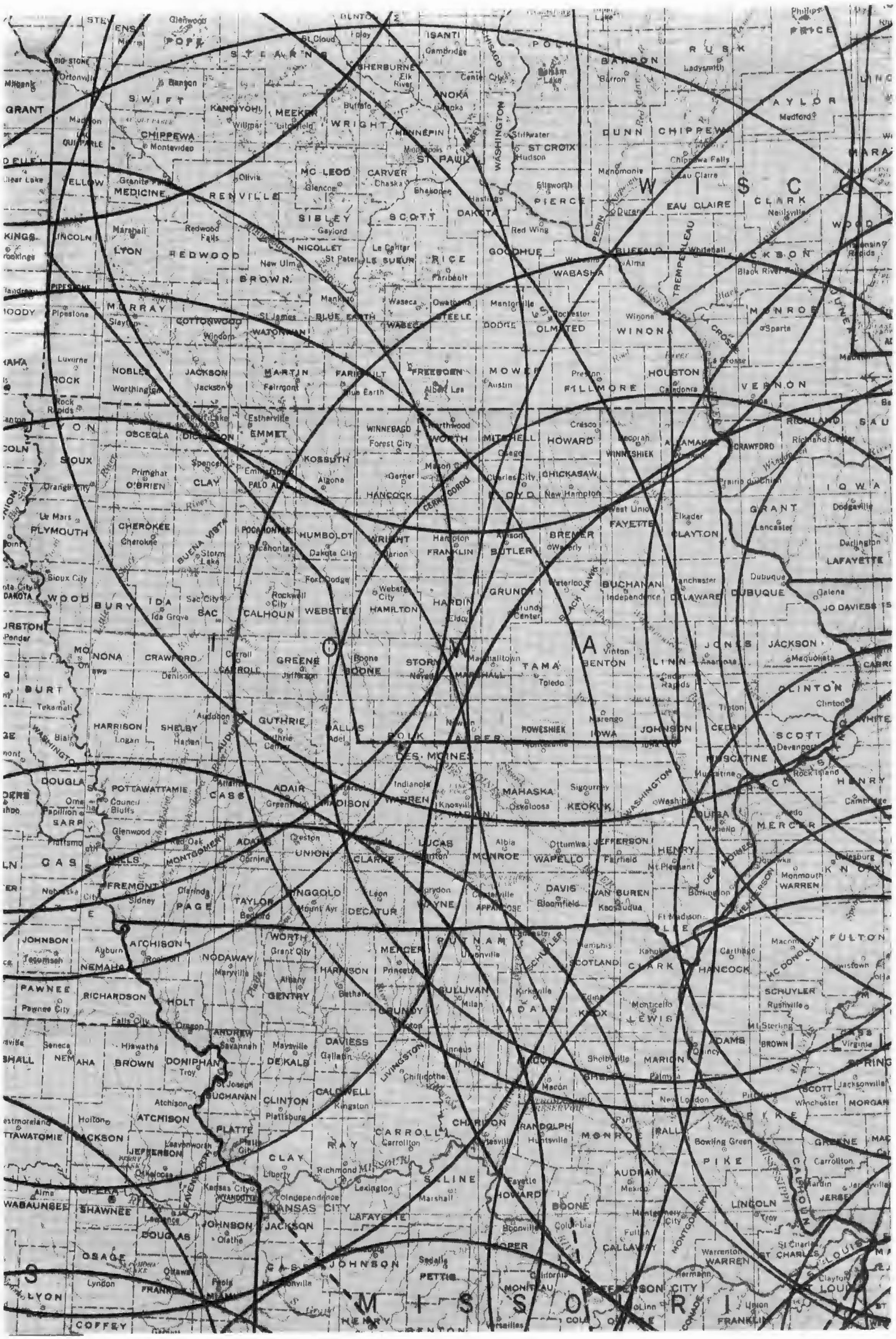


FIGURE A-78 CROSS COUNTRY OPERATING AREA COVERAGE FOR IOWA

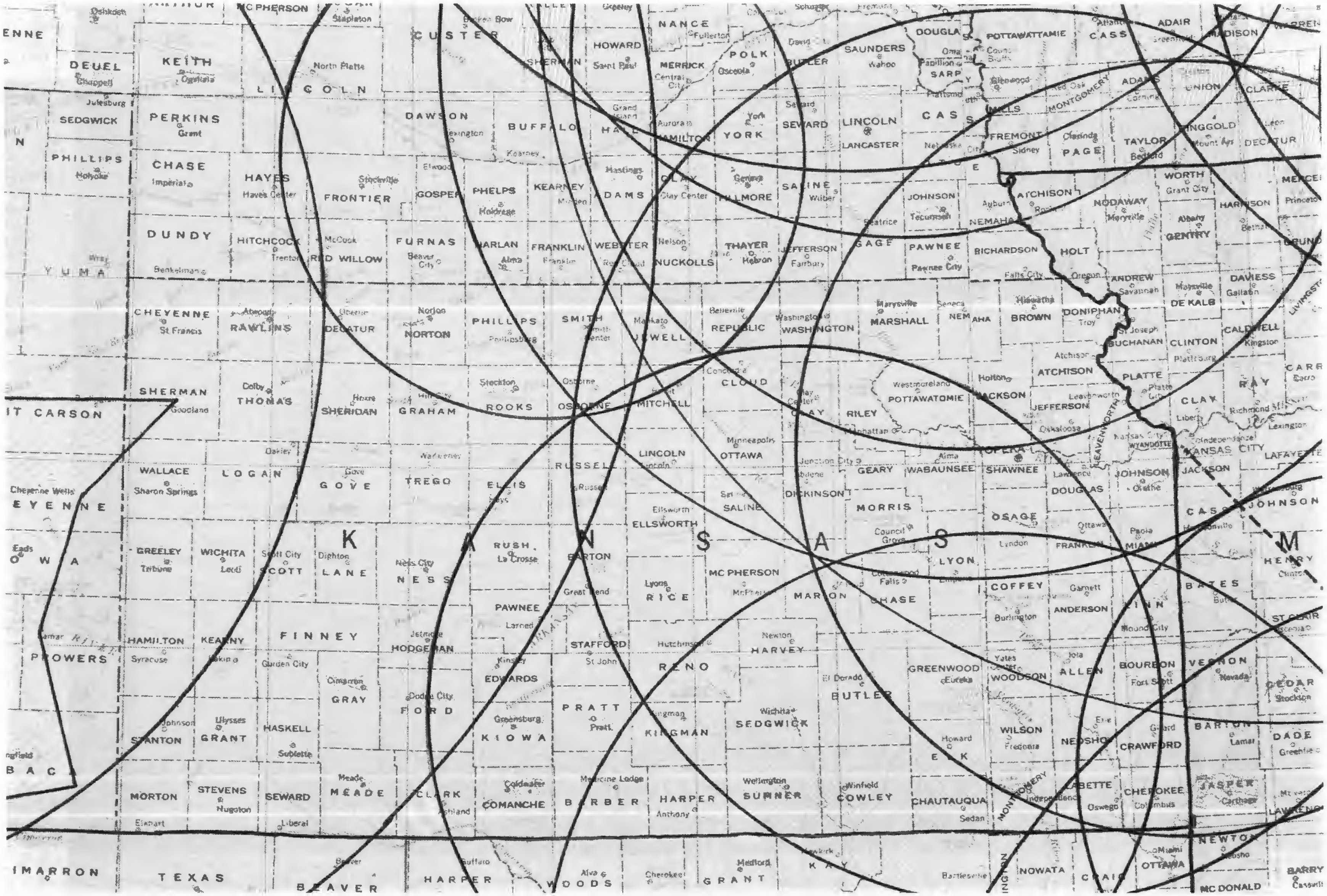


FIGURE A-79 CROSS COUNTRY OPERATING AREA COVERAGE FOR KANSAS

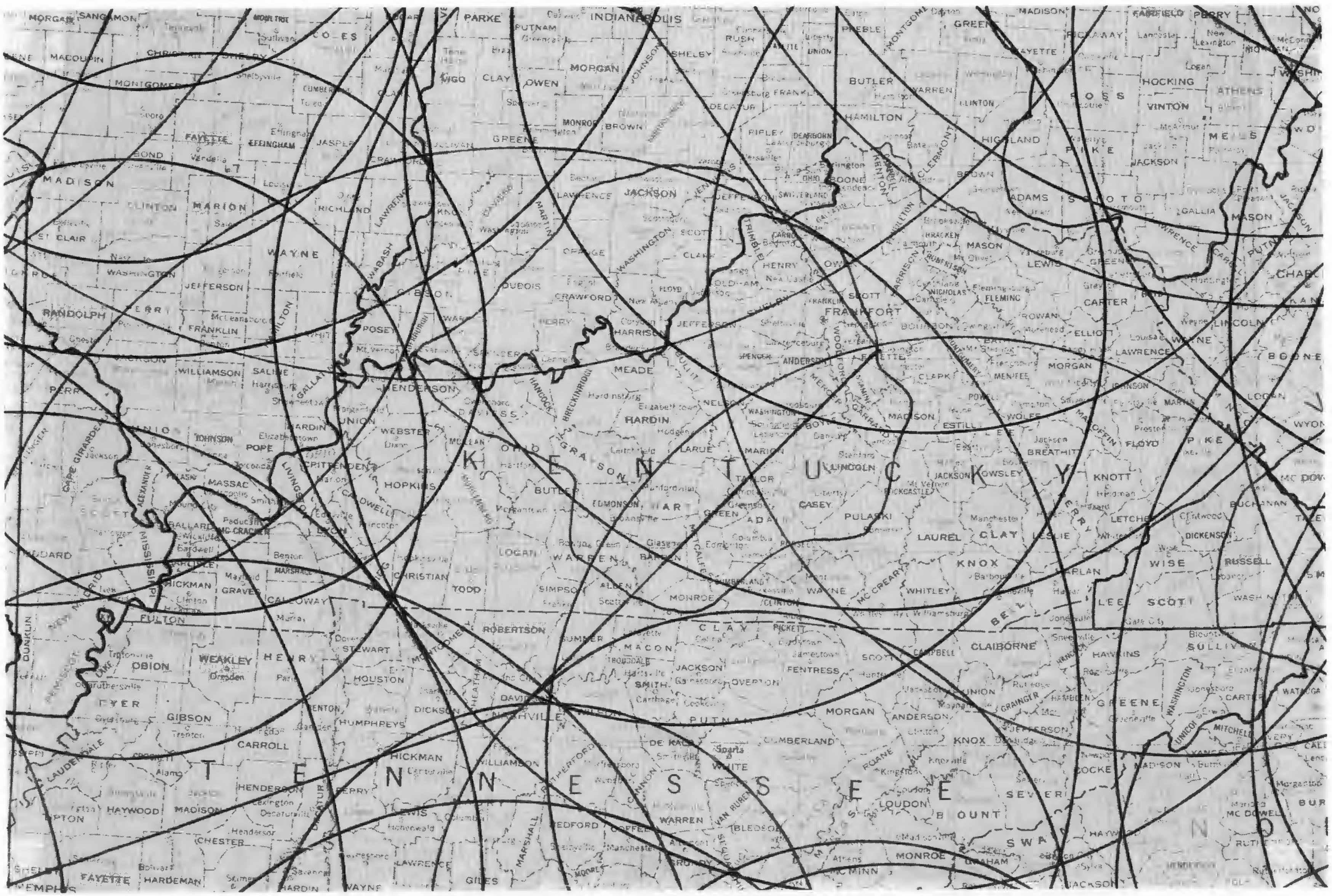


FIGURE A-80 CROSS COUNTRY OPERATING AREA COVERAGE FOR KENTUCKY

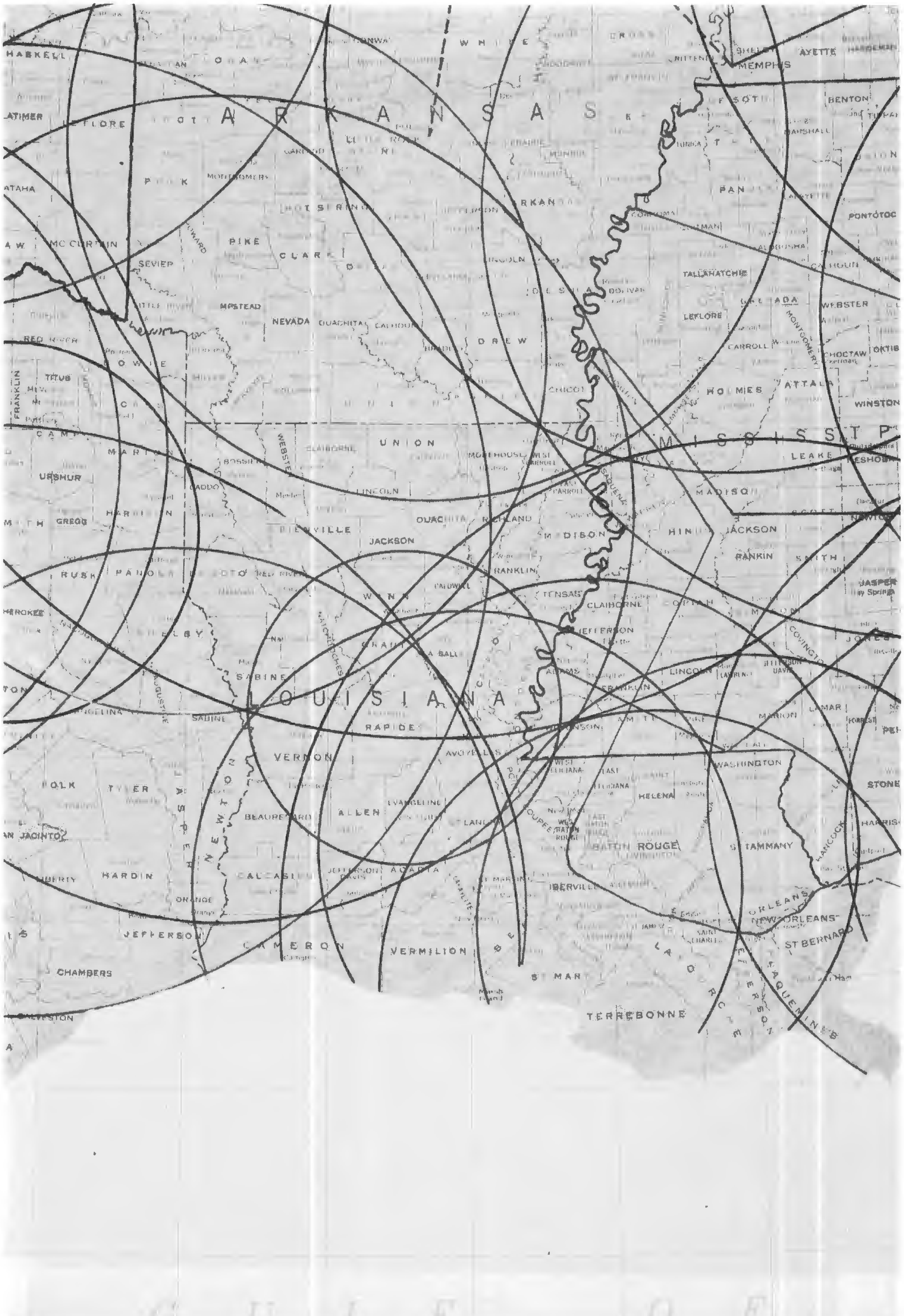


FIGURE A-81 CROSS COUNTRY OPERATING AREA COVERAGE FOR LOUISIANA

FIGURE A-82 CROSS COUNTRY OPERATING AREA COVERAGE FOR MAINE

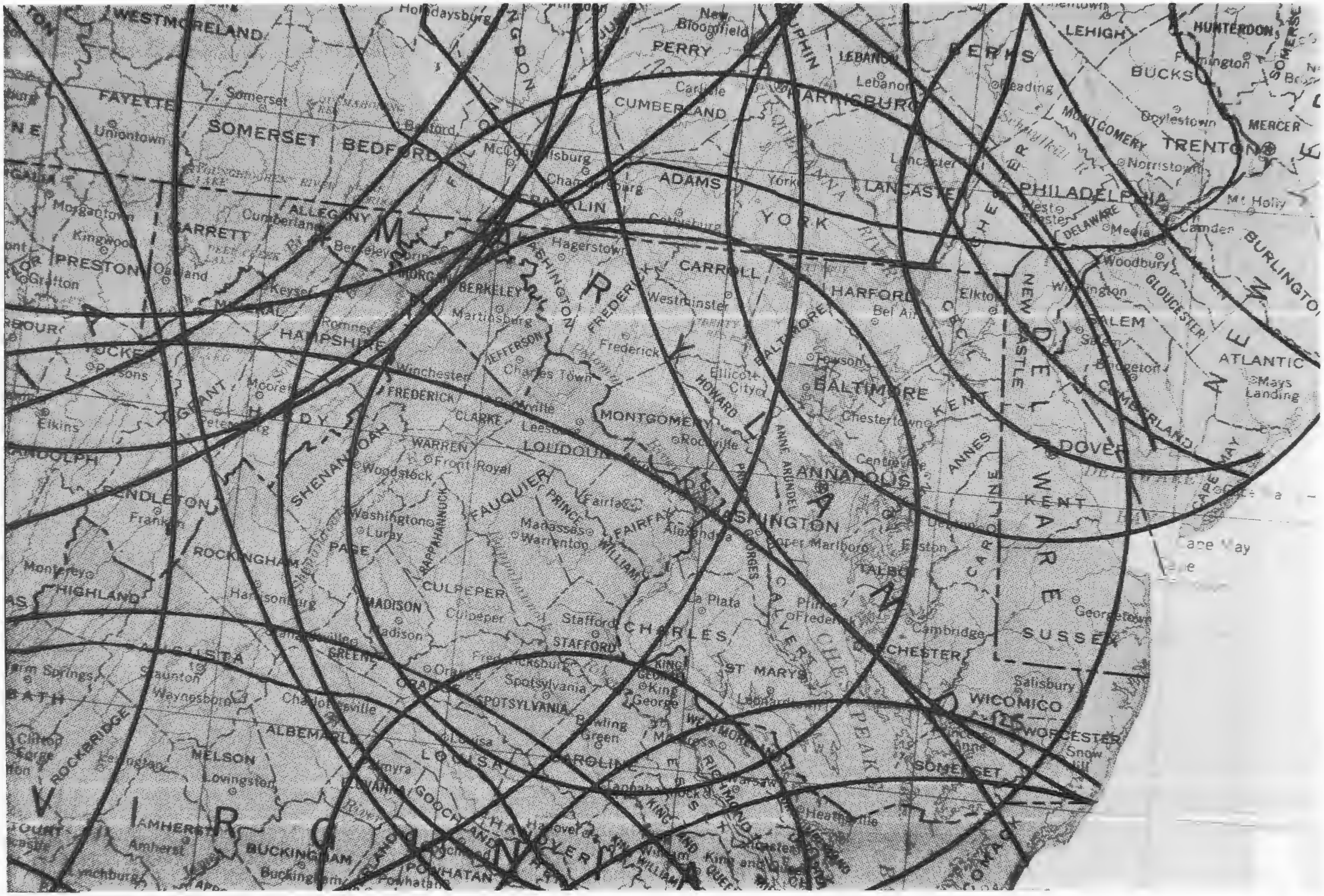


FIGURE A-83 CROSS COUNTRY OPERATING AREA COVERAGE FOR MARYLAND

FIGURE A-84 CROSS COUNTRY OPERATING AREA COVERAGE FOR MASSACHUSETTS

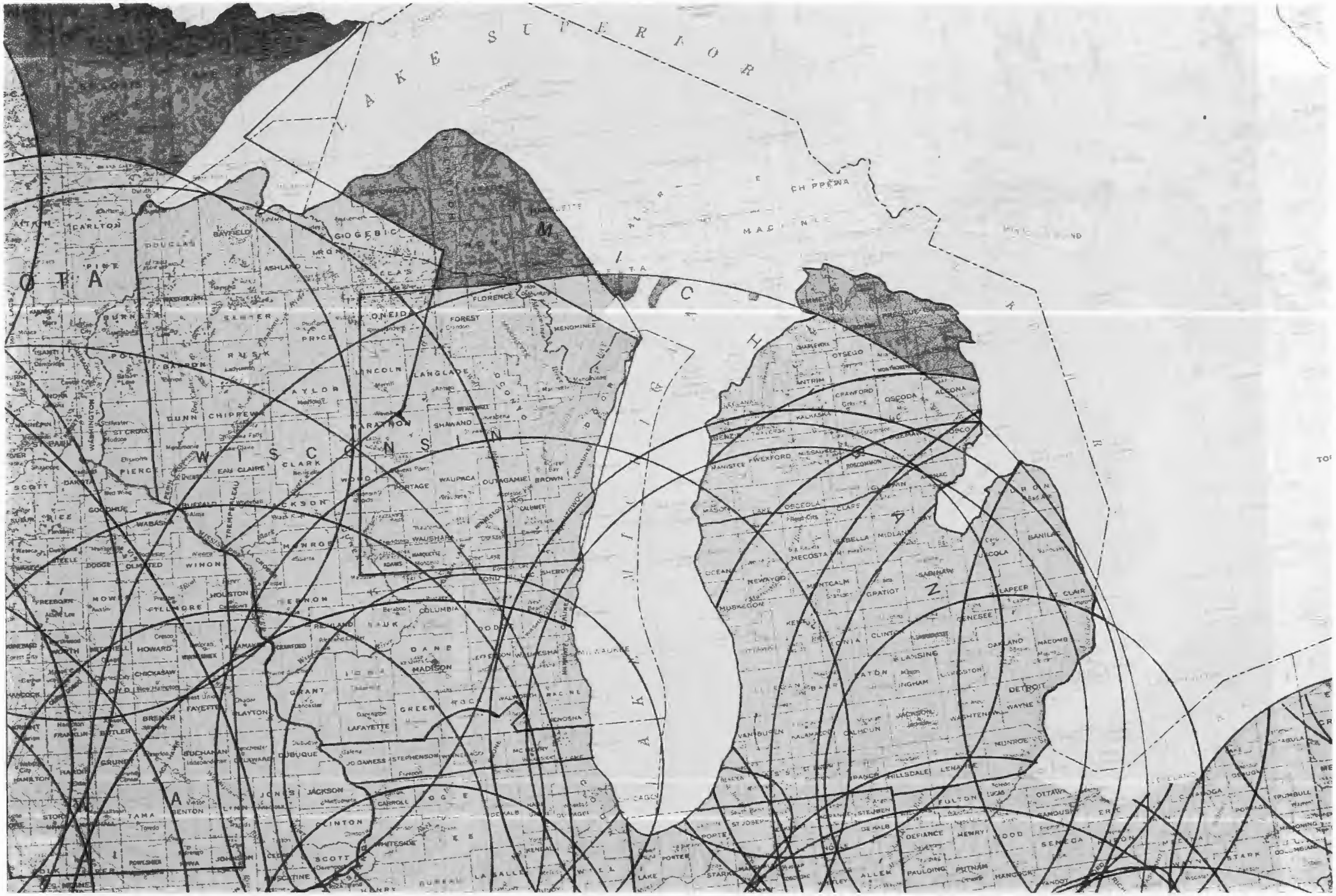


FIGURE A-85 CROSS COUNTRY OPERATING AREA COVERAGE FOR MICHIGAN

FIGURE A-86 CROSS COUNTRY OPERATING AREA COVERAGE FOR MINNESOTA

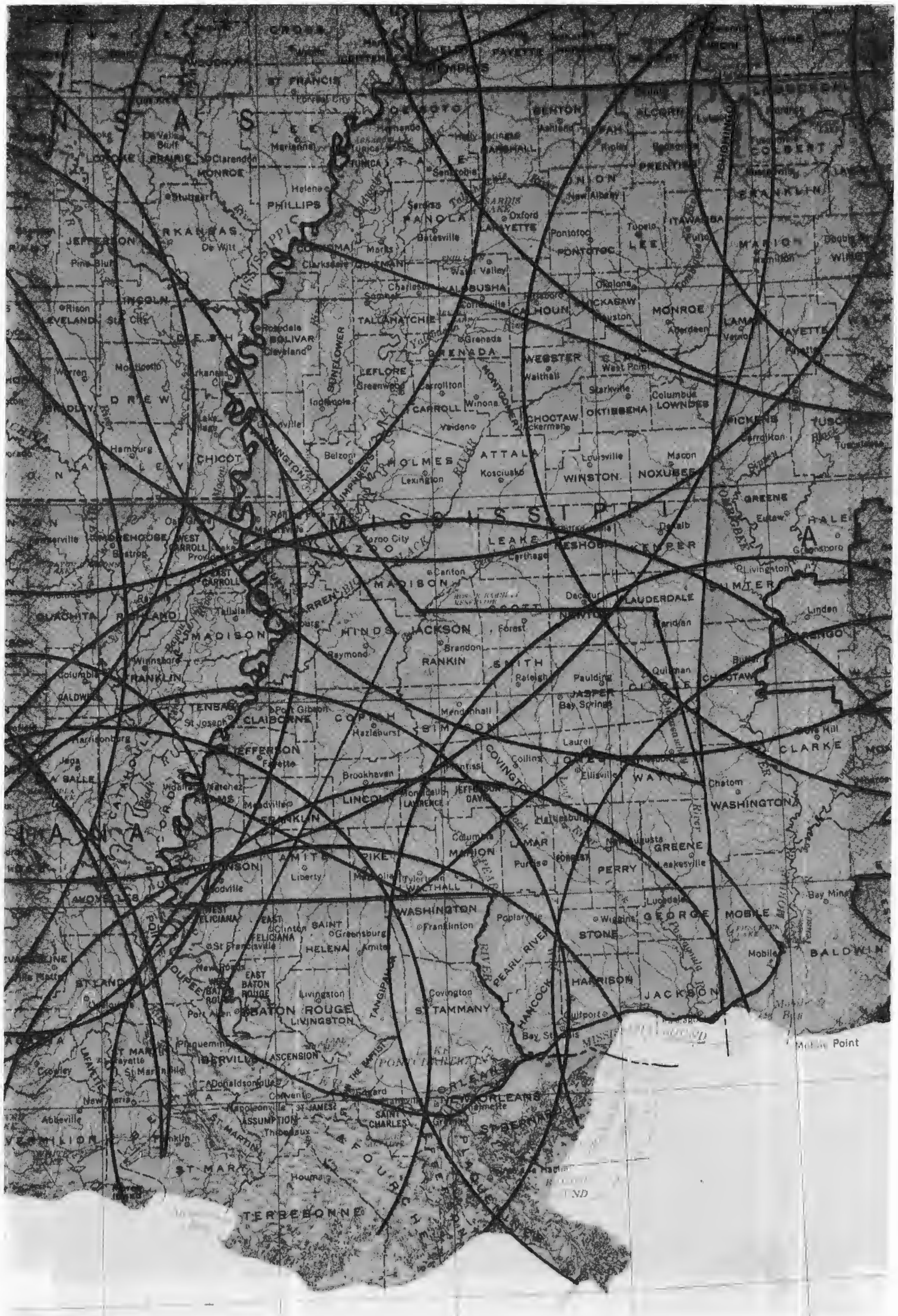


FIGURE A-87 CROSS COUNTRY OPERATING AREA COVERAGE FOR MISSISSIPPI

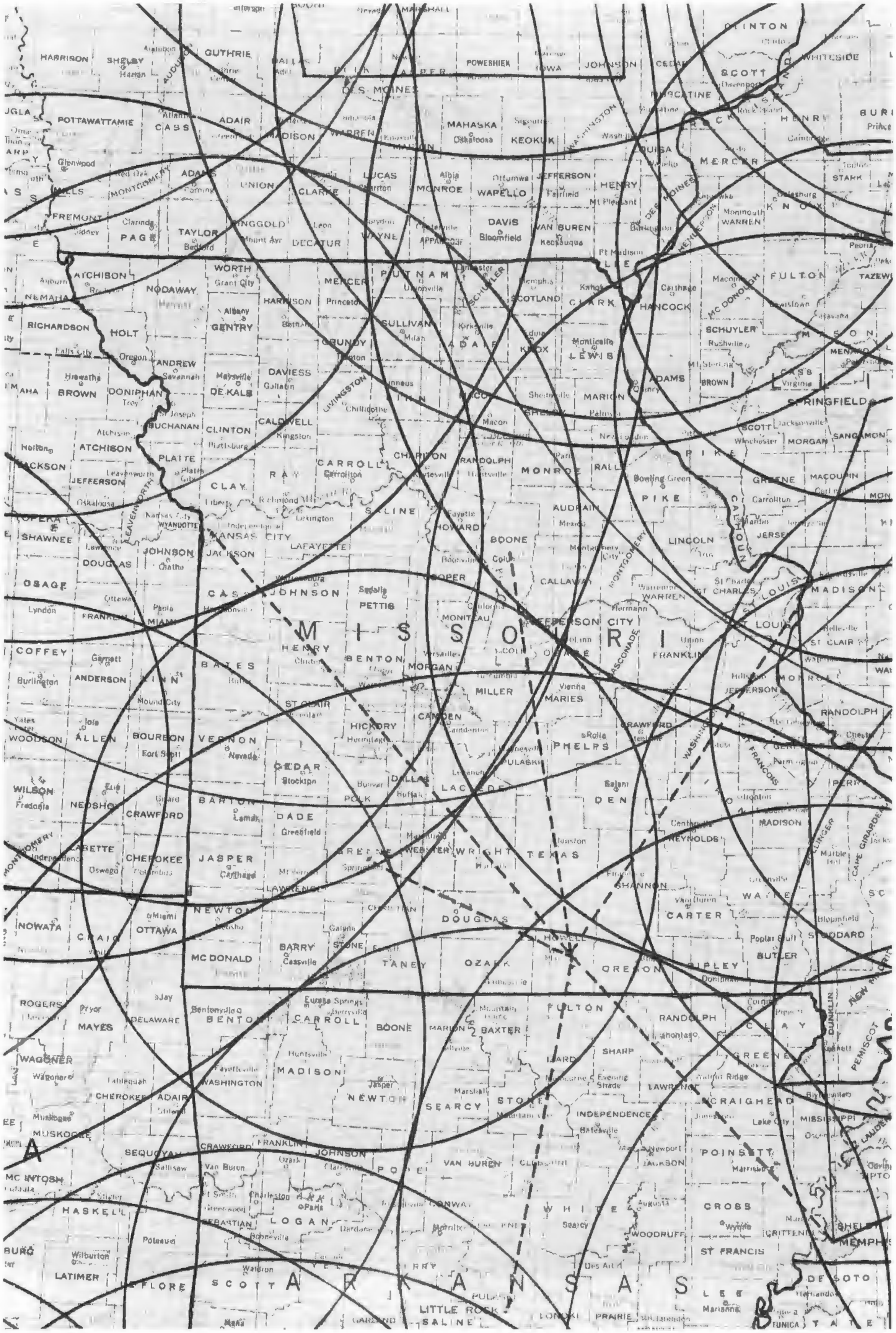


FIGURE A-88 CROSS COUNTRY OPERATING AREA COVERAGE FOR MISSOURI

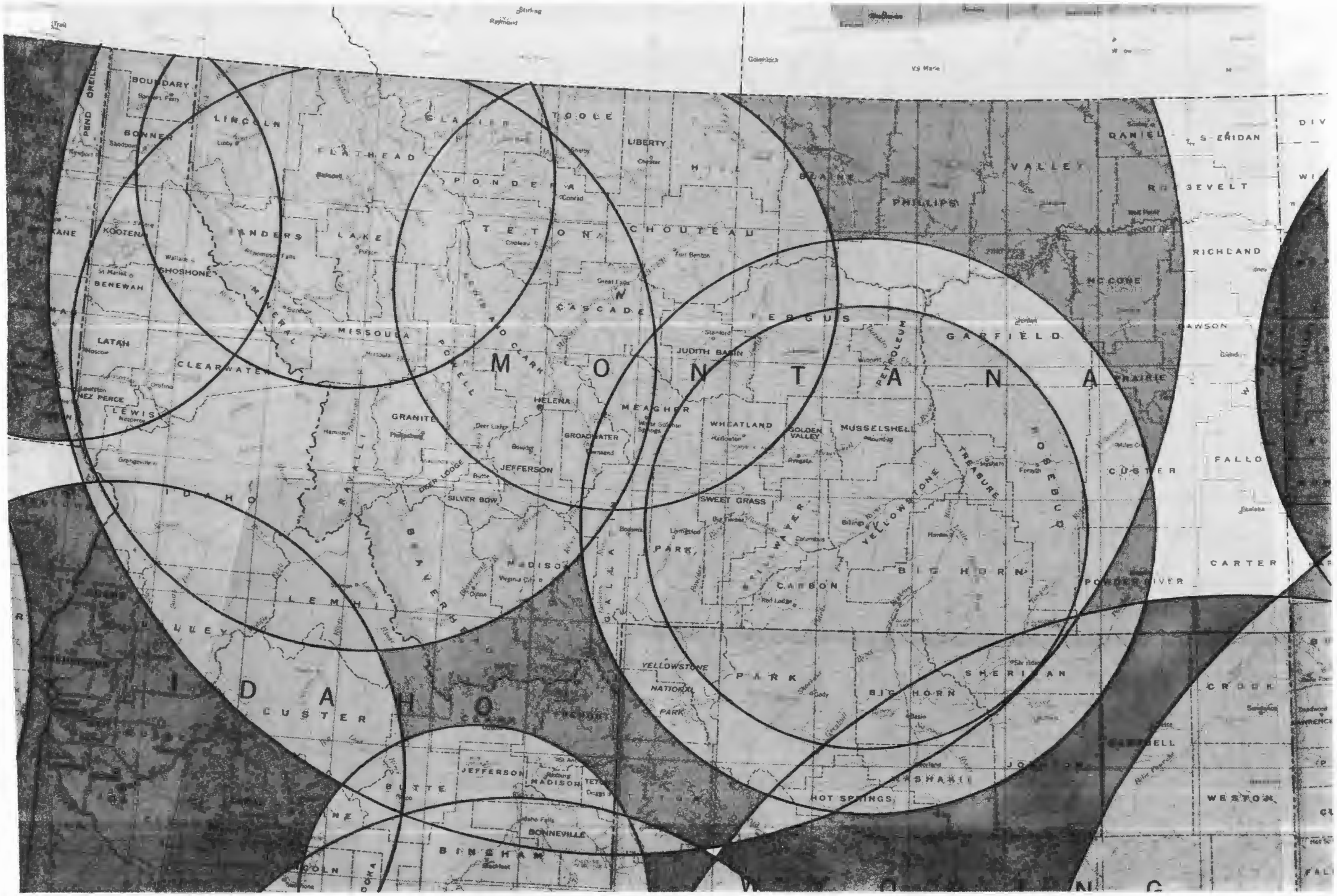


FIGURE A-89 CROSS COUNTRY OPERATING AREA COVERAGE FOR MONTANA

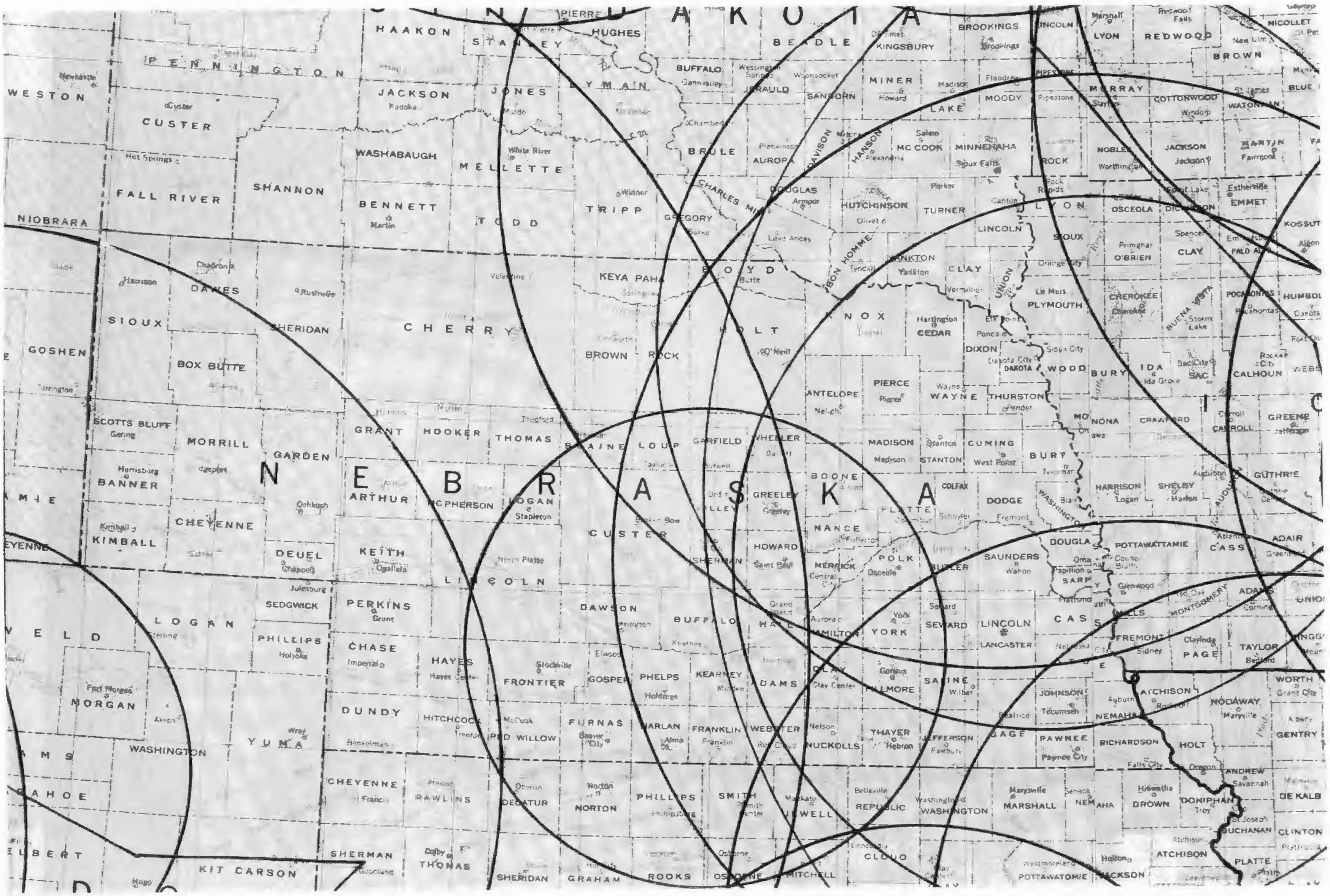


