REPORT FOR CONSULTATION ON THE PORTLAND INTERSTATE AIR QUALITY CONTROL REGION (OREGON-WASHINGTON)

NAPCA

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service

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PORTLAND INTERSTATE

AIR QUALITY CONTROL REGION

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Public Health Service
Consumer Protection and Environmental Health Service
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PREFACE

The Air Quality Act of 1967 directs the Secretary of Health, Education, and Welfare to designate "air quality control regions" to provide a basis for the adoption of regional air quality standards and the implementation of those standards.

The Act stipulates that the designation of a region shall be preceded by consultation with appropriate State and local authorities. This report is intended to serve as background material for the consultation. It proposes boundaries for the Portland Interstate Air Quality Control Region and discusses the factors which are the basis of the boundary proposal.

The Region* boundaries proposed in this report reflect consideration of available and pertinent information. However, the proposed boundaries remain subject to revisions suggested during consultation with State and local authorities. Formal designation of a Region will be made only after a careful review of all opinions and suggestions submitted during the consultation process.

The National Air Pollution Control Administration (NAPCA) appreciates assistance received from the State and regional air pollution control programs of Oregon and Washington, and the county and regional planning agencies in the Study Area.

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*For the purpose of this report, the word "region" when capitalized, will refer to the Portland Interstate Air Quality Control Region.

INTRODUCTION

THE REGIONAL APPROACH

Air pollution in the urban areas of the United States is a regional problem which frequently extends across State and local governmental boundaries. Since air pollution problems are rarely confined to any single municipality or county, successful control requires coordinated planning, standard setting, and enforcement by the several political jurisdictions which share a common problem. At the present, State and local governments across the Nation have only begun to develop a regional approach to air pollution control.

The Clean Air Act as amended provides a regional approach which depends upon coordination and cooperation between all levels of government: municipal, county, State and Federal. To set in motion the machinery for regional air pollution control, the Department of Health, Education, and Welfare first designates air quality control regions, issues air quality criteria, and publishes reports on control techniques. The region designation indicates which State and local jurisdictions will be involved in a regional air pollution control effort. The air quality criteria indicate the extent to which various concentrations of an air pollutant are harmful to health and damaging to property. The reports on control techniques provide information on the costs and effectiveness of various techniques for controlling air pollutant emissions.

After the Department of Health, Education, and Welfare completes these initial steps, State governments develop air quality standards and plans for implementation of those standards for portions of air quality control regions within their boundaries. An air quality standard defines the desired limit on the concentration of a pollutant in the ambient air of the region. It constitutes the degree of air quality which the regional control program will attempt to achieve. An implementation plan is a blueprint of the steps which will be taken to insure achievement of the air quality standards within a reasonable time. The Governors have 90 days to submit letters indicating that they intend to set standards, 180 days in addition to set the standards, and 180 days further to develop plans for implementing them. The procedure for setting standards includes a public hearing which allows residents of a region to express their views concerning desired standards.

The Department of Health, Education, and Welfare reviews air quality standards and implementation plans in order to ascertain their consistency with the provisions of the Clean Air Act as amended.

When air quality standards and implementation plans are approved, States proceed to prevent and control air pollution in accordance with those standards and plans. This system for establishing a regional approach to air pollution control is depicted in the flow diagram in Figure 1.

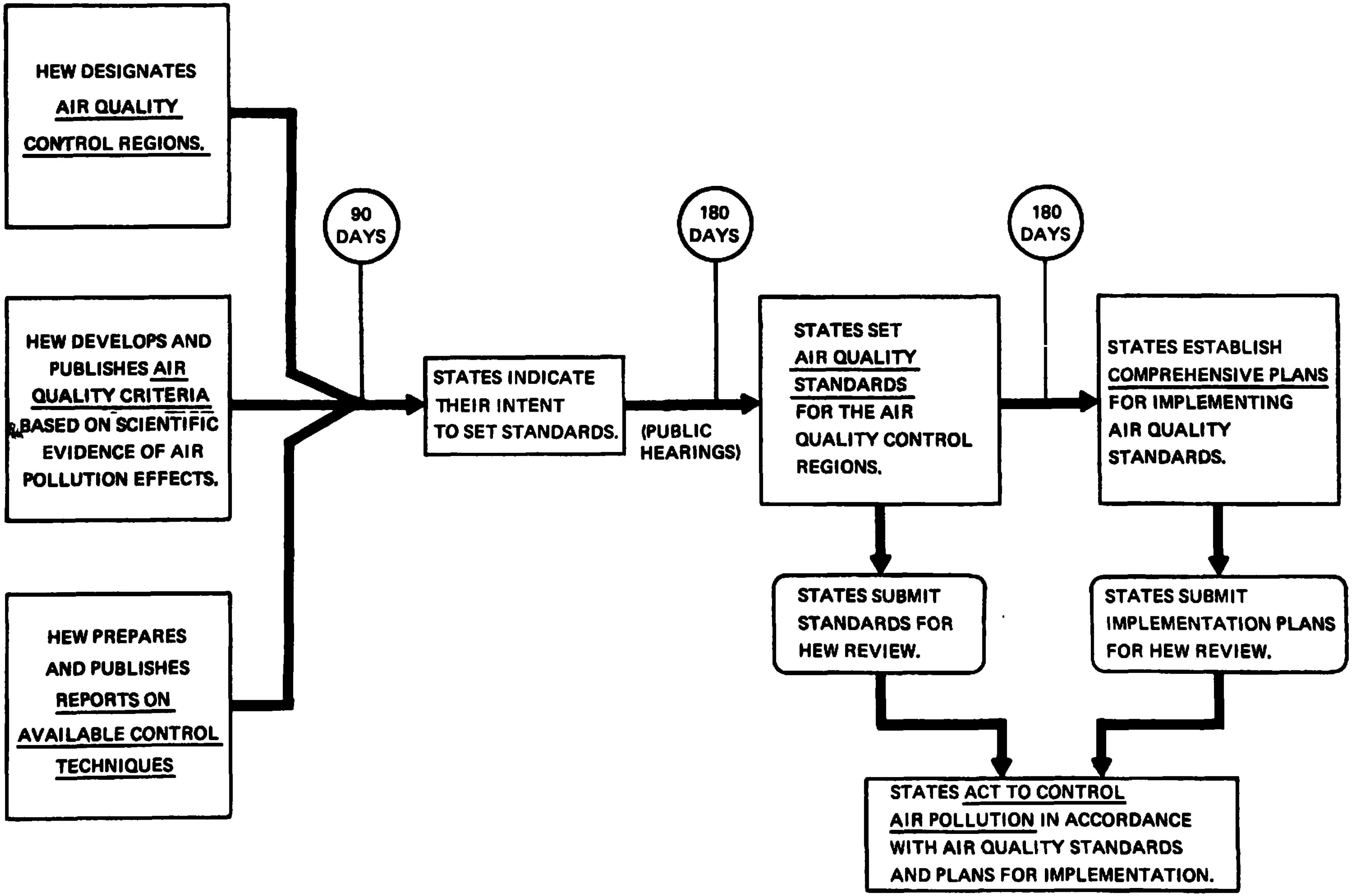

Figure 1 FLOW DIAGRAM FOR ACTION TO CONTROL AIR POLLUTION ON A REGIONAL BASIS, UNDER THE AIR QUALITY ACT.

DESIGNATION OF AIR QUALITY CONTROL REGIONS

Designation of an air quality control region is one of the first steps in the regional approach to air pollution control. Section 107(a)(2) of the Clean Air Act as amended directs the Secretary, Department of Health, Education, and Welfare to make such designations. The portions of the section relevant to this discussion state:

> "...The Secretary, after consultation with appropriate State and local authorities shall... designate air quality control regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atomspheric areas necessary to provide adequate implementation of air quality standards. The Secretary may... revise the designation of such regions...The Secretary shall immediately notify the Governors of the affected State or States of such designation."

The Size of a Region

As stipulated in Section 107(a)(2), the designation of air quality control regions should be based on "jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas necessary to provide adequate implementation of air quality standards." This language suggests a number of objectives which are important in determining how large an air quality control region should be. Basically, these objectives can be divided into three separate categories.

First, a region should be self-contained with respect to air pollution sources and receptors. In other words, a region should include most of the important sources in the area as well as most of the people and property affected by those sources. Unfortunately, since air pollutants can travel long distances, it is impractical if not impossible to delineate regions which are completely self-contained. The air over a region will usually have at least trace amounts of pollutants from external sources. During episodic conditions, such contributions from external sources may even reach significant levels. Conversely, air pollution generated within a region and transported out of it can affect external receptors to some degree. It would be impractical and inefficient to make all air quality control regions large enough to encompass these low-level trace effects. The geographic extent of trace effects overestimates the true problem area which should be the focus of air pollution control efforts. Thus, the first objective, that a region be self-contained, becomes a question of relative magnitude and frequency. The dividing line between "important influence" and "trace effect" will be a matter of judgment. The judgment should be based on estimates of the impact a source has upon a region and the level of pollution to which receptors are subjected. In this respect, annual and seasonal data on pollutant emissions and ambient air concentrations are a better measure of relative influence than short term data on episodic conditions. The second general objective requires that region boundaries be designed to meet not only present conditions but also future conditions. In other words, the region should include areas where industrial and residential expansion are likely to create air pollution problems in the foreseeable future. This objective requires careful consideration of existing metropolitan development plans, expected population growth, and projected industrial expansion. Such considerations should result in the designation of regions which will contain the sources and receptors of regional air pollution for a number of years to come. Of course, region boundaries need not be permanently fixed, once designated. Boundaries should be reviewed periodically and altered when changing conditions warrant readjustment.

The third objective is that region boundaries should be compatible with and even foster unified and cooperative governmental administration of the air resource throughout the region. Air pollution is a regional problem which often extends across several municipal, county, and even State boundaries. Clearly, the collaboration of several governmental jurisdictions is prerequisite to the solution of the problem. Therefore, the region should be delineated in a way which encourages regional cooperation among the various governmental bodies involved in air pollution control. In this regard, the existing pattern of governmental cooperation on the whole range of urban problems may become an important consideration. Certainly the pattern of cooperation among existing air pollution control programs is a relevant factor. In general, administrative considerations dictate that governmental jurisdictions should not be divided.

Although it would be impractical to preserve State jurisdictions undivided, usually it is possible to preserve the unity of county governments by including or excluding them in their entirety. Occasionally, even this would be impractical due to a county's large size, wide variation in level of development, or striking topographical features.

To the extent that any two of the above three objectives lead to incompatible conclusions concerning region boundaries, the region must represent a reasonable compromise. A region should represent the best way of satisfying the three objectives simultaneously.

Procedure for Designation of Regions

Figure 2 illustrates the procedures used by the National Air Pollution Control Administration for designating air quality control regions.

After evaluating relevant engineering factors and urban factors, the National Air Pollution Control Administration publishes a proposed delineation of the region boundaries. At the same time NAPCA sets a time and place for a consultation meeting and distributes to State and local authorities a report of the evaluation study which includes the boundary proposal. At the consultation meeting State and local authorities are encouraged to present fully their views and suggestions concerning the proposed boundaries of the region. Interested parties who

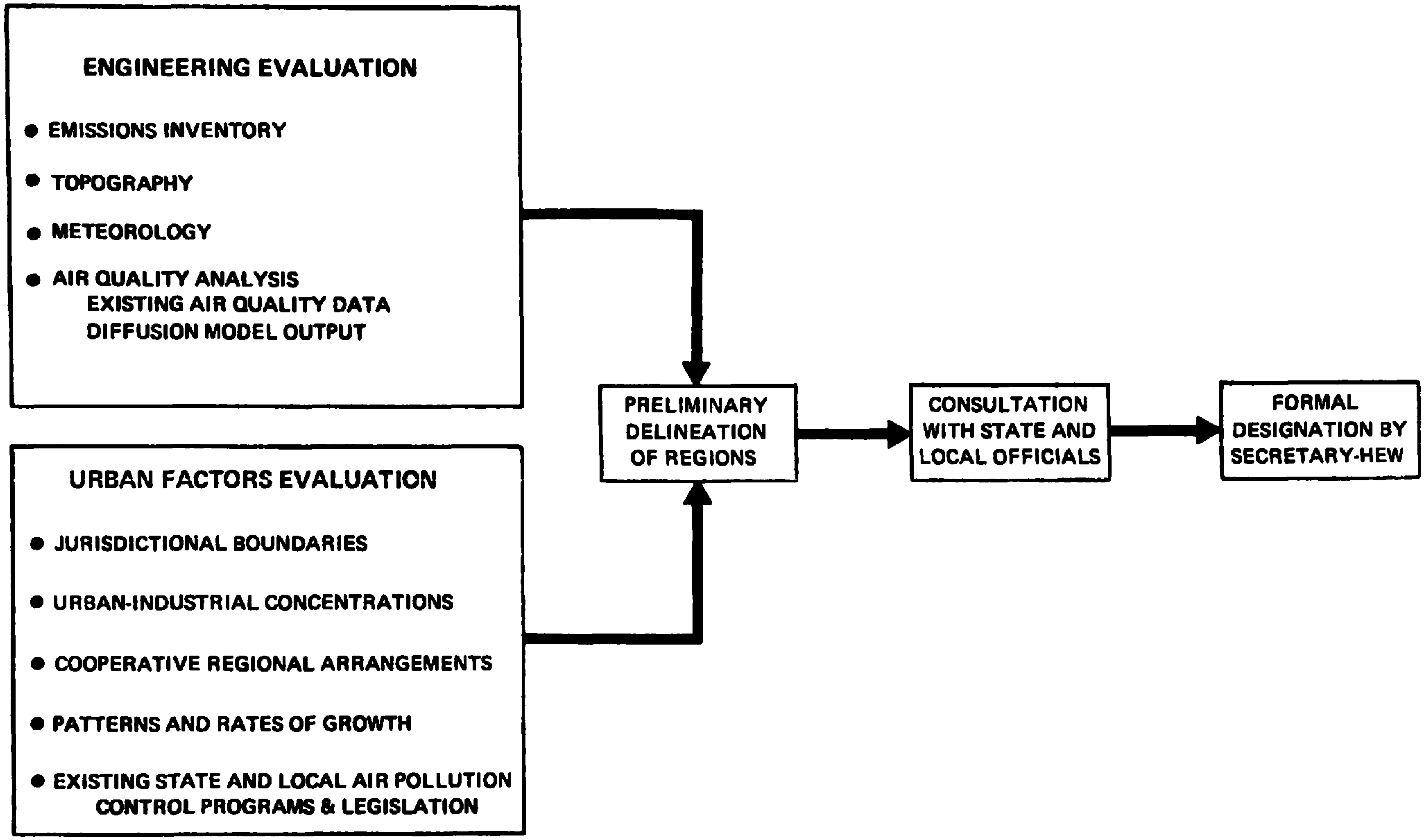

Figure 2. FLOW DIAGRAM FOR THE DESIGNATION OF AIR QUALITY CONTROL REGIONS.

do not have official status may submit comments in written form for the record. After careful review of all suggestions and opinions submitted for the record by interested parties, the Secretary of Health, Education, and Welfare makes a formal designation of the region boundaries and notifies the Governors of the designation.

As noted above, the evaluation of relevant engineering factors and urban factors forms the basis of the boundary proposals published by NAPCA. The evaluation of engineering factors is designed to indicate the location of pollution sources and the geographic extent of serious pollutant concentrations in the ambient air. Pollution sources are located by taking an inventory of emissions from automobiles, industrial activities, space heating, waste disposal, and other pollution generators. The transport and distribution of pollutants in the ambient air are analyzed on the basis of measured air quality data, the location of emissions, meteorological data, and topographic information. A mathematical diffusion model which predicts ambient pollution concentrations from information on emissions and meteorology can be used in areas where irregular topographical features would not invalidate the theoretical model. As a whole, the engineering study indicates how large the air quality control region must be in order to encompass most pollution sources and most people and property affected by those sources.

The study of urban factors encompasses non-engineering considerations. It reviews existing governmental jurisdictions, the location of urban and industrial concentrations, expected patterns of urban growth, cooperative regional arrangements, existing State and local air pollution control programs, and other associated factors. As a whole, the study of urban factors is designed to indicate how large a region must be in order to encompass expected regional growth and to encourage cooperation among political units in controlling air pollution.

The body of this report contains a proposal for the boundaries of the Portland Interstate Air Quality Control Region and outlines the evaluation of engineering and urban factors which were the basis of the proposal. The report is intended to serve as the background document for the consultation with appropriate State and local officials.

EVALUATION OF URBAN FACTORS

INTRODUCTION

A number of urban factors are relevant to defining air quality control region boundaries. Since human activity is the primary cause of air pollution, and humans are the ultimate victims, the location of population is an important consideration. The projected population growth pattern is another important consideration, since an air quality control region should be designed not only for the present but also for the future. Political and jurisdictional considerations are important since the Clean Air Act envisions regional air pollution programs based on cooperative efforts among many political jurisdictions. The following discussion of urban factors will present these considerations as they apply to the Portland area.

