Metropolitan Greenspaces Program Data Analysis

METROPOLITAN
Greenspaces

A Cooperative Regional System of Natural Areas, Open Space, Trails and Greenways, for Wildlife and People

Final Report
Map Data

November 1992

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METROPOLITAN GREENSPACES PROGRAM DATA ANALYSIS,

PART 2: MAP DATA

FINAL REPORT

for

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TABLE OF CONTENTS

PART 2: MAP DATA ANALYSIS

1. INTRODUCTION 1

2. BASIC GIS CONCEPTS AND METHODOLOGY
   - 2.1 Components of a GIS 2
   - 2.2 Data Organization 2
   - 2.3 Fundamental Analytical Operations of GIS Software 4

3. DESCRIPTION OF PRIMARY COVERAGES
   - 3.1 Study Boundary 5
   - 3.2 Natural Areas 8
   - 3.3 Buffered Natural Areas 35
   - 3.4 Natural Areas Habitat Types 43
   - 3.5 Parks and Recreation Areas 45
   - 3.6 Sherwood NWR Study Area 57
   - 3.7 Hydrography 64
   - 3.8 1990 Block Group Population 69
   - 3.9 Population Projections to 2010 71
   - 3.10 Watersheds and Polysheds 76
     - 3.10.1 Rationale for Watershed-based Analysis 76
     - 3.10.2 Delineation Strategy and Procedures 79
     - 3.10.3 Derivation of Polysheds 80
     - 3.10.4 Characteristics of the Polysheds 82
     - 3.10.5 Clarifications Regarding Polysheds 85

4. WATERSHED-BASED ANALYSIS
   - 4.1 Hydrography of the Polysheds 87
   - 4.2 Polyshed Natural Areas Parameters 94
   - 4.3 Polysheds and Habitat Types 108
   - 4.4 Topography and Polysheds 119
   - 4.5 Population By Polyshed 126
   - 4.6 Population Unserved By Natural Areas 131

5. DISCUSSION AND RECOMMENDATIONS 132

BIBLIOGRAPHY 137

PART 2: MAP DATA

1. INTRODUCTION

Natural areas are one portion of a complex mosaic of features that constitute a large metropolitan region such as the Portland/Vancouver urbanized area. It is possible to examine each set of features individually, considering total acreage, describing differences in characteristics of the feature throughout the area, identifying areas of concentration and sparseness, and, finally, developing generalizations about its pattern.

While generalizations about individual sets of features are very useful, they do not, however, provide a complete picture of a situation. Spatial patterns are not produced in a vacuum, and the pattern of one set of features is often influenced by and has an influence on the patterns of other features. As a result, a fuller understanding of the forces working to shape the landscape may be obtained by considering combinations of one spatial pattern with the patterns of other features in the same area.

The tool for examining spatial patterns is the map, and this part of the report will focus on an exploration of spatial patterns as recorded on, revealed by, and analyzed through maps. The study area is confined to a particular pre-defined portion of the Portland/Vancouver metropolitan region. There are three major objectives to this map-based analysis:

1) Develop a set of generalizations regarding the characteristics of natural areas and their patterns of occurrence within the study area.

2) Identify differences and similarities in the patterns of occurrence of natural areas and the patterns of other related natural and human features. Among the related features are existing parks and recreation areas, population, streams and watersheds.

3) Consider ways that the identified spatial patterns may be used to assist in identifying strategies for natural areas protection and acquisition. These strategies should be appropriate to the conditions, needs and opportunities that exist in different portions of the study area.

For the analysis, final display maps were produced in color at a scale of 1:70,400, or 1 inch = 1.1 miles, in a 33 inch X 44 inch format. For this report, black-and-white maps were prepared at page-size to facilitate reproduction. In most cases the black and white maps have been prepared as a scale of 1:246,600, or 1 inch = 3.9 miles. Though both smaller in scale than the color maps and simplified in terms of the number of categories, these page-size maps provide good representations of the patterns discussed in the text.

2. BASIC GIS CONCEPTS AND METHODOLOGY

The spatial analysis portion of this study was performed using geographical information system technology. A geographical information system, or GIS, is an integrated set of computer software that provides "a powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes" (Burrough, 1986, p. 6). By combining computer-assisted mapping capabilities with database management capabilities, a GIS provides the means of manipulating map data, analyzing individual maps, combining map data in numerous ways, and deriving answers to specific queries regarding spatial data. Results of the various manipulations and queries may then be used to generate maps, graphs and statistics.

The Arc/Info GIS software has been adopted by Metro for the implementation of their Regional Land Information System (RLIS) and the PC-based version of Arc/Info was used by Portland State University (PSU) for this project. In order to best understand the analyses, it is useful to be familiar with some of the basic terminology of GIS in general, and Arc/Info in particular. This section will present an overview of these basics.

2.1 Components of a GIS

The non-hardware portion of a GIS consists of two basic components -- a database of information and software for manipulating, analyzing and displaying the data. A GIS database consists of two primary classes of data:

1) geographic (or spatial) data that use coordinates to describe the position of features on the earth. These data provide the locational information that the GIS uses for spatial analysis, area calculations and map production.

2) attribute data consisting of measurements or qualities that characterize or describe information of a non-coordinate nature about individual features. These data provide the parameters on which most sort, search and tabulate operations are performed, and are the basis for many classifications, groupings and analyses of features.

The software, or GIS package, consists of a variety of computer routines for organizing, entering and editing data, asking questions about the data (i.e., querying the database), combining data to produce composite data sets, preparing statistical summaries, and producing maps. The software serves as a way of linking the two types of data, allowing the assignment of attributes or information to geographic features. It is this link-up of the geographic and the informational and the accompanying manipulation capabilities that imparts uniqueness to GIS technology and that distinguishes a geographical information system from other sorts of information systems.

2.2 Data Organization

When preparing a database to be used in conjunction with a particular software package, the phrases *building a GIS* or *developing a GIS* are often used. Implicit in this terminology is the notion that the GIS software and database are both components of a single system and must work in unison -- one without the other is not a GIS.

Building a GIS involves a number of operations. Primary among these is the entering of data into the system. The spatial data is put into the system through a process known as digitizing, which involves the recording of numbers or *digits* that represent coordinates describing the outlines of features on the map. Features are of three kinds: points, lines and areas (or polygons.) For this analysis, polygons representing the outlines of areas were by far the most common sort of feature dealt with. In a few instances, line features (e.g., roads or streams) were also used.

A key concern in the digitizing process is the map scale at which the data is digitized. All things being equal, a larger scale map will provide a greater level of detail and greater positional accuracy in the location of coordinates than will a smaller scale map. For example, property lines can be more precisely located on a 1 inch = 100 feet map (larger scale) than on a 1 inch = 2,000 feet map (smaller scale.) In such a case, the larger scale map is said to provide data with a higher or finer spatial resolution than a smaller scale map. The cost involved in obtaining higher resolution is the added time required to digitize at larger scales and the larger size data sets required to store the more detailed data. Thus, the choice of a map scale and its resulting resolution generally involves a trade-off between what would be optimal and what can be afforded or what is available inexpensively.

Spatial resolution is also a concern when comparing different sets of information. If two data sets are digitized at approximately equal scales, they are likely to have similar levels of spatial resolution and to be comparable in their levels of detail. However, if the difference in scale between two data sets is relatively great, it is likely that their levels of spatial resolution are very different and any but the grossest sort of comparison of the data sets is likely to be flawed.

Each digitized feature has assigned to it a numeric label or ID that the system uses to identify and recognize individual features. Operationally, the spatial data relating to a digitized feature are stored in a group of several data files and the unique ID attached to the same feature in different files serves to link together the variety of data associated with the feature in each of the files. Conceptually, the group of files can be considered as a single file of spatial information, and locational questions such as where particular features are located may be asked of the spatial file.

Separate, but directly related to the spatial data, is the attribute data, which includes characteristics or measurements for each of the features in the database. Attribute data is entered into a data file through the use of database software and is often manipulated within the database in an aspatial manner (e.g., to count how many features are of a particular kind, rather than to ask where the features are located). The numeric ID label that was assigned to each feature is also a part of this attribute file and allows the software to relate or associate the other attributes with the correct digitized features.

The file of digitized features constitutes the spatial data or *geographical* portion of the GIS. Attribute data represent the *information* portion of a geographical information system. Together the two kinds of files constitute the database portion of a GIS. A key step in building a database involves the process of ensuring that the spatial and attribute data can be linked up effectively. Once this verification has been performed, the combination of the geographic and the attribute data is called a coverage. Thus, a coverage is a set of related spatial and attribute map files, stored in the computer and available for use as data by GIS software.

2.3 Fundamental Analytical Operations of GIS Software

A number of analytical operations and manipulations are available within a GIS. Since the manipulations may generally be performed either individually or in conjunction with other operations, there are a wide variety of combinations possible, depending on the nature of the question being dealt with. In this analysis there were five operations that figured prominently, and each will be briefly described.

The first manipulation is the overlay operation, whereby one coverage (i.e., map) is laid over another to produce a third map that portrays the congruence of the two original map patterns. By performing sequential overlays of different maps, it is possible to produce a composite map of great complexity that incorporates a great deal of information concerning the correspondence between a variety of map attributes. Features in a composite coverage can retain the separate attributes that they held in the original coverages or can be identified with combinations of attributes from multiple coverages.

The second procedure is the eliminate operation, in which a particular group of features, having a specified characteristic, is removed from the map. When one coverage is overlain with another, there is rarely perfect correspondence between the delineation of the features on the two coverages. Even when a line is nominally at the same location on two different coverages, there will usually be at least a minor mismatch between the digitized representation in each of the coverages. These characteristically long, narrow areas between the mismatched lines are found along the edges of nearly-congruent larger polygons, often in a long series, forming a braid-like pattern. Though unintended, the areas created by these mismatched lines will be introduced as polygons in the newly-derived coverage. Due to their pointed, linear appearance, these bogus polygons are referred to as *slivers*.

Depending on the number and extent of the mismatches there may be a large proportion of sliver polygons produced. Slivers present a problem because they often occur in very large numbers, greatly enlarging the size of the new data file. It is not uncommon for half of the polygons in a composite coverage to be slivers. In addition, they generally are unwanted, since they do not represent any meaningful, real-world features. Fortunately, slivers can be easily identified and removed by the eliminate operation, which automatically dissolves the boundary between the sliver and one of its adjacent polygons, merging the sliver area into the adjacent polygon.

The third frequently-used procedure is the buffer operation, whereby the computer will identify and delineate a zone or area of a specified width surrounding a feature or features on the map. In effect, the width of the area serves as a *search radius* or delineation of a *zone of influence* around a feature. Once the buffer zone is delineated, it is possible to identify features within the buffer and tag them with a special code that distinguishes them and allows them to be manipulated independently.

The fourth procedure is the clip operation, where the pattern of features and the associated attribute data within a predefined boundary is extracted and a new coverage is produced that includes only these features. In essence, the clip operation allows the identification and isolation of features solely on the basis of their geography or location. Once identified, these features and their associated categories may be manipulated or mapped separately from other features in the coverage.

The fifth procedure may be loosely referred to as selection operations and actually consists of a group of closely-related manipulations. By specifying particular characteristics or ranges of attribute values, it is possible to differentiate or select out a desired group of features from a larger set. The new group of features may then be manipulated independently from other features. Thus, the selection operations allow the identification and isolation of categories of data based on attributes for a particular information class.

Understanding of the GIS concepts related to the terms coverage, overlay, sliver, eliminate, buffer, clip and select will facilitate the reader's understanding of the procedures used in the spatial analysis that follows.

3. DESCRIPTION OF PRIMARY COVERAGES

This section will present descriptions of the basic map layers or coverages that were employed in the spatial analysis of the Metropolitan Greenspaces. Each coverage will be discussed in detail and its key characteristics and spatial pattern described.

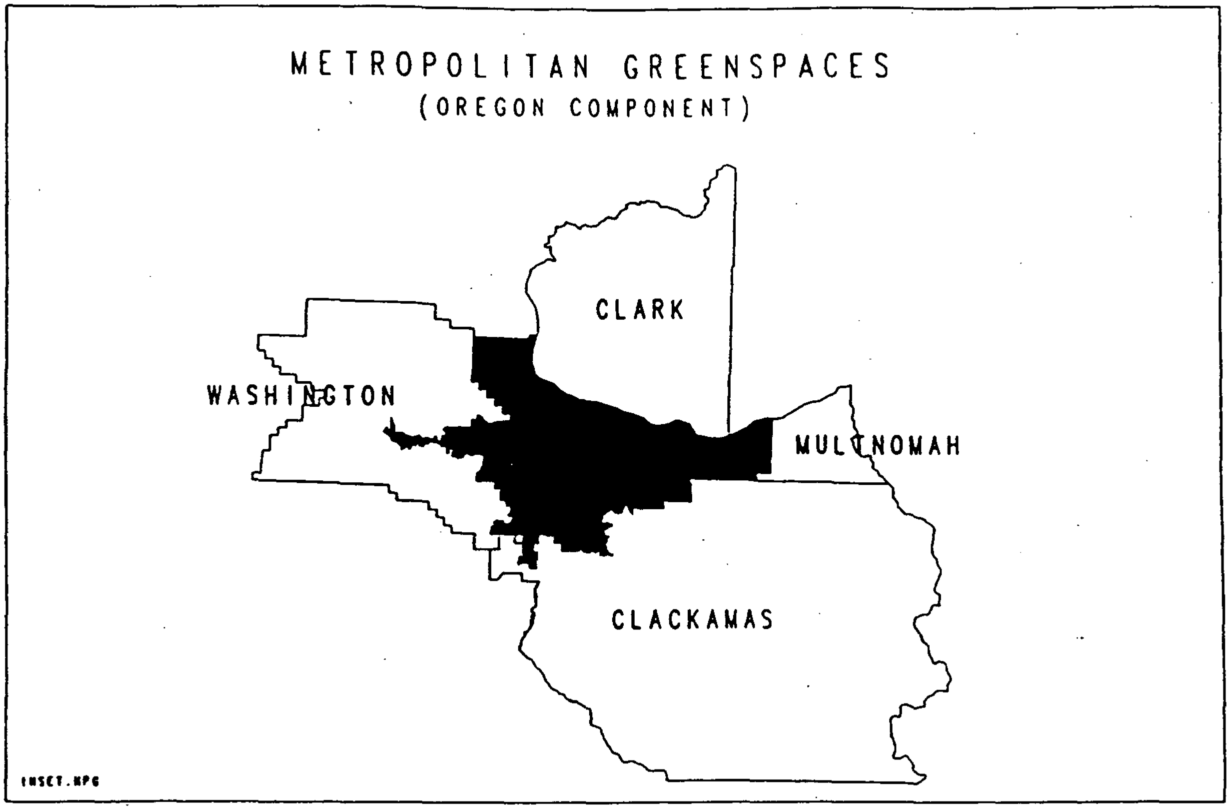
3.1 Study Boundary

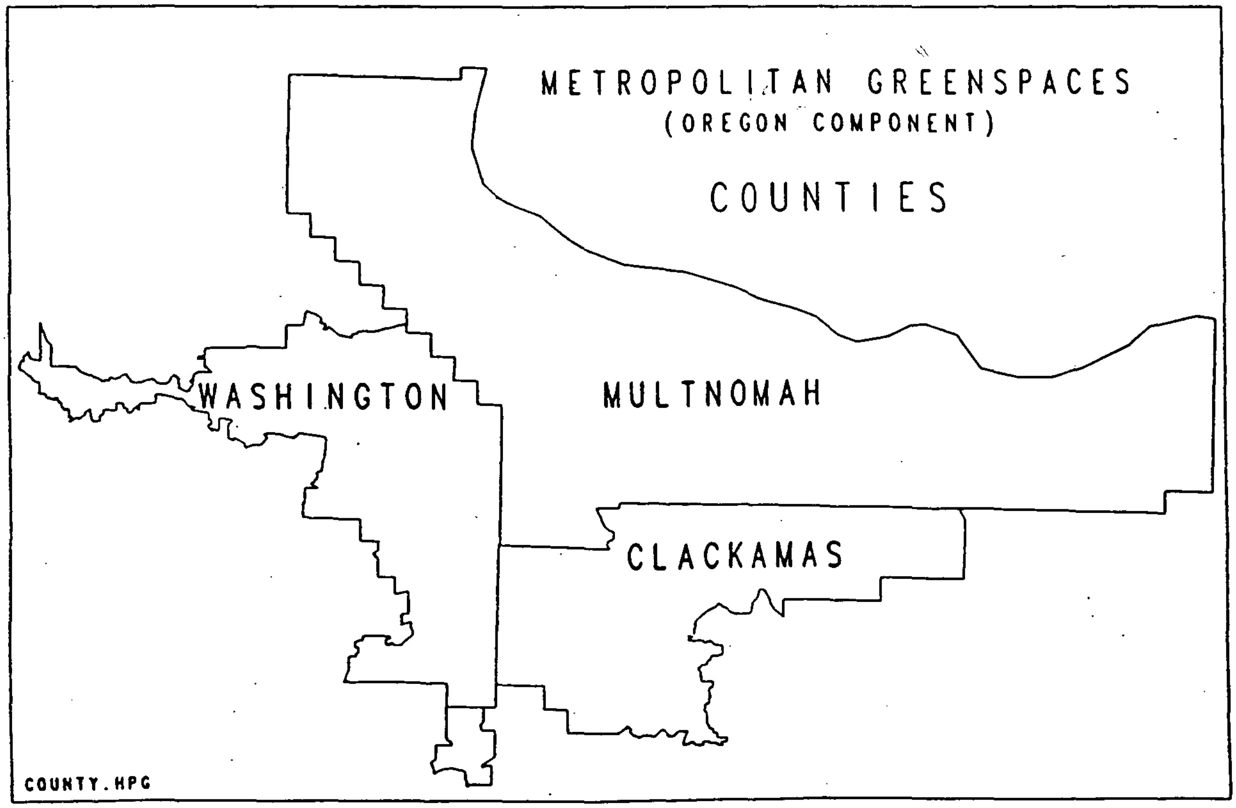
Since the study area has clearly-defined boundaries, a first step in the spatial analysis was to prepare a coverage that provided a delineation of the study area. This coverage was then used to define the study area boundaries during subsequent clip operations when data were extracted from coverages of areas larger than the study area.

The Oregon Component study area covers parts of three Oregon counties, as shown in Figure 1. The Oregon Component study area consists of two major pieces, as illustrated in Figure 2. The first piece is the 294,313 acres (460 square miles) of the Metro boundary, composed of portions of Multnomah, Washington and Clackamas Counties. The second piece is the remainder of Multnomah County outline, excluding the Mt Hood National Forest. Both the Metro boundary and the Multnomah County boundary coverages were obtained from Metro's RLIS. Note that the northern boundary of Multnomah County also corresponds to the Oregon-Washington state boundary along the Columbia River and thus represents the dividing line between the Oregon and Washington Components of the Metropolitan Greenspaces Program.