FIGURE A-90 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEBRASKA

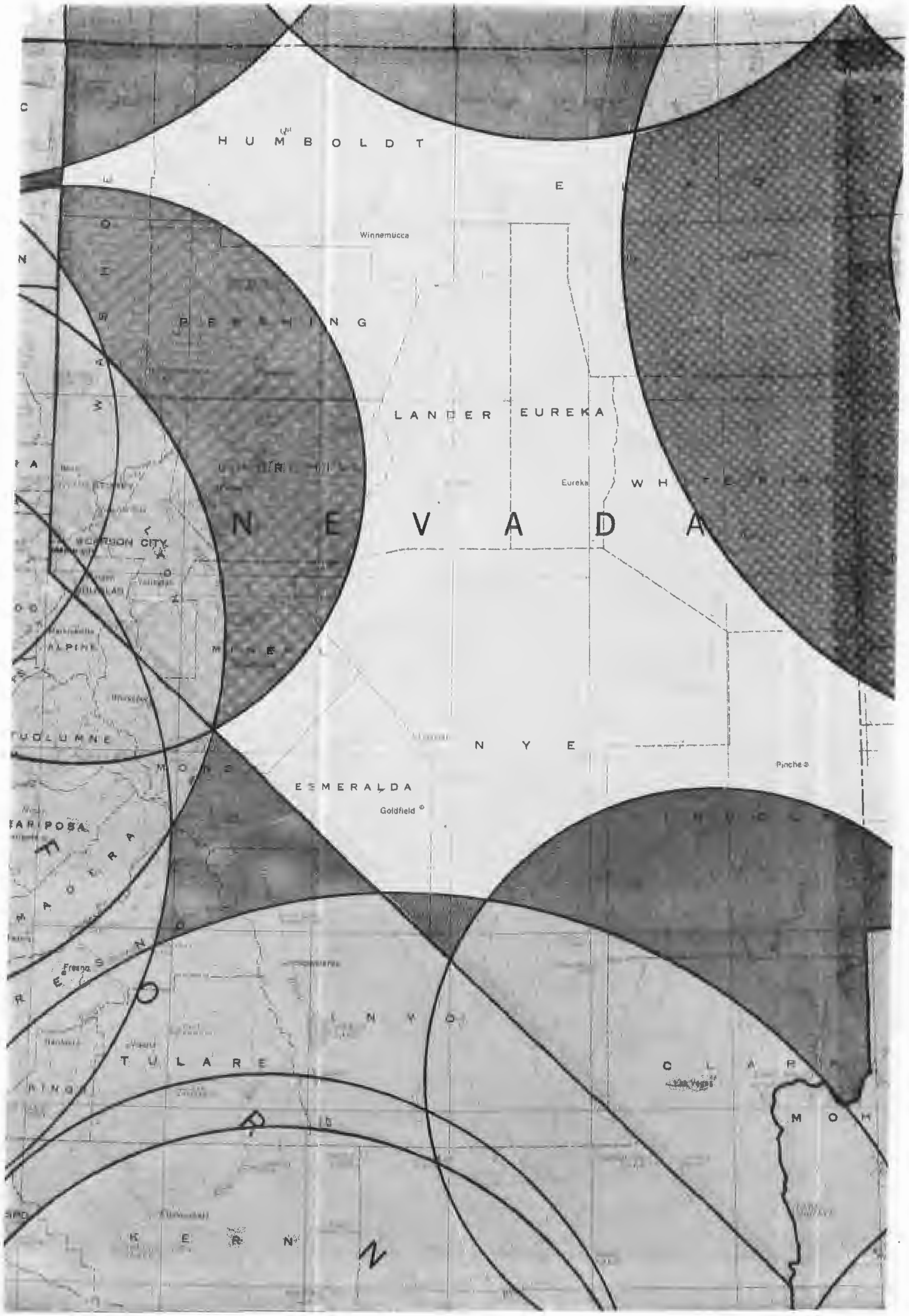


FIGURE A-91 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEVADA

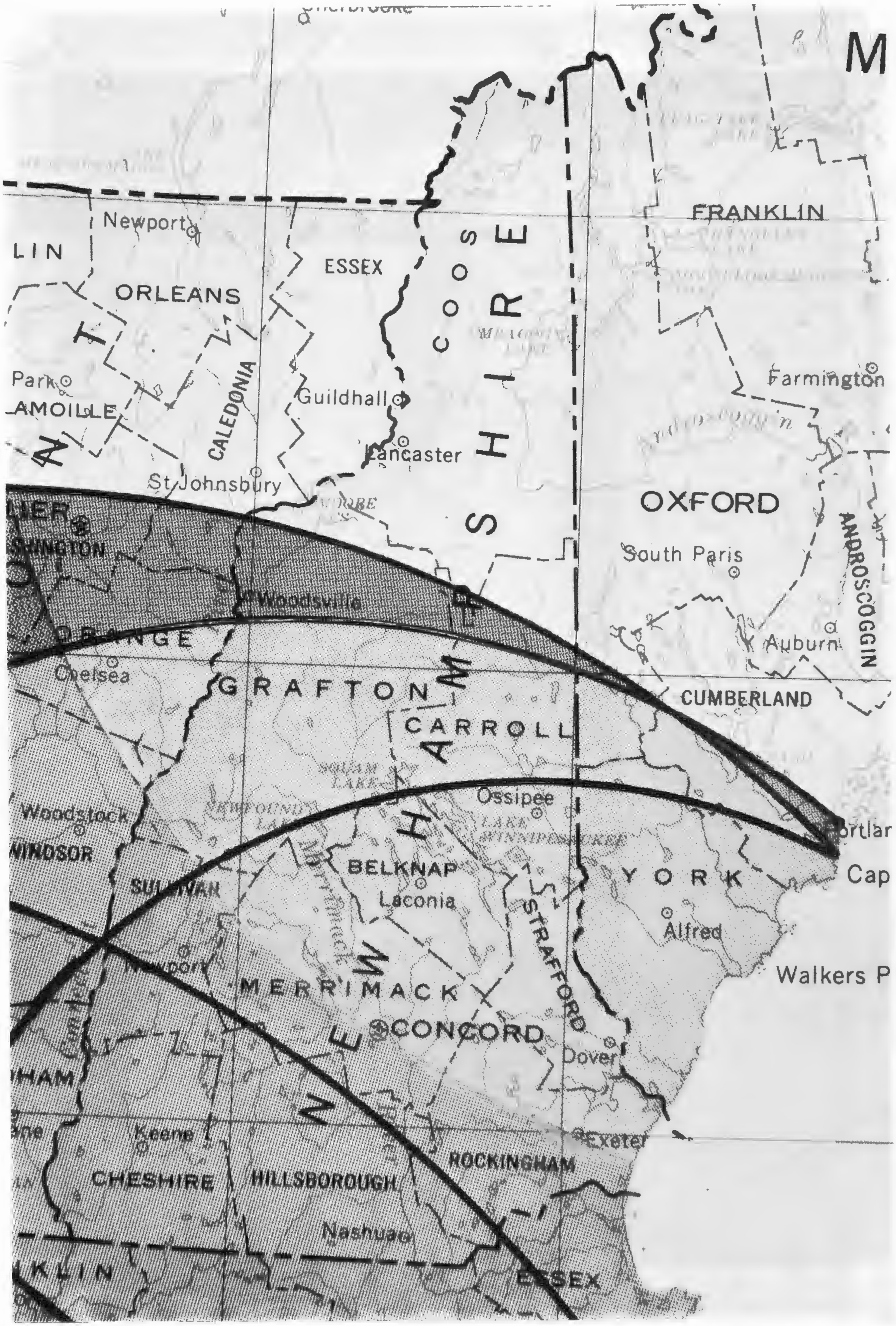


FIGURE A-92 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW HAMPSHIRE

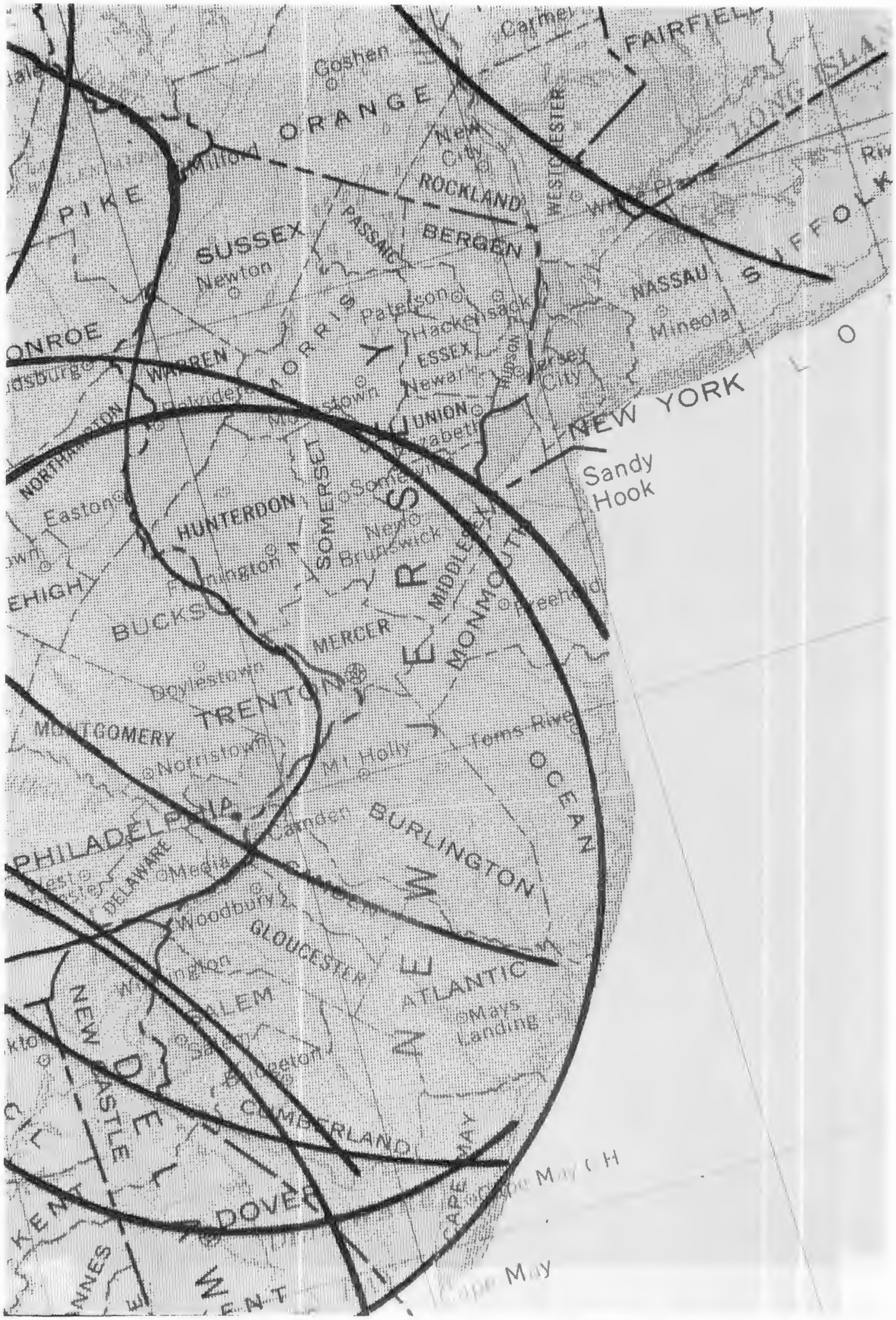


FIGURE A-93 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW JERSEY

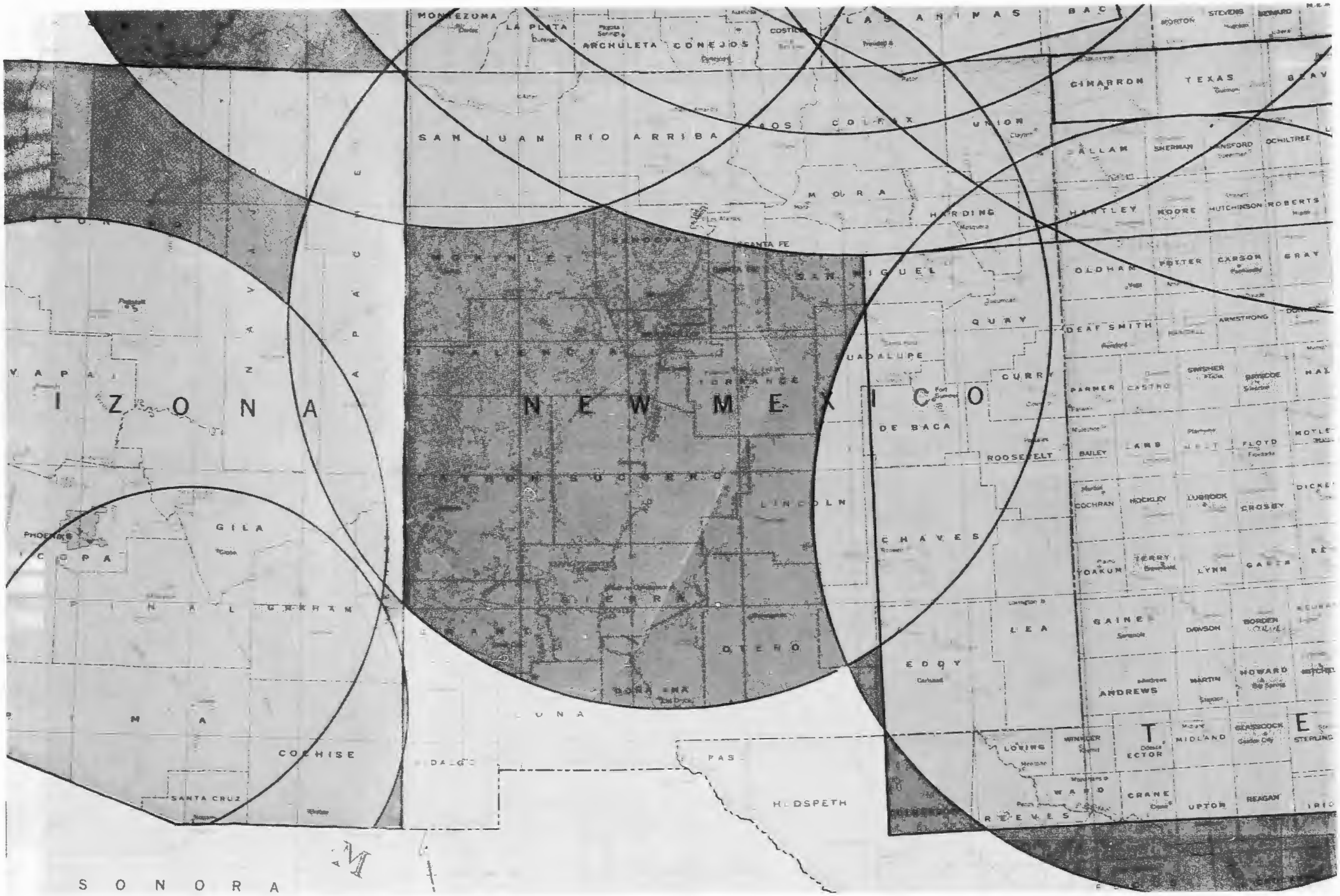


FIGURE A-94 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW MEXICO

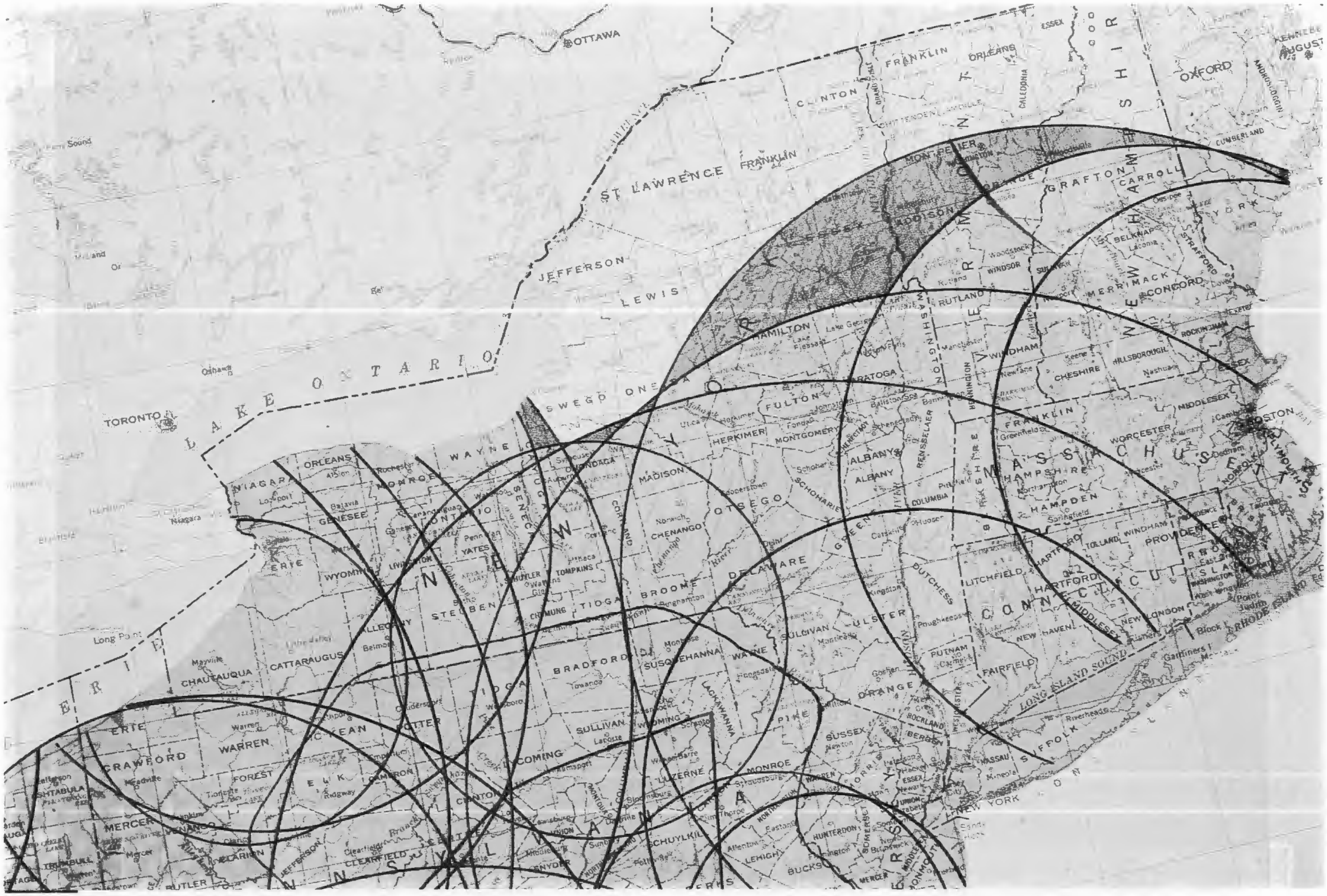


FIGURE A-95 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW YORK

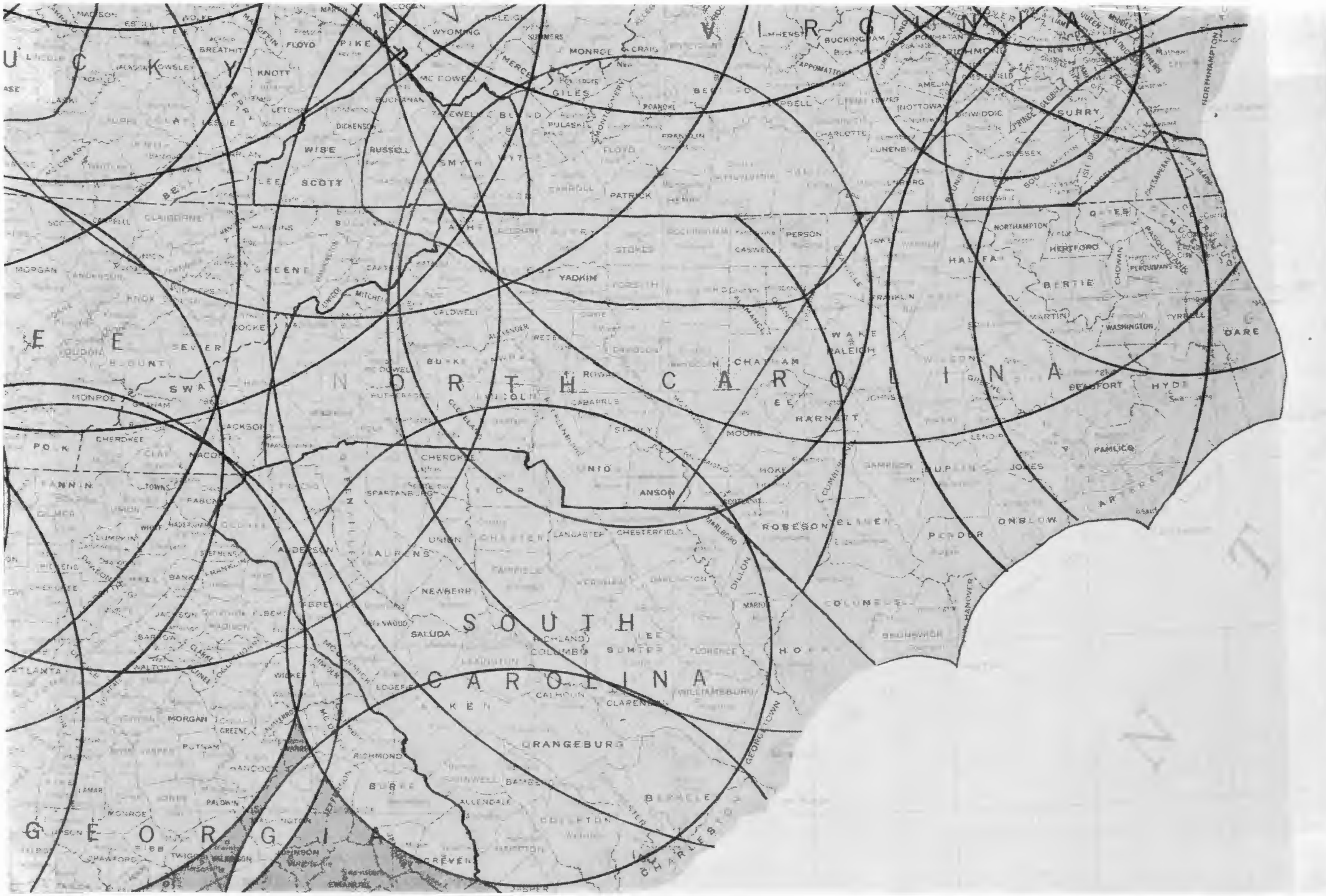


FIGURE A-96 CROSS COUNTRY OPERATING AREA COVERAGE FOR NORTH CAROLINA

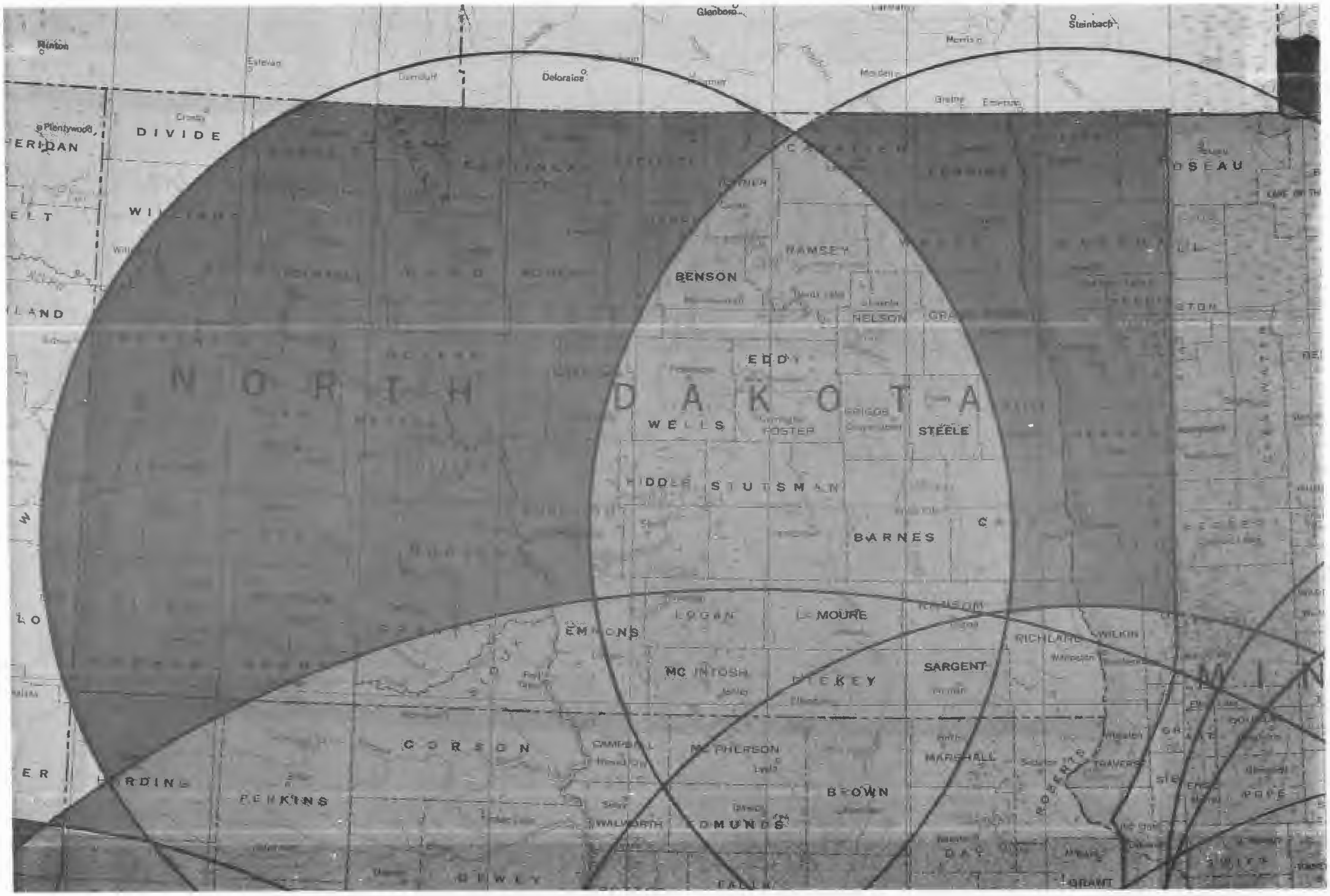


FIGURE A-97 CROSS COUNTRY OPERATING AREA COVERAGE FOR NORTH DAKOTA

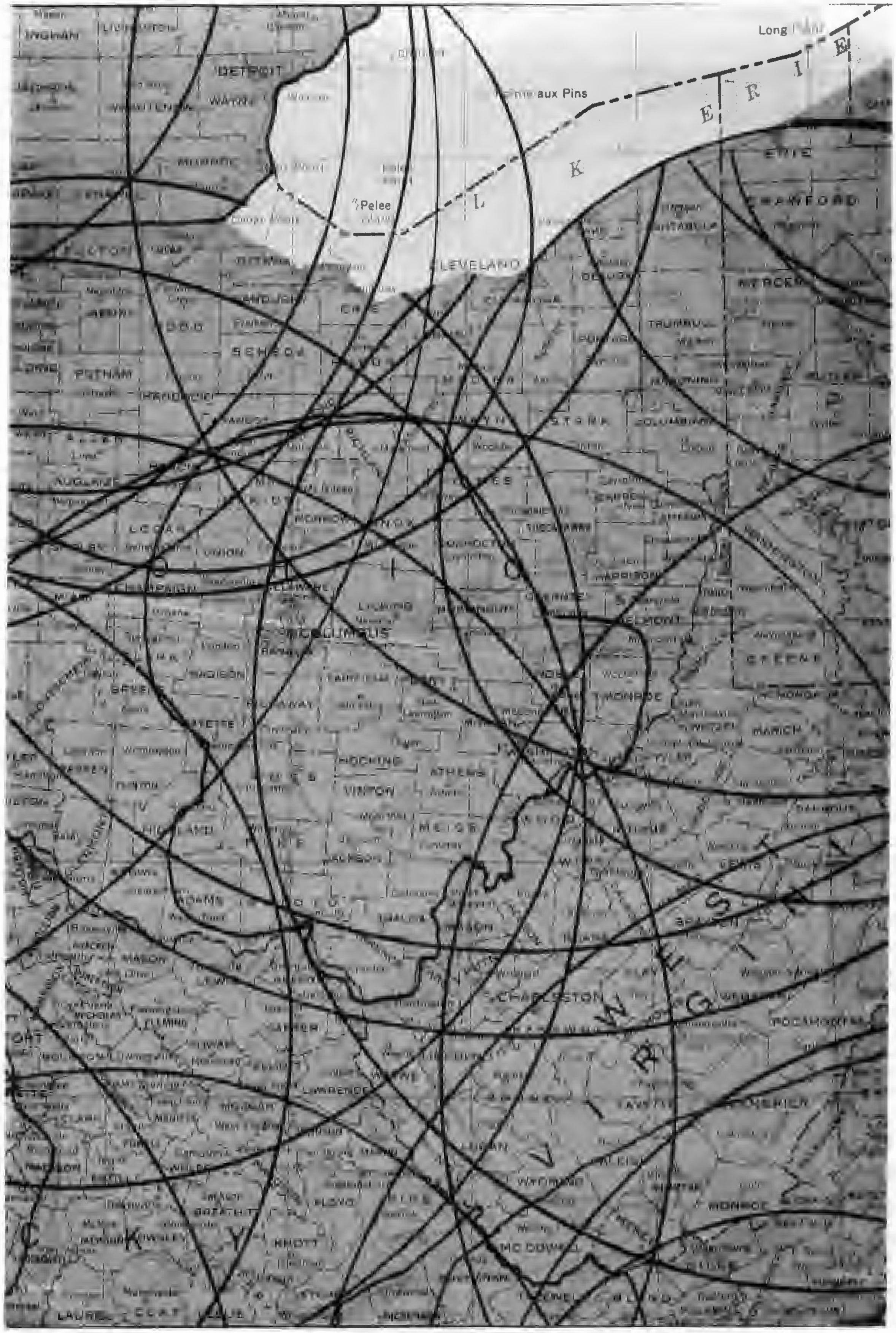


FIGURE A-98 CROSS COUNTRY OPERATING AREA COVERAGE FOR OHIO

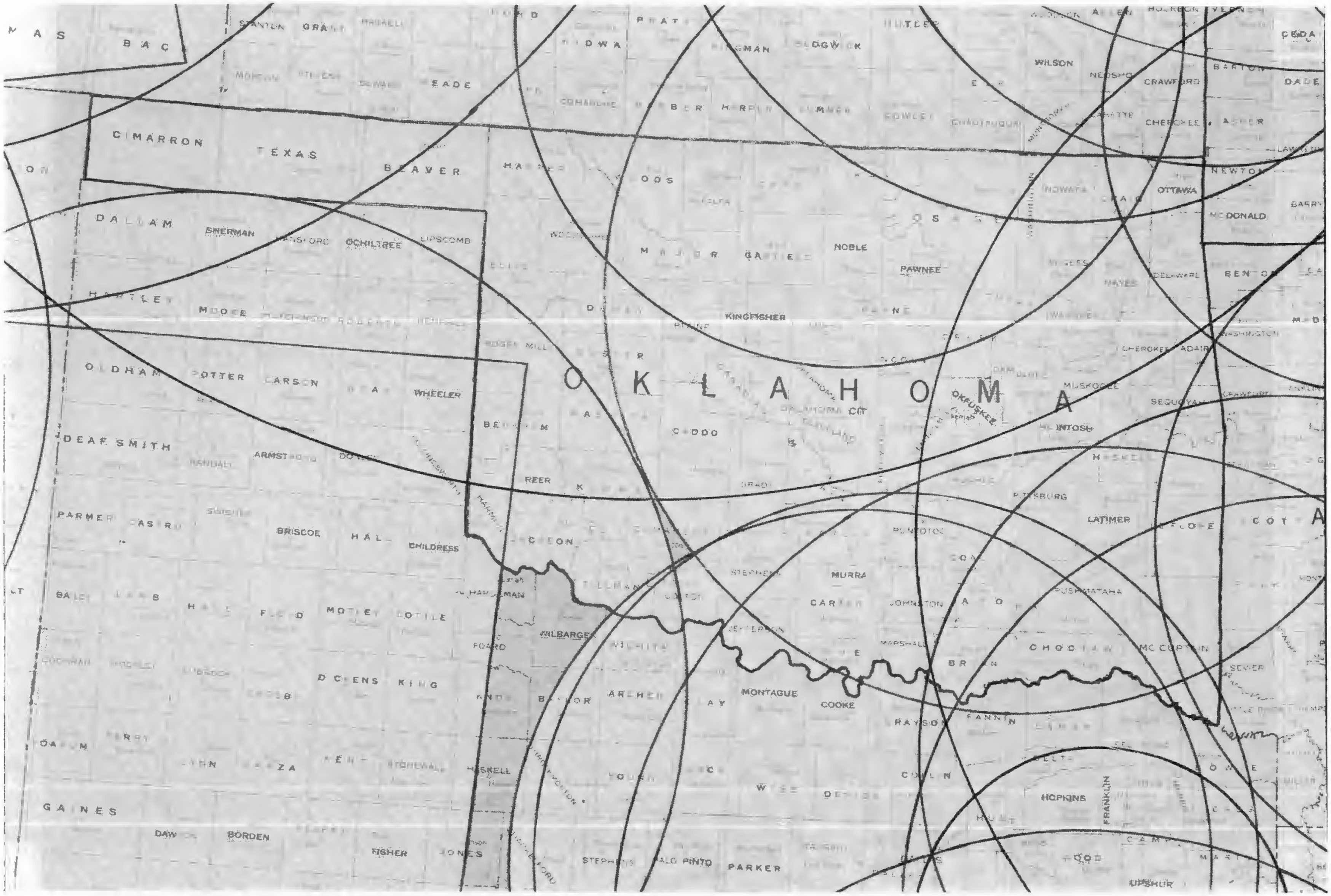


FIGURE A-99 CROSS COUNTRY OPERATING AREA COVERAGE FOR OKLAHOMA

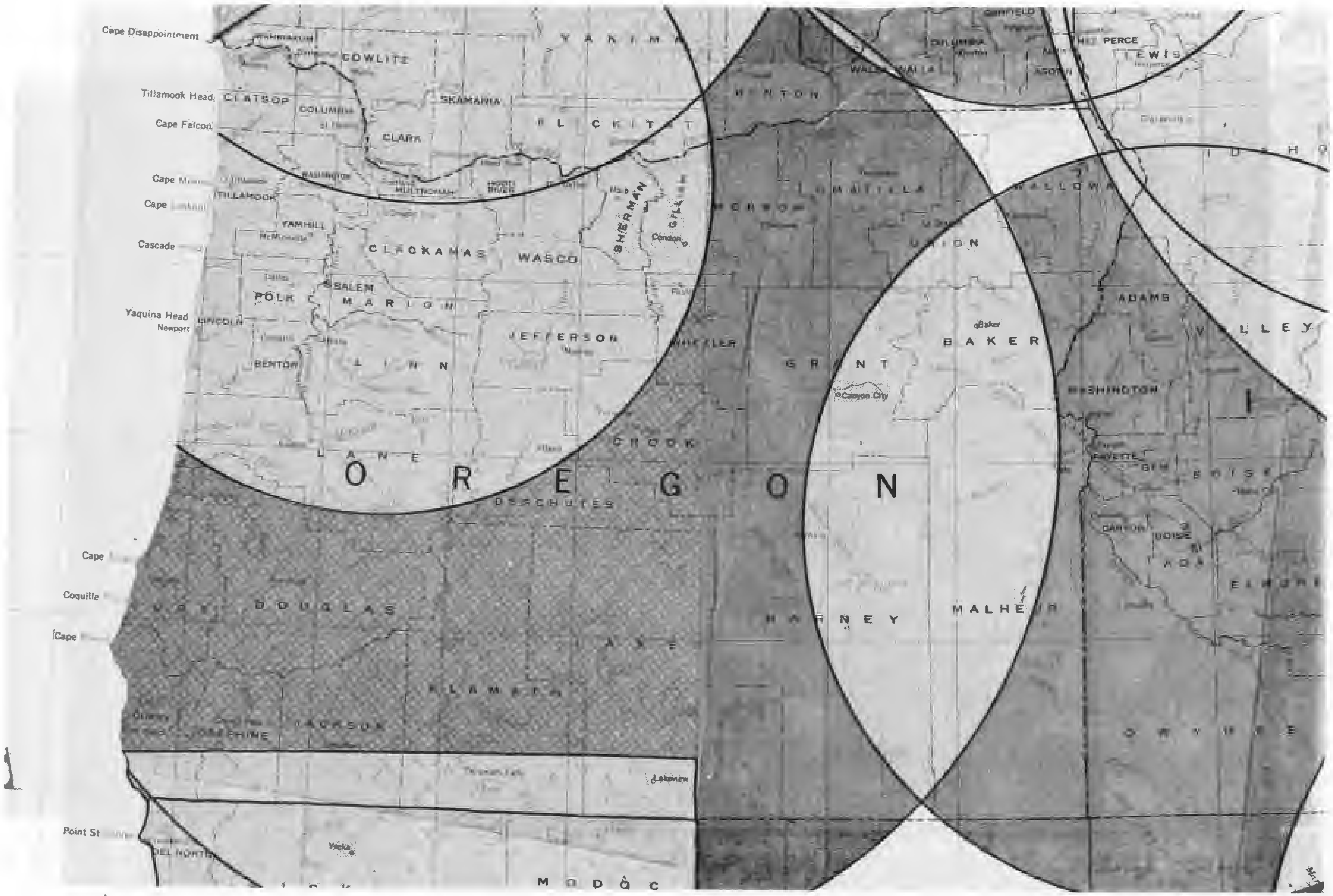


FIGURE A-100 CROSS COUNTRY OPERATING AREA COVERAGE FOR OREGON