REGIONAL SETTING

Portland, Oregon, lies at the confluence of the Columbia and Willamette Rivers in northwest Oregon. Other major cities in the area include Vancouver, Washington, located across the Columbia River from Portland, Kelso-Longview, Washington, lying north of Portland on the Columbia, and Salem and Eugene, Oregon, which lie south of Portland in the Willamette Valley. For the purposes of this study, a fifteen-county "study area" was chosen. The Study Area includes the counties of Columbia, Washington, Multnomah, Yamhill, Clackamas, Polk, Marion, Benton, Linn, and Lane, in Oregon, and Clark, Cowlitz, Wahkiakum, Skamania, and Lewis Counties in Washington. These counties were chosen on the basis of urbanization, regional planning and air pollution control arrangements, topography, and other factors which would indicate a close tie between the Portland metropolitan area and the surrounding counties. The Study Area counties lie in northwest Oregon and southwest Washington, in the valleys formed by the Columbia and Willamette Rivers.

The Portland Standard Metropolitan Statistical Area (SMSA)* consists of Clackamas, Multnomah, and Washington Counties in Oregon, and Clark County, Washington. Marion and Polk Counties comprise the Salem SMSA, and Lane County comprises the Eugene SMSA. Figure 3 outlines the Study Area and the Portland, Salem, and Eugene SMSA's. Also shown is part of the Seattle SMSA, which lies outside the Study Area.

The Puget Sound Air Quality Control Region, consisting of Snohomish, King, Pierce, and Kitsap Counties in Washington, was officially designated by the Secretary of Health, Education, and Welfare, in 1969.

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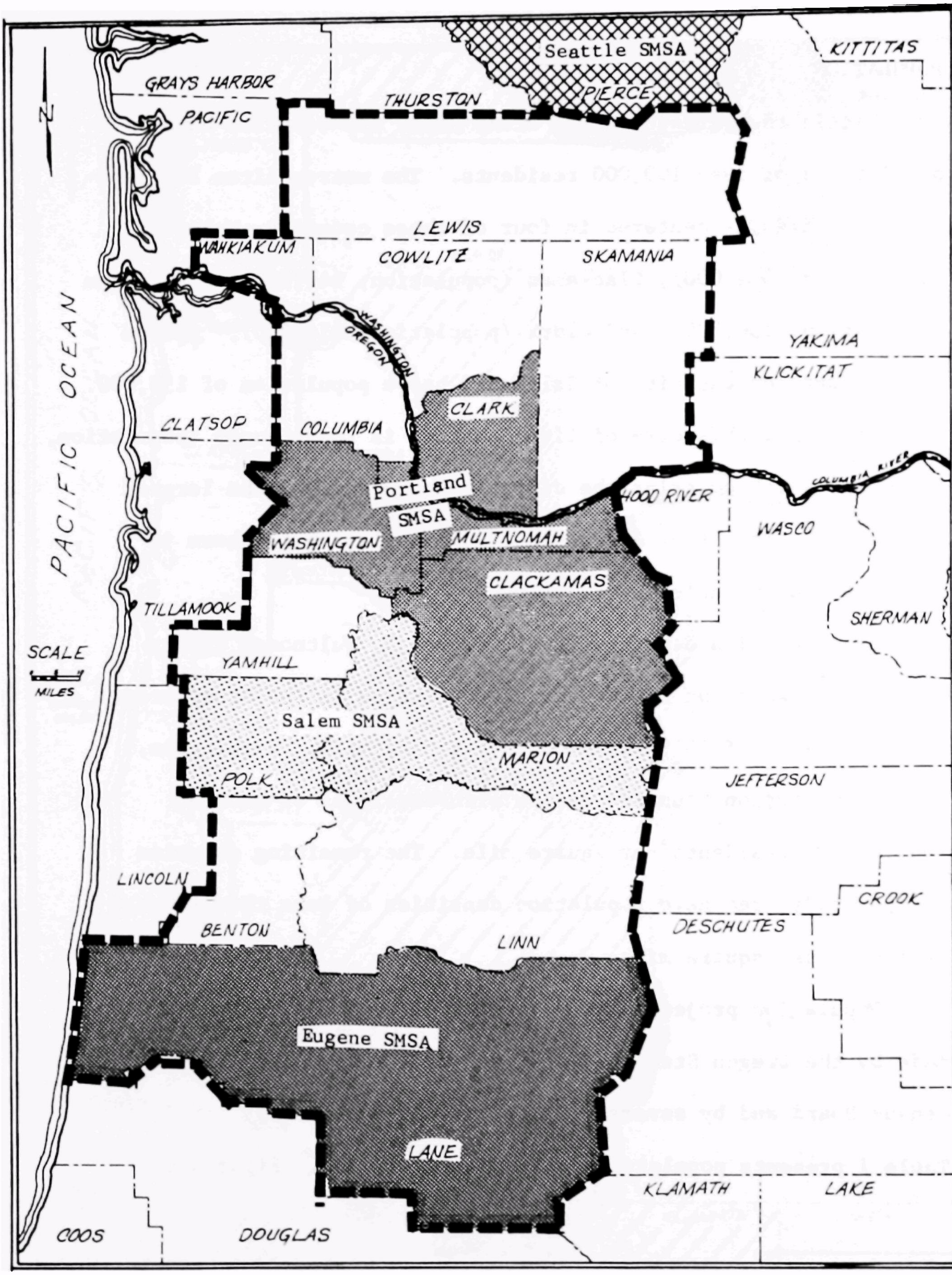
*SMSA's are defined by the Bureau of the Census and other Federal agencies for use in publishing census data and a variety of other government statistics. An SMSA is composed of one county or a group of contiguous counties which contain at least one central city of 50,000 inhabitants or more or twin-cities with a combined population of at least 50,000. In addition, other contiguous counties are included in an SMSA if, according to certain criteria, they are essentially metropolitan in character and are socially and economically integrated with the central city.



Boundary of Study Area

Figure 3. Portland Region Study Area and Standard Metropolitan Statistical Areas.

POPULATION

Within the fifteen-county Study Area, six counties have populations of over 100,000 residents. The metropolitan Portland-Vancouver area is centered in four of these counties--Multnomah (population, 552,000), Clackamas (population, 149,000), Washington (population, 136,000), and Clark (population, 114,000). Marion County contains the city of Salem and has a population of 155,000. Separated from this core of five counties is Lane County (population, 212,000), which contains the city of Eugene and has the largest land area in the Study Area. The 1969 population is shown in Figure 4 and in Table 1.[1]

By population density (1969), Figure 5, Multnomah County is again shown to be the center of population in the Study Area with a density of 1310 residents per square mile. Washington, Clark, and Marion Counties follow with densities of between 100 and 200 residents per square mile. The remaining counties in the Study Area have population densities of less than 100 residents per square mile.

Population projections by county in the Study Area have been made by the Oregon State Board of Census and the Washington State Census Board and by several regional planning agencies.[2,3,4,5,6,7] Table 1 presents population projections for 1980.* Figures 6

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*Where more than one projection was available, the projected 1980 population which most nearly conformed to an extrapolation of the growth from 1960-1969 was chosen. In the case of three counties (Benton, Linn, and Yamhill), only one set of projections was available, and based on the growth from 1960-1969, the projections were clearly in error. In these cases, it was assumed that growth from 1960-1980 would continue at the same rate as from 1960-1969.

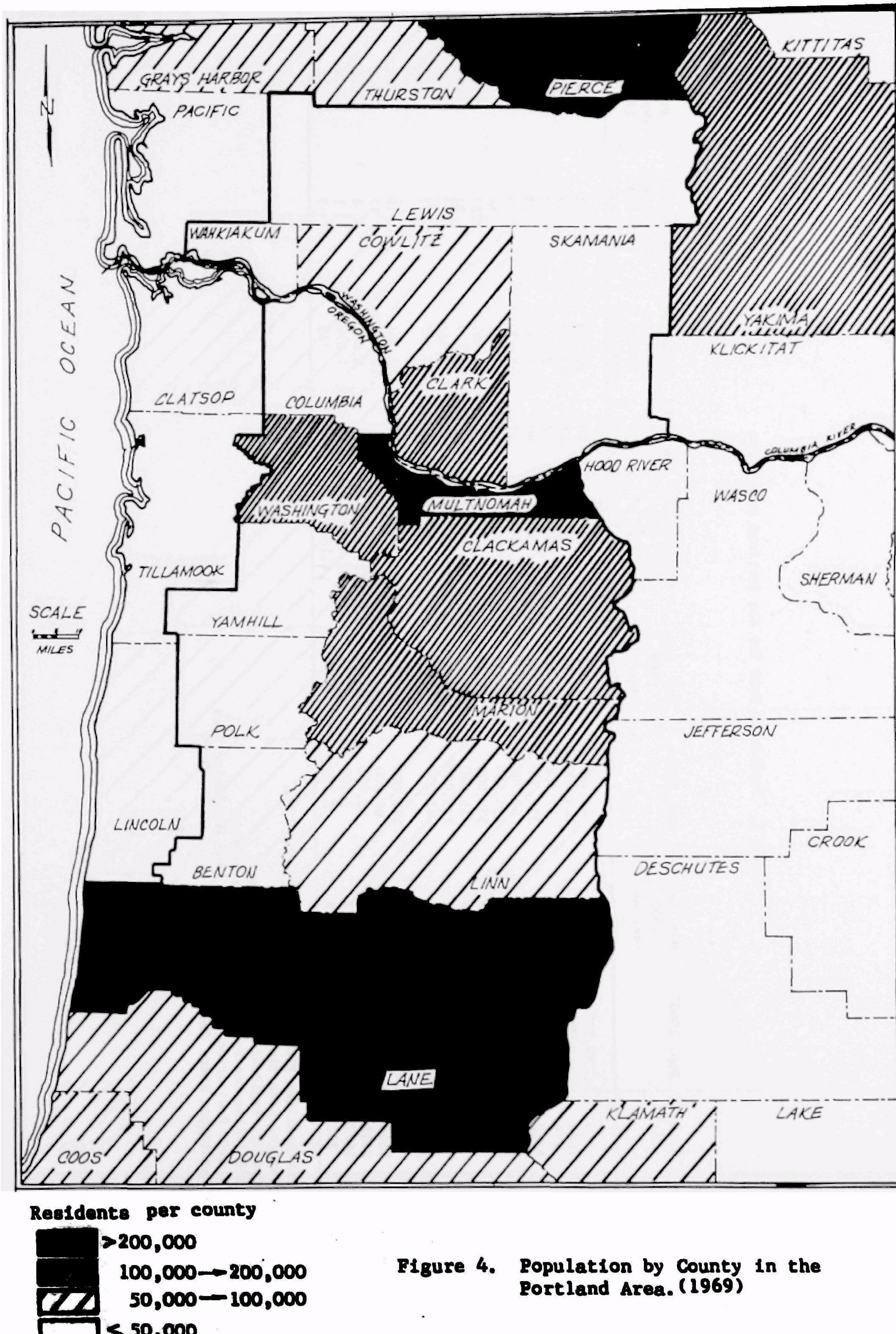
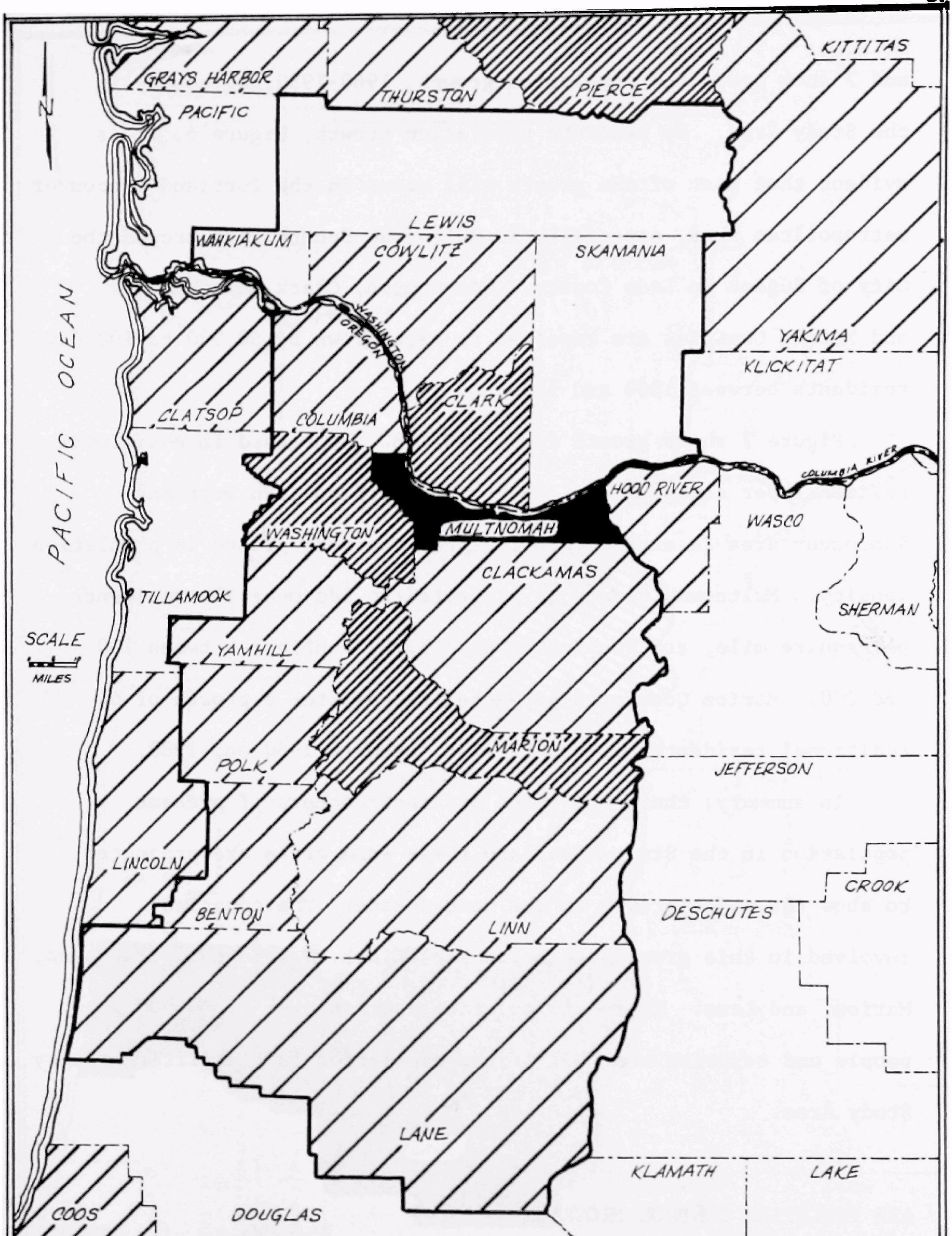


Figure 4. Population by County in the Portland Area. (1969)

Table I. Population Data for the Portland Study Area

State	County	Area mi.[2]	Pop. 1960[1]	Pop. Den. 1960 res./mi.[2]	Pop. 1969[1]	Pop. Den. 1969 res./mi.[2]	Proj. Pop., 1980[2,3,4,5,6,7]	Projected Pop. Den. 1980 res./mi.[2]	Projected Abs. Pop. Growth 1960-1980	Projected Pop. Growth 1960-1980 Add. res./mi.[2]	Projected Pop. Growth 1960-1980 %
Oregon	Benton	668	39,165	59	48,600	73	60,000[e]	90	20,835	31	53%
	Clackamas	1884	113,038	60	149,000	79	202,100[a]	107	89,062	47	78%
	Columbia	639	22,379	35	27,000	42	32,200[a]	50	9,821	15	43%
	Lane	4562	162,890	35	212,000	46	274,337[b]	60	111,447	25	71%
	Linn	2290	58,867	26	68,700	30	80,900[e]	35	22,033	9	35%
	Marion	1166	120,888	104	155,000	133	196,000[d]	168	75,112	64	62%
	Multnomah	422	522,813	1235	552,000	1310	640,400[a]	1522	118,587	287	23%
	Polk	736	26,523	36	35,000	48	49,000[d]	67	22,477	31	86%
	Washington	716	92,237	129	136,000	190	179,600[a]	251	87,363	122	95%
	Yamhill	711	32,478	46	41,200	58	52,000[e]	73	19,522	27	59%
Washington	Clark	627	93,809	149	114,000	182	166,000[a]	265	72,191	116	78%
	Cowlitz	1144	57,801	50	64,000	56	76,908[c]	67	19,107	17	34%
	Lewis	2449	41,858	17	43,000	18	50,669[f]	21	8,811	4	24%
	Skamania	1672	5,207	3	5,900	4	7,097[f]	4	1,890	1	36%
	Wahkiakum	261	3,426	13	3,200	12	4,141[f]	16	715	3	23%

[a] Metropolitan Planning Commission
[b] Central Lane Planning Council
[c] Cowlitz Regional Planning Commission
[d] Mid-Willamette Valley Council of Governments
[e] Linear Projection Based on 1960 and 1969 Population Data
[f] Washington State Census Board



Residents per mi.²

- >1000
- 100 → 1000
- 20 → 100
- < 20

Figure 5. Population Density by County, 1969.