The Oregon Component covers the area from the Columbia River on the north to Wilsonville on the south, a distance of 23 miles, and from Forest Grove on the west to the boundary of the Mt. Hood National Forest east of the Sandy River, a distance

FIGURE 1


METROPOLITAN GREENSPACES
(OREGON COMPONENT)
CLARK
WASHINGTON
MULTNOMAH
CLACKAMAS
INSET.HPG


METROPOLITAN GREENSPACES
(OREGON COMPONENT)
COUNTIES
WASHINGTON
MULTNOMAH
CLACKAMAS
COUNTY.HPG

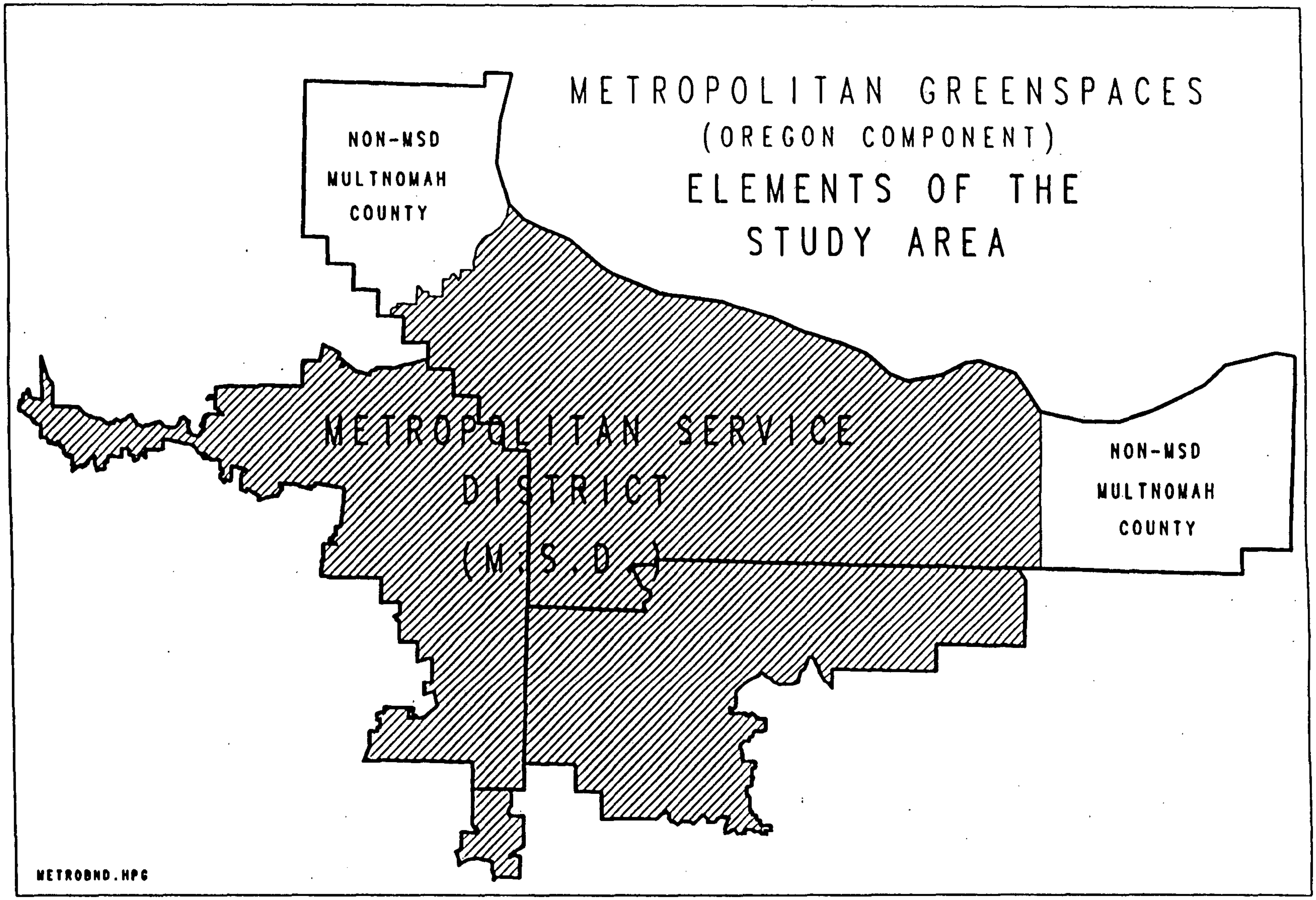

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
ELEMENTS OF THE
STUDY AREA
NON-MSD
MULTNOMAH
COUNTY
METROPOLITAN SERVICE
DISTRICT
(M.S.D.)
NON-MSD
MULTNOMAH
COUNTY
METROBND.HPG

FIGURE 2

of 36 miles. The irregular-shaped area encompassed by the study boundary is 372,682 acres (582 square miles.) Land within Multnomah County comprises 59 percent of the total area while land within Clackamas County and Washington County each accounts for just over 20 percent of the study area. The Metro boundary, which includes portions of all three counties, comprises almost 80 percent of the Oregon Component.

3.2. Natural Areas

Natural areas in the Oregon Component were mapped by visual interpretation of 1:24,000 (1 inch = 2,000 feet) scale color infrared aerial photographs acquired in May and June 1989. The map data was digitized at the interpretation scale into a PC-Arc/Info-based GIS and used to produce the natural areas coverage. Details of the mapping procedures are contained in Poracsky, Sharp and Lev (1991).

The natural areas map coverage produced by the inventory covered a somewhat larger area than the study area defined by the Oregon Component. Though the inventory coverage included some additional natural areas in all three counties, most notable was a large area surrounding Hagg Lake in western Washington County. In order to focus on the data within the defined area of interest, the inventory map was clipped with the study boundary coverage and these additional areas outside the study area boundary, including Hagg Lake, were eliminated.

The final clipped natural areas map that includes only the Oregon Component is shown in Figure 3 and includes 106,822 acres of natural area, representing 28.7 percent of the study area. On this map the natural areas are all shaded with a single solid tone, effectively masking out individual polygons outlines and visually aggregating all natural areas into a single map class.

The largest contiguous patches of natural area are in northwestern and eastern Multnomah County, and on Hayden Island and Government Island. Somewhat more fragmented but still moderately dense clusters occur along the southern portion of the map in western and northern Clackamas County. Natural areas in Washington County tend to be linear strips associated with streams. The other distinctive characteristic is the triangular wedge of developed -- and, therefore, non-natural -- area corresponding to the City of Portland.

Figure 4 portrays the natural areas without any shading, thus allowing the outlines of individual polygons to be seen and showing the complexity of the pattern of individual sites. The natural areas on the map consist of 3,031 different sites, recorded as individual polygons and classified into 105 different categories. Due to the regional scale of the mapping, there were minimum size limits nominally placed on the sites that were mapped. In wetland areas, sites smaller than one acre and, in upland areas, sites smaller than 10 acres, were generally not mapped. However, sites smaller than these nominal minimums were mapped if they were riparian (i.e., were adjacent to or contained water). A total of 40 percent of the sites mapped were smaller than the nominal minimum sizes, largely as a result of the great amount of water in the study area and the accompanying high percentage of riparian areas.

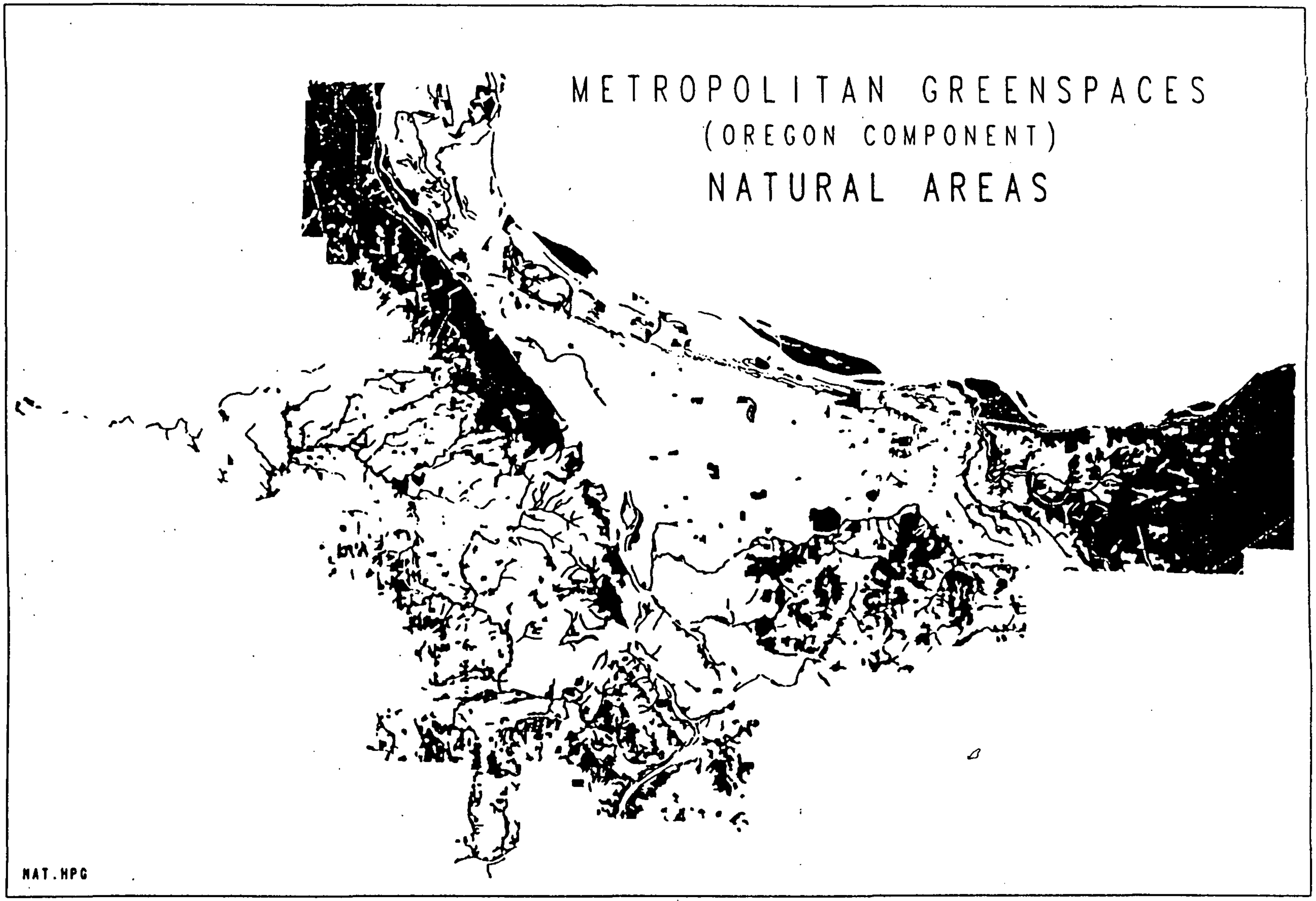

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS
NAT.HPG

FIGURE 3

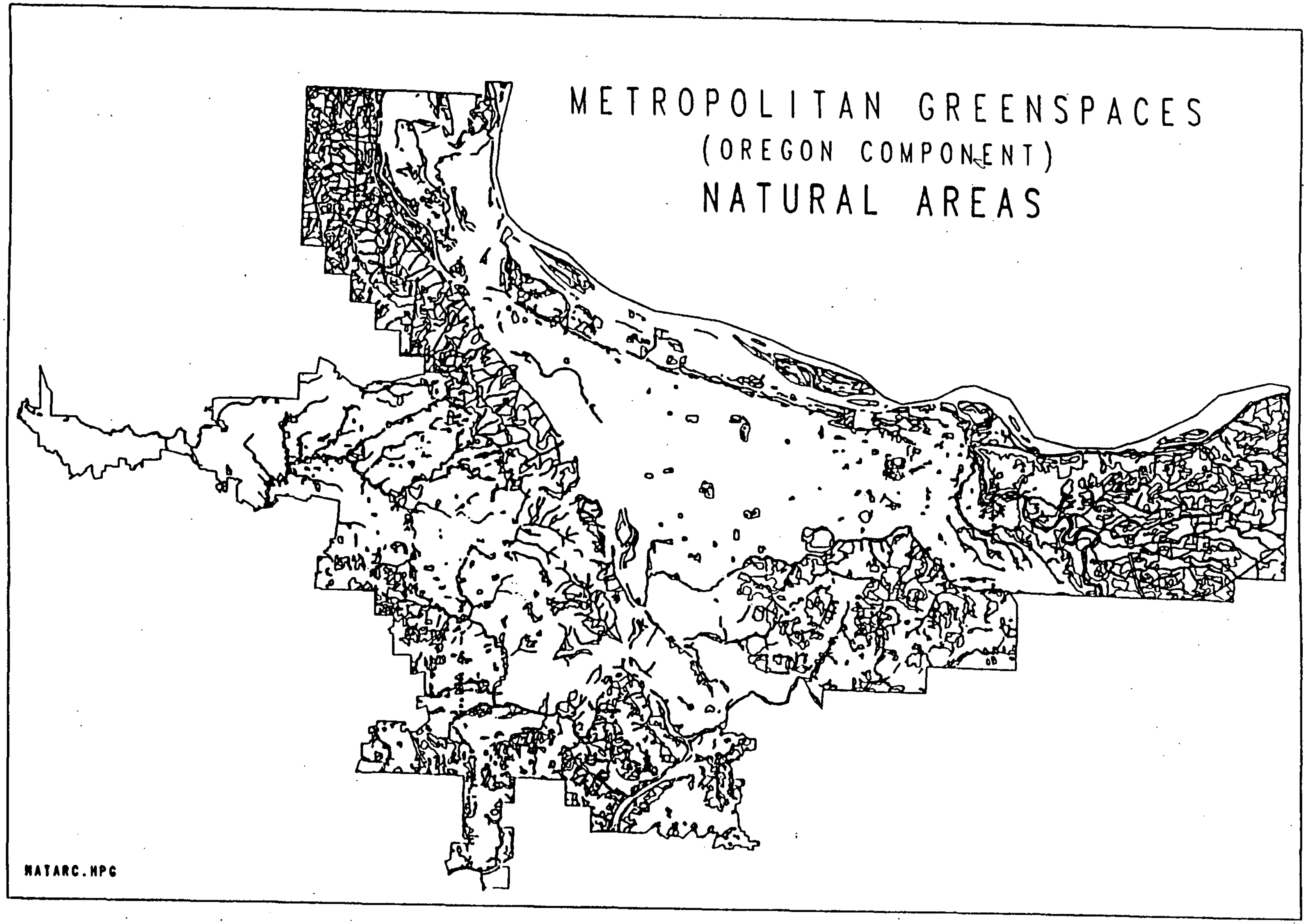

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS
NATARC.HPG

FIGURE 4

In distinguishing natural areas, four separate parameters are considered:

1) the wetland or upland character of the site; designated by codes W and U;

2) the basic vegetation cover type (forest, shrub-scrub, meadow, clearcut, rock, bare ground) and, in the case of woody vegetation classes, spacing of the crowns (closed, open and scattered); designated by codes FC, FO, FS, SC, SO, SS, M, CC, R and B;

3) deciduous-coniferous proportions within a woody vegetation site, expressed as percent deciduous, in 10 percent increments from 10 - 99 (representing 100 percent);

4) riparian situation (i.e., adjacent to or containing a water body); designated as R or no R (blank.)

Each site is assigned to a particular class relative to the parameter and that class becomes attribute data in the database. Identification of a site by a combination of all parameters indicates the category of natural area to which the site belongs.

Potentially, there are 280 categories that can result from the various combinations of the four parameters. However, each of the combinations does not represent a likely ecological situation within the local environment, and only 105 categories were actually identified on the maps.

Statistical summaries for the natural areas are contained in two tables. Table 1 lists the number of sites in each category and Table 2 lists the acres in each category. The discussion which follows is based on the data summarized in these tables.

Upland/Wetland Parameter

One parameter of the classification system indicates whether the site was photo interpreted as a wetland or an upland. There are a total of 418 wetland sites, covering 6,843 acres and constituting 6.4 percent of the acres of natural area. The size of wetland sites varied from less than one acre to 137.9 acres, with a mean of 16.4 acres and a median of 8.7 acres.

Figure 5 portrays the distribution of wetland sites. The distribution pattern, as would be expected, is closely associated with low-lying areas adjacent to water bodies, often in the flood plain of a river or creek. Generally, the larger the water body, the larger and more numerous the wetlands. Thus, the majority of the wetlands are found along the Columbia River, on Sauvie Island and adjacent to the Multnomah Channel. An area of secondary concentration is found in Washington County, associated with the broad floor of the Tualatin Valley and the meandering Tualatin River and its tributaries.

TABLE 1

Natural Areas: Number of Sites

Upland Non-Riparian	FC	FO	FS	SC	SO	SS	CC	M	R/B
	-	-	-	-	-	-	32	155	4
10	106	7	1	-	-	-	-	-	-
20	87	9	4	-	-	-	-	-	-
30	74	8	4	-	-	-	-	-	-
40	84	14	5	-	-	-	-	-	-
50	87	8	8	3	-	-	-	-	-
60	83	18	3	2	-	-	-	-	-
70	96	6	3	-	-	1	-	-	-
80	104	26	11	1	9	-	-	-	-
90	180	39	29	8	16	15	-	-	-
99	102	41	34	27	21	40	-	-	-
	1,003	176	102	41	46	56	32	155	4
Upland Riparian									
	-	-	-	-	-	-	3	191	18
10	12	1	-	-	-	-	-	-	-
20	24	-	1	-	-	-	-	-	-
30	20	2	-	-	-	-	-	-	-
40	32	4	-	-	-	-	-	-	-
50	34	-	1	-	1	-	-	-	-
60	37	4	2	1	-	-	-	-	-
70	42	8	-	-	-	-	-	-	-
80	58	15	3	-	-	-	-	-	-
90	105	31	12	-	4	4	-	-	-
99	148	105	33	13	11	18	-	-	-
	512	170	52	14	16	22	3	191	18
Wetland Non-Riparian									
	-	-	-	-	-	-	-	138	5
10	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
90	5	1	2	-	-	-	-	-	-
99	20	11	3	4	6	3	-	-	-
	25	12	5	4	6	3	0	138	5
Wetland Riparian									
	-	-	-	-	-	-	-	88	14
10	1	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-
60	-	1	-	-	-	-	-	-	-
70	2	1	-	-	-	-	-	-	-
80	-	1	-	-	-	-	-	-	-
90	7	3	1	-	-	-	-	-	-
99	35	20	13	21	8	4	-	88	-
	45	26	14	21	8	4	0	88	14
	1,585	384	173	80	76	85	35	572	41

TABLE 2

Natural Areas: Acres

Upland Non-Riparian	FC	FO	FS	SC	SO	SS	CC	M	R/B
	-	-	-	-	-	-	1,092	4,442	19
10	4,232	92	31	-	-	-	-	-	-
20	5,523	527	33	-	-	-	-	-	-
30	4,298	651	371	-	-	-	-	-	-
40	6,423	516	88	-	-	-	-	-	-
50	6,626	119	376	235	-	-	-	-	-
60	6,327	514	257	56	-	-	-	-	-
70	10,596	168	121	-	-	17	-	-	-
80	9,064	590	273	59	495	-	-	-	-
90	8,678	1,372	618	308	450	420	-	-	-
99	2,290	873	735	1,025	504	1,34	-	-	-
	64,057	5,422	2,903	1,683	1,449	1,786	1,092	4,442	19
Upland Riparian									
	-	-	-	-	-	-	19	1,441	398
10	91	3	-	-	-	-	-	-	-
20	254	-	5	-	-	-	-	-	-
30	282	16	-	-	-	-	-	-	-
40	665	62	-	-	-	-	-	-	-
50	522	-	21	-	7	-	-	-	-
60	831	86	12	4	-	-	-	-	-
70	1,276	133	-	-	-	-	-	-	-
80	1,684	350	71	-	-	-	-	-	-
90	3,008	517	199	-	24	17	-	-	-
99	3,210	1,201	225	158	164	170	-	-	-
	11,823	2,368	533	162	195	187	19	1,441	398
Wetland Non-Riparian									
	-	-	-	-	-	-	-	2,245	33
10	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
90	79	5	34	-	-	-	-	-	-
99	323	226	34	85	138	37	-	-	-
	402	231	68	85	138	37	0	2,245	33
Wetland Riparian									
	-	-	-	-	-	-	-	1,434	206
10	2	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-
60	-	13	-	-	-	-	-	-	-
70	10	12	-	-	-	-	-	-	-
80	-	12	-	-	-	-	-	-	-
90	108	73	7	-	-	-	-	-	-
99	564	346	275	386	75	79	-	-	-
	684	458	282	386	75	79	0	1,434	206
	76,966	8,479	3,786	2,316	1,857	2,089	1,111	9,562	656