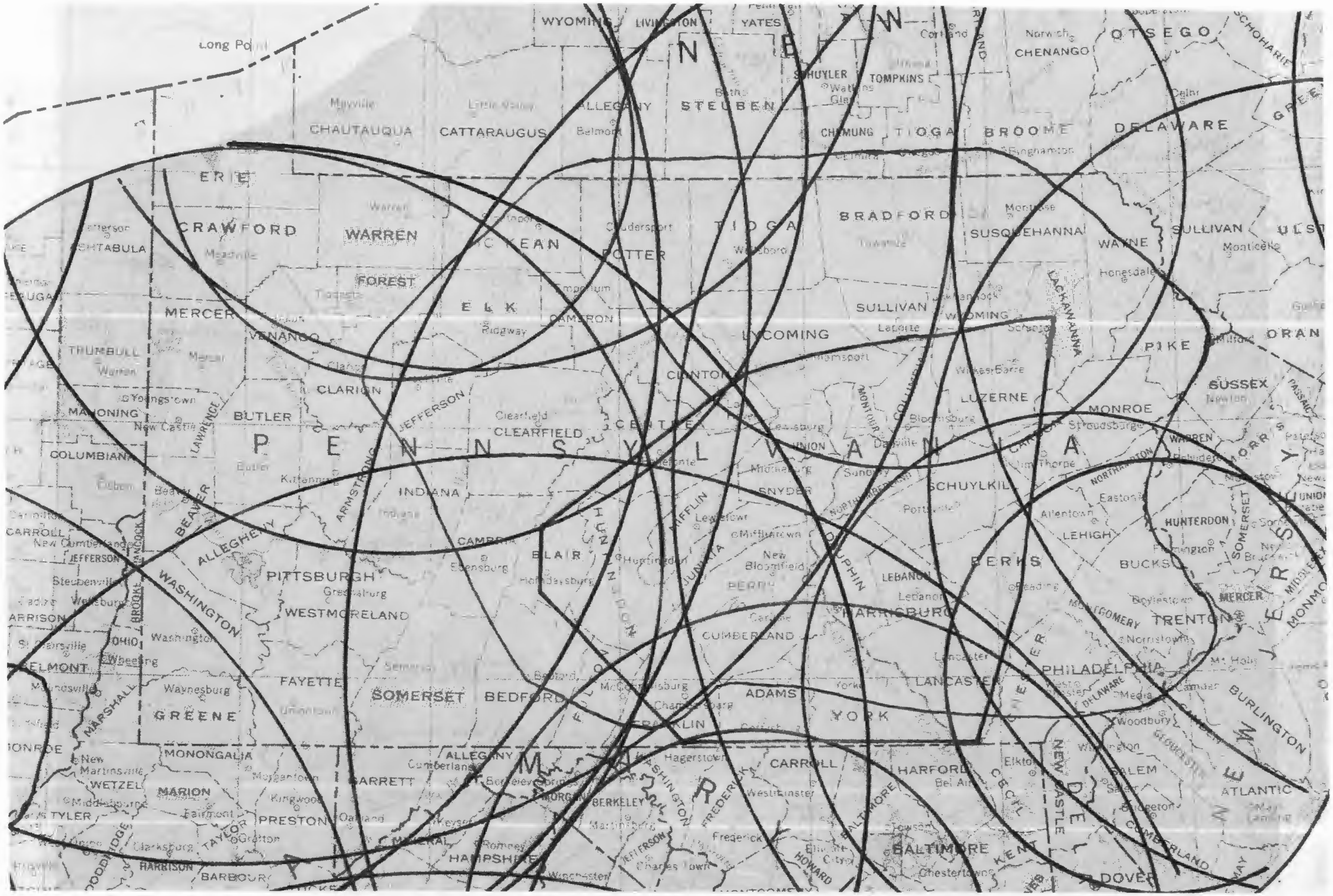


FIGURE A-101 CROSS COUNTRY OPERATING AREA COVERAGE FOR PENNSYLVANIA

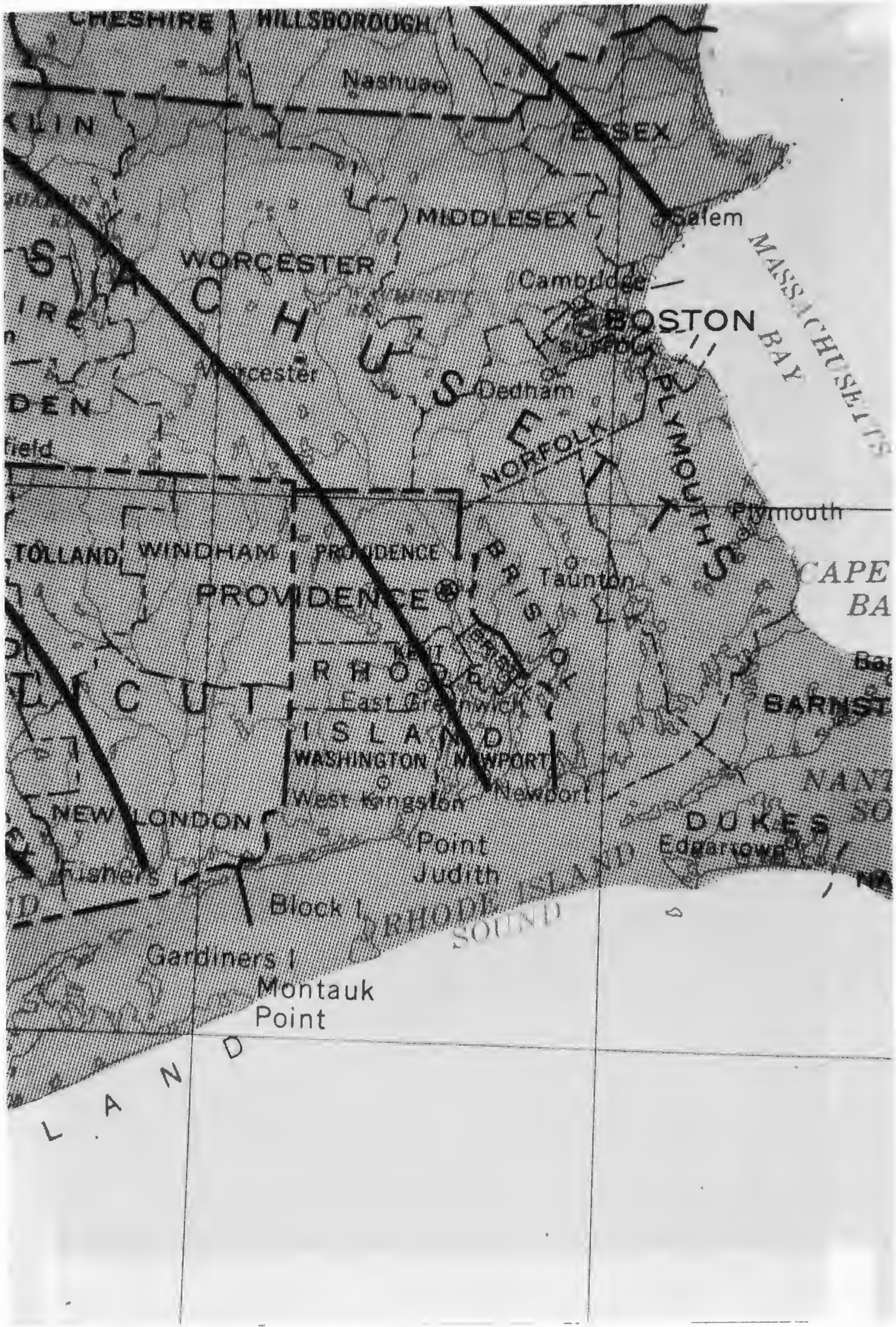


FIGURE A-102 CROSS COUNTRY OPERATING AREA COVERAGE FOR RHODE ISLAND

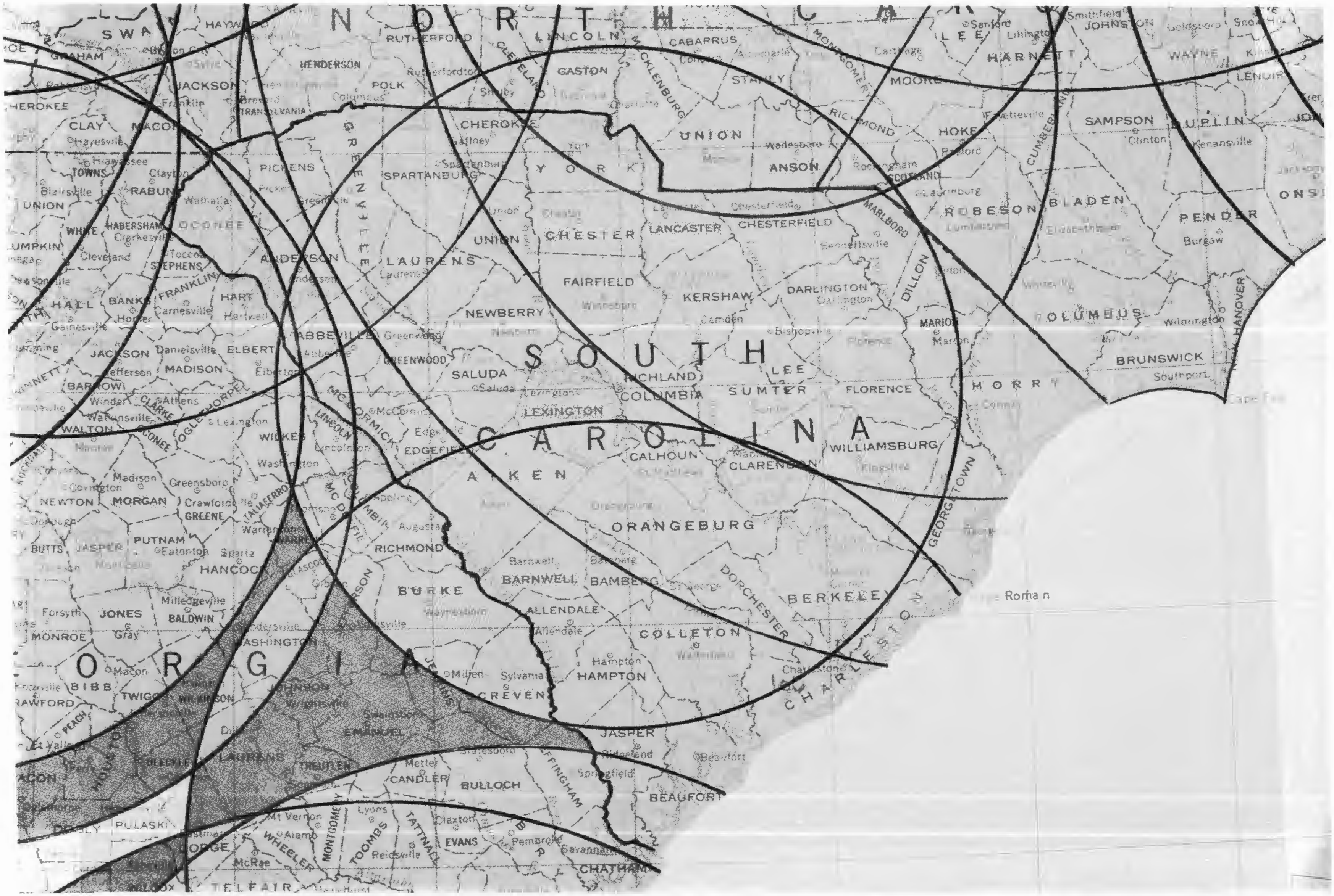


FIGURE A-103 CROSS COUNTRY OPERATING AREA COVERAGE FOR SOUTH CAROLINA

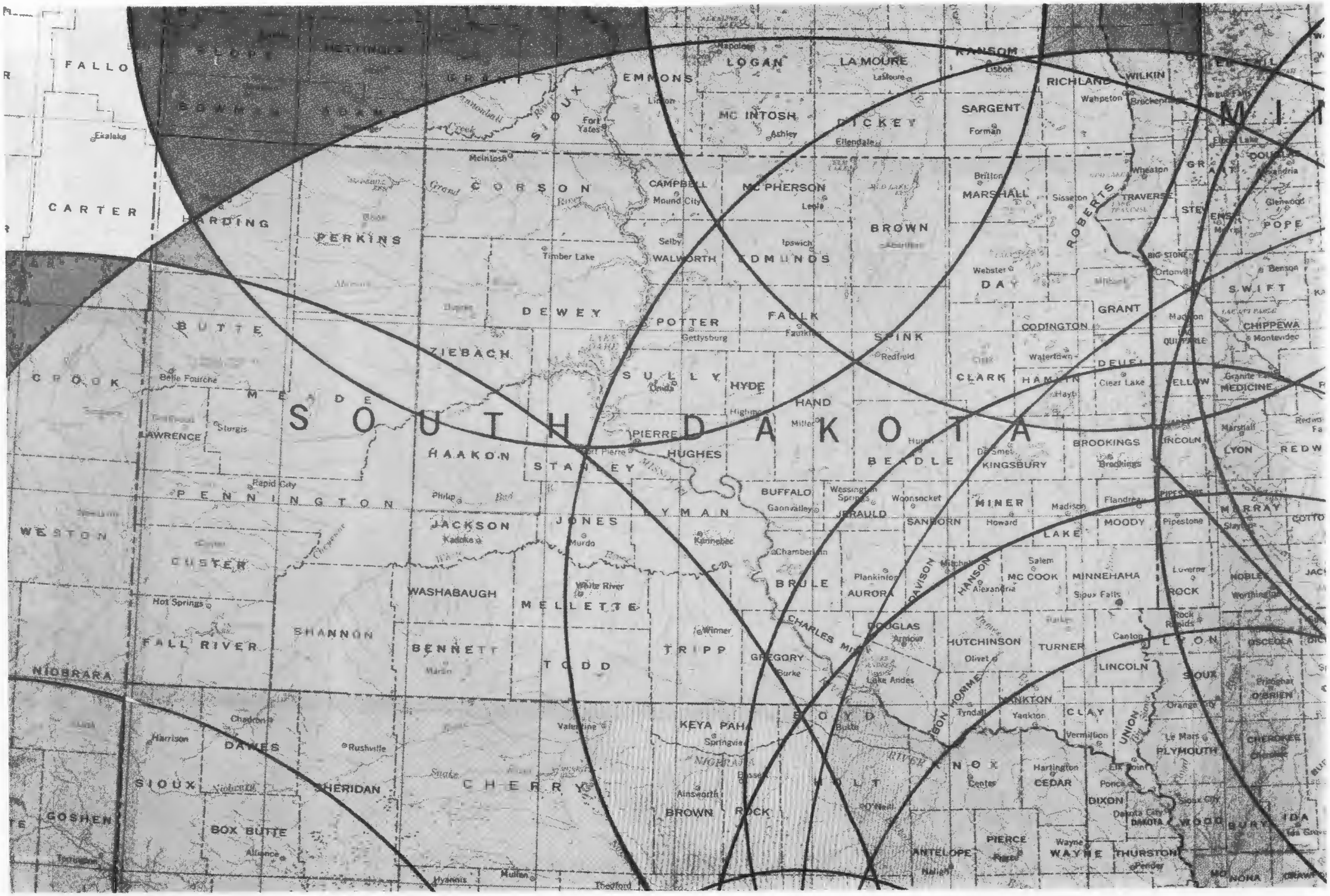


FIGURE A-104 CROSS COUNTRY OPERATING AREA COVERAGE FOR SOUTH DAKOTA

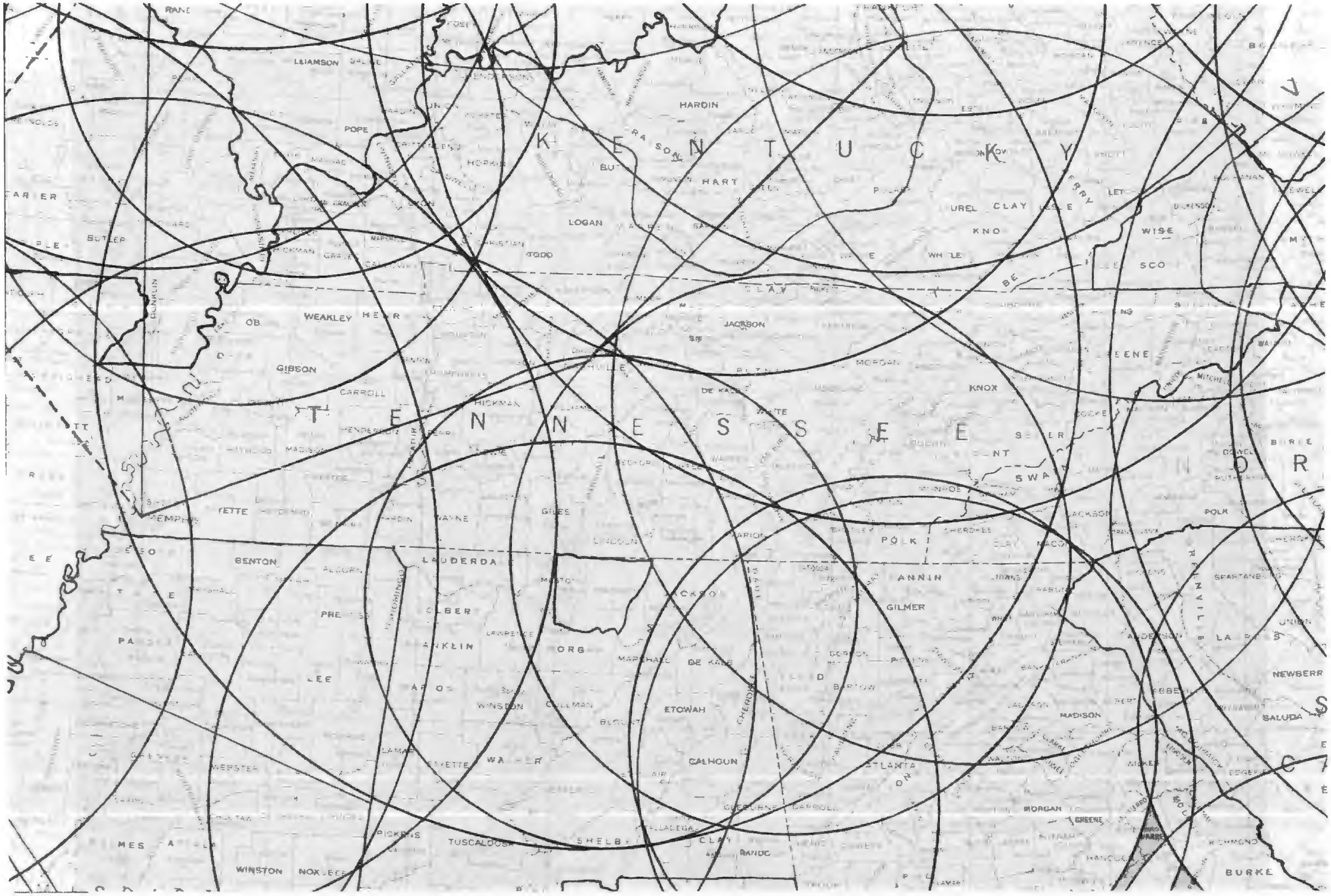


FIGURE A-105 CROSS COUNTRY OPERATING AREA COVERAGE FOR TENNESSEE

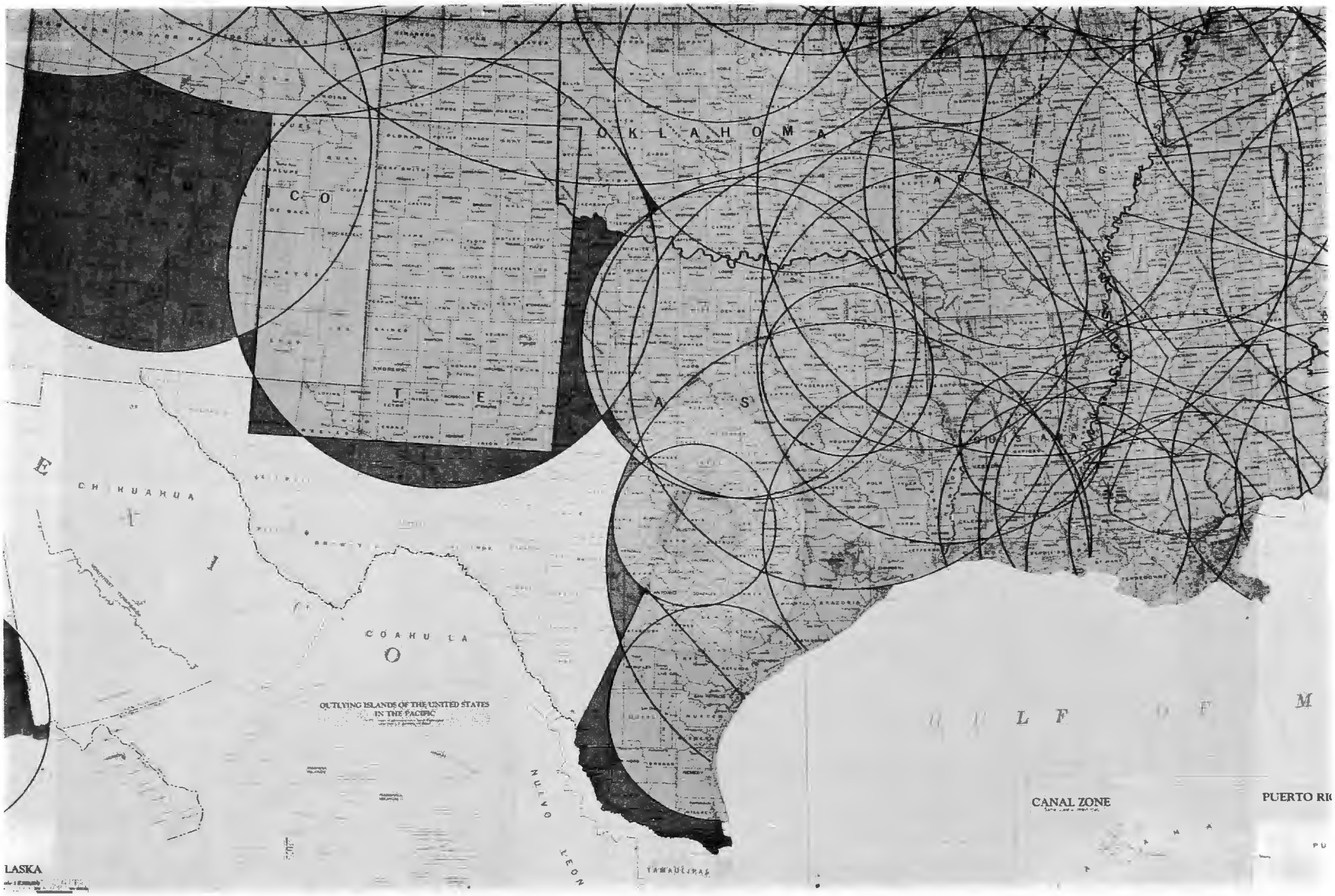


FIGURE A-106 CROSS COUNTRY OPERATING AREA COVERAGE FOR TEXAS

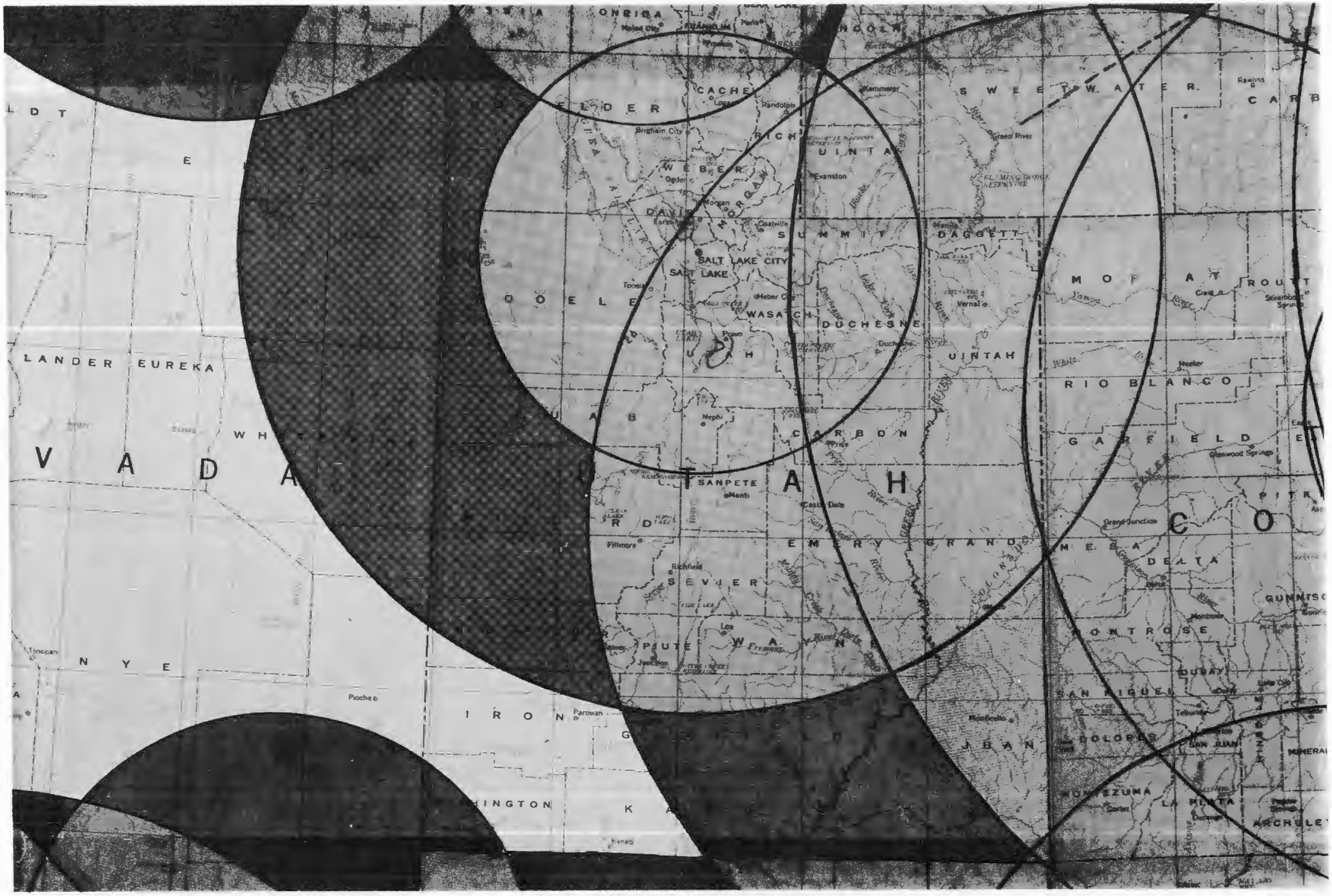


FIGURE A-107 CROSS COUNTRY OPERATING AREA COVERAGE FOR UTAH

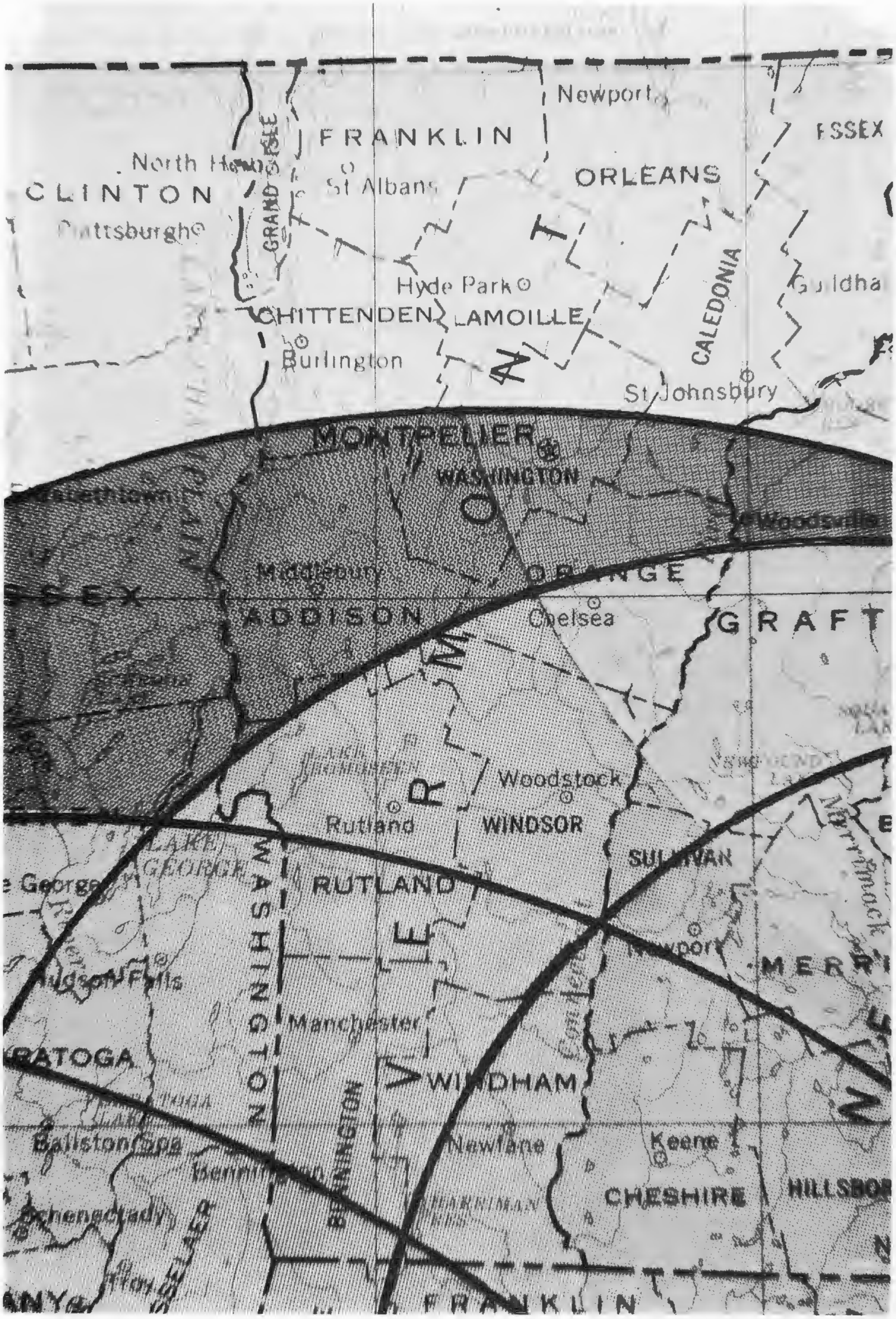


FIGURE A-108 CROSS COUNTRY OPERATING AREA COVERAGE FOR VERMONT

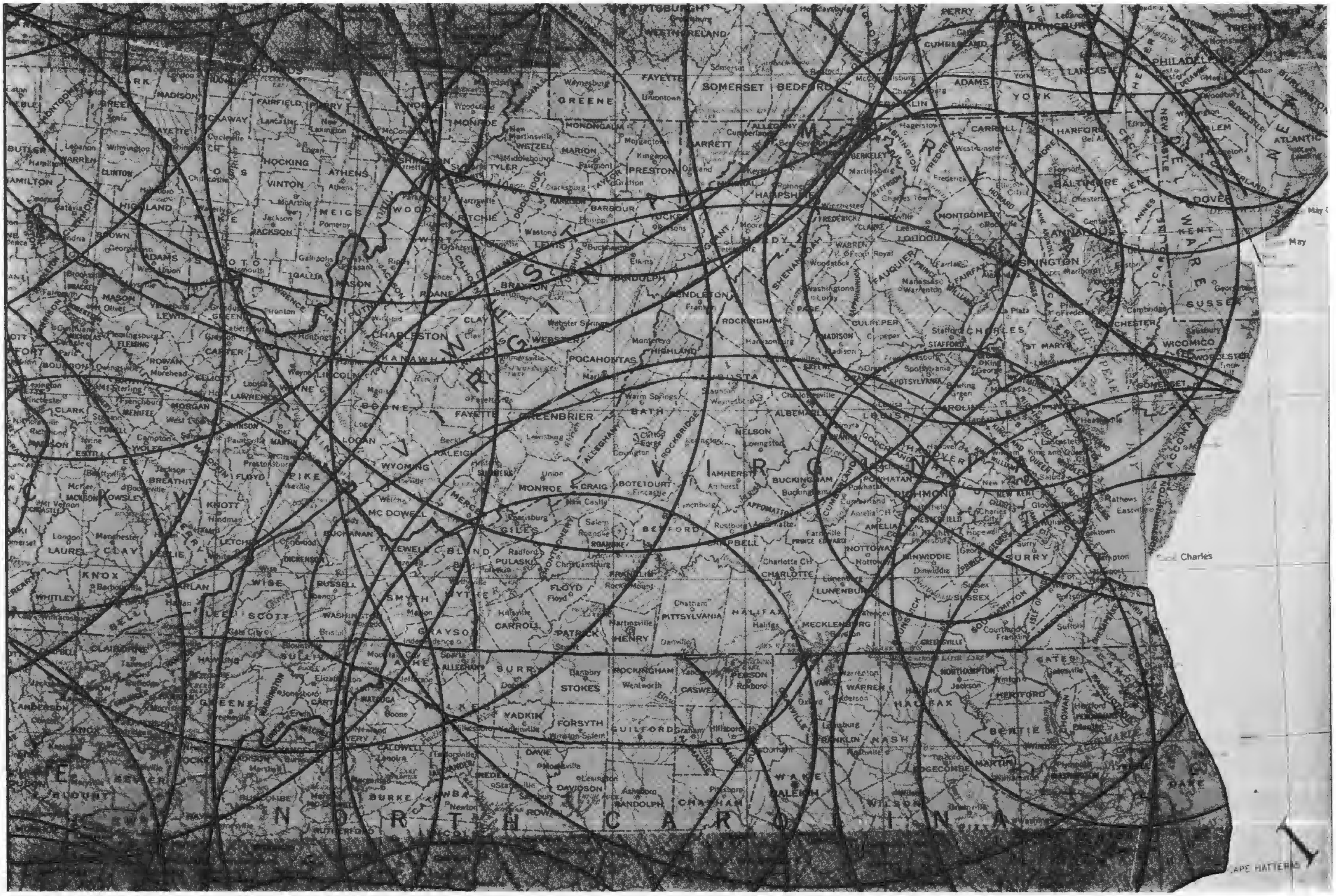


FIGURE A-109 CROSS COUNTRY OPERATING AREA COVERAGE FOR VIRGINIA

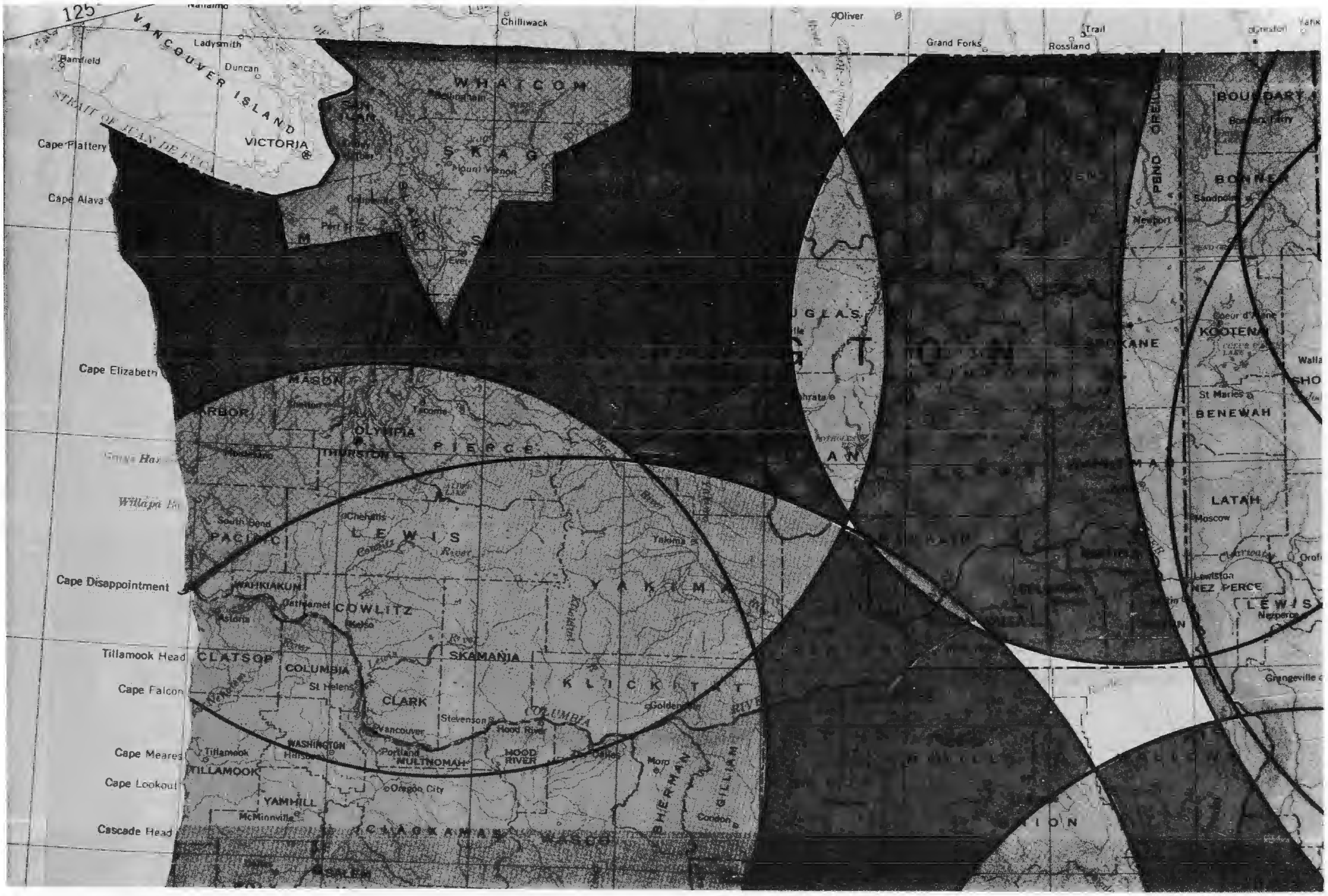


FIGURE A-110 CROSS COUNTRY OPERATING AREA COVERAGE FOR WASHINGTON

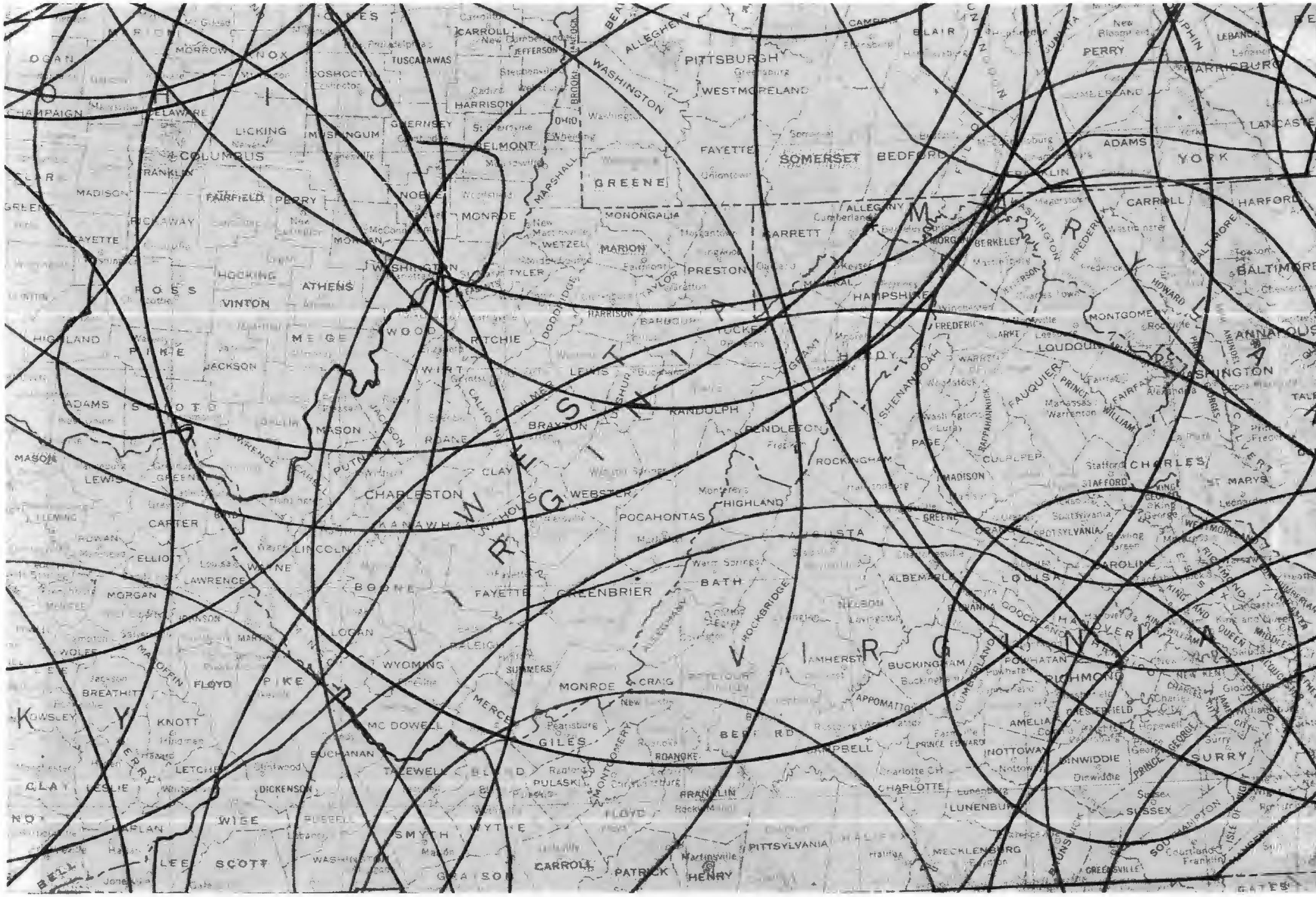