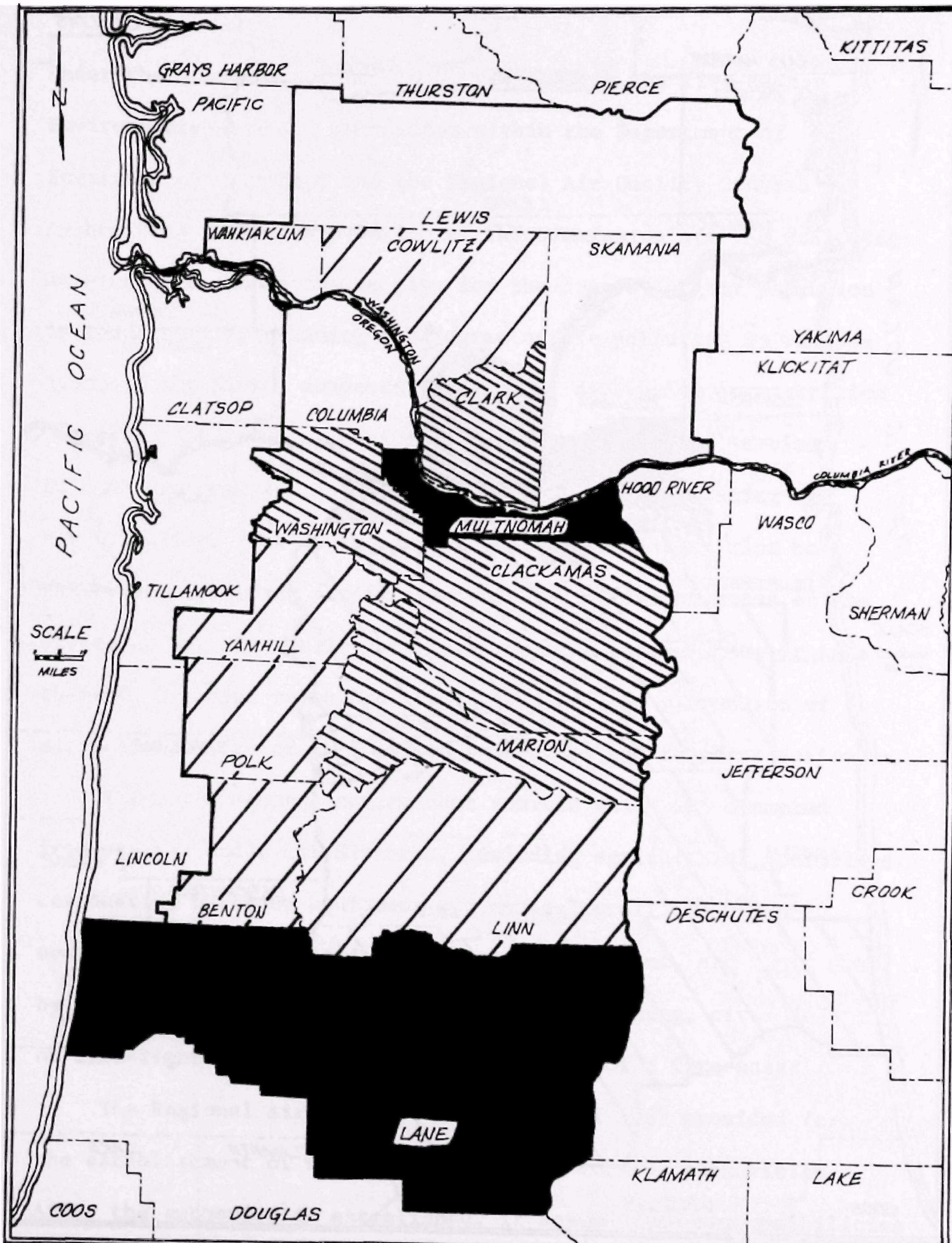
and 7 show projected population growth, 1960-1980, by county in the Study Area. By absolute population growth, Figure 6, it is evident that most of the growth will occur in the Portland-Vancouver metropolitan area, especially in Multnomah County, and around the City of Eugene in Lane County. Washington, Clark, Clackamas, and Marion Counties are expected to have grown by 50,000 to 100,000 residents between 1960 and 1980.

Figure 7 shows growth from 1960-1980, expressed in additional residents per square mile. Again, the metropolitan Portland-Vancouver area is expected to register the most growth in population density. Multnomah County is projected to add over 200 residents per square mile, and Washington and Clark Counties, between 100 and 200. Marion County is projected to register a growth of 64 additional residents per square mile, between 1960 and 1980.

In summary, there are three distinct centers of present population in the Study Area, and these same areas are projected to show the major growth in the next decade. The counties involved in this growth are Multnomah, Clark, Washington, Clackamas, Marion, and Lane. These six counties contain over 1,300,000 people and comprise over 80% of the population in the fifteen-county Study Area.

AIR POLLUTION CONTROL PROGRAMS

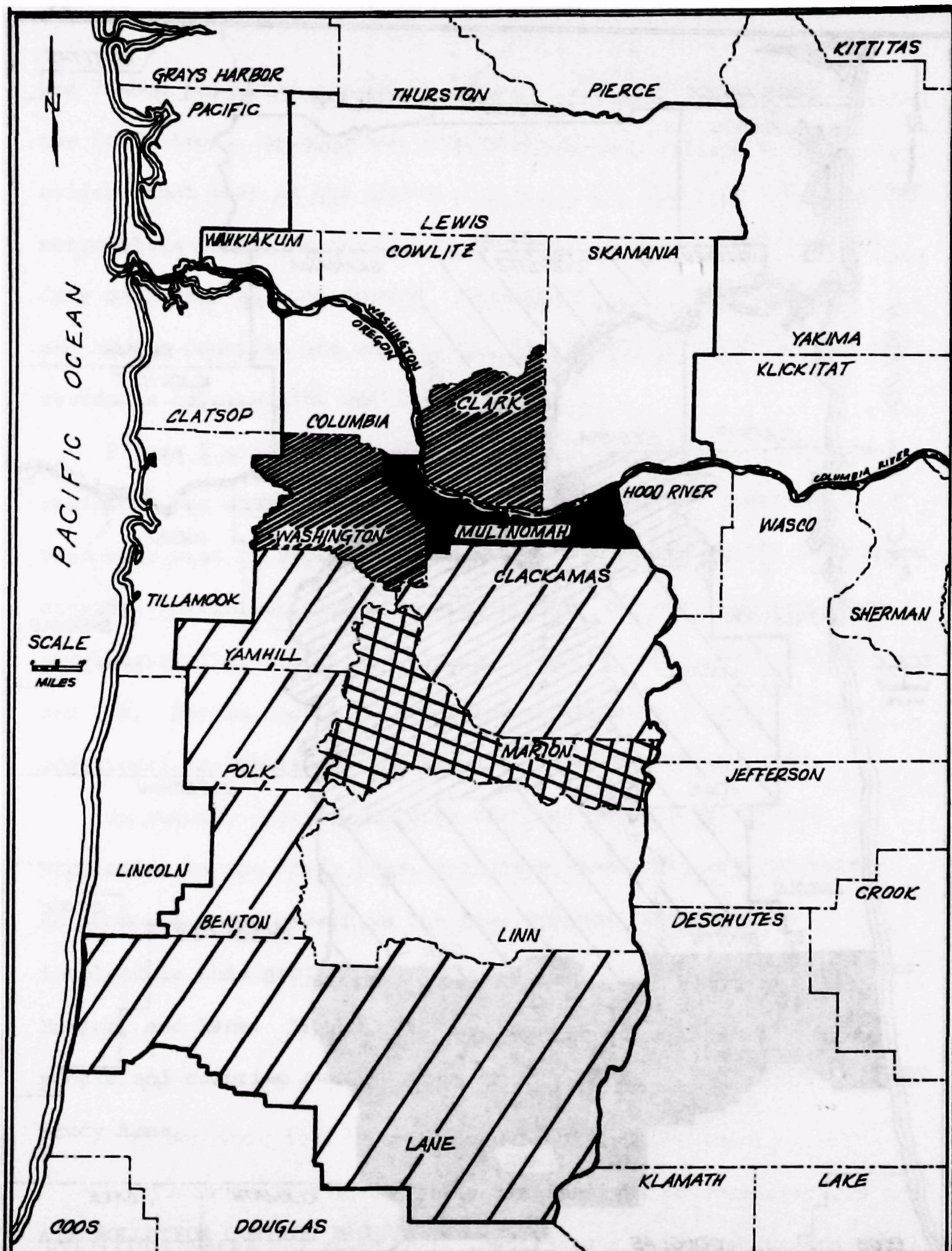
The Oregon Revised Statutes, Chapter 449, provides the legal authority for air pollution control in the State of Oregon.



Additional Residents per County, 1960-1980

- >100,000
- 50,000--100,000
- 10,000---50,000

Figure 6. Projected Population Growth, 1960-1980, of the Study Area Counties. (See References 1 through 7)



Additional Residents per mile

>200

100---200

50---100

25---50

Figure 7. Projected Population Density Growth of the Study Area Counties, 1960-1980

Under the Statutes, authority is vested with the five-member Environmental Quality Commission within the Department of Environmental Quality, and the Regional Air Quality Control Authorities. Among the duties of the Commission are the following: developing a comprehensive plan for the control of air pollution in the State, determining the degree of air pollution in various areas of the State, conducting research, developing demonstration programs with local communities, providing technical services to local communities, and enforcing the Statutes relating to air pollution. The Environmental Quality Commission also has the power to set air purity standards for different areas of the State, to set air quality standards for the entire State or areas thereof, to adopt rules and regulations for the prevention of air pollution, to adopt emission standards, and to grant variances.

There are several contaminant sources which are exempted from control under the Statutes, including agricultural operations, residential barbecue equipment and agricultural land-cleaning operations, certain residential heating equipment, and fires set by public officers in connection with weed-burning, civil defense or fire-fighting instruction, or prevention of a fire hazard.

The Regional Air Quality Control Act of 1967 provided for the establishment of regional air quality control authorities. After the authority is established, it assumes the responsibilities of the Sanitary Authority functions relating to powers and duties, rules and regulations, and enforcement. The regional authority has exclusive control within its jurisdiction except for the sources whose control is retained by the State. These include chemical pulp and paper industry, nuclear power generation, motor vehicles, aluminum reduction and agricultural field-burning. No regional authority may adopt a rule or standard which is less stringent than a rule or standard of the Environmental Quality Commission.

Three such regional authorities have been established under the Act. The Columbia-Willamette Air Pollution Authority, established in January, 1968, covers the counties of Clackamas, Columbia, Washington, and Multnomah Counties. The Mid-Willamette Valley Air Pollution Control Authority was formed in October, 1967, by joint agreement of the governing bodies of Marion, Polk, Yamhill, Linn, and Benton Counties. The Lane Regional Air Pollution Authority has control authority throughout Lane County. Figure 8 shows the boundaries of the regional jurisdictions, including the Southwest Air Pollution Control Authority in Washington.

The Washington Clean Air Act of 1967 established, within the State Department of Health, an Air Pollution Control Board which is composed of nine members appointed by the Governor. Among the duties assigned to the Board by the 1967 Act were the responsibilities to adopt and enforce air quality goals and emission regulations, to monitor air quality, and to give technical assistance to local programs within the State. Amendments to the law enacted during 1969 expanded and further defined the duties

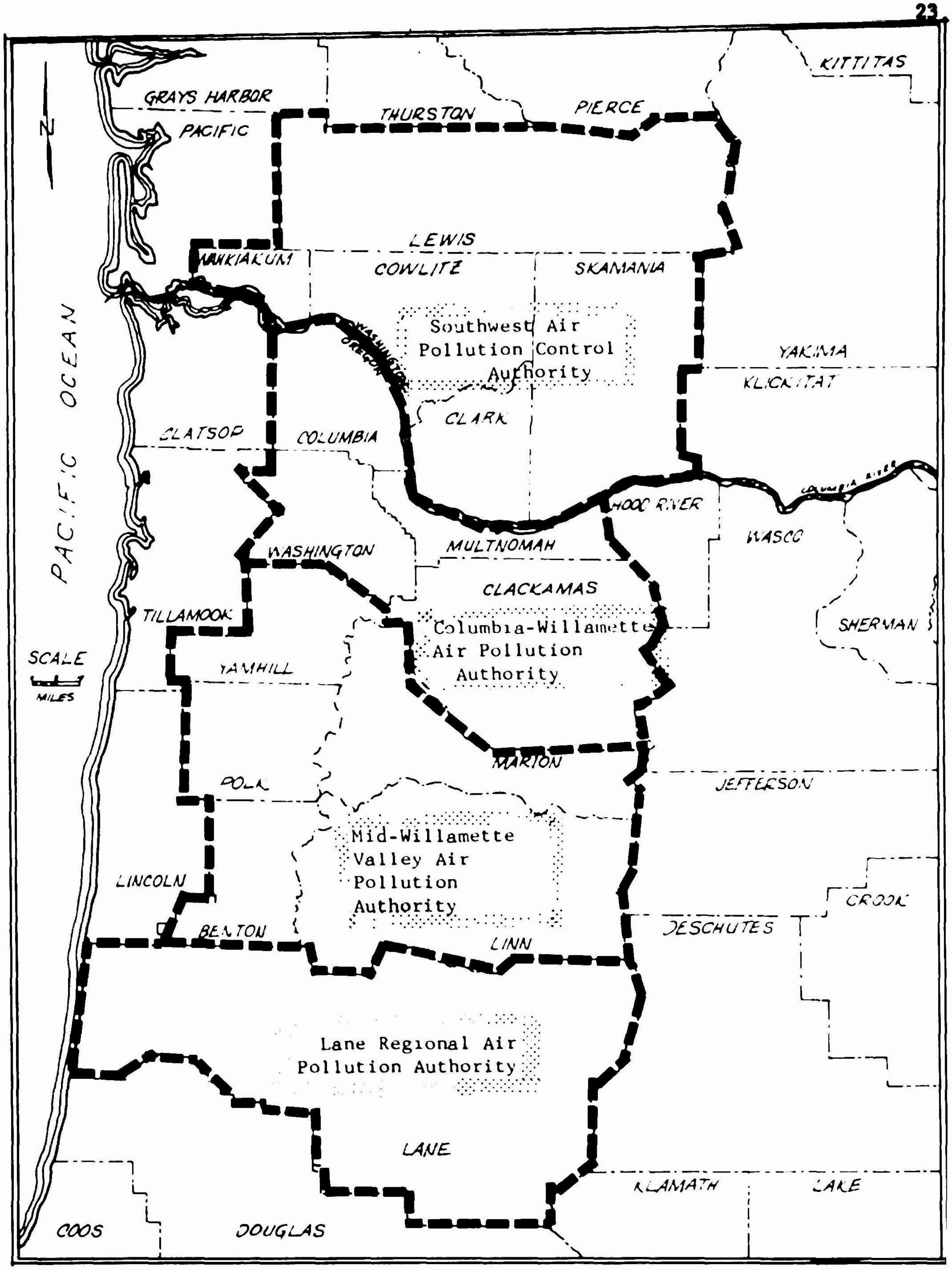


Figure 8. Air Pollution Control Authorities.

of the Board. It was given the authority to adopt air quality objectives (levels of contaminants in the air below which undesirable effects will not occur), air quality standards (levels of air pollution which shall not be exceeded), and emission standards (limitations on the release of contaminants into the ambient air). The State Board was assigned responsibility for enforcement of its standards except in areas where local programs are enforcing standards which are at least as stringent as those of the State. However, the State was directed to exercise statewide control over emissions from certain categories of pollution sources if such control was determined to be in the public interest and for the protection of the welfare of the citizens.

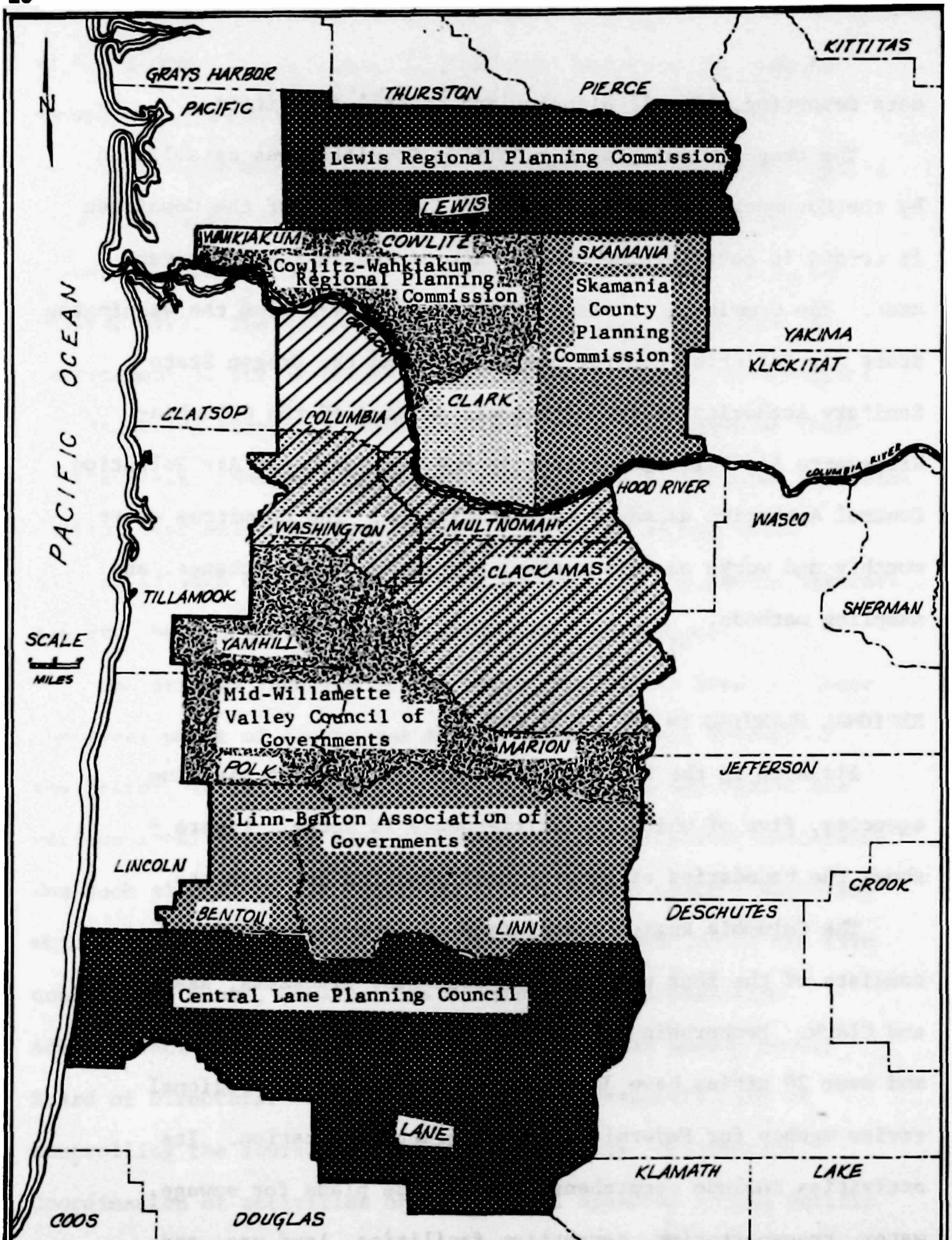
One primary function of the State program has been to foster the development of county and multi-county programs throughout the State. To serve this end, the State program may assist the various local programs with financial aid and technical assistance. One such program is the Southwest Air Pollution Control Authority which was formed in April, 1968, and has jurisdiction in the five counties of Clark, Cowlitz, Lewis, Skamania, and Wahkiakum. Administration of the Authority is handled by an eleven member Board of Directors. The Authority has the responsibility of controlling the sources within its five-county jurisdiction. Coordination of activities of the control agencies in the Pacific Northwest is achieved through the Washington State Control Officers Association. The objective is to coordinate air monitoring, data reporting, overall planning and control activities.