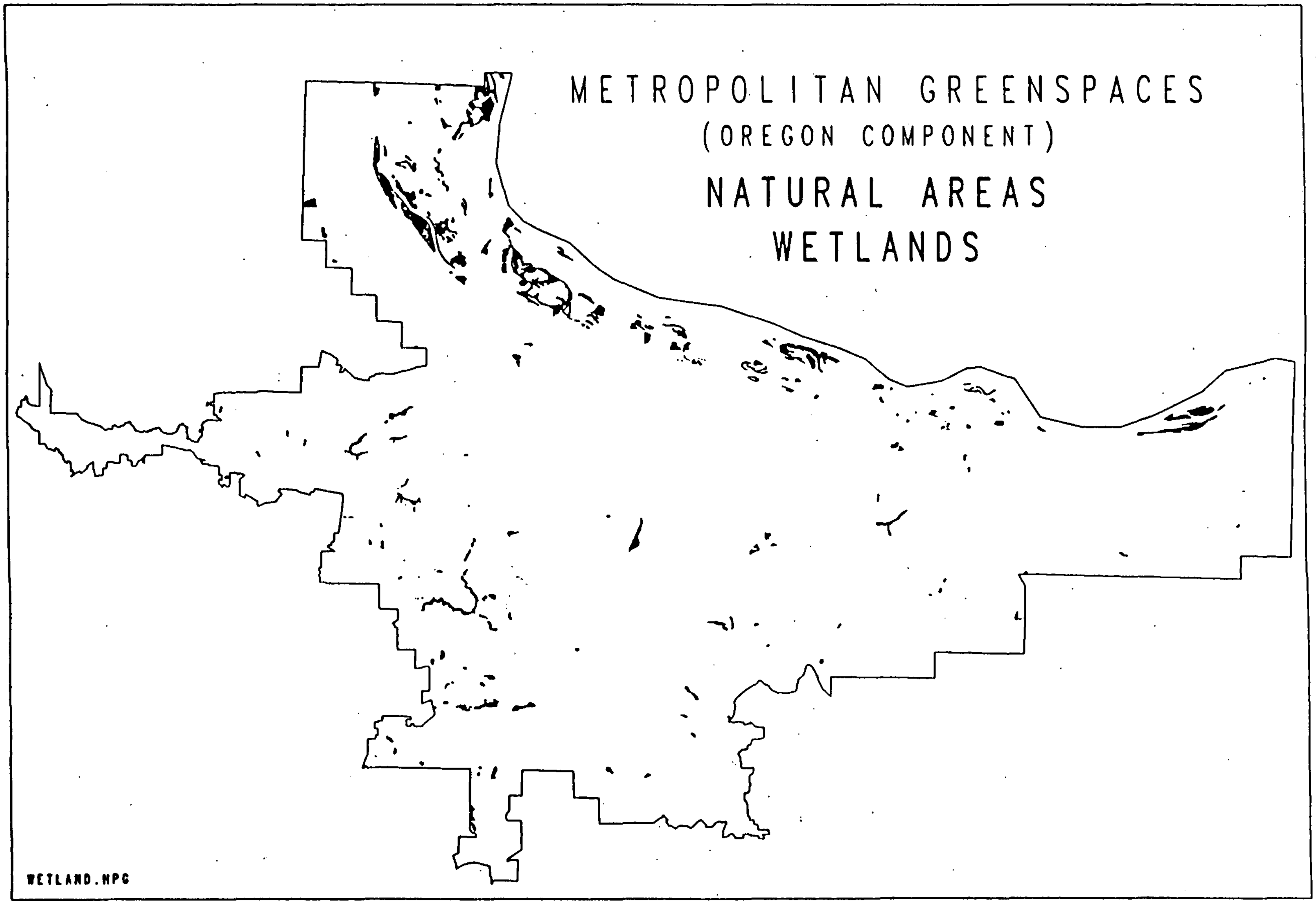

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS
WETLANDS
WETLAND.MPG

FIGURE 5

However, two areas on the map do not fit this pattern and are of note for the lack of wetlands adjacent to major water bodies. The Willamette, the second largest river in the study area, historically had numerous wetlands in the vicinity of Portland, but most of them have been filled during the course of urbanization. The two major remnants are Oaks Bottom and some areas just down river from Mocks Crest. A second major water body, the Sandy River, has wetlands of significant size only in the delta area at its mouth. This is due to the generally steep-sided character of the Sandy River Gorge and the absence of a wide floodplain.

It should be noted that the mapped wetlands were identified solely on the basis of interpreter judgement of aerial photographs. Wetlands in this study were not identified from a regulatory perspective, which is the task of the U. S. Army Corps of Engineers and the Oregon Division of State Lands.

Upland sites (i.e., those natural areas that are not wetlands) total 2,613 in number and 99,979 acres in area, constituting 93.6 percent of the acres of natural area. Sizes of upland sites vary from less than one acre to 988.3 acres, with a mean of 38.3 acres and a median of 14.4 acres.

Though the smallest nominal size for mapping upland sites was 10 acres, there are a large number on the map that are smaller. This comes about from two sources. First, if the interpreter was uncertain whether a site was at least 10 acres, it would be mapped anyway. This strategy results in a number of sites that may be perhaps 7 to 10 acres in size.

Second, in the case of a large group of contiguous natural areas, the interpreter will initially draw a boundary that encompasses the entire group. Having thus identified the whole as a natural area, they next proceed to delineate different categories within it, e.g, different canopy closures, different percent mixes of deciduous, and riparian vegetation strips. Very frequently, there are small areas between the individually delineated categories that are different enough than any of the adjacent categories that they are labelled separately; often, these *between* areas are smaller than the 10-acre minimum size, but since they are part of a larger unit, are retained.

Thus, in regard to the 10-acre minimum size for upland sites, it is best understood as the smallest size isolated upland area that the interpreter would delineate. In addition, the interpretation will err on the side of including an area that might be too small rather than on the side of omitting an area that might be too large.

Figure 6 portrays the pattern of upland sites. Note that uplands are such a large proportion of the total natural areas that the upland map is very dense and is hardly distinguishable from the total natural areas map. One major exception area is along the Columbia River, where the uplands map is noticeably sparser than the total natural areas map.

Vegetation Cover Parameter

Another parameter of the classification system indicates the vegetation cover of the site as interpreted from the aerial photographs. This parameter includes 10 classes.

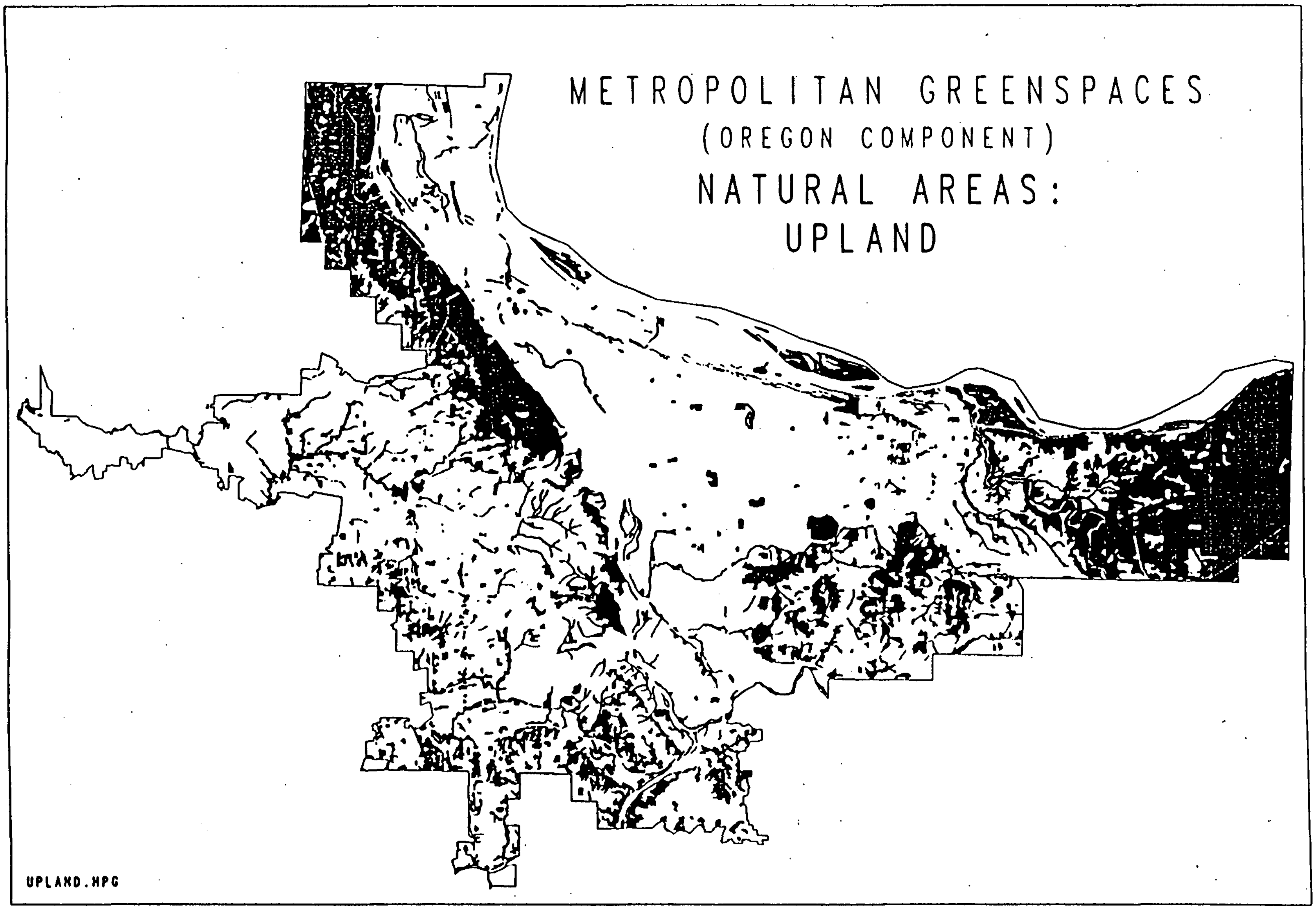

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
UPLAND
UPLAND.HPG

FIGURE 6

Class 1 is **forest** (sites dominated by trees, defined as woody vegetation over 15 feet in height) with a **closed canopy** (FC.) Classes 2 and 3 are **forest open canopy** (FO) and **forest scattered canopy** (FS.) The combined forest classes consist of 2,142 sites totalling 89,231 acres, or 83.5 percent of the acres of natural area. Individual sites vary in size from 0.2 acre to 988.3 acres, with a mean of 41.7 acres and a median of 15.4 acres. The numbers clearly indicate that the forest classes constitute, by far, the largest vegetation class of all the natural areas. The predominance of the forest classes is reinforced visually in Figure 7. Comparison of this map with Figure 3 reveals only a slightly smaller shaded area on the forest map than on the map of all natural areas.

Considering each of the three canopy closures separately reveals that the forest closed canopy category includes 1,585 sites and covers 76,966 acres or 72.1 percent of all natural areas. The 384 sites and 8,479 acres of forest with open canopy constitute 7.9 percent of all natural areas, and the 173 sites and 3,786 acres of forest scattered canopy forest constitutes 3.5 percent of the acres of natural area. Clearly, the closed canopy forest is the dominant class among the three forest classes and among all vegetation types in the study area. In addition, the closed canopy forest class has the largest mean size of all the forest classes at 48.6 acres, compared to means of 22.1 acres and 21.9 acres for the open and scattered canopy forests, respectively.

Figure 8 indicates that the closed canopy forest is widely distributed over the entire area. Figures 9 and 10 show a less dense pattern, though a wide distribution, for the open and scattered canopy forests. Both maps also seem to indicate a somewhat lower relative proportion of open and scattered canopy forests in the large forested patches of northwestern and eastern Multnomah County.

Shrub-scrub vegetation describes sites dominated by shrubs, defined as woody vegetation between 3 and 15 feet in height. As with the forest classes, shrub-scrub is divided into three classes based on the canopy closure. Class 4 is **shrub-scrub** with a **closed canopy** (SC) and classes 5 and 6 are **shrub-scrub open canopy** (SO) and **shrub-scrub scattered canopy** (SC.) The three forest classes and the three shrub-scrub classes together constitute the woody vegetation class.

The combined shrub-scrub classes consist of 241 sites totalling 6,262 acres, or 5.9 percent of the acres of natural area. Individual sites vary in size from 0.6 acre to 143.6 acres, with a mean of 26 acres and a median of 14.6 acres.

Figure 11 presents the map of the combined shrub-scrub classes. Three patterns of association can be identified. First, there are clusters of shrub-scrub at either end of Multnomah County and in a sparse band of curving along the southern portion of the map in Clackamas County. These are probably transition areas, consisting of former clearcut areas in hilly areas that are in the process of regenerating into forests. Second, there is a sparse but noticeable band of shrub-scrub areas associated with the wetlands along the Columbia River. Third, there is a conspicuous lack of shrub-scrub sites in the Washington County portion of the study area. This is likely the result of the intensive agricultural land use in this area which has turned many potential wetland shrub-scrub areas into wetland fields.