FIGURE A-111 CROSS COUNTRY OPERATING AREA COVERAGE FOR WEST VIRGINIA

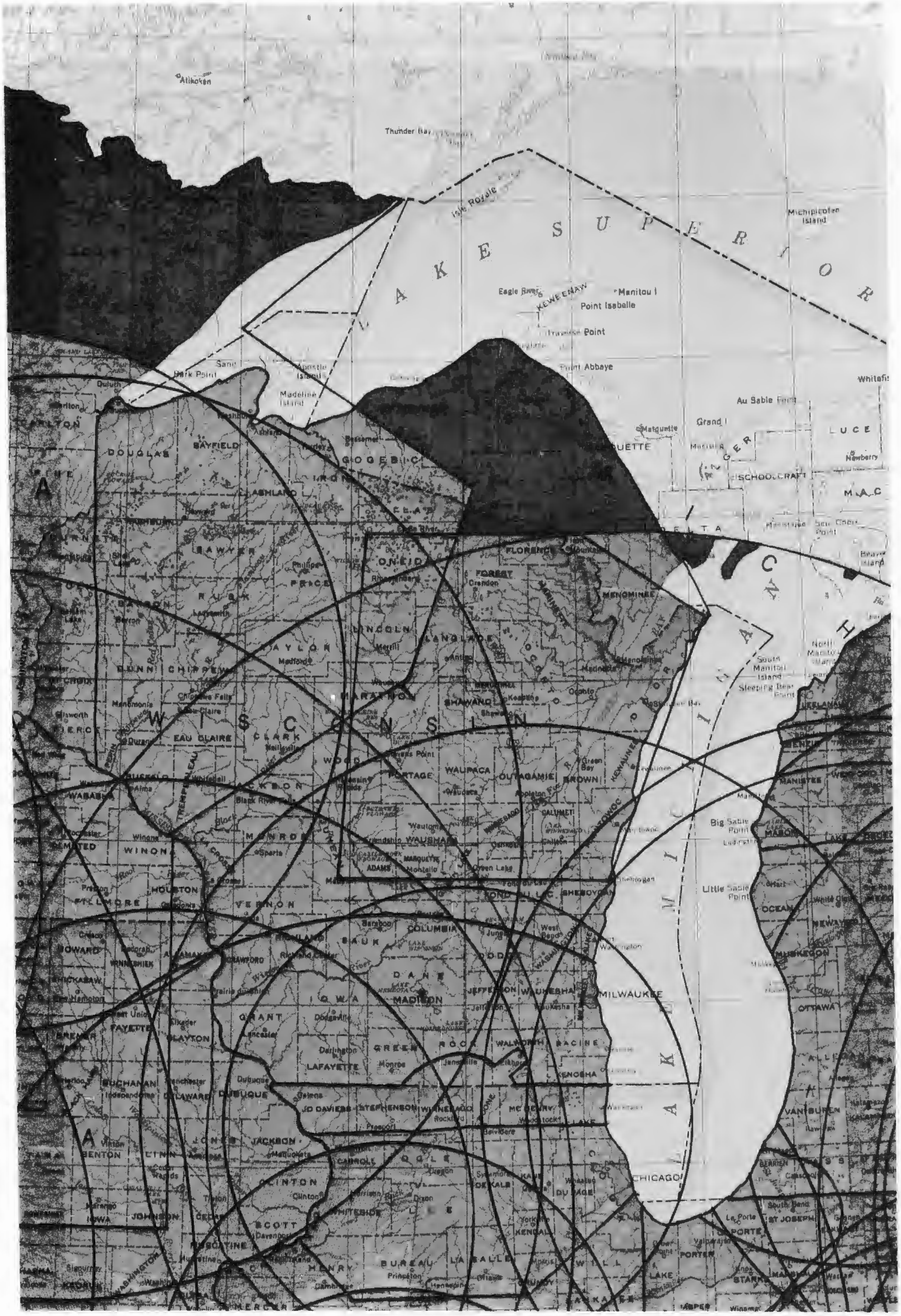


FIGURE A-112 CROSS COUNTRY OPERATING AREA COVERAGE FOR WISCONSIN

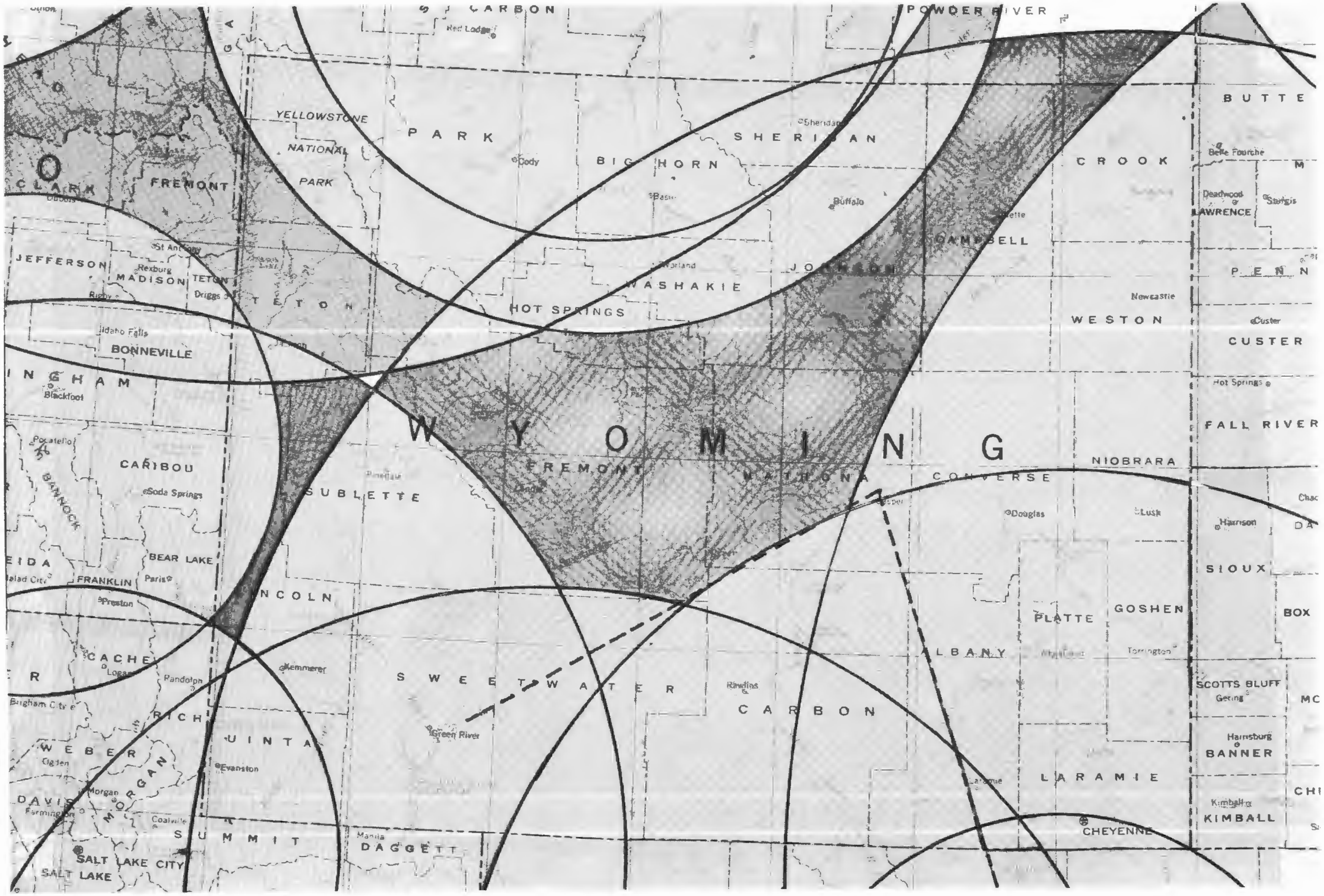


FIGURE A-113 CROSS COUNTRY OPERATING AREA COVERAGE FOR WYOMING

APPENDIX B
SAMPLE QUESTIONNAIRE

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

June 19, 1989

Dear Sir,

The Federal Aviation Administration (FAA) is engaged in a research and development project to determine what areas of the United States should be provided with additional low altitude communication, navigation and surveillance facilities, and associated air traffic control services. The study is being performed as a benefit/cost analysis assessing a wide variety of rotorcraft missions. Based on prior analysis and the evaluations completed thus far in this study, we believe that a large percentage of the public benefits that would accrue from providing additional facilities/services would result from the life saving possibilities associated with the air ambulance helicopter mission. Thus, in our ongoing analysis, we are striving to understand the complexity of the air ambulance mission so as to properly assess services currently provided, additional services required, their cost and the benefits that may be derived if they are provided.