The Oregon-Washington Air Quality Committee was established by the Governors of the two States. The purpose of the Committee is to aid in coordinating control activities in the interstate area. The Committee consists of representatives from the Washington State Air Pollution Control Board staff and the Oregon State Sanitary Authority staff, with staff members of the Columbia-Willamette Air Pollution Authority and the Southwest Air Pollution Control Authority as advisory participants. The Committee meets monthly and works on inventories, standards, data exchange, and sampling methods.

REGIONAL PLANNING IN THE STUDY AREA

Planning in the Study Area is handled by eight planning agencies, five of which are multi-county in scope. Figure 9 shows the boundaries of the regional planning arrangements.

The Columbia Region Association of Governments, CRAG, consists of the four counties of Multnomah, Clackamas, Washington, and Clark. Membership is open to all cities within these counties, and over 20 cities have joined. CRAG serves as the regional review agency for Federal financial grant application. Its activities include comprehensive area-wide plans for sewage, water, transportation, recreation facilities, land-use, and other services.



Portland Metropolitan Study Commission (MSC)

Columbia Region Association of Governments (CRAG)

Counties in Both MSC and CRAG

Figure 9. Regional Planning Agencies in the Portland Study Area.

The Portland Metropolitan Study Commission was created by the Oregon State Legislature in 1963 and serves the counties of Clackamas, Columbia, Multnomah, and Washington. Its main functions have been the following: "to determine the boundaries within which it is desirable that one or more metropolitan services be provided" and to prepare a "comprehensive plan for the furnishing of such metropolitan services as it deems desirable in the metropolitan area". (ORS 199.230) Originally it was planned that the Commission would expire in June, 1969, but the life of the Commission has been extended to June, 1971.

The Mid-Willamette Valley Council of Governments covers Marion, Polk, and Yamhill Counties. Besides the counties, the membership also includes the State of Oregon, six cities, a school district, and a fire district. The Council was formed in 1967 by the merger of the Mid-Valley Planning Council and the Inter-governmental Cooperation Council. Areas of interest and activities include land-zoning, transportation, urban renewal, comprehensive plans for sewer and water facilities, and population studies.

The Linn-Benton Association of Governments (LBAG) has representatives from Linn and Benton Counties and from four cities in these counties. The LBAG was organized in June, 1967, and is now the official review agency for Federal funds in the two-county region. The Corvallis-Benton County Planning Agency and the Linn County Planning Agency have contributed staff to LBAG, which has just recently taken on its first full-time staff member. Among its activities are comprehensive health and law enforcement planning. There is a possibility that Lincoln County will join LBAG in the next few months.

The Central Lane Planning Council was originally established in 1945 as the Central Lane County Planning Commission. The Commission was changed to the Council in 1961, and in 1964, it required that voting members be elected officials. The Council has initiated or supported land-use, transportation, and long range development plans for the urbanized portions of Lane County. It has also worked in such areas as employment forecasts, zoning, park development, and urban renewal.

In October, 1968, Wahkiakum County joined the previously established Cowlitz Regional Planning Commission to form the Cowlitz-Wahkiakum Regional Planning Commission. The Commission is now the planning agency for all cities, towns, and counties in the Cowlitz-Wahkiakum Region. The Commission has conducted studies of population, urban area economics, land-use, subdivision and zoning, and building codes. Other areas of concern are urban area sewer and water supply, location of future schools, housing, transportation, industrial land sites, and solid-waste disposal.

Lewis County has two commissions--the Lewis County Planning Commission and the Lewis Regional Planning Commission. The County Commission was formed in 1962 and is composed of nine members, three each from each commission district. The prime function of the County Commission is to review subdivision plats and to hold work sessions on codes and ordinances for the County. The Regional Commission was formed in 1965 and has representatives from the County and, at present, six cities. The Commission's main purpose is to coordinate and approve planning in the Region.

The Skamania County Planning Commission was formed in 1967. To date, it has no full-time staff. The Commission deals with platting regulations and is presently working on a comprehensive land-use plan for the county.

EVALUATION OF ENGINEERING FACTORS

INTRODUCTION

The engineering evaluation for the Portland Study Area was based on a study of topography, meteorology, air pollutant emissions, pollutant diffusion, and air quality. The emission inventory indicated the location of point and area sources and quantity of pollutants emitted from these sources. Emission densities were calculated from the emission quantities and grid zone areas. A qualitative evaluation of air quality was made based on air flow and thermal stability.

EMISSIONS INVENTORY

The National Air Pollution Control Administration conducted an inventory of air pollutant emissions for the Portland Study Area.[8] Five pollutants were inventoried--total particulates, sulfur oxides, carbon monoxide, nitrogen oxides, and hydrocarbons. Only three of these--total particulates, SO_x, and CO--are considered in this report, since these pollutants provide an indication of the general air pollution problem. Particulate emission levels indicate primarily the location and extent of pollution emanating from industrial, power, incineration, and heating sources. Levels of sulfur oxides illustrate the impact of fuel burning activities at stationary sources. Levels of carbon monoxide show the impact of gasoline-powered motor vehicles on the regional air pollution pattern. A summary of the emissions inventory by jurisdiction and source category is given in Table II.

Figure 10 breaks down the total emissions into percent contribution by the various source categories. Process losses contribute 48% of all sulfur oxide emissions. Most of these emissions come from the kraft pulping, aluminum, and wood products industries. Fuel combustion accounts for 39%, transportation for 11%, and refuse disposal for 2% of sulfur oxide emissions. Process losses also contribute most of the particulate emissions (65%). Besides the kraft pulping, aluminum, and wood products industries, high process emissions are found in the cement, grain, and foundary industries. Emissions from Wigwam-type burners are also included under process losses. Slash and field burning account for 15% and refuse disposal for 11% of particulate emissions. The remaining 9% eminate from transportation and fuel combustion sources. Transportation sources account for the majority of carbon monoxide emissions in the Study Area (69%) since the motor vehicle is the main contributor. Wigwam-type burners contribute most of the 14% shown under process losses, and slash and field burning contribute 11% of the carbon monoxide emission load.

Figure 11 shows the percent contribution to the total emissions of particulates, SO_x, and CO by the counties making up the four regional air pollution control agencies (see page 34).

Eighty-six percent of the Study Area's sulfur oxide emissions are from the nine counties in the Columbia-Willamette and the

Summary of Emissions from the Portland Study Area by Source Category (Tons per year)

	County	Total Fuel Combustion	Industrial Process Losses	Transportation	Refuse Disposal	Miscellaneous Field and Slash Burning	Total	% Contribution By County
Sulfur Oxides	Clark	1,152	10,475	277	130	--	12,034	24
	Cowlitz	858	8,604	170	25	--	9,657	19
	Lewis	816	7	139	21	--	983	2
	Skamania	71	7	13	3	--	94	--
	Wahkiakum	52	1	8	1	--	62	--
	Columbia	857	408	64	14	--	1,343	3
	Clackamas	485	299	324	130	--	1,238	3
	Multnomah	11,284	2,065	2,390	300	--	16,039	32
	Benton	342	14	107	27	--	490	1
	Marion	834	803	399	99	--	2,135	4
	Linn	417	56	314	23	--	810	2
	Polk	91	7	101	19	--	218	--
	Yamhill	273	804	117	23	--	1,217	2
	Lane	1,062	431	539	204	--	2,236	5
	Washington	591	0	274	118	--	983	2
	Totals	19,185	23,981	5,236	1,137	0	48,539	
Particulates	Clark	245	7,104	538	1,529	--	9,416	8
	Cowlitz	98	12,132	314	360	--	12,904	11
	Lewis	89	437	257	241	--	1,024	--
	Skamania	7	255	25	44	--	331	--
	Wahkiakum	6	51	15	21	--	93	--
	Columbia	139	3,432	119	176	14	3,880	3
	Clackamas	177	11,563	548	1,529	1,328	15,145	13
	Multnomah	1,444	15,396	2,586	2,399	134	21,959	18
	Benton	49	3,659	209	337	1,414	5,668	5
	Marion	152	599	740	829	2,042	4,362	4
	Linn	116	8,770	648	243	6,546	16,323	14
	Polk	25	1,789	176	234	1,093	3,317	3
	Yamhill	54	2,120	202	287	706	3,369	3
	Lane	199	9,839	1,115	2,949	4,155	18,257	15
	Washington	106	45	481	1,485	95	2,212	2
	Totals	2,906	77,191	7,973	12,663	17,527	118,260	
Carbon Monoxide	Clark	20	482	47,253	7,899	--	55,654	5
	Cowlitz	12	11,387	30,581	1,894	--	43,874	4
	Lewis	11	9,489	25,069	1,239	--	35,808	3
	Skamania	1	9,489	2,433	234	--	12,157	1
	Wahkiakum	0	1,897	1,524	156	--	3,577	--
	Columbia	11	285	11,739	917	95	13,047	1
	Clackamas	19	4,990	68,110	7,899	8,386	119,419	11
	Multnomah	188	556	180,156	12,899	860	194,659	19
	Benton	7	22,001	17,446	1,749	8,998	50,201	5
	Marion	24	1,172	72,160	4,089	12,898	90,343	9
	Linn	11	33,639	43,531	1,241	41,442	119,864	11
	Polk	5	11,281	20,466	1,216	6,901	39,869	4
	Yamhill	7	2,399	23,810	1,493	4,490	32,199	3
	Lane	27	28,762	93,014	15,534	26,578	163,915	16
	Washington	16	1,630	62,239	7,720	729	72,334	7
	Totals	359	139,459	699,531	66,179	111,377	1,046,920	

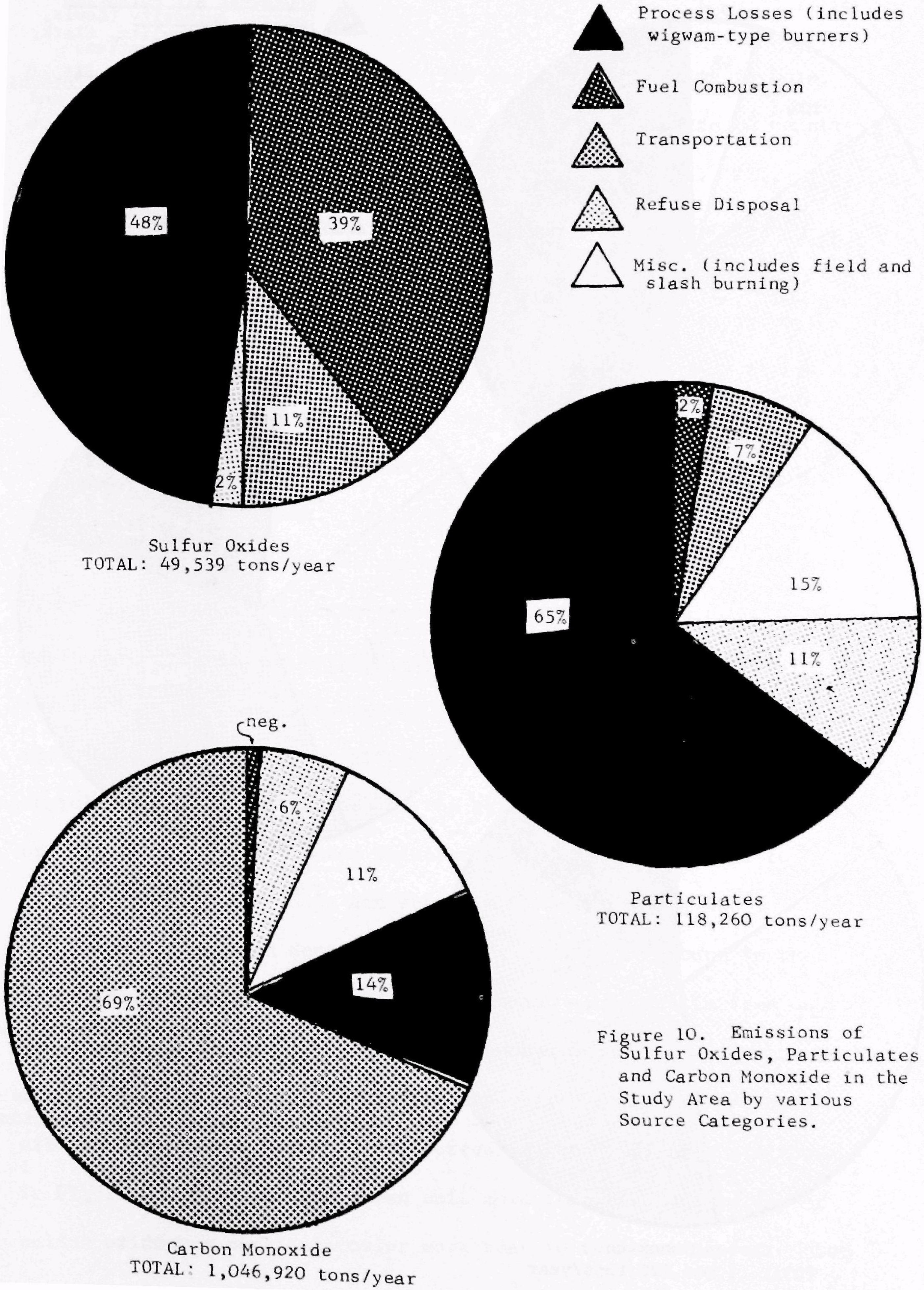


Figure 10. Emissions of Sulfur Oxides, Particulates and Carbon Monoxide in the Study Area by various Source Categories.

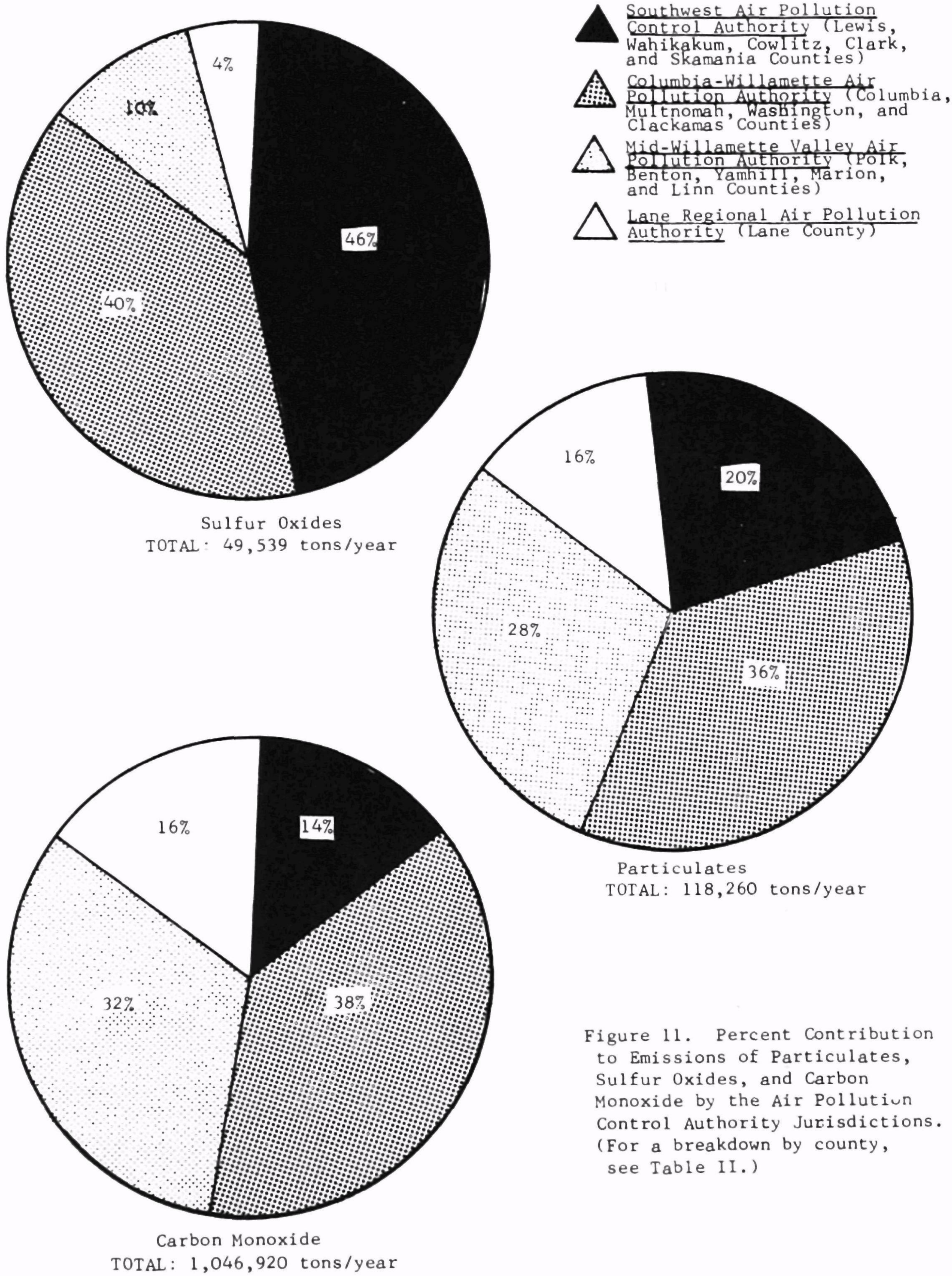


Figure 11. Percent Contribution to Emissions of Particulates, Sulfur Oxides, and Carbon Monoxide by the Air Pollution Control Authority Jurisdictions. (For a breakdown by county, see Table II.)