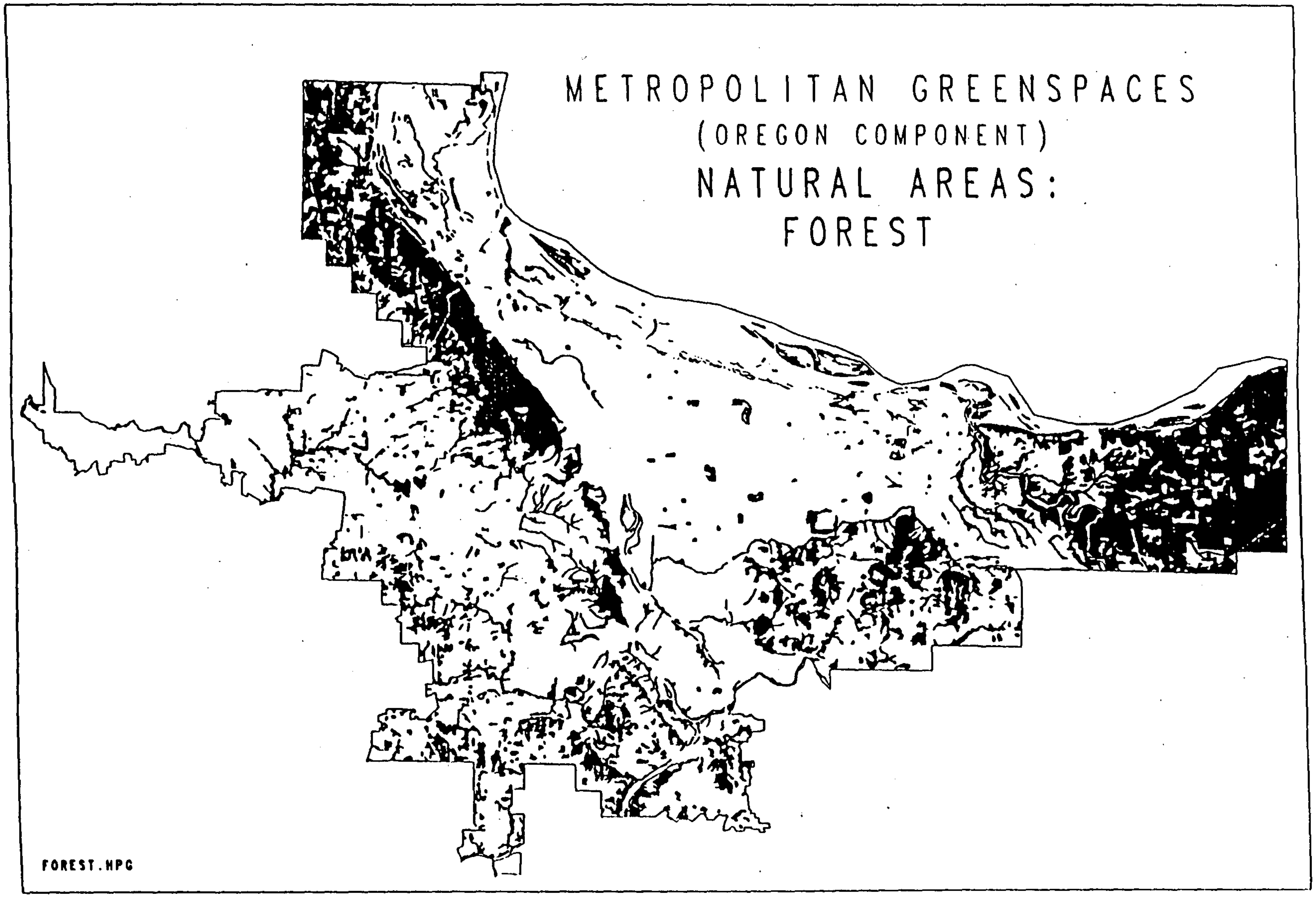

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
FOREST
FOREST.HPG

FIGURE 7

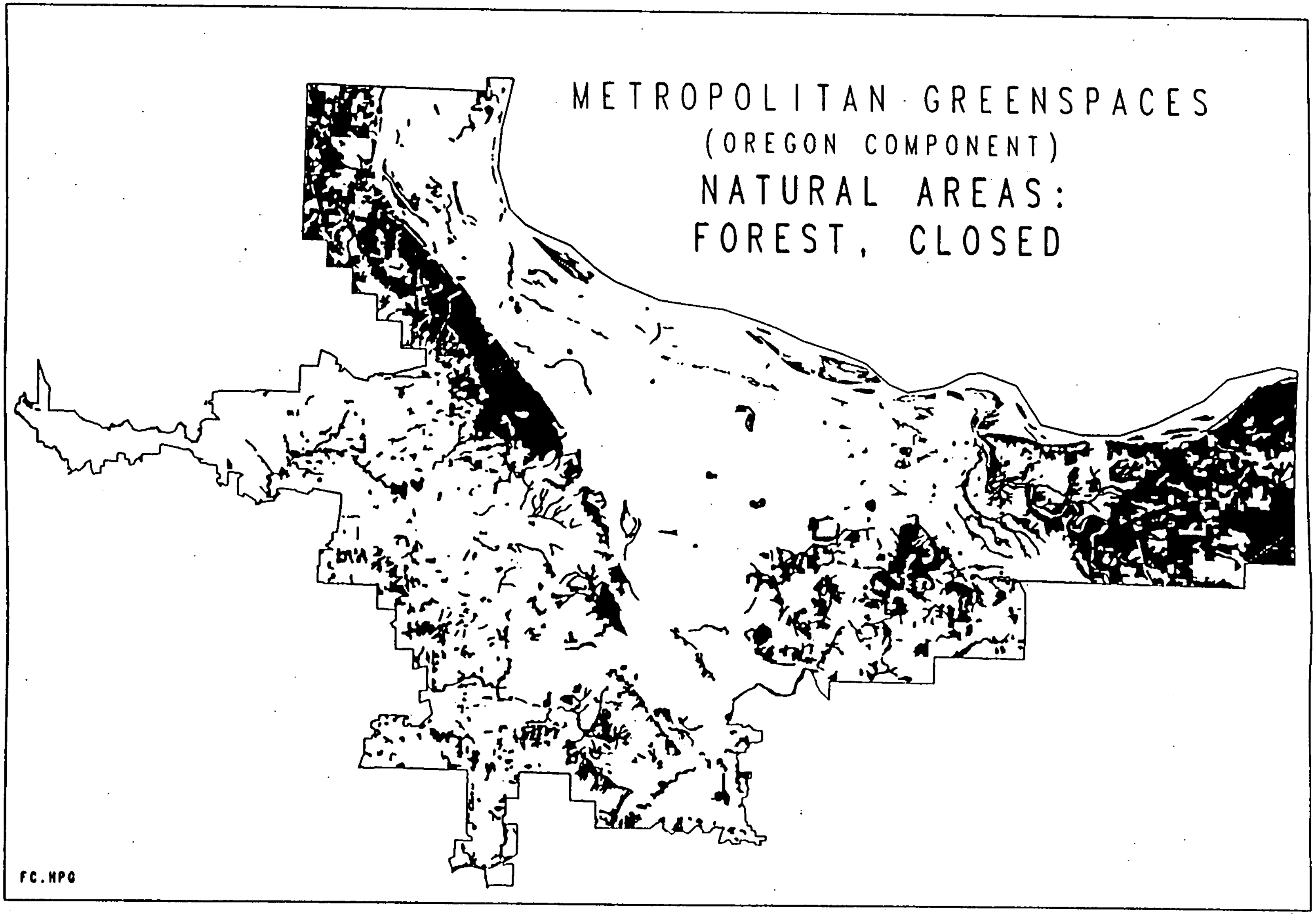

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
FOREST, CLOSED
FC.HPG

FIGURE 8

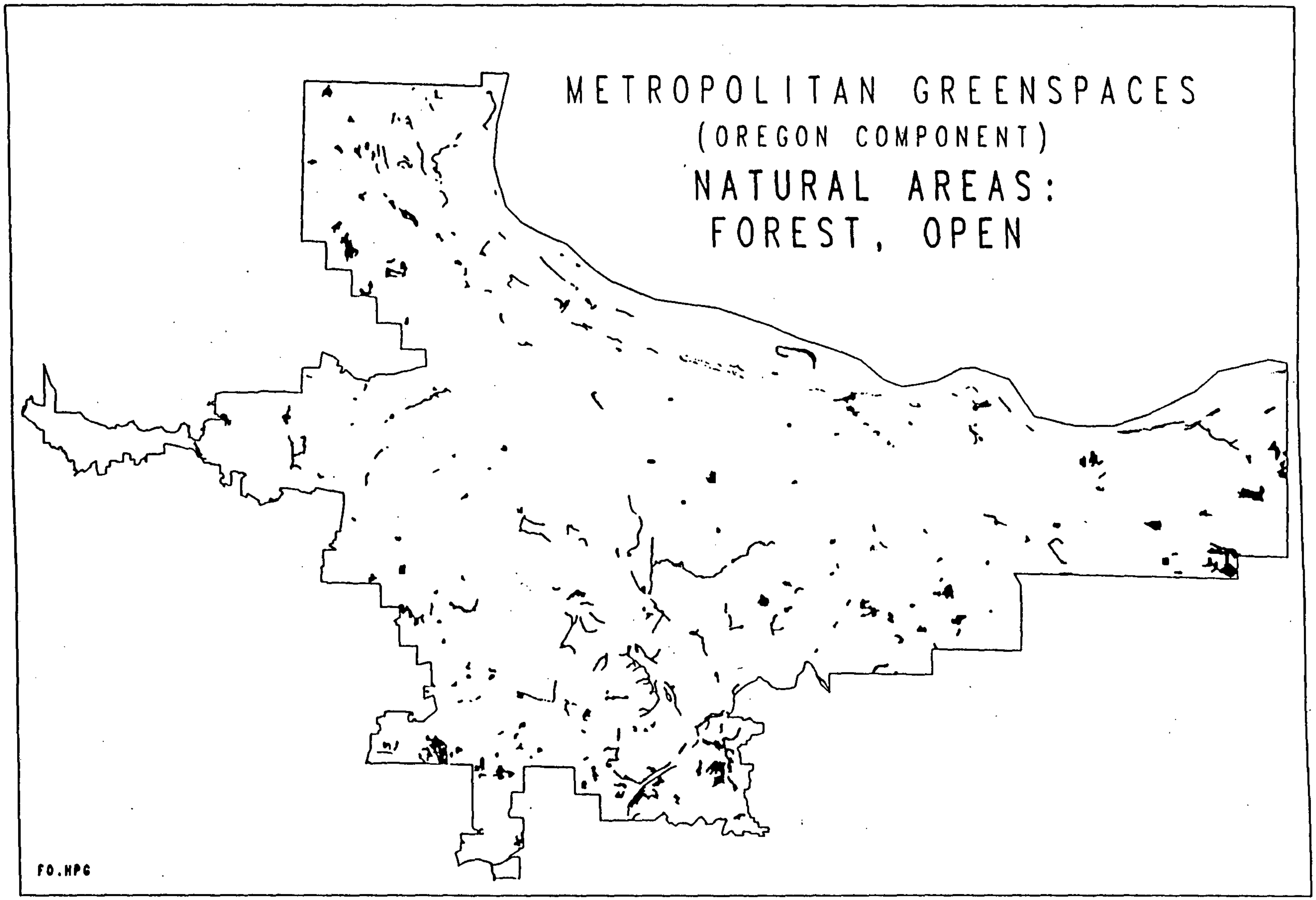

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
FOREST, OPEN
FO.HPG

FIGURE 9

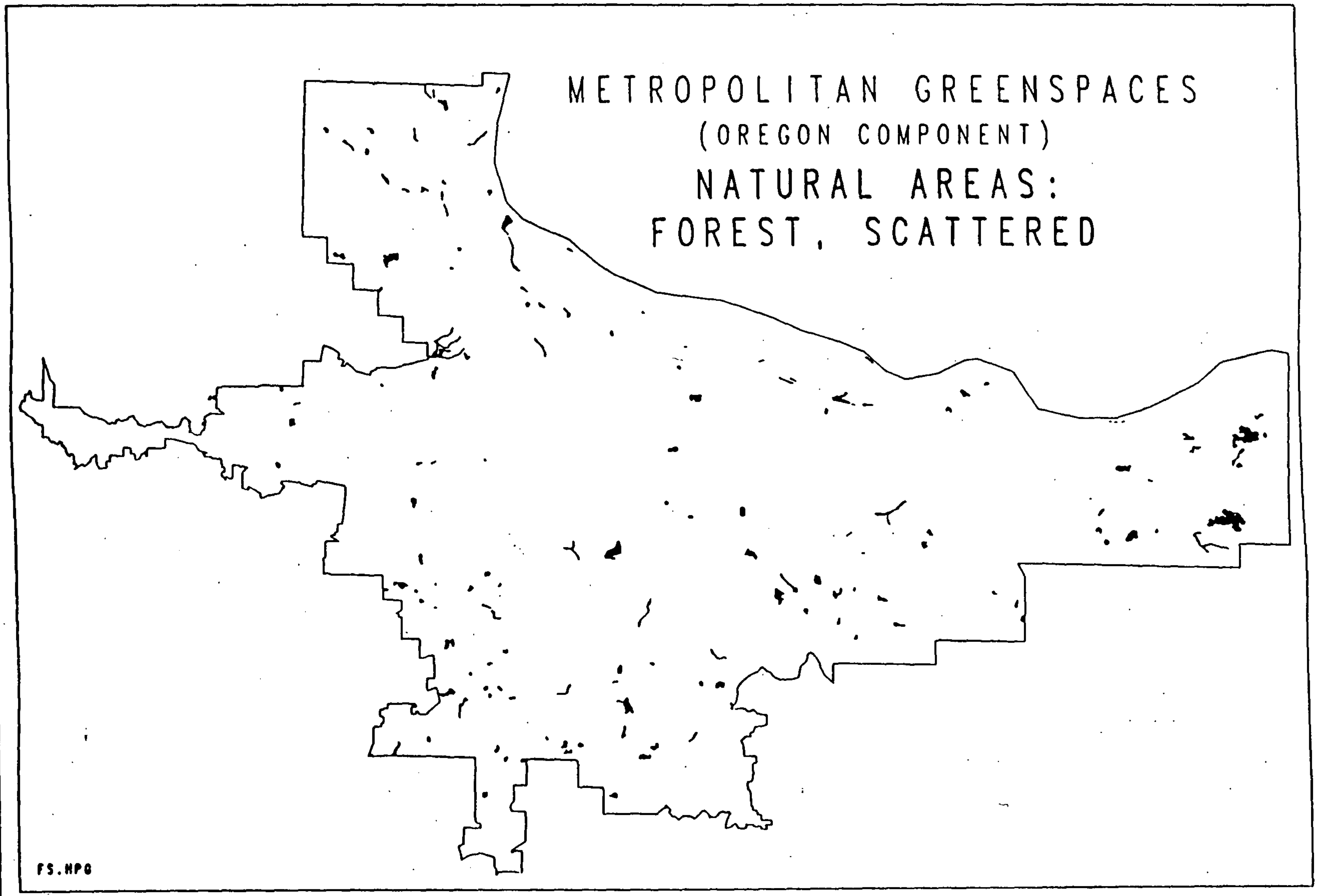

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
FOREST, SCATTERED
FS.MPG

FIGURE 10

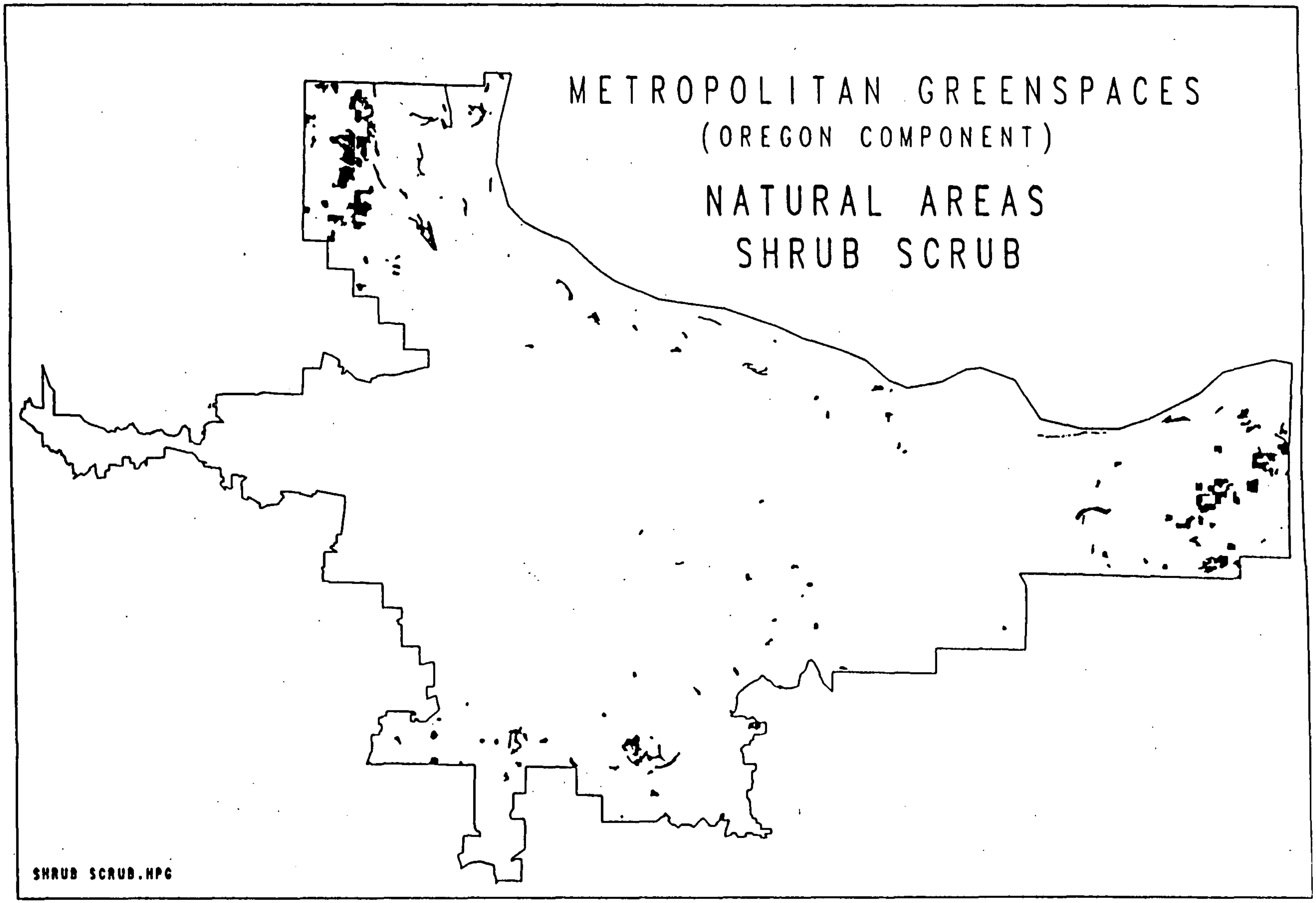

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS
SHRUB SCRUB
SHRUB SCRUB.HPG

FIGURE 11

Considered separately, there is not a great deal of difference between either the number of sites or the acreage of the these three canopy closures. Shrub-scrub closed canopy forest includes 80 sites, covering 2,316 acres or 2.2 percent of all natural areas. The 76 sites and 1,857 acres of shrub-scrub with open canopy constitute 1.7 percent of all natural areas, and the 85 sites and 2,089 acres of shrub-scrub scattered canopy constitutes 2 percent of the acres of natural area. There are no major difference in the mean sizes of the sites, with figures of 29 acres for closed canopy, 24.4 acres for open canopy, and 24.6 acres for scattered canopy.

Maps of the three shrub scrub classes are shown in Figures 12, 13 and 14. Each individual class map is similar in pattern to the combined map, with the exception of the scattered canopy map, which appears to have relatively more sites in northwestern Multnomah County and northern Clackamas County than the other maps, and a lack of sites along the central Columbia River.

Class 7 is **clearcuts** (CC), tracts of formerly forested areas that have either been recently logged (generally no more than about three years earlier) and are in the early stages of regeneration. Clearcuts tend to be dominated by grasses and other non-woody vegetation, but usually have a large amount of woody debris and -- depending on the age of the clearcut -- varying amounts of seedlings or very young trees.

A key characteristic of a clearcut, resulting from the fact that it is an artificial, heavily human-impacted area, is that successional processes within a clearcut tend to happen at an accelerated rate. Natural ecological processes, either working alone or assisted by human replanting efforts, will cause the grass-dominated environment to change dramatically in a short time. Clearcut is generally a transitional or temporary category, changing in a matter of a few years from an open, meadow-like area to shrub-scrub-dominated vegetation, and in a few more years returning back to forest.

There are 35 clearcut sites, totalling 1,111 acres, or 1 percent of the acres of natural area. Individual sites vary in size from 2.2 acres to 272.2 acres, with a mean of 31.7 acres and a median of 14.3 acres.

The map of clearcuts is presented in Figure 15 and it is readily apparent that the pattern of occurrence of these areas is both sparse and very localized. The two primary clusters of clearcuts are in northwestern and eastern Multnomah County, in areas of higher elevation that are dominated by forest, privately-owned, and prime logging sites within the study area. A large forested area that is notable for its lack of clearcuts is the approximately 5,000 acres just west of Portland, protected from logging by the fact that it is the City of Portland-owned Forest Park.

Class 8 is **meadows** (M) and includes grasslands, old fields, upland and wetland meadows, and emergent wetlands. It should be noted that some discrepancies were noted between the map of meadows and the field observations. Some areas identified as meadows may likely have been pasture or hayfields and some areas that should have been called meadows were likely ignored as being either pastures or hayfields. Since there was a one- or two-year difference between the date of the flight and dates of the field work, it was not possible to determine if the