To properly assess the services provided/needed, we must know the geographic areas in which you normally operate. In a recent advisory circular, Emergency Medical Services/Helicopter (AC 135-14), the FAA recommended (Par 6b (1)), that each EMS dispatch location establish a local flying area and a cross-country area. We have urgent need of that information to support our efforts to provide additional services where it can be shown to be cost beneficial to do so. We are therefore requesting your help in providing us with information concerning your operation. Because operations differ dramatically, with boundaries dictated by terrain, politics, competition, equipment, etc., we recognize that inputs may vary widely. We will sort out the responses when we receive them. We have however provided samples (Attachments 1 thru 3) received from one operator indicating the type of information needed. It is very important that we know any company minimums establiished for local and cross country areas and how they differ day and night. It is our intent to compare existing and planned services to the needs of your operation for purposes of identifying shortfalls.

Please send chart(s) and any necessary textual description of your operating area and minimums to the following address.

Federal Aviation Administration
Mr. Robert D. Smith, ADS-220
800 Independence Avenue S. W.
Washington, D. C. 20591

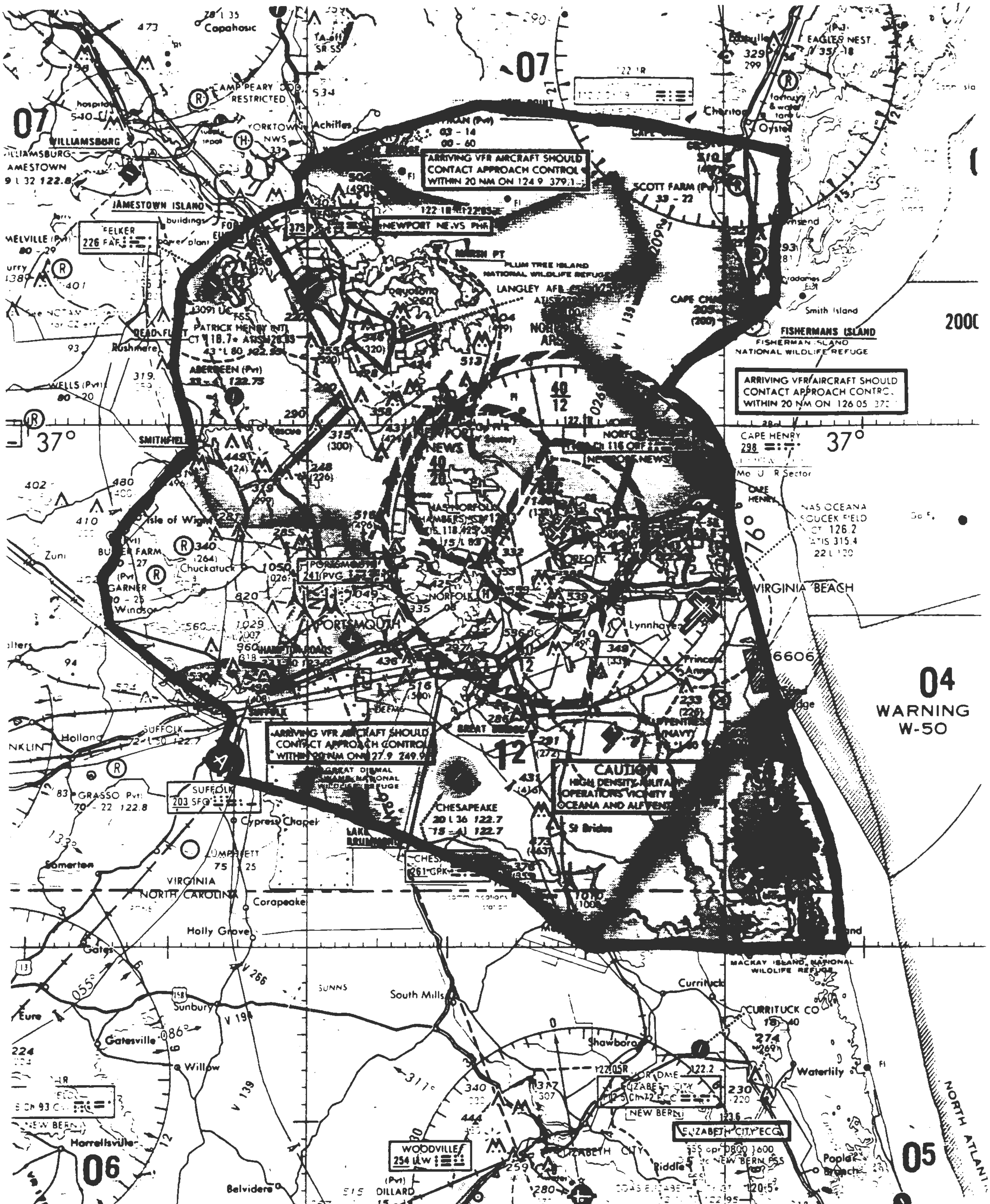
If possible, we would like to receive this material by July 7.

Thank you for your assistance in this matter. Should you have any questions, please feel free to call me at (202) 267-3783. Please be aware that the information we are requesting does not fulfill or eliminate any obligations you may have to your local Flight Standards Office as we are not involved directly in their work.

Robert D. Smith

Robert D. Smith
Rotorcraft Technology Branch, ADS-220

Attachment 1 - Local Area
Attachment 2 - Cross Country Area
Attachment 3 - Weather Minimums



Capahosic
CAMP PEARY
RESTRICTED
YORKTOWN
WILLIAMSBURG
JAMESTOWN ISLAND
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 124.9 379.1
NEWPORT NEWS PHF
SCOTT FARM (Pvt)
FELKER
PLUM TREE ISLAND NATIONAL WILDLIFE REFUGE
LANGLEY AFB
Smith Island