Southwestern Washington Regions. The particulate loading is more evenly distributed by region with the Columbia-Willamette (4 counties) contributing 36%, the Mid-Willamette Valley (5 counties), 28%, Southwestern Washington (5 counties), 20%, and Lane County, 16%. The ten Oregon Counties contribute 86% of the carbon monoxide emissions, since most of the population (and therefore motor vehicles) are located there, and most of the slash and field burning is found there.

Grid coordinates based on the Universal Transverse Mercator System were used in the inventory to aid in determining the location of sources and emissions. As shown in Figure 12, the Study Area was divided into 71 grids of three different sizes--100, 400, and 1600 square kilometers. The estimated annual emissions of each of the three contaminants by grid zone were converted to daily emissions for average, maximum, and minimum space-heating days. Average emission densities were determined by relating the total quantity of pollutants emitted in each of the grid zones to the land area of each zone. The estimated emission densities by grid zone for average space-heating days are shown in Figures 13, 14, and 15.

Highest emission densities of sulfur oxides are found in the Portland, Longview, Salem, and Eugene areas. The same is true of particulates. Particulates and carbon monoxide emissions appear to be more widespread than sulfur oxides, especially in the Oregon section of the Study Area. Major point sources in the Study Area are shown in Figure 16. The sources shown emit more than one ton per day of sulfur oxides or particulates,or more than 10 tons per day of carbon monoxide.

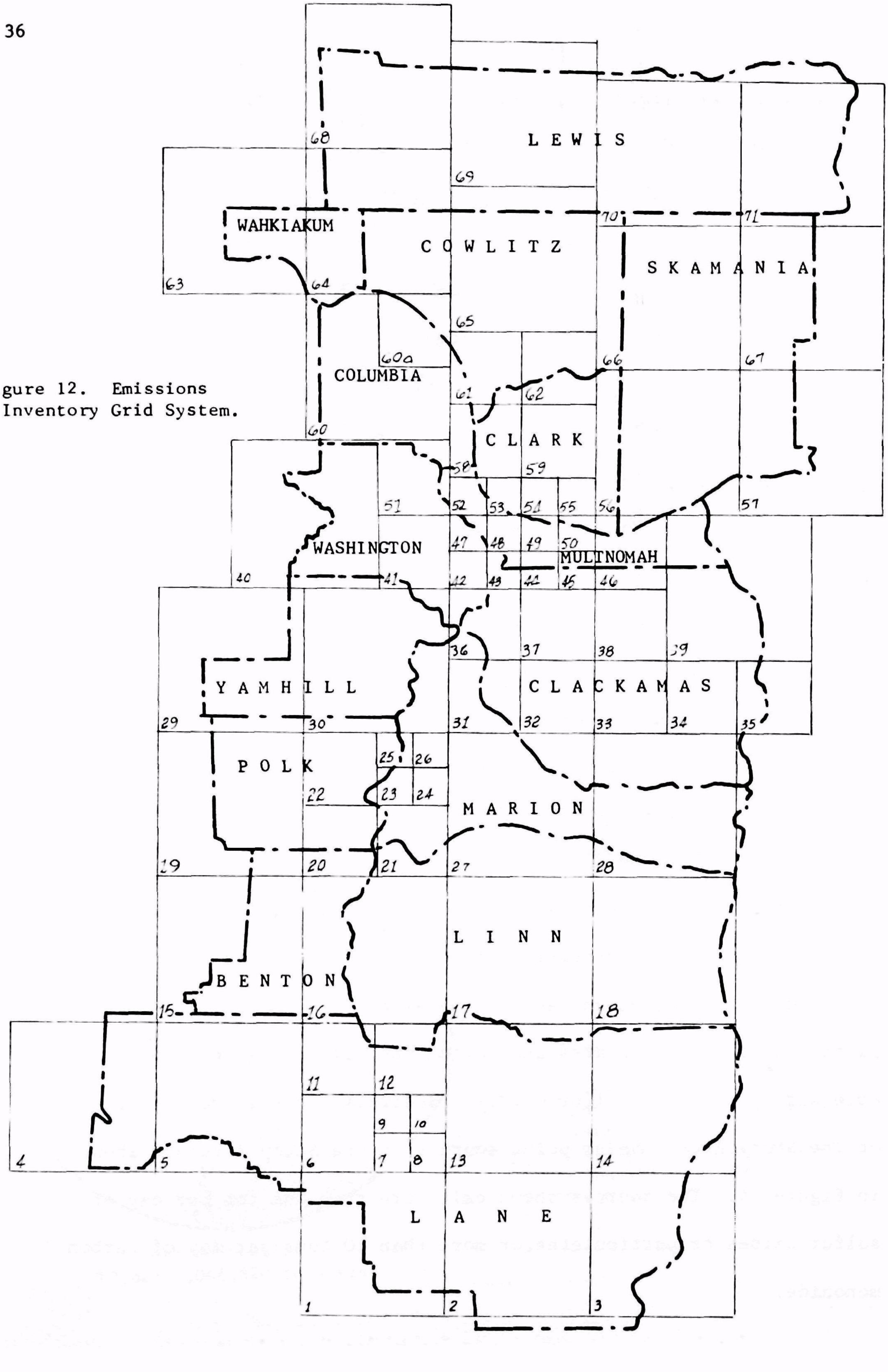
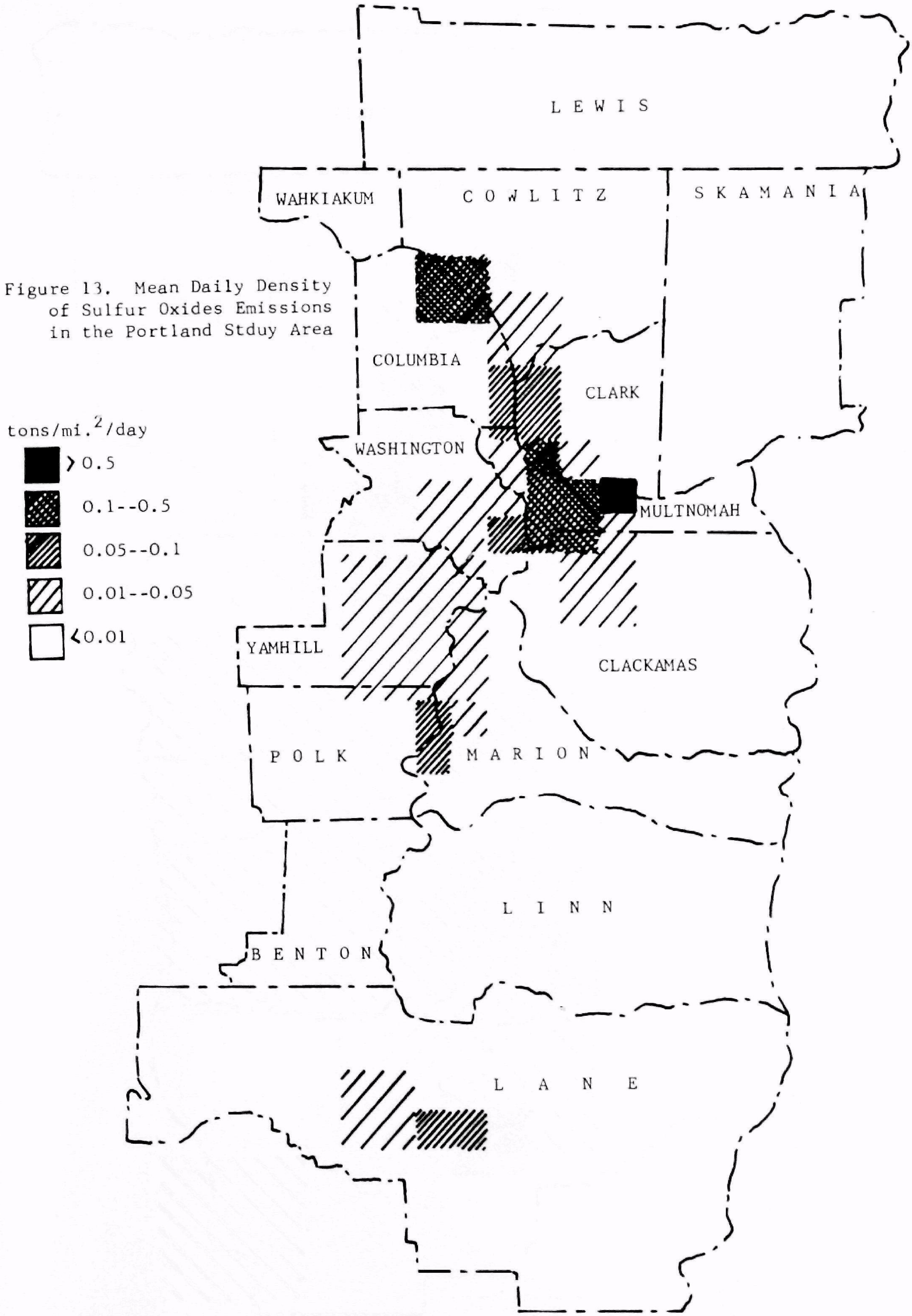


Figure 12. Emissions Inventory Grid System.

Figure 13. Mean Daily Density of Sulfur Oxides Emissions in the Portland Stduy Area



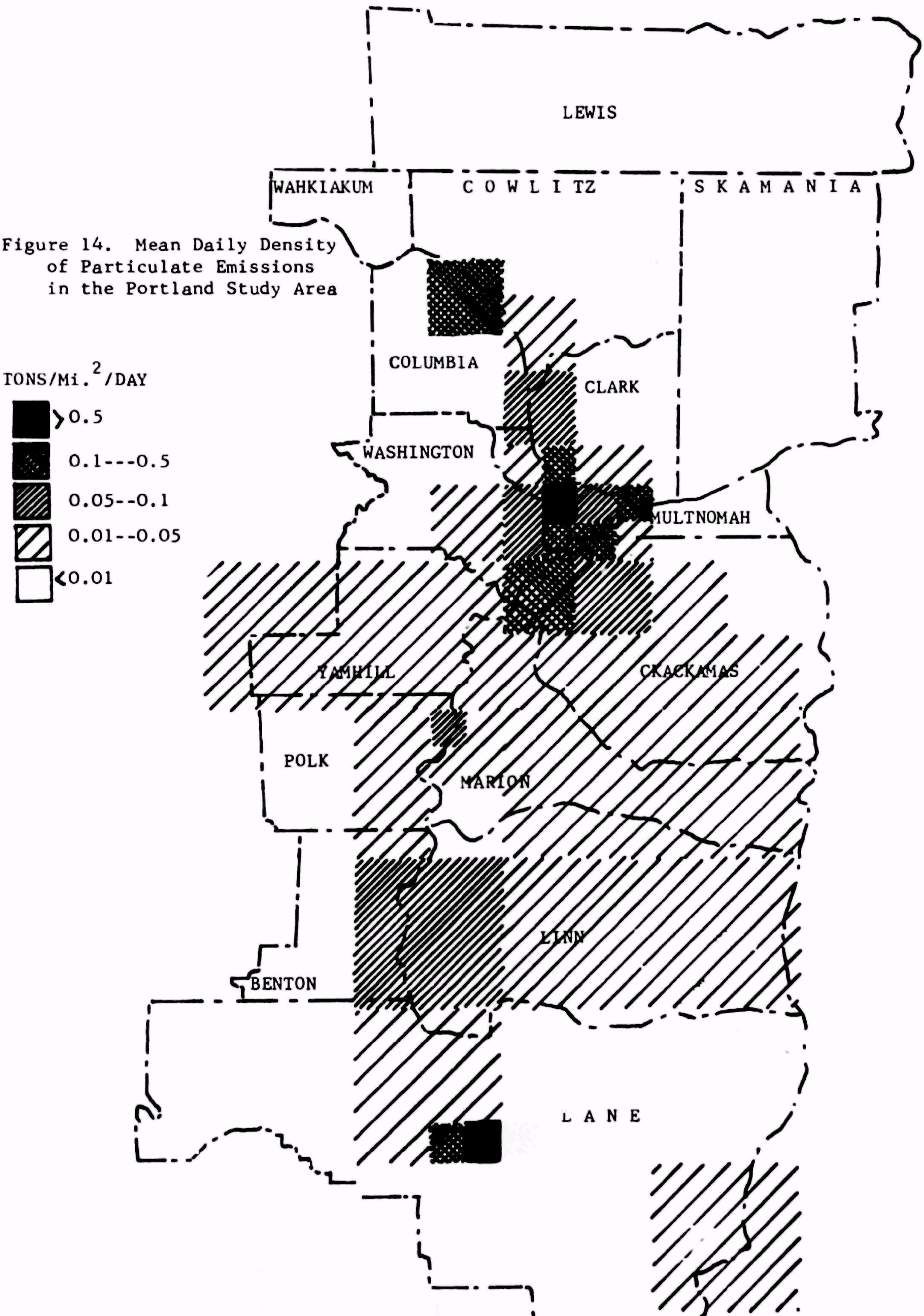


Figure 14. Mean Daily Density of Particulate Emissions in the Portland Study Area

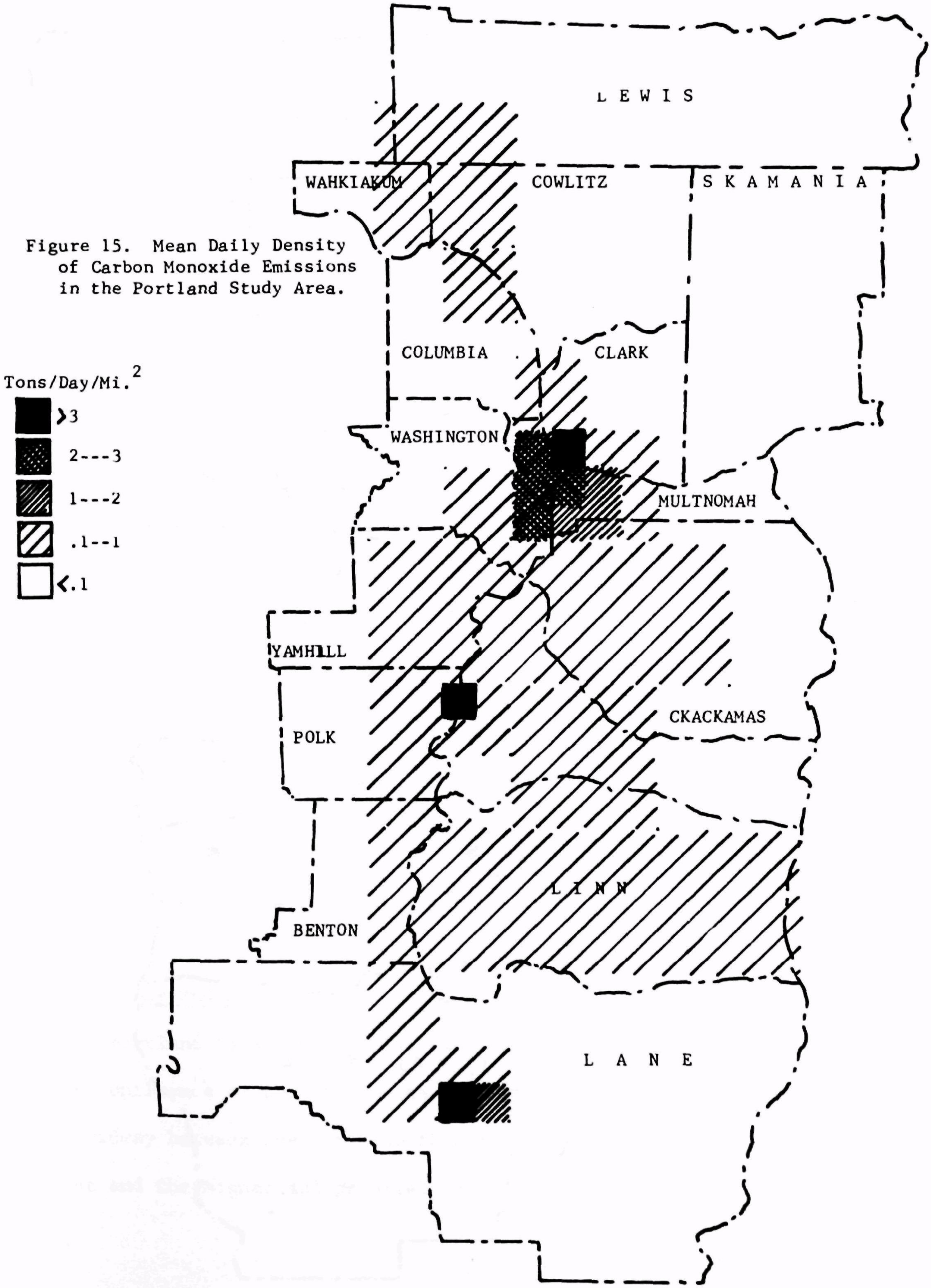


Figure 15. Mean Daily Density of Carbon Monoxide Emissions in the Portland Study Area.