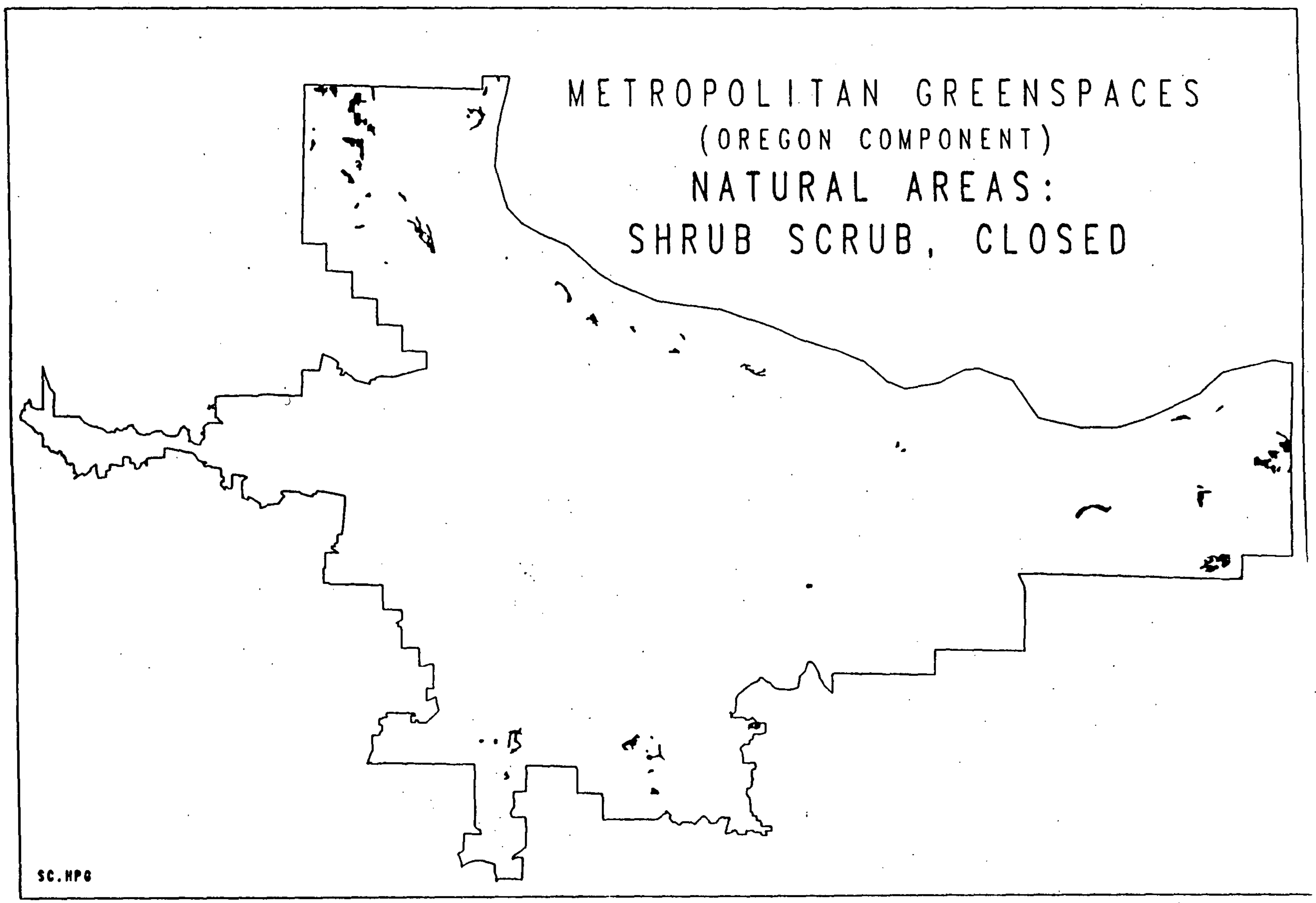

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
SHRUB SCRUB, CLOSED
SC.HPG

FIGURE 12

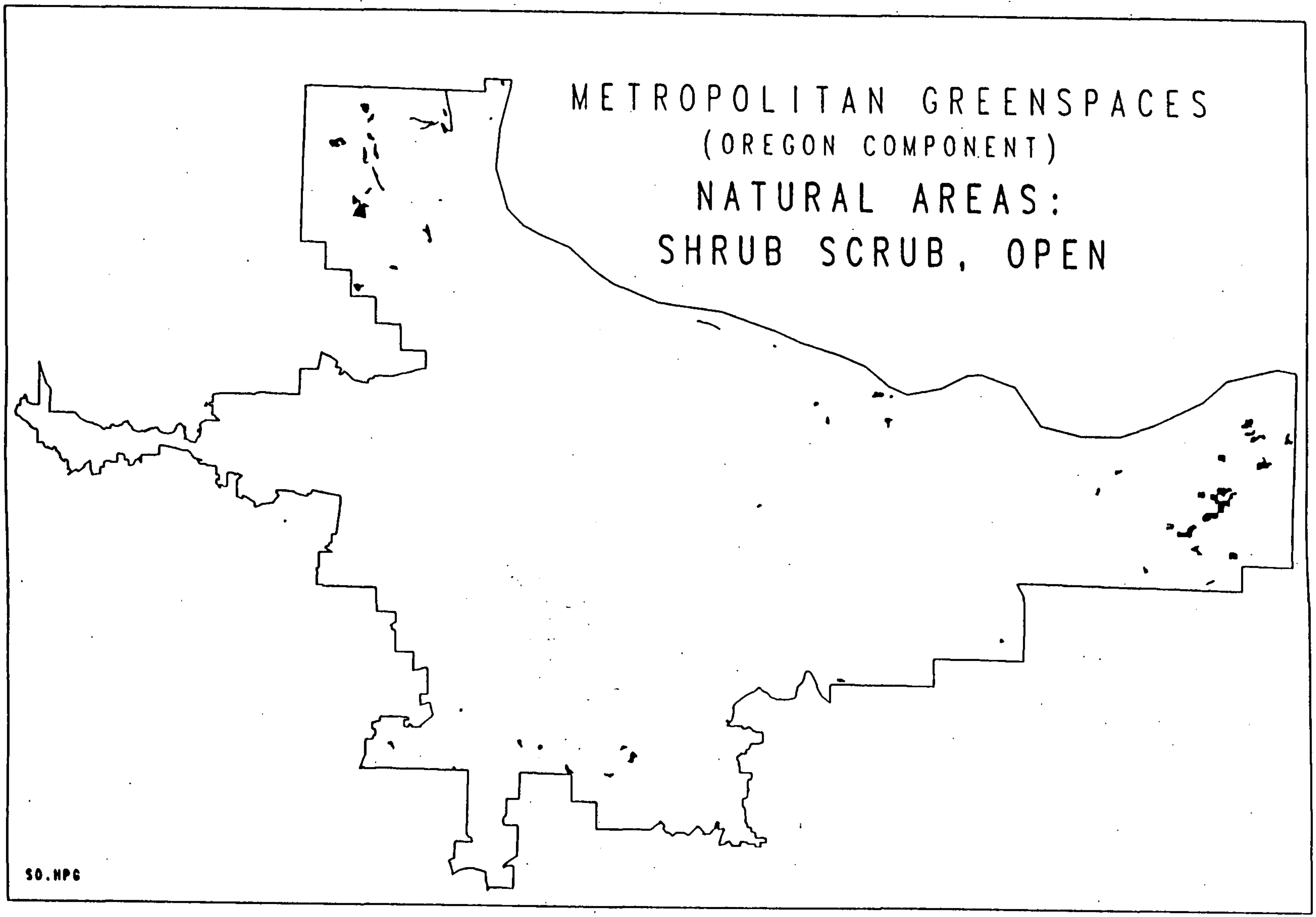

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
SHRUB SCRUB, OPEN
SO.HPG

FIGURE 13

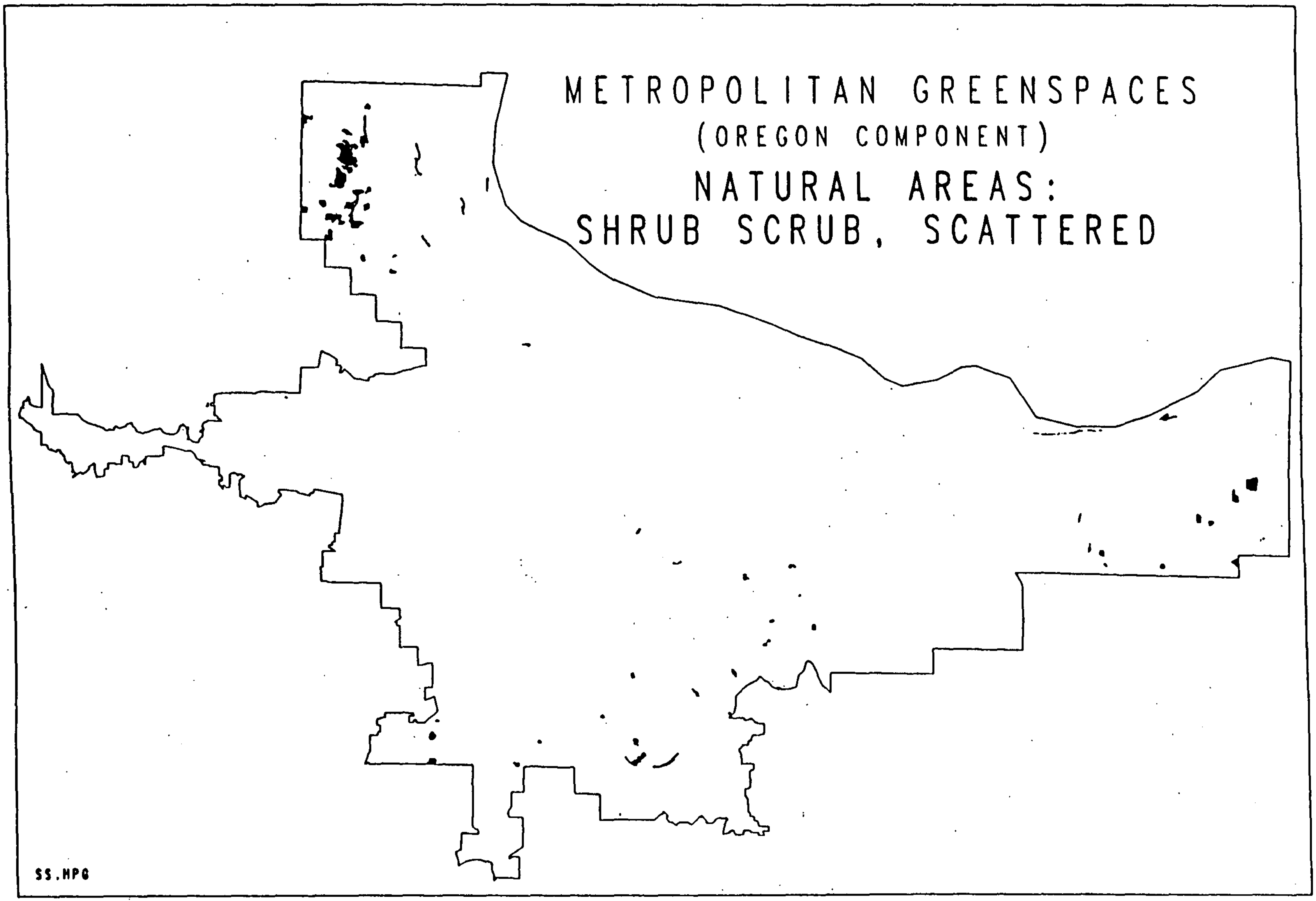

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
SHRUB SCRUB, SCATTERED
SS.HPG

FIGURE 14

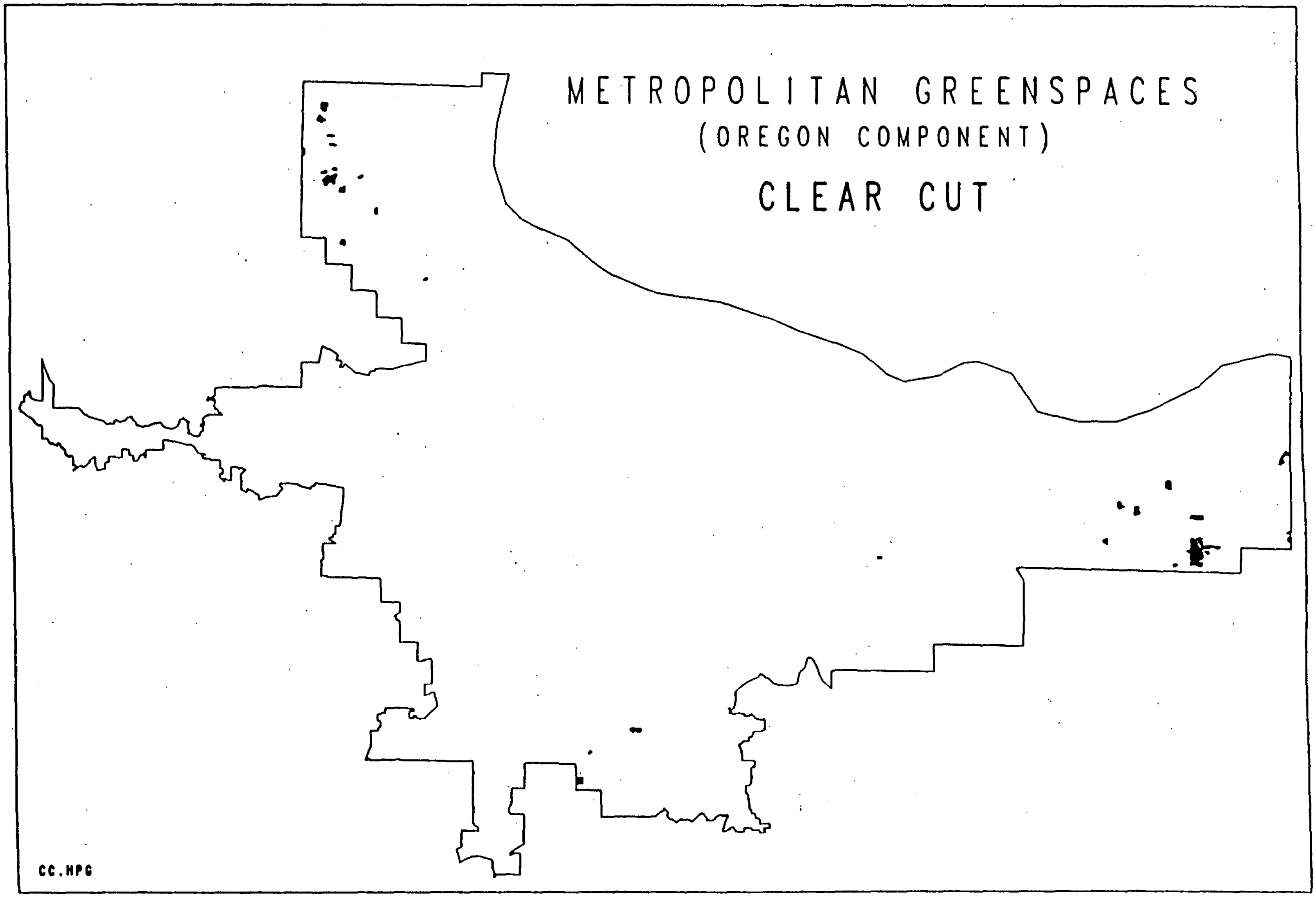

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
CLEAR CUT
CC.HPG

FIGURE 15

discrepancies were real, or due to changes in land use, or due to the timing of the flight relative to cutting and grazing dates. As a result, there may be either an underestimation or an overestimation in the meadow area mapping. However, the data discussed here represents the best estimation of the interpreters from the available remote sensing data.

As determined from the photo interpretation process, the meadow class includes 572 sites totalling 9,562 acres, or 9 percent of the total acres of natural area. Individual sites vary in size from 0.3 acre to 510.1 acres, with a mean of 16.7 acres and a median of 7.4 acres.

The map of meadows is presented in Figure 16 and indicates a pattern of wide dispersal throughout the study area, broken only by the conspicuous blankness of the developed triangle of Portland. Many of the meadows are in more low-lying areas, often associated with water, and these are likely to be emergent wetlands. This association is most apparent in the band of relatively large patches along the Columbia River, Multnomah Channel and on Sauvie Island. No other vegetation class map has as high a relative density along the Columbia River.

Other less-dense concentrations of smaller, linear bands, especially in Washington County, also tend to be associated with stream courses. There are relatively few meadows associated with higher elevations and greater relief, though the exceptions of Powell Butte in south central Multnomah County and a couple large patches in northwestern Multnomah County are especially notable.

It has been suggested that in earlier times meadows were much more common, especially in the upland areas of Washington County. The origin of these former meadows was human-activity, initially burning and, more recently, mowing. In recent years, many of these former meadow areas have been built on.

Class 9 is **rock outcrops** (R), and class 10 is **bare soil** (B.) These classes both include only a very few small areas and are similar in that they are both non-vegetated; as a result, they are combined into a single class for statistical reporting and discussion. Together, these two classes consist of 41 sites totalling 656 acres, or 0.6 percent of the acres of natural area. Individual sites vary in size from 0.5 acre to 150.2 acres, with a mean of 16 acres and a median of 6.9 acres.

Figure 17 is the map of rock outcrops and bare soil. The distribution is very sparse and localized, representing primarily sand and gravel bars along the Columbia and Sandy Rivers.

Percent Deciduous Parameter

Another parameter of the classification system applies only to the woody vegetation classes of forest and shrub-scrub. The ecological character of wooded areas can differ a great deal depending on the mix of deciduous to coniferous species and the percent deciduous parameter provides a measure of these differences in the form of a number representing the percent of the site canopy that is deciduous. The numbers are derived from a visual estimate by the interpreter. Estimates are made in

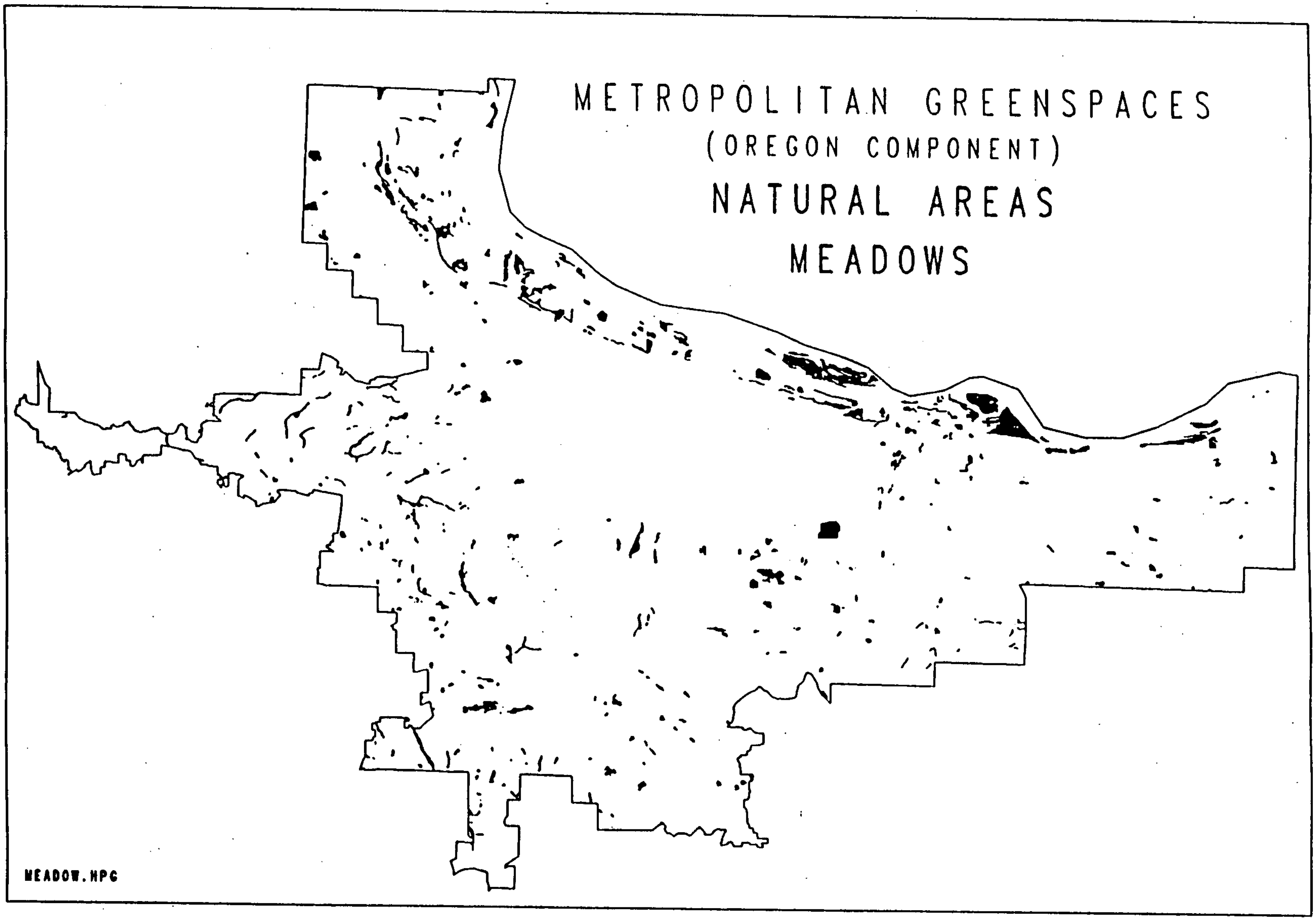

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS
MEADOWS
MEADOW.HPG

FIGURE 16

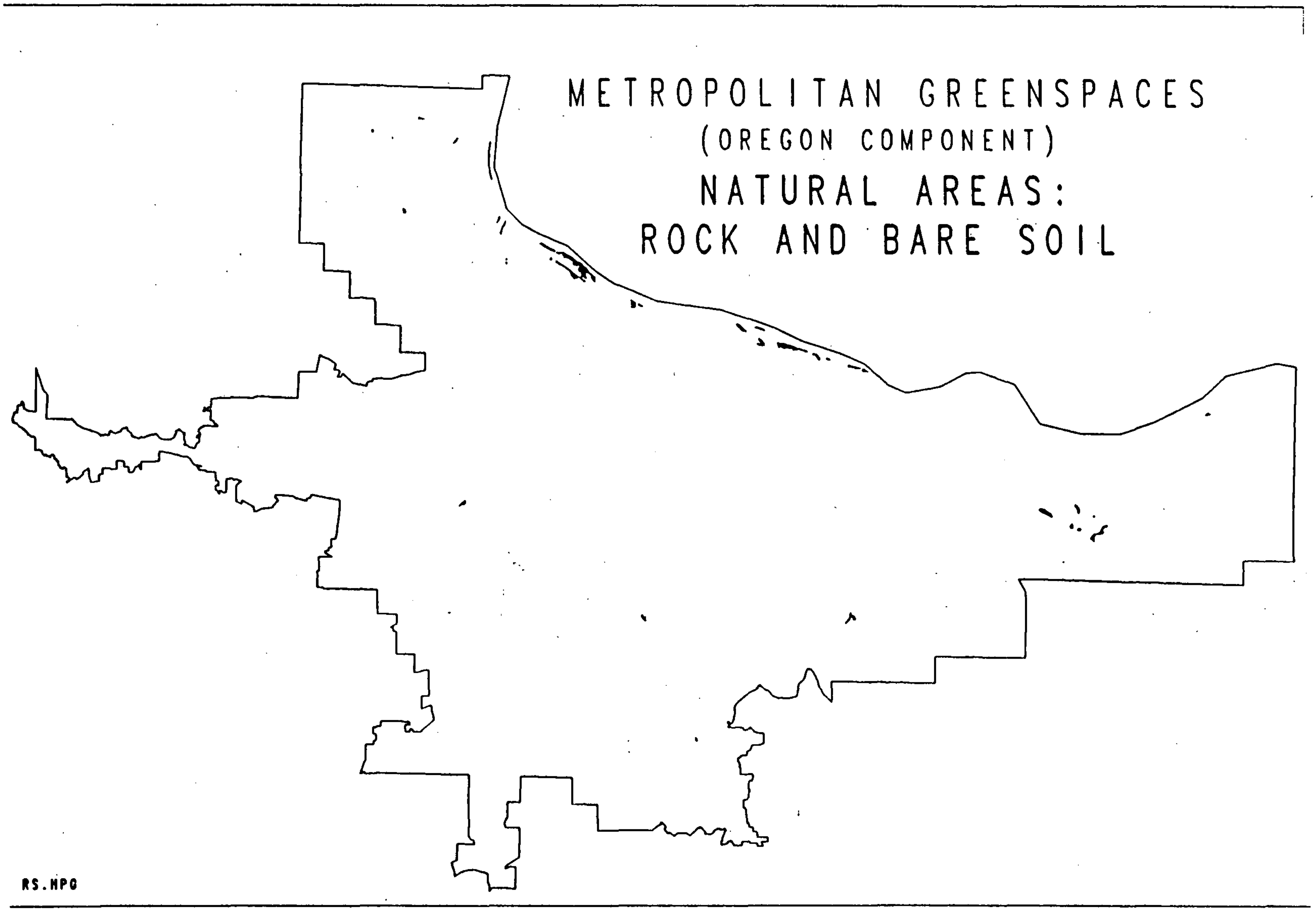

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
ROCK AND BARE SOIL
RS.MPG

FIGURE 17

10 percent increments, ranging from 00 percent to 100 percent (with 100 coded as 99). Thus, each of the six woody vegetation classes potentially can be further subdivided into one of 11 *percent-deciduous* classes. The 00 percent class was not assigned to any of the sites and does not appear in the table. The blank spaces for percent-deciduous under the non-woody vegetation cover classes reflect the fact that the percent-deciduous parameter does not apply to these classes.

In examining the percent deciduous data in Table 1, one major characteristic that is quickly apparent is the association of predominately-deciduous sites with water. First, note the difference between the upland and wetland classes. Of 173 wetland woody class sites, only two are in the less than 70 percent deciduous classes and only six are in the less than 90 percent deciduous classes. Thus, 97 percent of the sites in the 12 wetland forest and shrub scrub classes are 90 percent or more deciduous. This contrasts markedly with the situation that occurs with the upland classes. Of the 2,210 upland woody sites, 791 are in the less than 70 percent deciduous classes and 1,174 sites are in the less than 90 percent deciduous classes. Thus, only 47 percent of the upland forest and shrub scrub sites are 90 percent or more deciduous.

Second, in the upland group of classes there is a noticeable difference between the riparian (i.e., water-associated) and non-riparian sites. For example, only 64 percent of the non-riparian sites are identified as being 60 percent or more deciduous while 83 percent of the riparian sites are in that group.