FISHERMANS ISLAND
FISHERMAN ISLAND NATIONAL WILDLIFE REFUGE
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 126.05
PATRICK HENRY (NT)
ABERDEEN (Pvt)
WELLS (Pvt)
SMITHFIELD
37°
CAPE HENRY
NAS OCEANA
SOUCEK FIELD
Isle of Wight
Zuni
BUTLER FARM
Chuckatuck
GARNER
Windsor
PORTSMOUTH
NORFOLK
VIRGINIA BEACH
Lynnhaven
04
WARNING
W-50
SUFFOLK
Holland
GRASSO (Pvt)
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL
GREAT DISMAL SWAMP NATIONAL WILDLIFE REFUGE
CHESAPEAKE
CAUTION
HIGH DENSITY MILITARY OPERATIONS VICINITY OCEANA AND ALVENTS
St Brides
Cypress Chapel
Somerton
VIRGINIA
NORTH CAROLINA
Corapeake
Holly Grove
Gates
MACKAY ISLAND NATIONAL WILDLIFE REFUGE
South Mills
Sunbury
Currituck
CURRITUCK CO
Gatesville
Willow
Shawboro
Waterlily
NORTH ATLANTIC
ELIZABETH CITY ECG
WOODVILLE
DILLARD
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06
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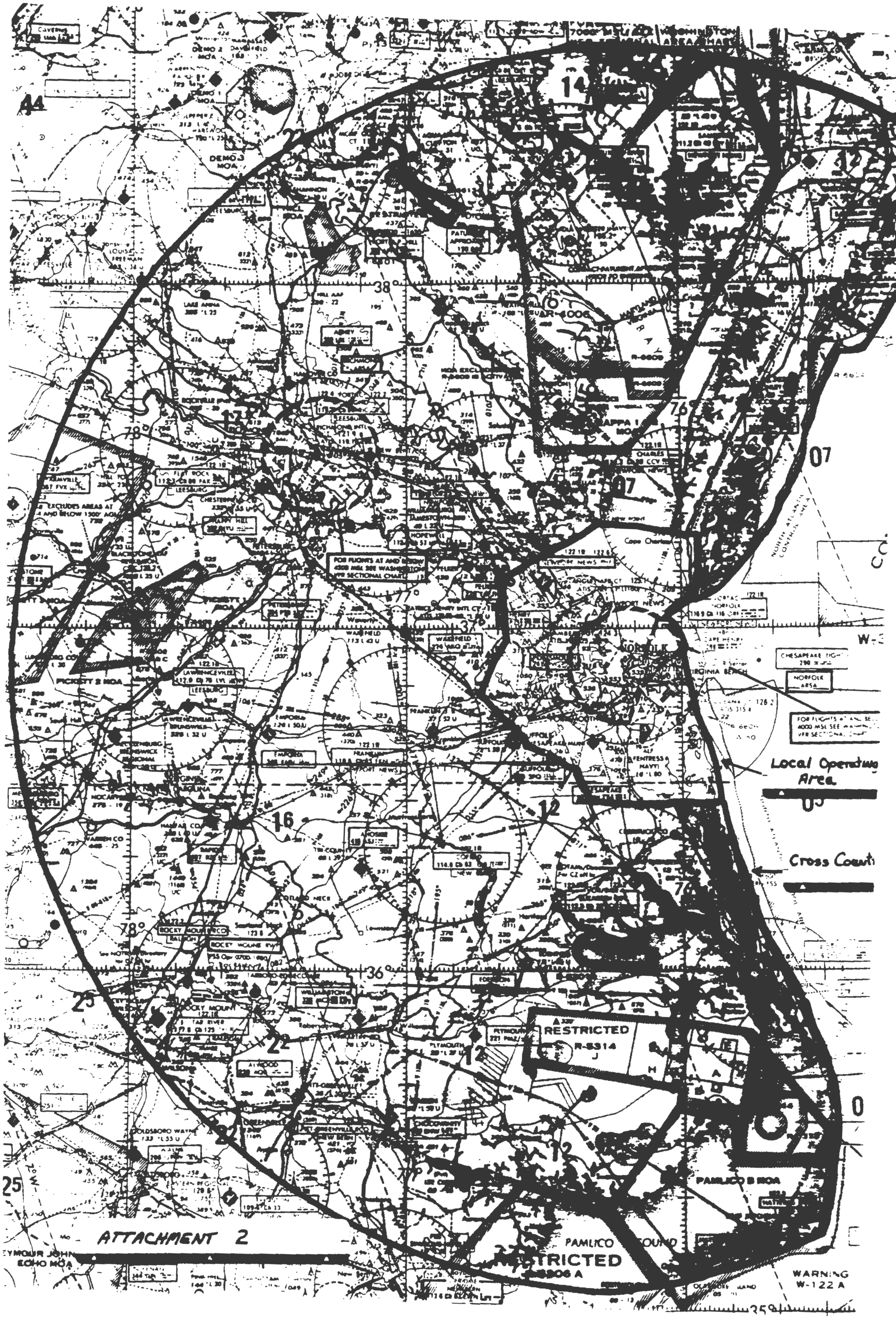
Local Operating Area
Cross Country
ATTACHMENT 2
RESTRICTED
R-5314
RESTRICTED
PAMLICO SOUND
PAMLICO B MOA
WARNING
W-122 A
PICKETT 2 MOA
DEMO 3 MOA
NORFOLK
VIRGINIA BEACH
FOR FLIGHTS AT AND BELOW 4000 MSL SEE WASHINGTON VFR SECTIONAL CHART