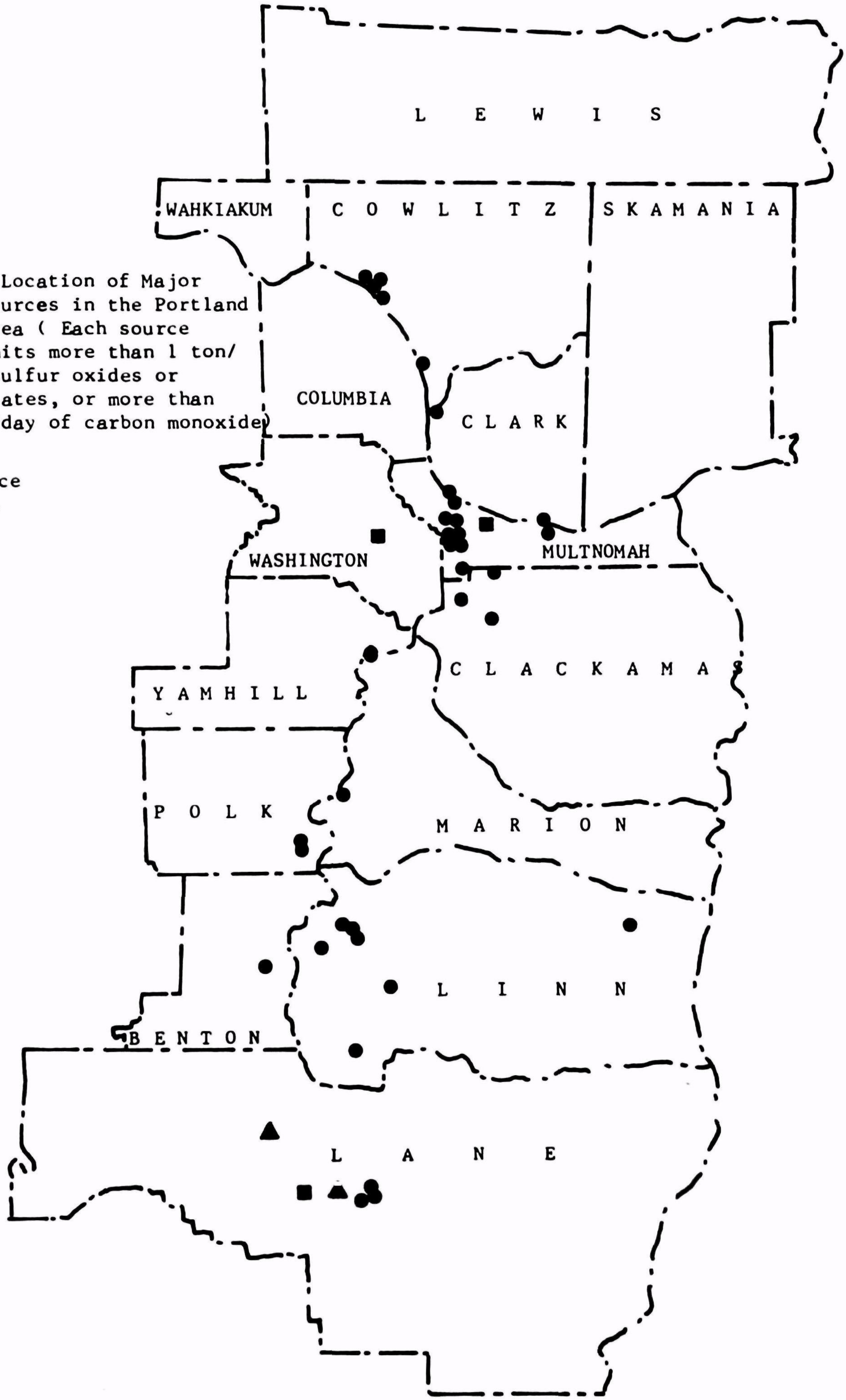


Figure 16. Location of Major Point Sources in the Portland Study Area (Each source shown emits more than 1 ton/day of sulfur oxides or particulates, or more than 10 tons/day of carbon monoxide)

Type of Source
●–Industry
■–Dump
▲–Airport

DIFFUSION AND AIR QUALITY

Introduction

A meteorological diffusion model[9] is generally employed in an engineering evaluation to determine the extent of the air pollution problem. Source locations, an emission inventory and meteorological data, particularly wind direction frequencies and thermal stability characteristics of the atmosphere, are the major input factors of the model. The model gives fairly good results in areas where the terrain is flat and there are no major topographic features. However, the high mountains to the east and west of Portland and the valleys of the Columbia and Willamette Rivers have such marked effects on the flow patterns and stability of the atmosphere that the model cannot be satisfactorily employed in the Portland area. Discussions of air flow patterns and thermal stability and a qualitative evaluation of the extent of the pollution problem are substituted for estimates from the diffusion model. (The location of major sources and emission inventory are discussed in the preceding section.)

Topography and Air Flow

Portland is about 65 miles east of the Pacific coast at the confluence of the Willamette and Columbia Rivers. The city is midway between the north-south oriented coast range on the west and the higher and parallel Cascade range on the east, each about 30 miles distant. The Columbia River flows through both of these ranges within narrow gorges. Figure 17 shows the area and displays elevations above 2000 feet.

In evaluating the air flow in the Columbia River Valley, data from the following locations are considered: a) the Dalles at the eastern end of the gorge in the Cascades; b) Portland, where the downriver flow changes from westward to northward; c) Kelso, where the direction changes from northward to westward; and d) Astoria, at the mouth of the river. The flow in the broad Willamette Valley is evaluated through observations from the following locations: a) Eugene, at the south end of the Valley; b) Salem; c) Portland, and d) Kelso. The Cowlitz Valley to the north of Kelso is a straight extension of the valley in which the Columbia River flows northward, so observations from Toledo, Washington, near the point where the Cowlitz River starts its southerly flow toward the Columbia River, are included. Data for each mid-season month are presented.

The prevailing surface flow in January, as shown in Figure 18, indicates that there is a general movement from east to west in the Columbia River Valley and from south to north in the Willamette-Cowlitz Valley areas. This northward flow is so frequent and persistent that a backward trajectory technique demonstrates that many air parcels eventually found over Portland and Kelso were at one time over Eugene.

In April, the prevailing surface flow is more complicated than that of January (Figure 19). The flow is upvalley in the

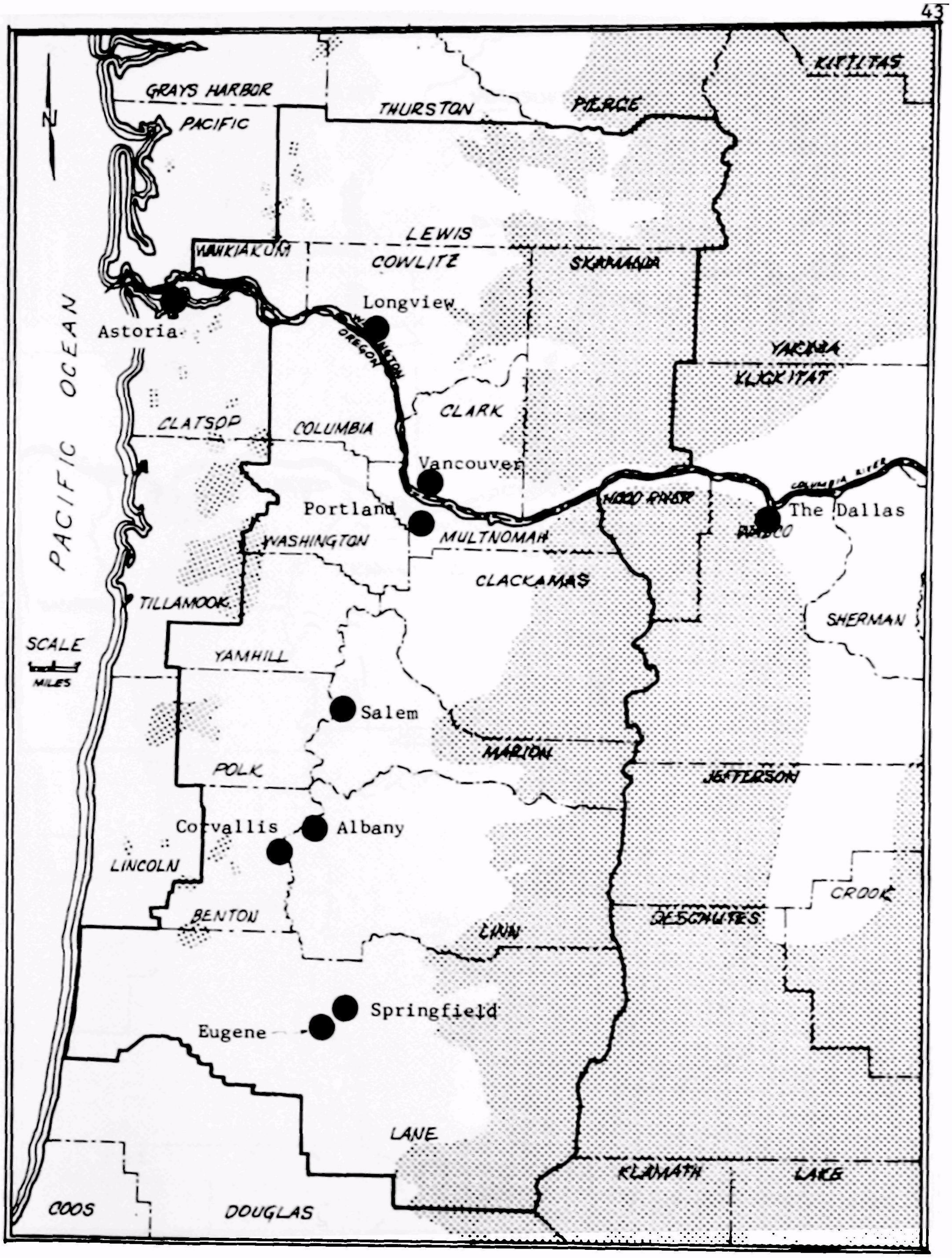


Figure 17. Portland Study Area Topography
(Shaded areas show elevations over 2000 feet)

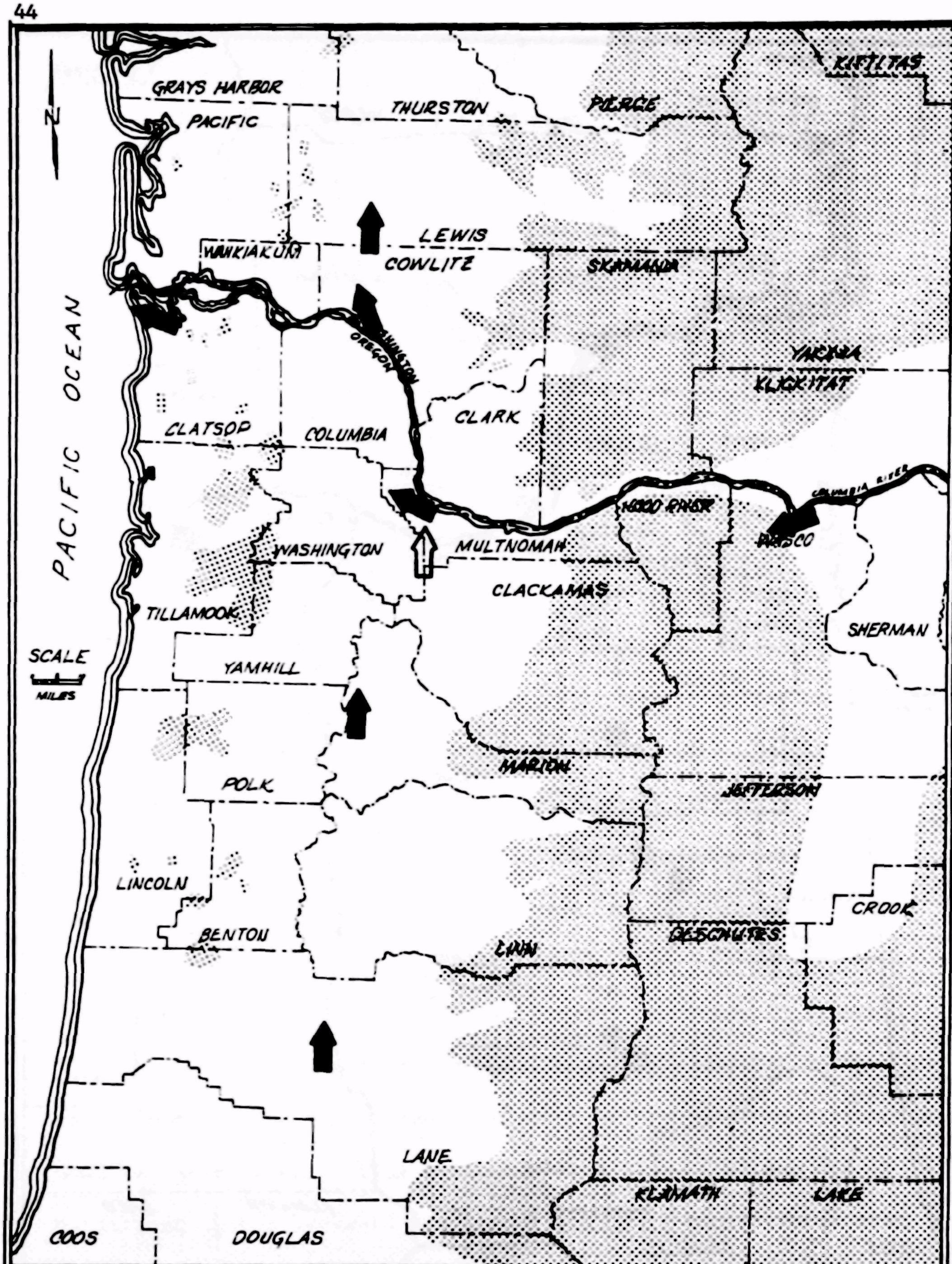


Figure 18. Prevailing Flows, January

Arrows Indicate Direction of Flow

Primary Secondary

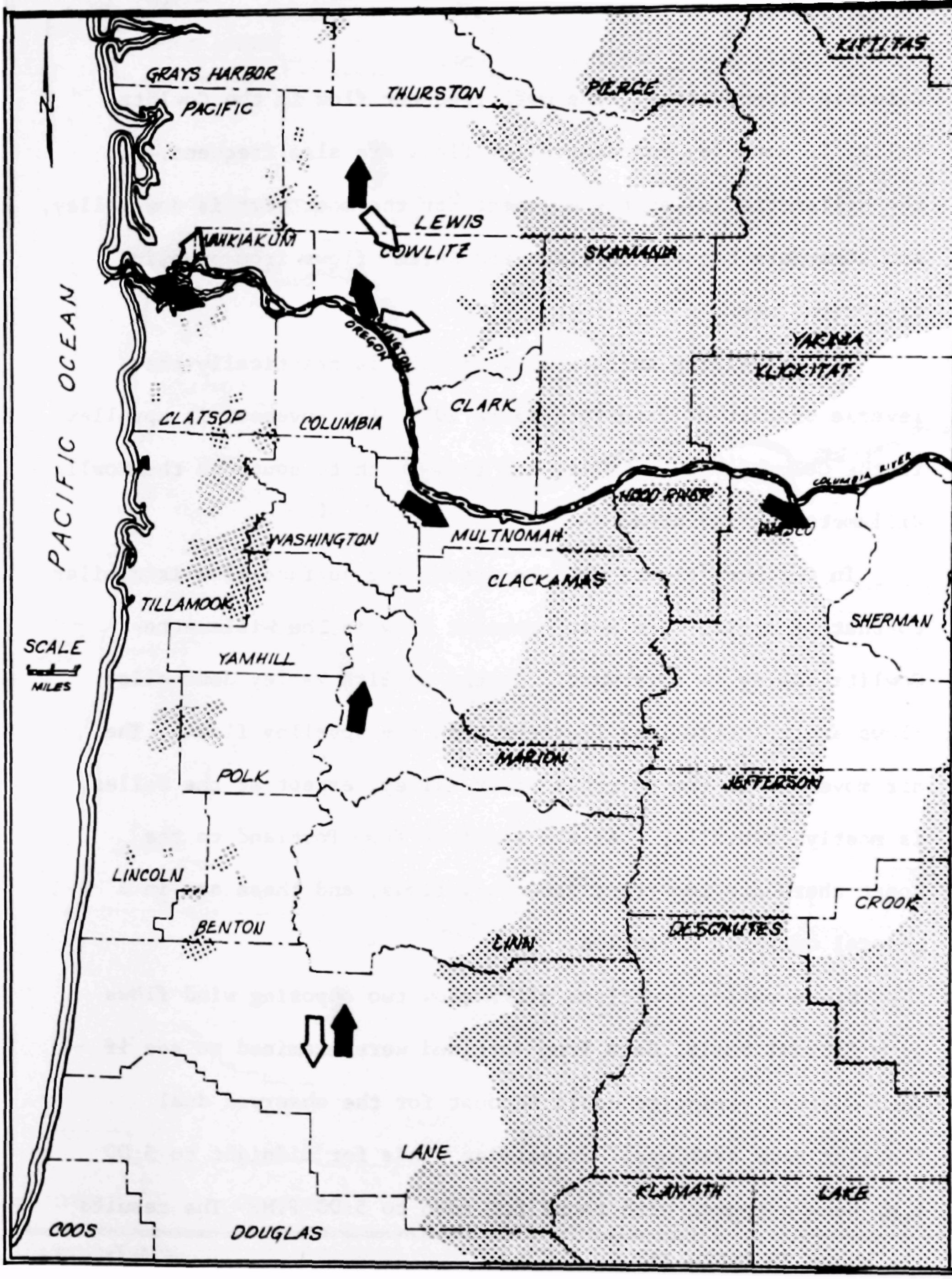


Figure 19. Prevailing Flows, April

Arrows Indicate Direction of Flow

Primary **Secondary**

Columbia River Valley. The most frequent flow in the Cowlitz Valley is upvalley but downvalley flows are also frequent. In the Willamette Valley the movement for the most part is downvalley, and somewhere between Portland and Salem, flows from opposing directions meet.