It is important to note that the overall proportion of deciduous to coniferous forest in the study area is the result of human activity rather than an indicator of some long-term condition. In northwestern Oregon the dominant native species are, by far, coniferous (Franklin and Dyrness, 1973, p. 53.). Deciduous-dominated forest is simply a transitional stage that occurs following disturbance. In the study area, the primary forest disturbance has been logging, and the response of the vegetation has been to initially regenerate in deciduous species. Through time, if no other disturbance occurs, the conifers would again become dominant. In many cases, the areas with relatively high percentages of conifers represent locations that were logged longer ago and have begun to make the transition from deciduous dominance back to conifer dominance.

Riparian Parameter

The final parameter of the classification system indicates whether the site is riparian, that is, whether it is adjacent to or contains a water body. Water features were derived from hydrology information contained on the base map and included creeks, rivers, sloughs and lakes.

A total of 1,218 sites, representing 20,730 acres or 19.4 percent of the natural area acres are in the riparian class. The mean size of the riparian sites is 17 acres and the median size is 8.4 acres. The largest number (998) and greatest area (17,126 acres) of the riparian sites are upland, representing 82.6 percent of the riparian area.

Non-riparian sites total 1,813 and include 86,092 acres, or 80.6 percent of all natural areas. The mean size of these sites is 47.5 acres and the median size is 18.6 acres. As with the riparian class, the largest number (1,615) and greatest area (82,853 acres) of the non-riparian sites are upland, though the 96.2 percent represents a much higher relative portion than for the riparian area.

Maps of the riparian and non-riparian classes are presented in Figures 18 and 19, and neither of them indicate any unexpected patterns. Riparian sites are widely distributed over the entire map, with the very noticeable exception of the developed triangle of Portland. The non-riparian map is much denser and made up of predominantly blocky-shaped sites. Numerous linear white bands on the large black areas represent the riparian strips along streams and give the map a negative-like appearance.

Summary Observations on Natural Area Categories

It should be kept in mind that the natural areas data was interpreted from aerial photography and, like all data collected and interpreted by human observers, has a factor of subjectivity and a certain amount of error associated with it. There are undoubtedly some sites that have been mis-identified and some sites that may have not been mapped. However, the overall rate of error has been shown to be very low, based on verification of portions of the map by people with on-the-ground knowledge of individual sites. Thus, there is a great deal of reliability in the map data, especially when the data is considered in terms of the statistics for the overall study area. With this in mind, four general points can be made about the frequency of occurrence of natural areas categories:

1) Fewer than half of the potential categories actually occur on the map. The 105 categories that were mapped out of the 280 possible combinations represent only 38 percent of the potential number of categories.

2) There are great differences in the frequencies and total areas associated with the categories that do occur. The data values span a great range, with some categories occurring a great number of times and in relatively large acres, while other categories occur only a very few times and in relatively small acreage.

3) The categories that have the higher frequencies of occurrence are very few in number. For example, 90 percent of all the sites are represented within only 45 of the categories, 75 percent are represented within only 26 categories, and more than 50 percent are represented within only 12 categories. The area included within these 12 largest categories is 51,841 acres, or 48.5 percent of the total acres of natural area. These 12 are the upland open canopy 99 percent deciduous riparian forest (UFO99R) category, all four categories of meadow, including the upland and wetland and the non-riparian and riparian cases (UM, UMR, WM and WMR), and

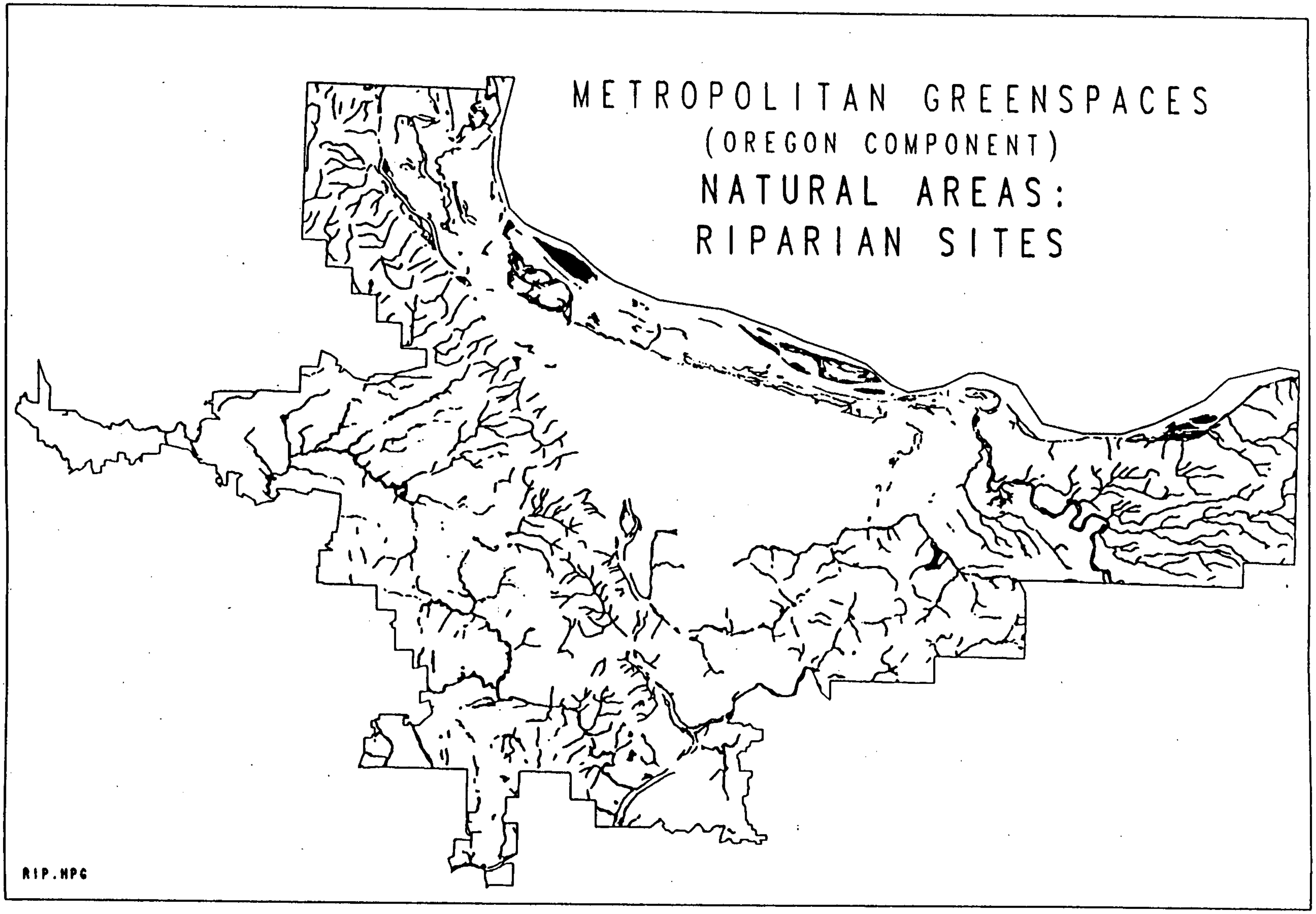

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
RIPARIAN SITES
RIP.MPG

FIGURE 18

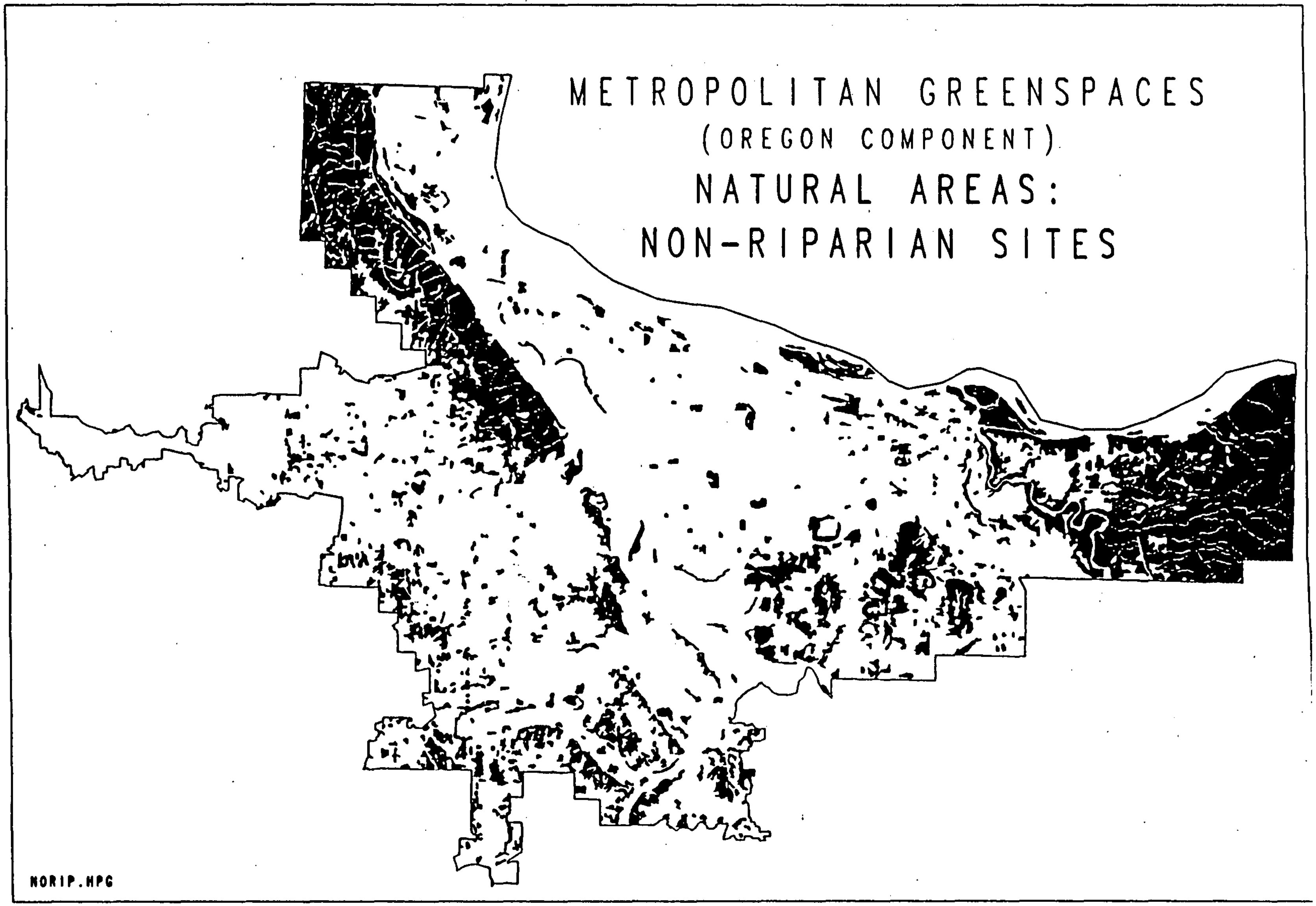

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
NON-RIPARIAN SITES
NORIP.HPG

FIGURE 19

seven categories of upland closed canopy forest (UFC10, UFC70, UFC80, UFC90, UFC99, UFC90R and UFC99R.) Thus, it is apparent that upland forest and all classes of meadows constitute the dominant categories of natural area within the Oregon Component.

4) The categories that occur with lower frequency generally have very low frequencies and include a large number of categories. Of the 105 categories and 3,031 distinct sites, 51, or nearly half of all categories in the inventory, are represented by less than ten sites each. These 51 categories include 191 sites, or only 6.3 percent of the total number of sites, and 5,341 acres, or only 5 percent of the total area of natural areas.

Table 3 summarizes the data for each of the basic parameters except percent deciduous. In terms of both number of sites and percent of natural area acres, the parameters with the greatest frequency are upland, closed canopy forest and non-riparian. Upland sites heavily dominate the area, accounting for 94 percent of the total natural area acreage. Meadows and open canopy forest occur with moderately high frequency but lag far behind the closed canopy forest, which has nearly three times as many sites and more than eight times the area as the next largest category, meadows. Non-riparian areas include about one-and-one-half times as many sites and more than four times the acreage of riparian areas.

The lowest frequency of occurrence belongs to wetlands, the rock and bare soil cover class, and riparian. Other especially low frequencies are associated with scattered canopy forest, all three classes of shrub-scrub and clearcuts.

3.3 Buffered Natural Areas

The natural areas coverage provides information regarding the location and kinds of natural areas. However, one spatial parameter that is not explicitly a part of the coverage is information concerning distance or proximity of natural areas to each other. This information has utility in regard to the biological analysis as well to a number of other features.

Several manipulations were performed on the coverage of natural areas in order to develop this specialized distance and proximity information. Due to the nature of these manipulations, they were more efficiently performed on a different GIS than Arc/Info. Pacific Meridian Resources, working as a subcontractor to PSU completed this work, partially using Arc/Info and partially using an ERDAS GIS. Three tasks were performed:

1) Data were tallied for each site regarding the total number of contiguous natural area sites, the total length of the site perimeter that is contiguous to other sites, and the percentage of the total perimeter of the site that is contiguous to other sites. This data provides the basis for measuring the interconnectedness of various groups of sites.

TABLE 3

NATURAL AREAS CLASSES: SUMMARY STATISTICS
(Sizes rounded to whole acres)

Class	Number of Sites	Total Acres	Percent of Natural Areas	Sizes (Acres) Minimum	Maximum	Mean	Median
Wetland	418	6,843	6.4	< 1	138	16	9
Upland	2,613	99,979	93.6	< 1	988	38	14
Forest (three classes)	2,142	89,231	83.5	< 1	988	42	15
Closed	1,585	76,966	72.1			49	
Open	384	8,479	7.9			22	
Scattered	173	3,786	3.5			22	
Shrub-Scrub (three classes)	241	6,262	5.9	< 1	144	26	15
Closed	80	2,316	2.2			29	
Open	76	1,857	1.7			24	
Scattered	85	2,089	2.0			25	
Clearcuts	35	1,111	1.0	2	272	32	14
Meadows	572	9,562	9.0	< 1	510	17	7
Rock/Bare Soil	41	656	0.6	< 1	150	16	7
Riparian	1,218	20,730	19.4			17	9
Non-Riparian	1,813	86,092	80.6			48	19

2) Boundaries between contiguous natural areas were removed or *dissolved*. This resulted in larger natural area *clumps* with no category identifier associated with them other than that of a *generic* natural area. In map form this would look just like the natural areas map in Figure 3. These data provided additional information about the connectedness of sites and were the basis for developing a hierarchy of increasingly larger *clumps* of generic natural areas.

3) Buffer zones were identified around each clump at distances of 325 feet (100 meters), 975 feet (300 meters) and 2,340 feet (720 meters.) Figure 20 portrays all three buffered natural areas. These buffered coverages were then used to identify natural area clumps that were within the specified buffer distances from each other.

The primary purpose in producing the buffered natural areas coverage was to provide data on the hierarchy of connectivity and adjacency that was used as a part of the biological analysis. However, the buffered natural areas coverage provides other useful information as well, allowing the combination of natural areas data with other sorts of features and identifying other features that lie within the specified buffer distances from natural areas.

Figures 21, 22 and 23 are maps of each of the individual buffered natural areas coverages. The natural areas and the corresponding buffer zone is shaded on the maps. The unshaded portions represent areas that are more than the specified buffer distance from any natural areas.

Data on the amount of buffered (i.e., natural area plus buffer zone) and non-buffered area on each of the three maps are presented in Table 4. On the original natural areas map, there are 106,822 acres of natural area within a study area of 372,685 acres, meaning that there are 265,860 acres <u>not</u> in natural areas. From the coverage where the natural areas have been buffered by 325 feet, it can be calculated that there are 185,366 acres within the buffer and 187,316 acres outside, meaning that 187,316 acres, or 50 percent of the study area, that is 325 feet or more from a natural area. With the 975-foot buffer there are 102,421 acres, or 27 percent of the Oregon component, in the non-buffered area, and with the 2,340-foot buffer there are 33,468 acres, or 9 percent of the Oregon component in the non-buffered area.

The *swiss-cheese-like* progression from one map to another is interesting to follow. Note, in particular, the east Portland/Milwaukie developed triangle. In all three maps the triangle is a prominent feature, but by the third map the lower portion of the triangle, around Milwaukie, is clearly separated from the rest of the triangle as the buffer around Johnson Creek expands. This example points out one aspect of the wisdom of attempting to protect the integrity of linear natural areas: although the actual area associated with a linear corridor is relatively small, the impact in terms of the surrounding *service area* is very high. The Johnson Creek riparian corridor is an especially good example, incorporating both high natural area value in

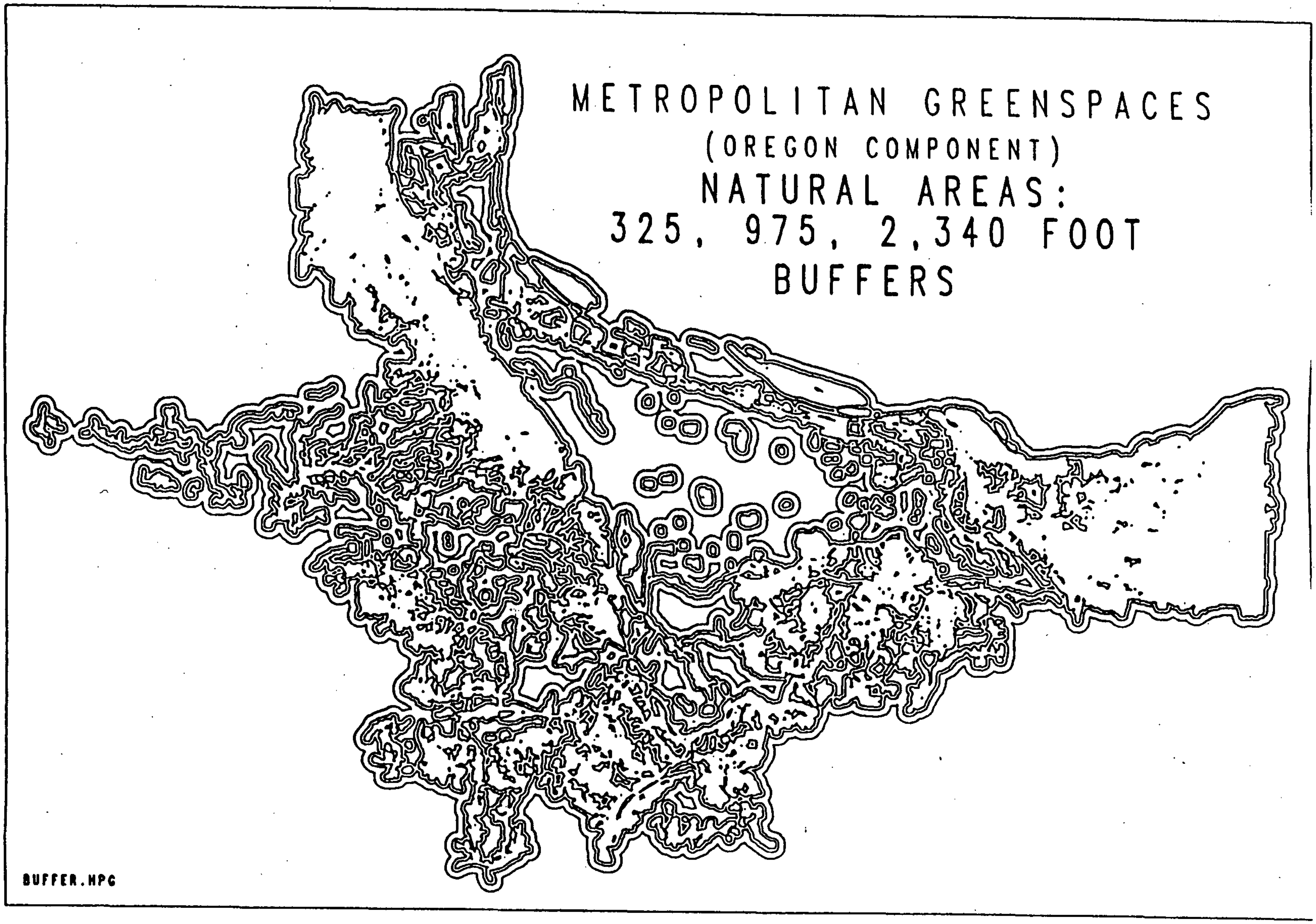

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
325, 975, 2,340 FOOT
BUFFERS
BUFFER.HPG