APPENDIX C
WEATHER DATA MODEL

The weather data provided in the Airport Specific File (ASF) is derived from the national average weather data (NAWD) and corrected with site specific weather data. However, the ASF data is organized in such a way that the joint (combined) probabilities of only eight specific combinations of ceiling and visibility limits being exceeded are reported. For the purposes of this study, unconditional (independent) probabilities are of more value than joint probabilities, since the unconditional probabilities will allow the many varied combinations of ceiling and visibility minimums reported by the operators to be computed. It is not possible to calculate all of the various combinations of ceiling and visibility directly from the ASF data.

For example, one EMS/H operator reported day/local minimums of a 500 foot ceiling and 1 mile visibility. The ASF data contains data for the combined limits of ceiling less than or equal to 400 feet and visibility less than or equal to 1 mile, or for the combined limits of ceiling less than or equal to 600 feet and visibility less than or equal to 1.5 miles. Nothing in between is reported. Neither category in the ASF exactly fits the operator's minimums. The reported probabilities for the two categories are 1.0 percent and 3.38 percent, respectively. The model developed herein computes the joint probability for 500/1 at the operator's location to be 1.6 percent. Thus, it can be seen that a greater degree of flexibility has been obtained by using the independent probabilities than would be possible using the ASF data alone.

NATIONAL AVERAGE WEATHER DATA

Table C-1 contains the national average weather data which was linearly interpolated directly from a table of NAWD in appendix C of the report "Development of Revised and Expanded ASF." Table C-1 gives the average joint probabilities of either the ceiling or the visibility minimums, or both, being exceeded for the entire United States. There are several justifications for the use of linear interpolation on the

TABLE C-1 PLOT OF NATIONAL AVERAGE WEATHER DATA

Ceiling	Visibility (miles)						
(feet)	1/2	3/4	1	1-1/2	2	2-1/2	3
200	1.12	1.52	2.02	3.14	4.46	5.78	7.10
300	1.48	1.79	2.22	3.26	4.55	5.84	7.13
400	2.13	2.37	2.72	3.63	4.85	6.07	7.29
600	3.67	3.84	4.10	4.82	5.88	6.93	7.99
800	5.46	5.60	5.81	6.40	7.32	8.23	9.15
1000	7.24	7.36	7.54	8.05	8.86	9.67	10.48
1200	8.67	8.78	8.95	9.42	10.17	10.93	11.69
1500	10.82	10.92	11.06	11.47	12.15	12.82	13.50

A national average percentage of weather observations with ceilings or visibilities less than selected values. Example: 1.79 percent of the time, the ceiling is less than 300 feet, or the visibility is less than 3/4 mile, or both.

NAWD. The ASF itself uses linear interpolation of NAWD in order to fill gaps in the reported data. The ASF reports eight different combinations of ceiling and visibility minimums, but the data source used in generating the ASF weather data contains only six combinations. Linear interpolation, based on the NAWD, was used to expand the data to eight combinations. In appendix D of the ASF report, there is an explanation of the method of linear interpolation used. In appendix E of the ASF, there are numerous graphs depicting the linear nature of the probability data when either the ceiling or the visibility limit is held constant. The method of interpolation suggested in appendix D of the ASF was not adopted for this report. It was considered to be less accurate than the method described herein, since it relied upon joint probabilities.

Figures C-1 and C-2 illustrate the piecewise linear nature of the national average weather data. Figure C-1 illustrates the piecewise linear nature of the data when the ceiling is fixed. Note that the probability is a piecewise linear function of the visibility for all ceiling values. Figure C-2 illustrates the piecewise linear nature of the data when the visibility is fixed. Note that the probability is a piecewise linear function of the ceiling for all visibility values. Several site specific plots of independent ceiling and visibility probabilities were also developed. In all cases, the plots were found to exhibit the same piecewise linear behavior as the NAWD model.

In order to derive the unconditional probabilities for the ceiling and visibility limits being exceeded, the data was linearly extrapolated to zero percent probability for both the ceiling and the visibility percentages.

Table C-2 is a reconstruction of the NAWD using the unconditional probabilities derived from the NAWD and the CMSI model (described in the following paragraph) for combining unconditional weather probabilities to produce a joint weather probability. Table C-2 presents: 1) the extrapolated values of the unconditional probabilities of a 0 foot ceiling and 0 nm visibility, and 2) the computed values for the same weather data as given for the national average weather data in table C-1.

TABLE C-2 PLOT OF CALCULATED AVERAGE WEATHER DATA

K = 0.813

Ceiling	Visibility (miles)							
(feet)	0	1/2	3/4	1	1-1/2	2	2-1/2	3
0		0.93	1.39	1.92	3.08	4.41	5.75	7.08
200	0.66	1.16	1.58	2.09	3.23	4.55	5.88	7.21
300	1.18	1.52	1.85	2.30	3.39	4.69	6.01	7.33
400	1.86	2.13	2.36	2.71	3.67	4.92	6.21	7.52
600	3.43	3.65	3.80	4.02	4.67	5.67	6.83	8.06
800	5.23	5.43	5.56	5.72	6.20	6.94	7.87	8.94
1000	7.01	7.20	7.32	7.46	7.86	8.44	9.19	10.09
1200	8.45	8.64	8.74	8.88	9.24	9.75	10.40	11.18
1500	10.60	10.79	10.89	11.02	11.34	11.79	12.33	12.98

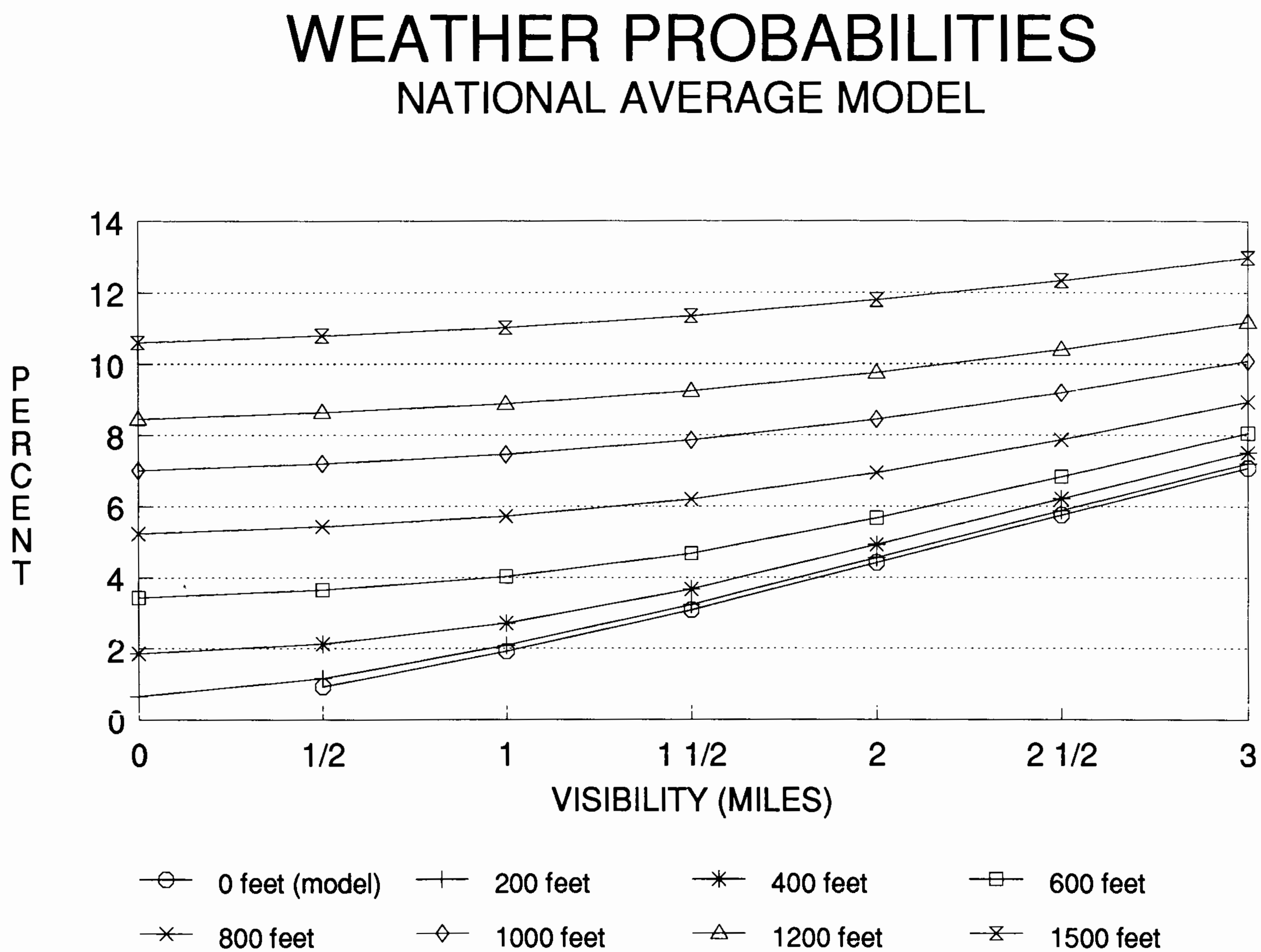

FIGURE C-1 CEILING PROBABILITIES AS A FUNCTION OF VISIBILITY

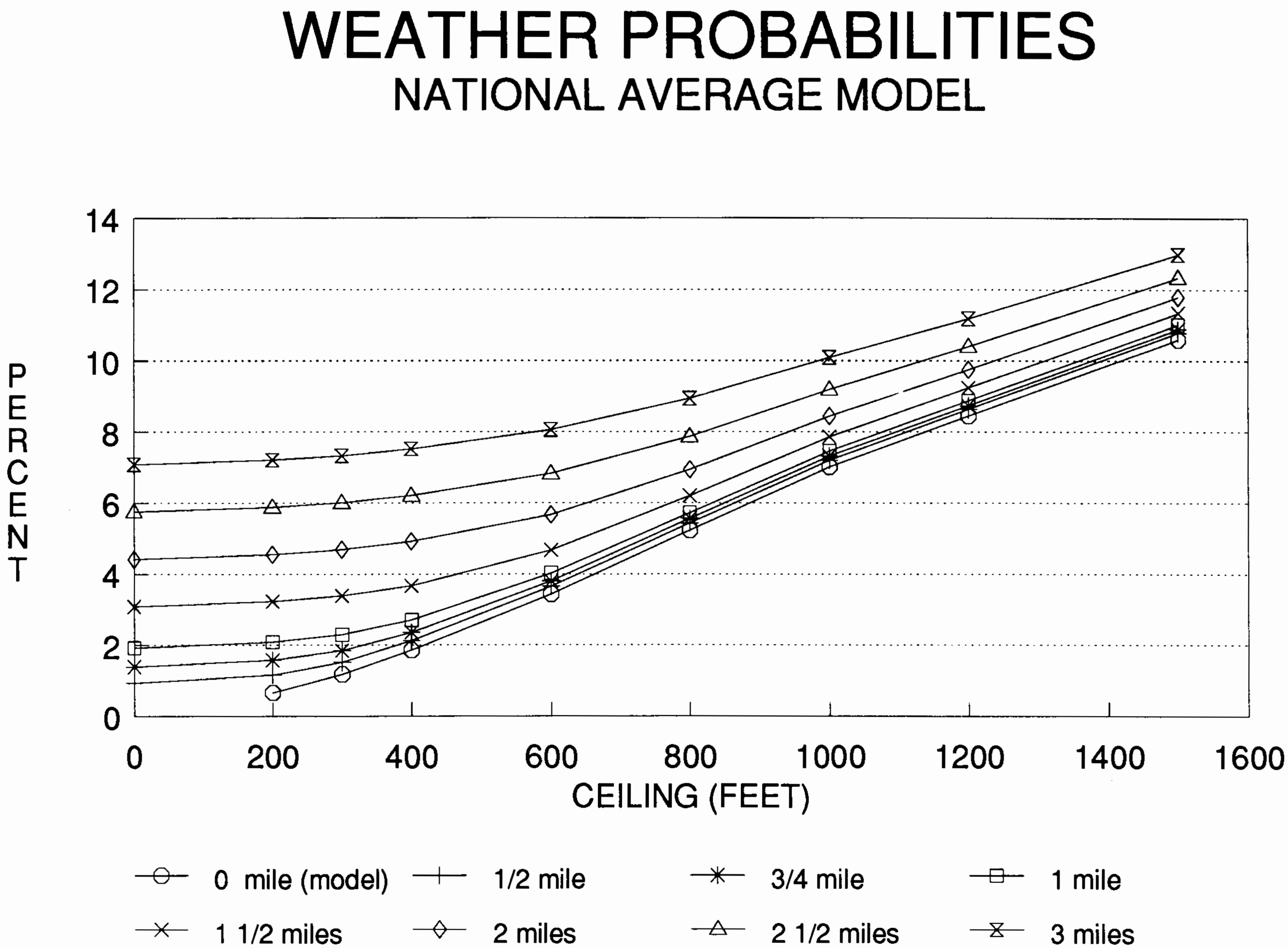

FIGURE C-2 VISIBILITY PROBABILITIES AS A FUNCTION OF CEILING

The computed values are based upon using the independent probabilities from the linear extrapolation in the following Climatic Mission Success Indicators (CMSI) equation:

$$P_{cv} = \frac{(P_c + P_v)}{2} + \frac{(P_c + P_v)^2}{4} - K * P_c * P_v$$

Where P_{cv} is the joint probability of a ceiling/visibility combination
P_c is the unconditional probability of the ceiling limit being exceeded
P_v is the unconditional probability of the visibility limit being exceeded
K is a correlation factor used to represent the dependency of ceiling and visibility probabilities

The CMSI equation can be found in "Climatic Models That Will Provide Timely Mission Success Indicators For Planning and Supporting Weather Sensitive Operations," contract number AFGL-TR-78-0308, page 3, equation 4, where its use is thoroughly explained. Basically, the procedure is to enter the unconditional probability of ceilings, the unconditional probability of visibilities and a K-value into the CMSI equation.

Table C-2 was developed as a check of both the CMSI equation and of the validity of linear extrapolation of the data in the NAWD to produce the unconditional probabilities. First, the average K-value of the NAWD data in table C-1 was computed by using the CMSI equation with the extrapolated 0 foot ceiling and 0 mile visibility values and solving for K instead of for P_{cv}. A K-value of 0.813 was found to be the average for the NAWD. Next, using a K-value of 0.813, the values in table C-2 were calculated. Note that in half the cases the difference is less than 0.1 percent and the difference is never greater than 0.6 percent. In addition, the error is never more than 5 percent of the NAWD value. Thus, it appeared valid to use the extrapolated, unconditional values for ceiling and visibility along with the CMSI equation. This model of the NAWD, called the unconditional NAWD model, was then used to compute location specific weather probabilities.

WEATHER DATA ANALYSIS METHODOLOGY

The unconditional NAWD model was used to calculate the percentage of time that a specific EMS/H operator cannot fly due to the various combinations of weather minimums considered in the main body of this report. Several steps were required before application of the model. First, a computer program was written to compare all of the joint probabilities in the ASF with the joint probabilities computed with the unconditional NAWD model. The ratio of the NAWD model probability to the ASF probability was computed to produce an SS-factor (site specific factor) and stored in a new data base that contains the same eight combinations of weather data as the ASF. This database is used to convert the unconditional NAWD model data to site specific weather probabilities.

The file of SS-factors was converted into a dBASE IV database and linked to the EMS database according to the county of the EMS operator's base. Then, a dBASE IV program was written and used to calculate the percentage of time that each EMS/H operator cannot operate under the various weather minimums. Before the CMSI equation could be applied in each location, it was necessary to linearly interpolate for the specific ceiling/visibility limits of interest for both the SS-factor of the location and for the ceiling/visibility limits in the unconditional NAWD model . Once the program had performed the interpolations, the CMSI equation was applied, and the joint probability was calculated and stored in the EMS database.

APPENDIX D
TOOLS AND METHODS USED TO PRODUCE COVERAGE MAPS

The coverage areas reported by the EMS/H operators were transferred to two 1:2,500,000 scale United States geologic survey maps, one composite map to depict local operating areas and one composite map to depict cross country operating areas. The borders of each operator's area were outlined in ink and covered with a 20 percent shading film. A photographer was commissioned to make half-tone images of the contiguous United States, each FAA region, and each state.

The area covered in each state was measured using a Tamaya Digital Planimeter, model Planix 7. A planimeter is an electronic instrument which computes the areas of irregular shapes using precision rollers in a hand-held cursor. As the cursor is moved across the outline, the two perpendicular rollers record the movement and calculate the enclosed area. For each state, measurements were taken for single, multiple, and total coverage for both the local and the cross country operating areas.

*U.S. GOVERNMENT PRINTING OFFICE: 1991--522-711/40183