The prevailing surface flow in July is practically the reverse of that of January (Figure 20). Air movement is upvalley in the Columbia River Valley and from north to south in the Cowlitz-Willamette Valley area.

In October (Figure 21) the prevailing surface flow is similar to that of April. The most frequent flow in the Willamette-Cowlitz Valley is northward. In the Cowlitz Valley downvalley flows are a little less frequent than the upvalley flows. The air movement in the Columbia River Valley, except at the Dalles, is mostly downvalley. At all stations from Portland to the Coast there are important secondary flows, and these are in a general upvalley direction.

Since valley locations often show two opposing wind flows on a diurnal basis, data from Portland were examined to see if such diurnal variation could account for the observed dual flows at some stations. Prevailing winds for midnight to 5:00 A.M. were compared with those for noon to 5:00 P.M. The results are shown in Table III.

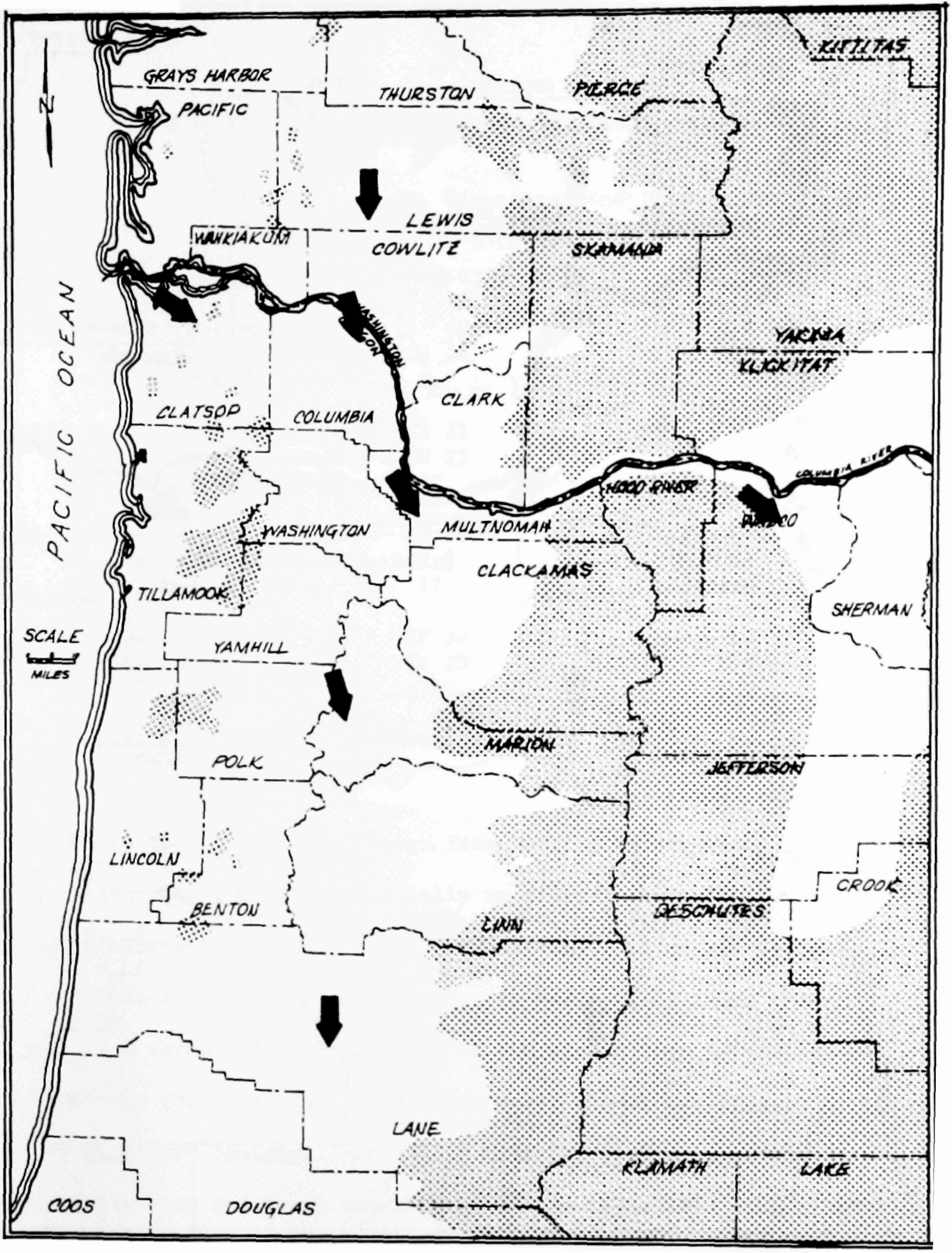


Figure 20. Prevailing Flows, July

Arrows Indicate Direction of Flow

Primary **Secondary**

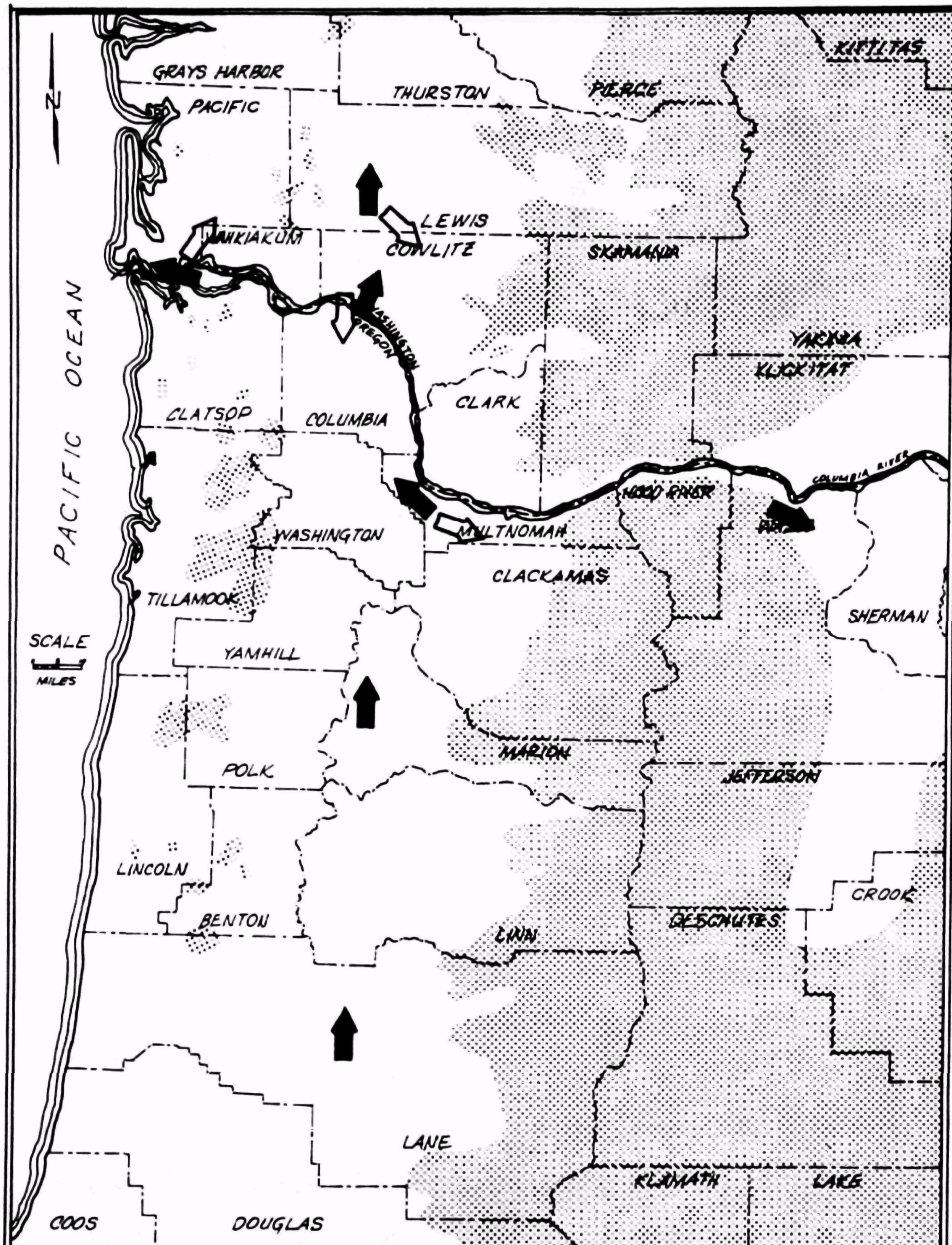


Figure 21. Prevailing Flows, October

Arrows Indicate Direction of Flow

Primary **Secondary**

Table III. Prevailing Winds*, Portland, Oregon

Month/Time		Directions and Percent Frequency (Based on data supplied by C. Hopper) 0000-0500	1200-0700
January-	Most Frequent	ESE 48	ESE 45
	Next Most Frequent	SSW 24	SSW 25
	Calms (%)	9	5
April-	Most Frequent	ESE 22	NW 39
	Next Most Frequent	NW 22	SW 17
	Calms (%)	22	15
July-	Most Frequent	NW 52	NW 75
	Next Most Frequent	SSE 8	SSW 6
	Calms (%)	17	1
Oct.-	Most Frequent	SE 30	NW 32
	Next Most Frequent	SSW 20	SE 25
	Calms (%)	23	5

* 3 sectors wide centered on indicated sector, based on 16 point compass.

In January there is little change from morning to afternoon indicating that there is practically no diurnal variation in winter. There is a considerable increase in NW winds and decrease in SE winds from morning to afternoon in April, indicating that there is a marked diurnal shifting of the wind. This is assumed to indicate that the stations showing dual, almost opposing, flows in Figure 19 (April prevailing flow data) also experience this daily back and forth movement of air in their area; the flows are primarily downvalley in the morning and upvalley in the afternoon. In July there is a marked increase in the frequency of NW winds from morning to afternoon. This indicates that at times during the night the flow becomes so light that it is undetectable by the instruments, or variable; but there is no marked reversal of flow from night to day. The air movement during July is thus fairly persistent in one direction. In October there is only a slight decrease in the frequency of SE winds from morning to afternoon. As in April, the change in the most frequent flow is from downvalley in the morning to upvalley in the afternoon.

Since movement of air within the first few thousand feet of the surface is important in air pollution evaluations, a summary of these data for Portland is shown in Table IV.

Table IV. Prevailing Winds, and Winds Aloft, Portland, Oregon (Winds Aloft Data from Airway Meteorological Atlas for the United States [12]).

Height / m	Period (feet)	Dec-Jan-Feb	Mar-Apr-May	June-July-Aug	Sept-Oct-Nov
Surface		ESE^z	NW^z	NW^z	SE^z
500	(1640)	E	NNW	NNW	NNW*
1000	(3280)	SSW	SW	NNW	SW
2000	(6560)	SSW	SW	WSW	SW
3000	(9840)	SW	WSW	SW	WNW

z - midseason month data
* - E winds are almost as frequent

It is obvious that most of the year there is one wind regime in the layer from the surface to some height between 1640 and 3280 feet and that there is another wind regime above. This phenomenon appears to be related to the stability characteristics of the atmosphere (discussed in the next section). A study[12] now in progress is obtaining additional data. On December 5, 1969, the investigators found that there were weak winds from the surface to 1000 feet, a strong easterly gorge wind between 1000 and 3000 feet and W-SW winds above 3000 feet. The easterly gorge wind is practically restricted to the winter. When it occurs it changes a complicated two-layer flow into a very complicated three-layer flow. These drastic changes in direction with height, complicates the problem of trying to make a model of the atmosphere. Diffusion evaluation would be most difficult to make if these changes in direction with height had to be taken into account. However, as explained in the following section, vertical mixing is very frequently restricted to the lower 2000 to 3000 feet and movement in the upper layer does not have to be considered.

Thermal Stability

The stability characteristics of the atmosphere give an indication of the depth through which vertical mixing takes place. When the temperature increases with height, an inversion of temperature is said to exist. When the inversion layer is based at the surface and sufficiently deep, effluents generally tend to spread out horizontally in a flat layer, or initially rise for a time (until they lose their buoyancy) and then spread out. Inversions are described as being thermally stable. If the inversion layer is aloft, the base of it acts as a lid and inhibits vertical mixing up into the inversion. An opposite effect is caused by a superadiabatic layer in which the adiabatic lapse rate (a decrease in temperature with height at the rate of 5.4°F per 1000 feet) is exceeded. In a superadiabatic layer, conditions are unstable, vertical motion is constant and vertical mixing is considerable. In a neutrally stable layer, i.e., one with an adiabatic lapse rate, parcels tend to remain in place or if displaced up or down by an outside force, will move only as long as that force is applied. A layer which shows no change of temperature with height is called isothermal, and vertical air movement in such a layer is similar to that in an inversion. Layers showing a decrease in temperature with height but a decrease less than adiabatic are also stable and exhibit little vertical mixing.

Over undeveloped, rural areas radiation or surface based inversions readily form around sunset when the skies are clear and the winds light. In built-up areas, the frequency of surface based inversions is not as great, and often an inversion base is displaced a few hundred feet from the surface. A seasonal summary of the percent frequency of inversions at or within 500 feet of the surface in the Portland area is shown in Table V.

Table V. Percent Frequency of Inversion And/Or Isothermal Conditions, Based on Below 500 Feet Above Station Elevation - Portland-Salem Area

Time P.S.T. Season	4 AM	7 AM	4 PM	7 PM
Winter	51	41	8	36
Spring	63	20	1	19
Summer	74	3	0	14
Fall	71	43	2	49

From: C. R. Hosler's Low-Level Inversion Frequency in the Contiguous United States (8).

It is seen that low-level inversions are present over half of the nights in each season. Another investigator using only the Salem data fround that stable layers with bases at the ground occurred 87% of the time at 4:00 A.M.[14] In the afternoon, as shown by the 4:00 P.M. data in Table V, the inversions are eliminated almost everyday. It should be remembered that these nocturnal inversions are generally present for several hours or more each time they occur, whereas the maximum mixing depth, which is discussed in a following paragraph, is a phenomenon lasting an hour or less in time.

The data on surface based, or low-level inversion, indicate the frequency of the stable extreme in vertical mixing. This extreme is generally eliminated shortly after sunrise; at times in winter it may be noon or 1:00 P.M. before the inversion is eliminated. The other extreme occurs when the sun heats the ground and ground-based adiabatic or superadiabatic layer is formed and gets progressively deeper until a maximum depth is reached during the afternoon. Holzworth[15] used a standard technique for computing mean maximum mixing depths for Portland and his results are shown in Table VI.

Table VI. Computed Afternoon Mean Mixing Depths - Holzworth (6)

Season	Height in Feet
Winter	1970
Spring	4920
Summer	5250
Autumn	3610

Since it is well documented[16] that subsidence inversions or inversions aloft occur over the Willamette Valley and sections of the Columbia River Valleys, these computed mixing depths have to be compared to observations of inversion base heights. Cramer,[17] through temperature profile observations obtained from an aircraft, has found that the inversion generally has bases between 2000 and 3000 feet above the surface. He reported[18] that these observations are further confirmed by his observations of air pollution plumes in the area; these plumes generally have tops of 2000 to 3000 feet above the surface. These temperature and air pollution plume observations are more in agreement with the winds aloft (Table IV) than the computed mixing depths; the winds aloft indicate that the winds associated with the subsidence, SW, are at lower levels than the computed mixing depths. It thus appears that a base about 2000 to 3000 feet above the surface most frequently limits the vertical mixing on most days of the year, and that during the summer vertical mixing is probably a little greater than 3000 feet.