FIGURE 20

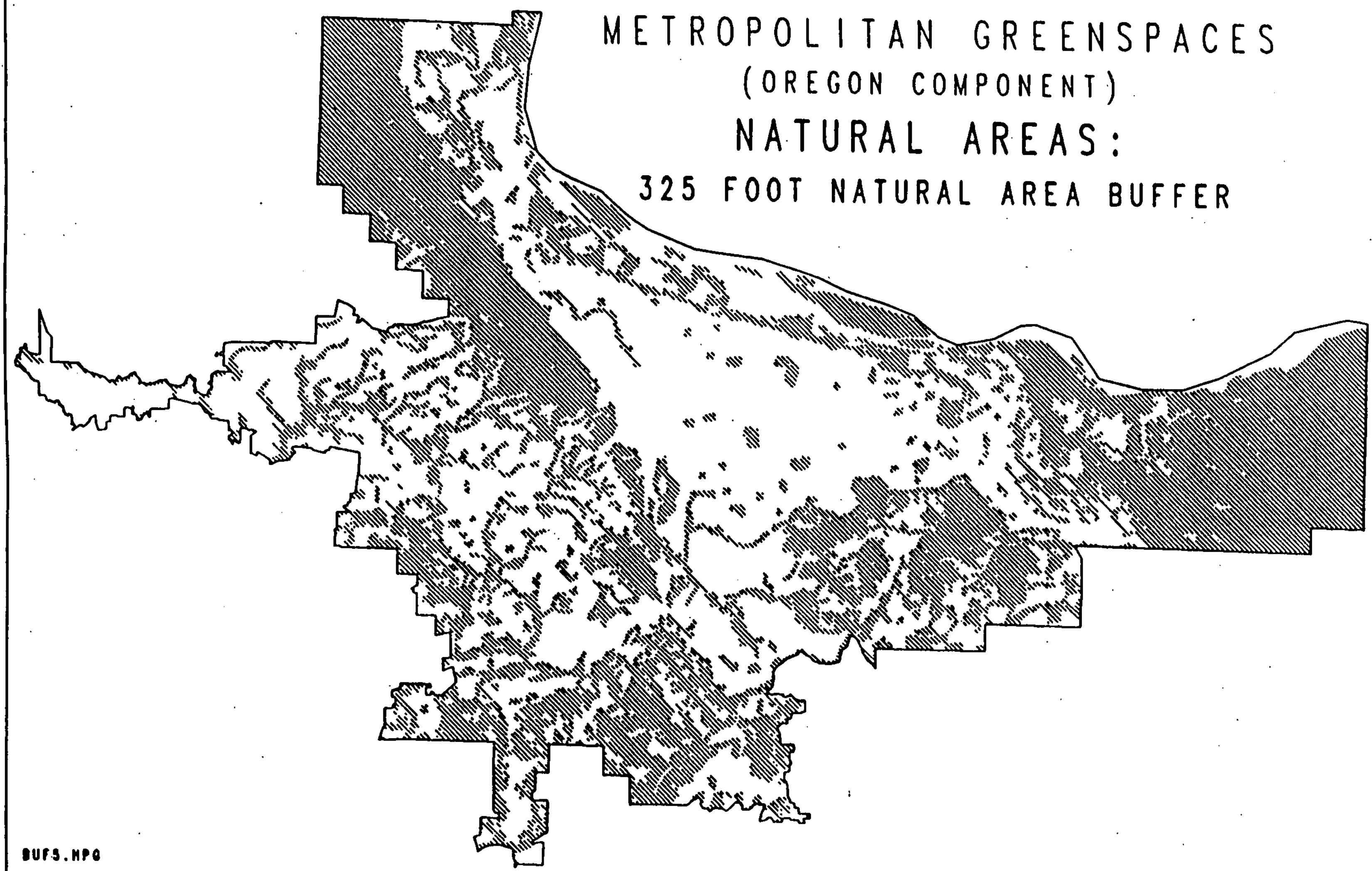

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
325 FOOT NATURAL AREA BUFFER
BUFS.HPG

FIGURE 21

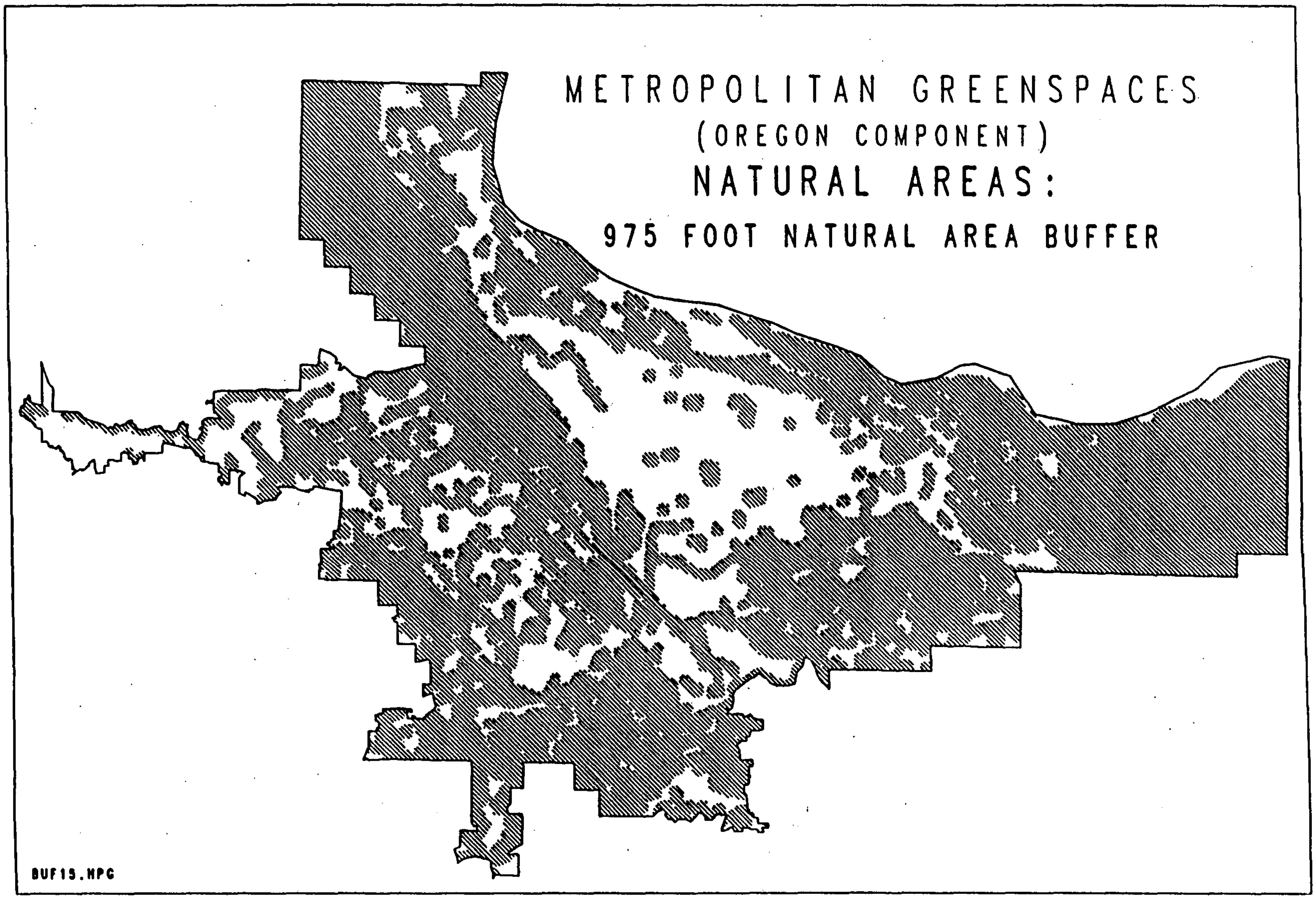

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
975 FOOT NATURAL AREA BUFFER
BUF15.HPG

FIGURE 22

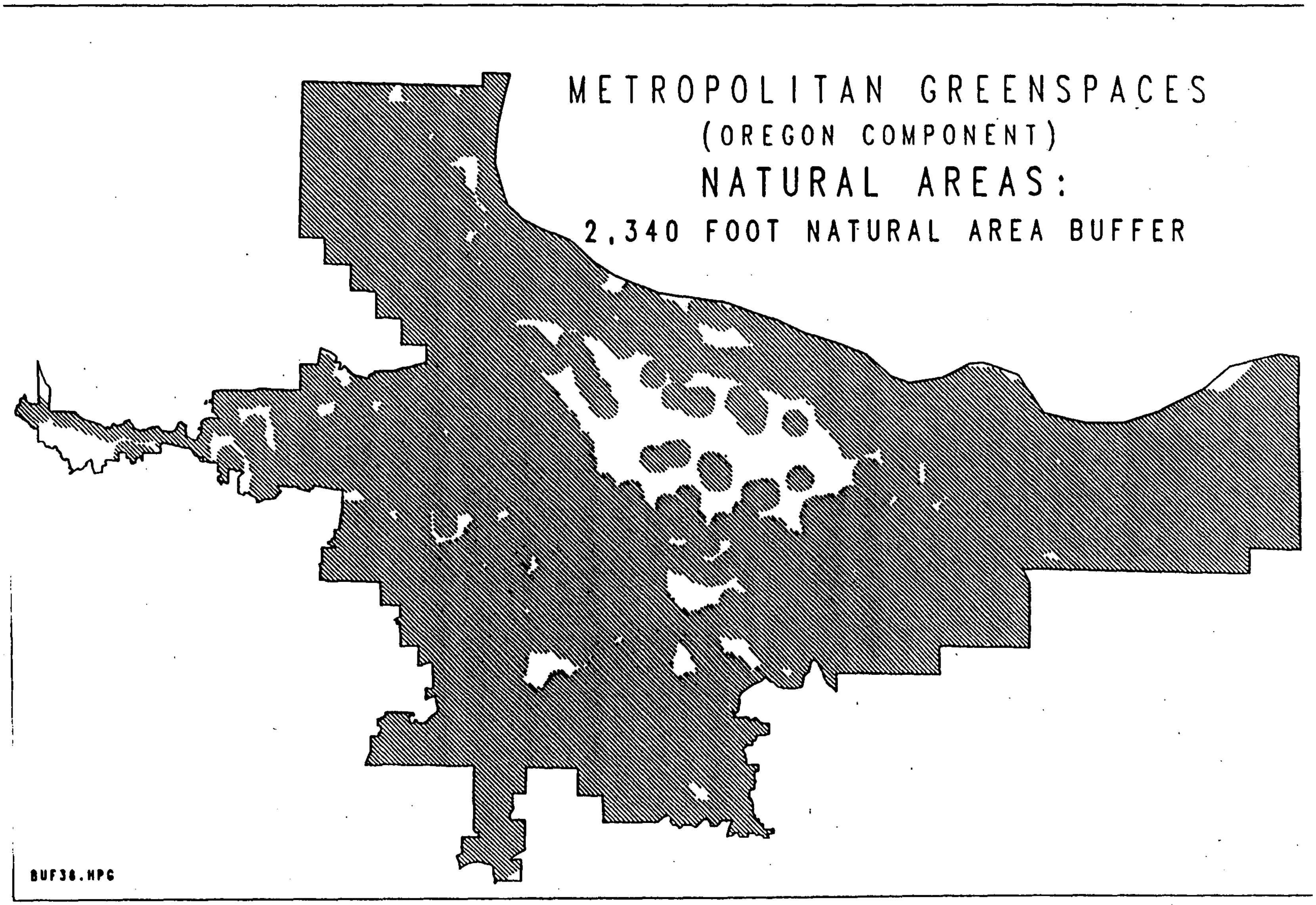

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS:
2,340 FOOT NATURAL AREA BUFFER
BUF36.HPG

FIGURE 23

TABLE 4

ACRES OF NATURAL AREA AND NON-NATURAL AREA AT THREE DIFFERENT BUFFER WIDTHS

Map	Acres Within	Acres Outside	Percent of Area Outside
Original Natural Areas	106,822	265,860	71%
Natural Areas plus 325-Foot Buffer	185,366	187,316	50%
Natural Areas plus 975-Foot Buffer	270,261	102,421	27%
Natural Areas plus 2,340-Foot Buffer	339,217	33,465	9%

terms of fish and wildlife habitat and high human value in terms of aesthetics and flood control.

3.4 Natural Areas Habitat Types

The photo interpretation and mapping inventory process was designed to capture as much information as possible about the characteristics of the sites. The resulting 105 identified categories provide the ability to make detailed discriminations of group characteristics when aggregating categories into larger, generalized groups. The more precisely that the individual members of each larger group can be defined, the better the final groupings and the generalization system is likely to be.

Aggregation of the natural areas data was based on the eight habitat types that were identified by the field biologists during the field data collection and analysis (see PART 1 of this report for details.) The habitat types were defined on the basis of field data collected for a sample of the mapped sites and represent collections of categories that were observed to have similar groups of plant and animal species.

The 3,031 inventory sites were grouped into eight habitat types. Table 5 lists the natural area categories included in each type. This list reflects three minor changes that were made in the original eight habitat types when they were used to group the map data.

The first change involved the natural area categories of clearcuts. These are disturbance-related areas and represent a temporary vegetation grouping that will, within a matter of few years, return to a shrub-scrub woodland and eventually to a forest again. This sequence of change may occur as a result of natural processes or as the result of human replanting efforts. The agent of change will affect the species diversity and, to some extent, the rate of change, but, unless management action is taken to inhibit the successional process, the sequence of change will occur.

The sites classed as clearcuts generally have an open aspect, and most often tend to function as a temporary form of meadow in terms of wildlife habitat. No clearcuts were visited during the field surveys and the category was not included within any of the original eight habitat types. Since all the clearcuts in the inventory were upland sites, they were combined with the Upland Meadow habitat type, and renamed Upland Meadow/Clearcut.

The second change involved two wetland riparian forest sites which are the sole occurrences of their respective categories. One is a closed canopy 10 percent deciduous site and the other an open canopy 60 percent deciduous. Neither of these categories are included in the definitions for any of the eight habitat type groups. Since they are both wetland forests, these two sites were combined with the Wetland Deciduous Forest type, the only habitat type that includes wetland forest, and renamed Wetland Forest.

The third change concerned the rock outcrop and bare soil categories. Like clearcuts, these categories were not visited during the field sampling and are not included among any of the eight habitat types. Unlike clearcuts, however, the rock

TABLE 5

THE EIGHT HABITAT TYPES USED TO GENERALIZE THE MAPPED NATURAL AREAS

Habitat Type	Component Natural Area Categories
Upland Decidous Forest	UF[C,O,S]70 to 99 and UF[C,O,S]70R to 99R)
Upland Mixed Forest	UF[C,O,S]30 to 60 and UF[C,O,S]30R to 60R)
Upland Conifer Forest	UF[C,O,S]00 to 20 and UF[C,O,S]00R to 20R)
Upland Meadow/Clearcuts	UM and UMR
Upland Shrub-Scrub	UF[C,O,S]0 to 99 and UF[C,O,S]0R to 99R
Wetland Meadow	WM and WMR
Wetland Forest	WF[C,O,S]70 to 99 and WF[C,O,S]70R to 99R
Wetland Shrub-Scrub	WS[C,O,S]0 to 99 and WS[C,O,S]0R to 99R

and bare soil categories cannot be logically included among any of the eight habitat types. They were, therefore, excluded from consideration as part of the regrouping operation as well. Since the rock and bare soil categories include only 41 sites consisting of 656 acres, the impact of eliminating them is minimal.

Maps portraying the distribution of each of the eight habitat types are included in Figures 24-31. Summary data for the regrouping of the sites into the eight habitat types are presented in Table 6. The two largest groups are the Upland Deciduous Forest and the Upland Mixed Forest habitat types, covering 44.2 percent and 27.2 percent, respectively, of the mapped natural areas. Upland habitat types compose the five largest groups, while the wetland habitat types compose the three smallest groups.

It is important to emphasize that the habitat types represent groupings of natural area categories that are capable of supporting different wildlife assemblages. It is clear from the habitat type summary statistics that there are great differences in the amount of area available in each habitat type, and, therefore, differences in the number of potential opportunities to protect particular wildlife species through natural areas preservation. Purely in terms of the relative availability of sites, it is not equally easy (or equally difficult) to protect all wildlife species. These differences in habitat availability must be carefully considered in the wildlife portion of the planning and selection process for natural areas acquisition.

3.5 Parks and Recreation Areas

In 1989, the Metro Recreation Resource Study was completed by Murase & Associates for Metro. Developed as part of that study was a map of park and recreation areas within the Metro boundary, compiled from a variety of local, state and federal park-providers. The study that produced the map was confined largely to the boundaries of Metro and, with few exceptions, did not include any data for the 20 percent of the study area that is outside the Metro boundary (i.e., the rest of Multnomah County).

The information from that map was digitized by Metro and provided to the PSU Geography Department in an unedited form in Spring 1991. Information was not available to complete a full and systematic update, but a limited amount of updating was performed at PSU with the assistance of David Yamashita, Park Planner with the City of Portland. The result was the *Park and Recreation Areas* map coverage shown in Figure 32. This coverage represents the most comprehensive and up-to-date information available on parks and recreation for the study area.

Given the composition of the coverage, three important points need to be made about its characteristics so that generalizations can be made from the data in an appropriate manner. First, it is not possible to identify precisely the total number of park and recreation areas from the coverage. There are 666 individually-identified polygons within the coverage, consisting of a total of 17,575 acres of park and recreation areas. However, in many cases, what would commonly be considered as single park or recreation area is identified within the coverage as multiple polygons, generally representing the various original components that taken together constitute

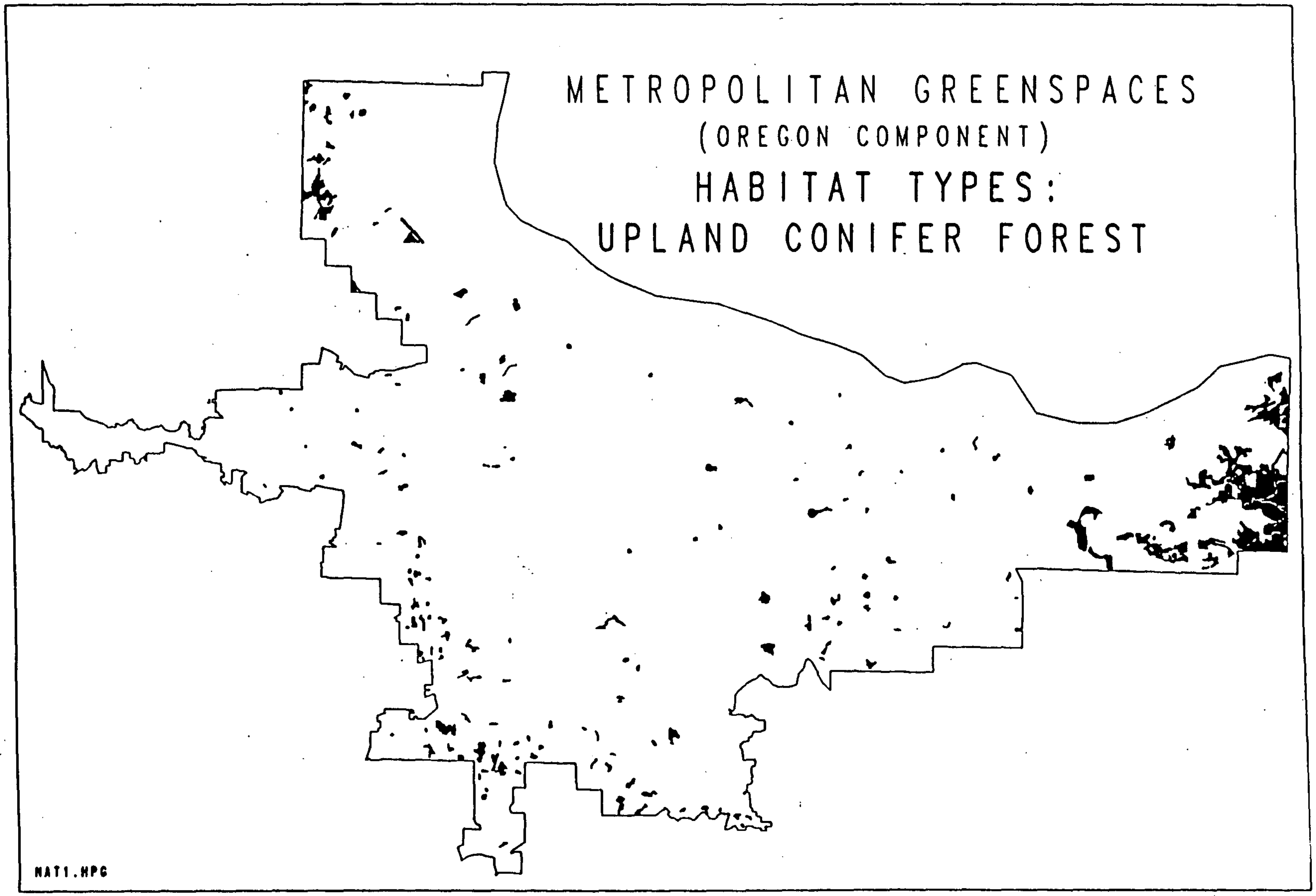

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
UPLAND CONIFER FOREST
NAT1.HPG