The air flow patterns indicate that air parcels are readily transported long distances in a north or south direction in the Willamette Valley. In the Columbia River Valley, east and west flows predominate to the east of Portland and west of Kelso but the net transport in one direction is not as great as that in the Willamette Valley. The poor vertical mixing which occurs on a majority of nights combined with vertical mixing restricted to 3000 feet or less on most days aggravates any pollution problem because these phenomena allow for little dilution in the vertical.

Relating the potential diffusion discussed above to the sources of the area, the following are found. Pollution from a number of major point sources in the Kelso-Longview area[19] could be expected to readily reach places in Cowlitz, Columbia, Clark, Washington, and Multnomah Counties. Pollution from the numerous major sources in the Portland-Vancouver-Camas[19] area would affect the air quality of Multnomah, Skamania, Clark, Cowlitz, Columbia, Washington, Clackamas, Yamhill and Marion Counties and possibly Hood River County. Pollution from the area-wide agriculture burning during the summer of approximately 300,000 acres in the area south of Salem generally contaminates the whole southern end of the Willamette Valley, including Marion, Polk, Benton, Linn and Lane Counties. Evidence of the magnitude of this problem was given on August 12, 1969.[20] The situation became so bad in Eugene that a temporary ban was put on agricultural burning in the area. Paper plants ringing Corvallis are also major sources of pollution in the southern end of the Willamette Valley and cross-county air flow causes them to offend neighbors in other counties.

Thus, it appears that there is mutual responsibility for air quality in the Willamette Valley by all counties in the Willamette Valley and Columbia, Clark, Cowlitz and Skamania County.

THE PROPOSED REGION

Subject to the scheduled consultation, the Secretary, Department of Health, Education, and Welfare, proposes to designate an air quality control region for the Portland area, consisting of the following jurisdictions:

In the State of Oregon:		In the State of Washington:
Benton County	Marion County	Clark County
Clackamas County	Multnomah County	Cowlitz County
Columbia County	Polk County	
Lane County	Washington County	
Linn County	Yamhill County	

As so proposed, the Portland Interstate Air Quality Control Region would consist of the territorial area encompassed by the outermost boundaries of the above jurisdictions and the territorial area of all municipalities located therein and as defined in Section 302(f) of the Clean Air Act, 42 U.S.C. 1857th(f). Figure 22 shows the boundaries of the proposed Region while Figure 23 indicates the geographic relationship of the Region to the surrounding area.

DISCUSSION OF PROPOSAL

To be successful, an air quality control region should meet three basic conditions. First, its boundaries should encompass most of the pollution sources as well as most of the people and property affected by those sources. Second, the boundaries should encompass those locations where industrial and residential development will create significant air pollution

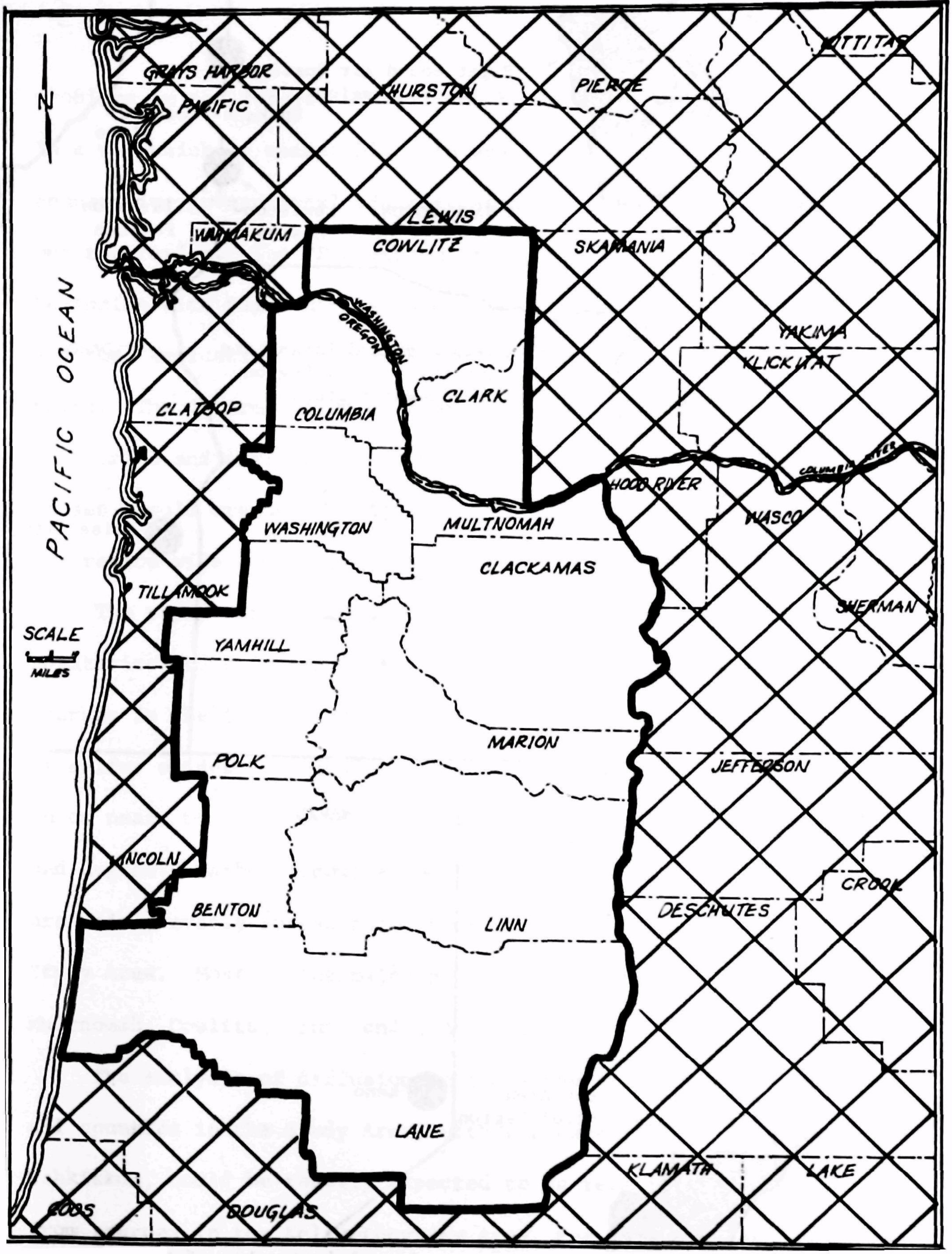


Figure 22. Proposed Boundaries of the Portland Interstate Air Quality Control Region (Oregon-Washington)

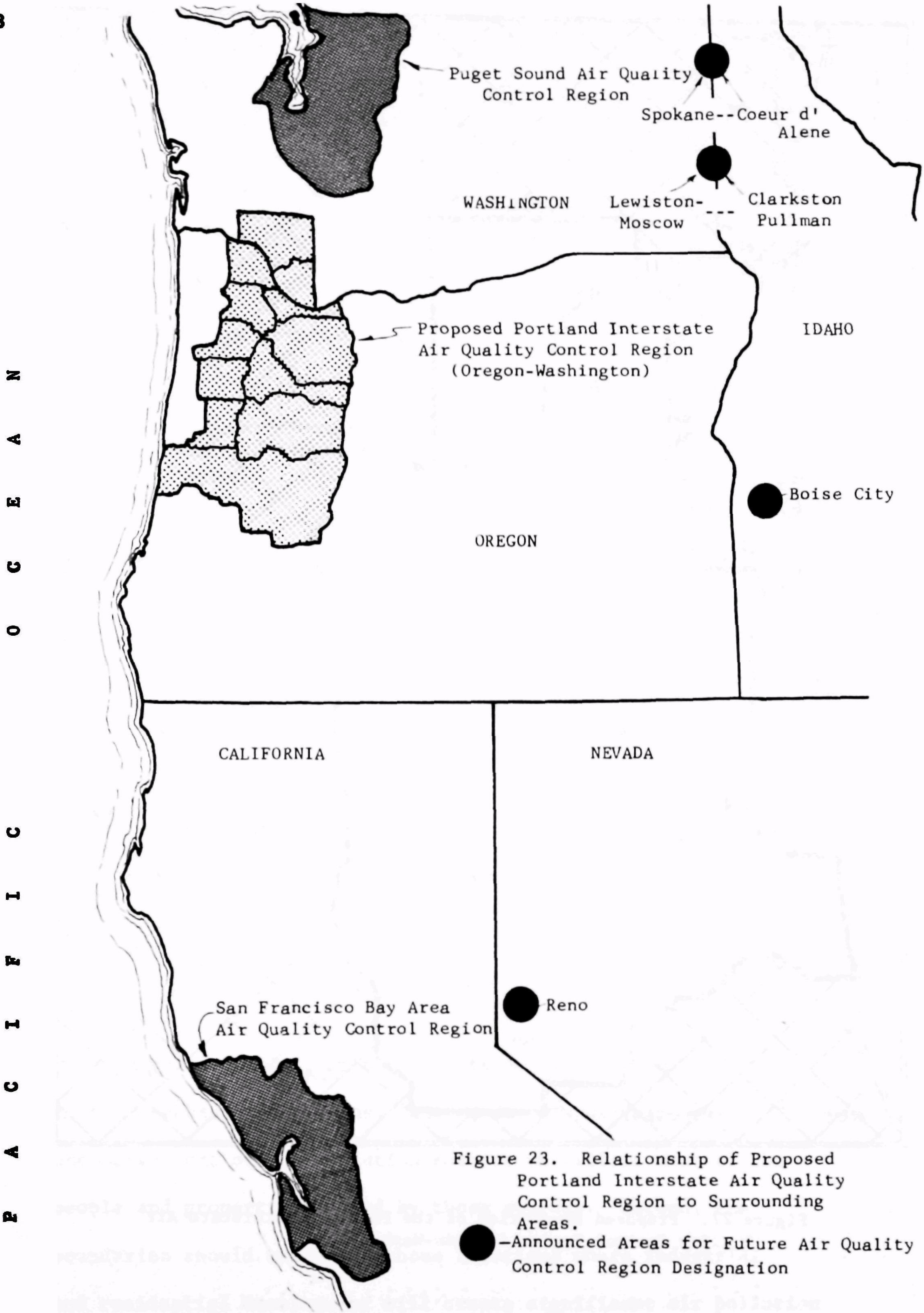


Figure 23. Relationship of Proposed Portland Interstate Air Quality Control Region to Surrounding Areas.

● —Announced Areas for Future Air Quality Control Region Designation problems in the future. Third, the boundaries should be chosen in a way which is compatible with and even fosters unified and cooperative governmental administration of the air resource throughout the region. The "Evaluation of Engineering Factors" (discussion beginning with page 30) discussed the first of these conditions, and the "Evaluation of Urban Factors" (page 11), the second and third. The determination of regional boundaries requires that both urban and engineering factors be considered. The boundaries chosen should create a cohesive combination of jurisdictions suitable for region-wide administration of an air resource management program.

The rapid-survey emissions inventory gave estimates of emission quantities and emission densities, and the location of point sources in the fifteen-county Study Area. Highest emission densities of sulfur oxides, particulates, and carbon monoxide are found in or near the cities of Kelso-Longview, Portland-Vancouver, Salem, and Eugene. Carbon monoxide and particulate densities, however, are fairly evenly spread throughout the Oregon portion of the Study Area. Most of the major point sources are located in Multnomah, Cowlitz, Linn, and Lane Counties.

The analysis of diffusion in the Study Area indicates that all counties in the Study Area, with the exception of Lewis and Wahkiakum, could be readily expected to be receptors of pollution from sources in the Kelso-Longview area, the Portland-Vancouver-Camas area, or the area south of Salem where agricultural burning takes place.

The proposed twelve-county Region has a population of over 1,600,000 people which represents approximately 97% of the people in the Study Area. There are three main centers of population in the area: Portland-Vancouver (Clark, Washington, Clackamas, and Multnomah Counties), Salem (Marion County), and Eugene (Lane County). The Oregon portion of the proposed Region includes about 70% of the total population of the State, and the Washington portion represents over 5% of the population of Washington.

The proposed Region allows for both population and industrial growth in the future. Major population growth is expected to occur in the metropolitan areas of Portland-Vancouver, Salem, and Eugene (Clark, Multnomah, Washington, Clackamas, Marion, and Lane Counties). The remaining six counties are also projected to have shown population increases from 1960-1980 ranging from 34% in Cowlitz County to 86% in Polk County.

The third objective, that existing regional jurisdictions be considered, is most difficult to meet. The Oregon portion of the proposed Region includes three regional air pollution control authorities, and all ten counties are included in the authorities (see Figure 8). There are five regional planning groups in the Oregon portion, and none of these agencies has jurisdiction outside the proposed Region boundaries. In Washington, only two of the five study area counties are proposed for inclusion in the Region--Cowlitz and Clark. Most of the population and industry are located in these counties. Inclusion of the remaining counties in the Southwest Air Pollution Control Authority seems unnecessary due to their relatively low population densities and growth projections and the lack of large pollution sources. Cowlitz County has added Wahkiakum County to its Regional Planning Commission. It is the policy of the Planning Commission, however, to cooperate with all State, Federal, and local air pollution authority commissions,[21] so there should be no conflict in having only Cowlitz County in the Region.

The final decision on the inclusion or exclusion of Lewis, Wahkiakum and Skamania Counties, however, will be made only after careful review of comments submitted to the Consultation record by State and local officials. Should they be excluded from the Region at the present time, they should nevertheless be observed carefully and added at a later date if it appears that the air pollution menace is growing due to increases in population and industry.

The boundaries proposed in this report for the Portland Interstate Air Quality Control Region will serve as a starting point for discussion with State and local officials at the scheduled Consultation.

REFERENCES

1. Commercial Atlas and Marketing Guide, 100th Edition, Rand-McNally and Company, 1969.

2. "Population Growth in the Mid-Willamette Valley" Staff Papers: Population, Annual Series, Issue No. 4, January, 1970, Mid-Willamette Valley Council of Governments.

3. "Population - Economics - Land Use", Cowlitz-Wahkiakum Regional Planning Commission, Cowlitz County Courthouse, Kelso, Washington, October, 1968.

4. "Population and Employment, Technical Appendices", excerpts from: Eugene-Springfield Metropolitan Area Preliminary 1990 General Plan, Central Lane Planning Council, 1969.

5. "Employment and Population Projections to Year 2000", Portland-Vancouver SMSA, Columbia Region Association of Governments, Portland, Oregon, August, 1968.

6. "Population Forecasts, State of Washington, 1965 to 1985," State of Washington, Department of Commerce and Economic Development, Olympia, Washington, 1966.

7. "Population Bulletin", Release Number P-9, Oregon State Board of Census, Portland State College, Portland, Oregon, October, 1963.

8. "Rapid Survey Technique for Estimating Community Air Pollution Emissions," PHS Publication No. 999-AP-29, Environmental Health Series, USDHEW, NAPCA, Cincinnati, Ohio, October, 1966.

9. Martin, D. O. and Tikvart, J. A. - A General Atmospheric Diffusion Model for Estimating the Effects on Air Quality of One or More Sources, Paper No. 68-148, 61st Annual Meeting, APCA, St. Paul, Minnesota, June 1968.

10. Hopper, C. - (Personal Communication) Letter of January 14, 1970, including wind rose data for each three-hour period of each midseason month.

11. U. S. Weather Bureau - Airway Meteorological Atlas for the United States. W.B. No. 1314, U. S. Department of Commerce, New Orleans, La., 1941.

12. Olsson, L. E. - Proposed Work Plan--Investigation of Natural Ventilation of the Portland Area and the Willamette Valley. Department of Atmospheric Sciences, School of Science and Air Resources Center, Oregon State University, Corvallis, Oregon, January 1970.

13. Hosler, C. R. - Low-Level Inversion Frequency in the Contiguous United States. Monthly Weather Review 89 (9): 319-339, (September) 1961.

14. Oregon State Board of Health - Air Pollution in the Portland Metropolitan Area, September, 1963.

15. Holzworth, G. C. - (Personal Communication) Letter on computed mixing depths over the United States, April 15, 1969.

16. Cramer, O. P. and R. E. Lynott - Cross-Section Analysis in the Study of Windflow over Mountainous Terrain. Bulletin American Meteorological Society, 42 (10), 693-702, (October) 1961.

17. Cramer, O. P. - Implications of Atmospheric Potential Temperature Structure on the Distribution of Aerosols in Western Oregon. Paper presented at Pacific Northwest International Section Meeting, Air Pollution Control Association, Salem Oregon, November 9, 1967.

18. Cramer, O. P. - (Personal Communication) Letter on movement and depth of polluted layers west of the Cascades, October 18, 1968.

19. Hendrickson, E. R., Kengy, D. M., and R. L. Stockman - Evaluation of Air Pollution in the State of Washington. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1957, 145 p.

20. Colby, R. - (Newspaper Article) Eugene Becomes 'State of Anarchy' As Battle on Field Burning Rages. The Sunday Oregonian, August 17, 1969, p. 34.

21. "Regional Planning Scope and Purpose," Cowlitz-Wahkiakum Regional Planning Commission.