FIGURE 24

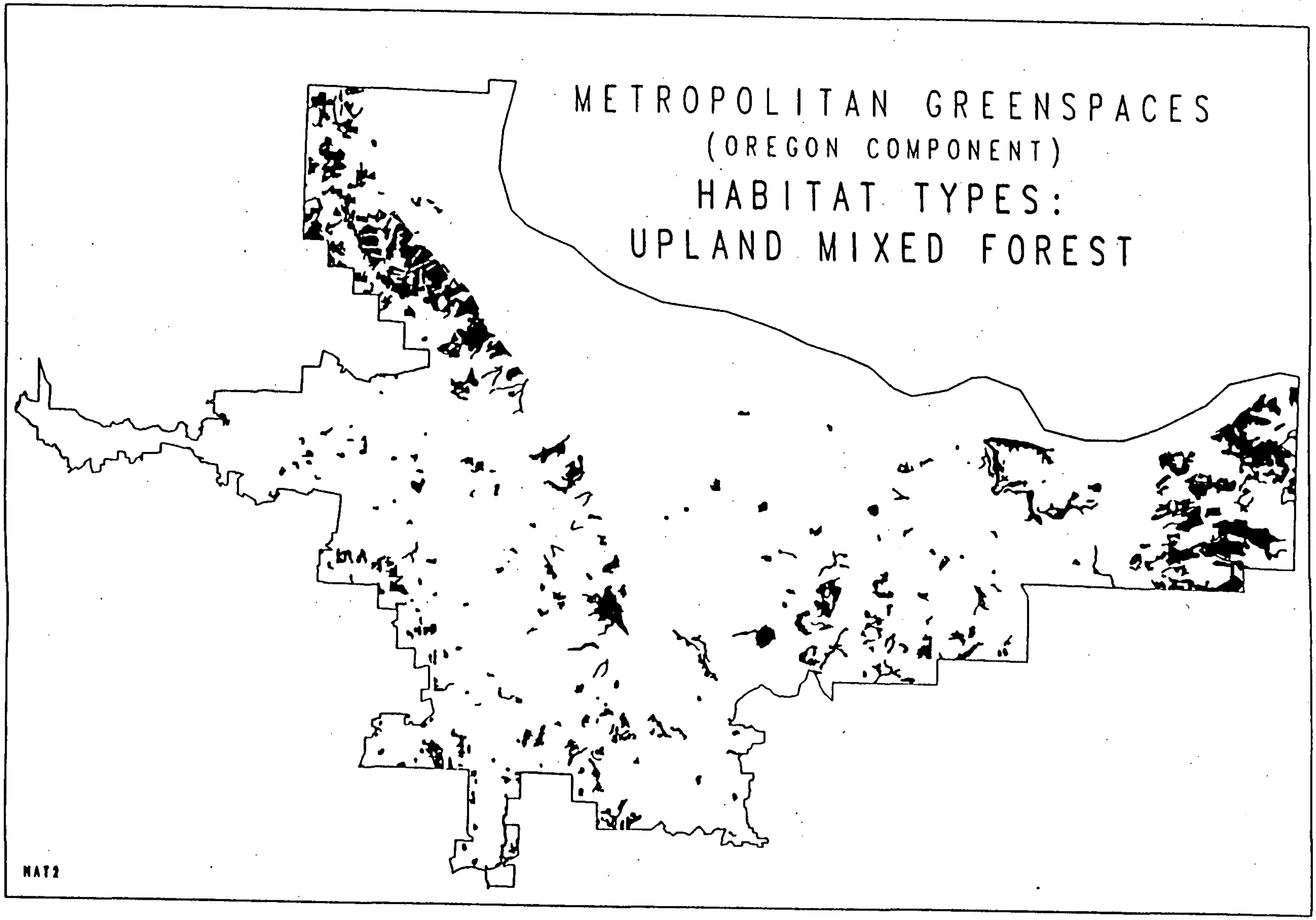

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
UPLAND MIXED FOREST
NAT2

FIGURE 25

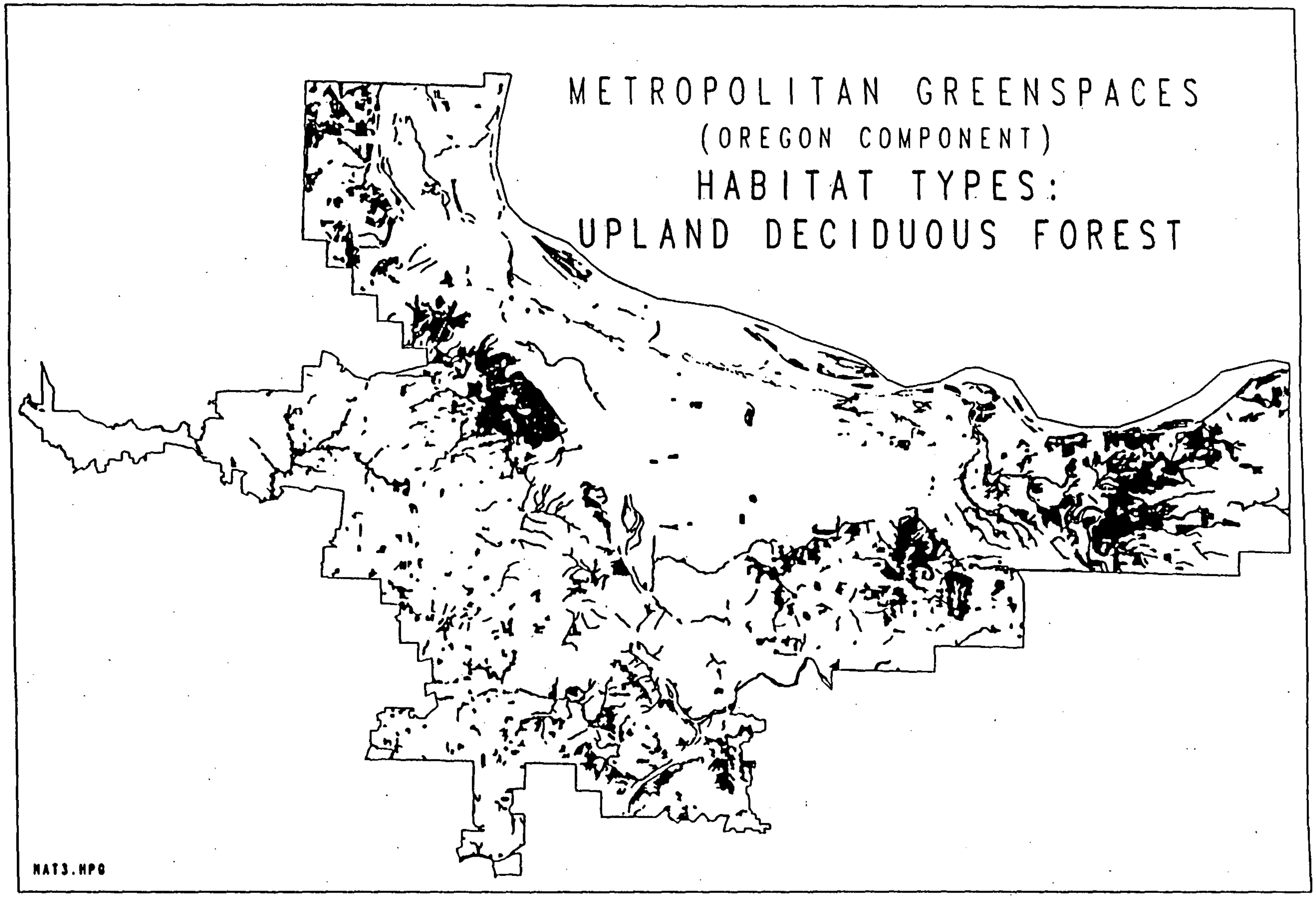

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
UPLAND DECIDUOUS FOREST
HAT3.HPG

FIGURE 26

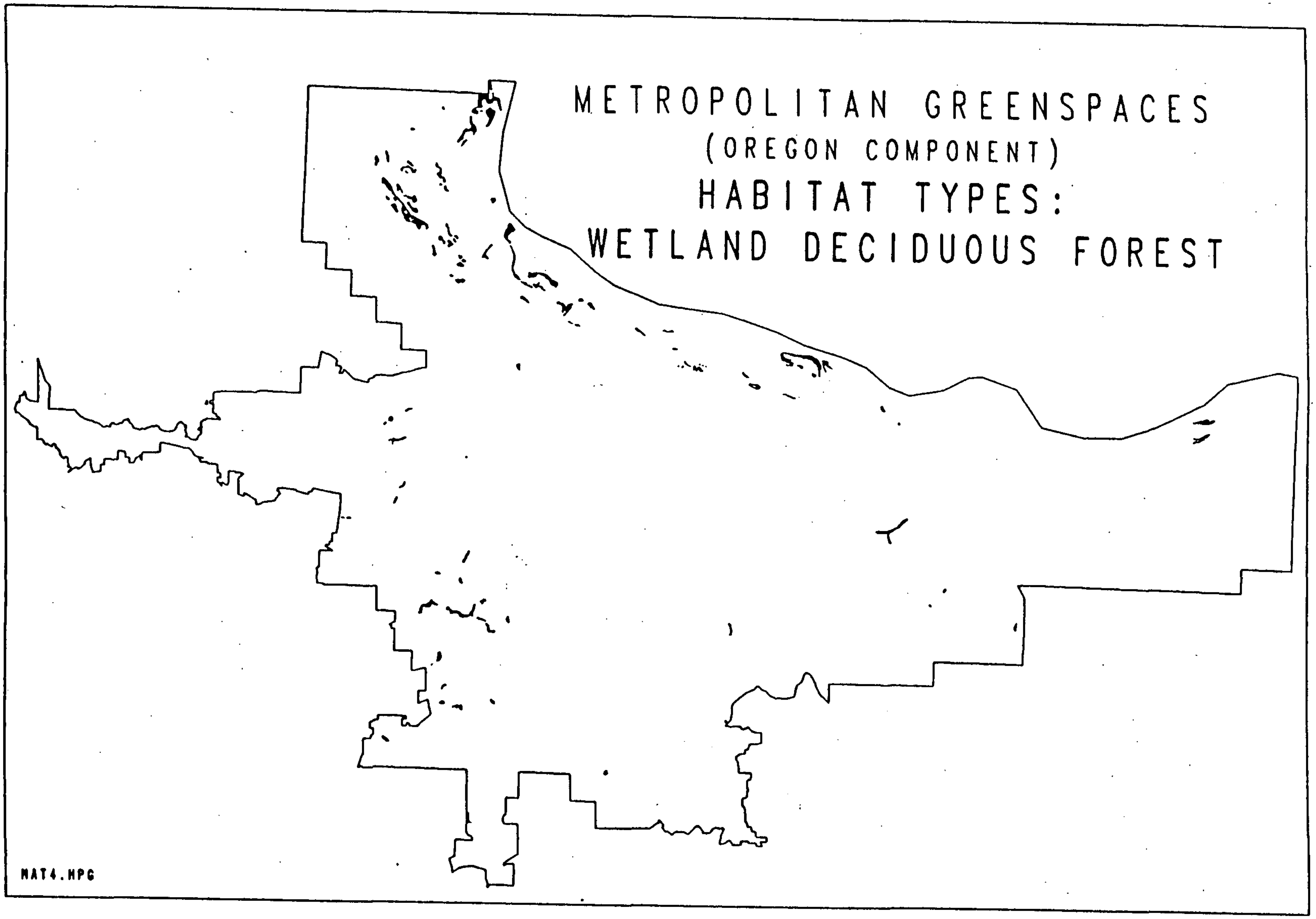

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
WETLAND DECIDUOUS FOREST
NAT4.HPG

FIGURE 27

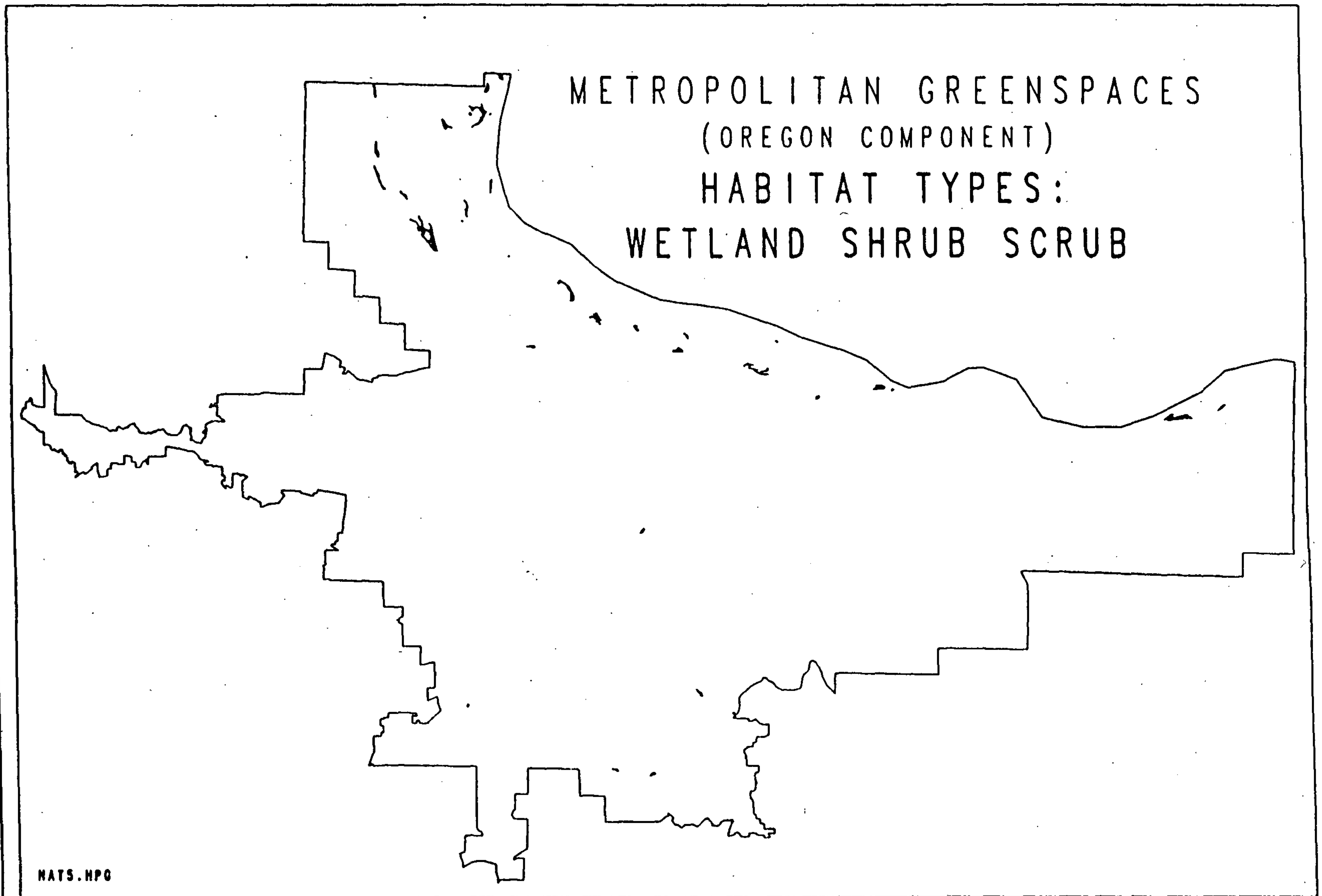
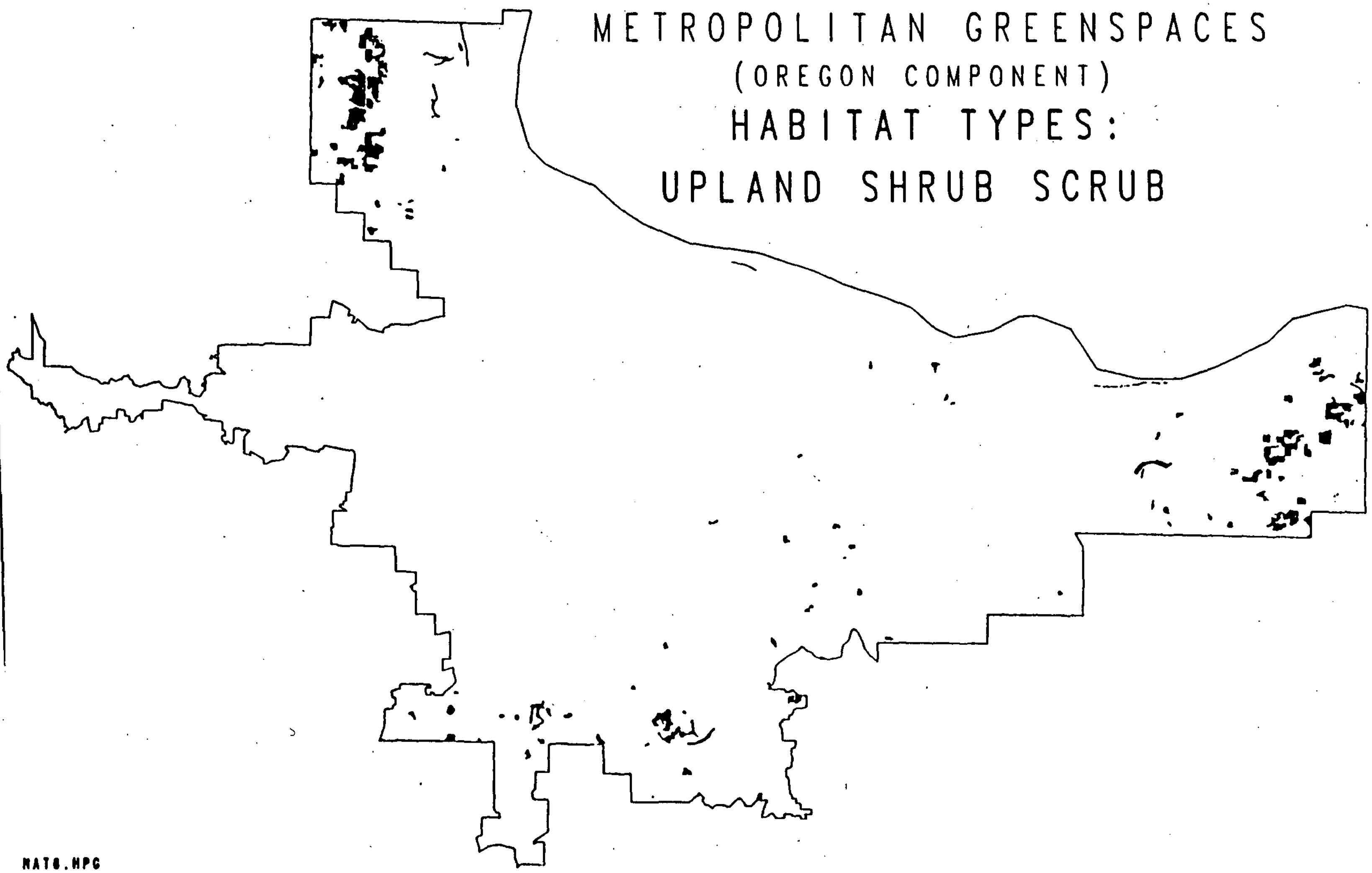

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
WETLAND SHRUB SCRUB
NATS.HPG

FIGURE 28

FIGURE 29


METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
UPLAND SHRUB SCRUB
NAT6.HPG

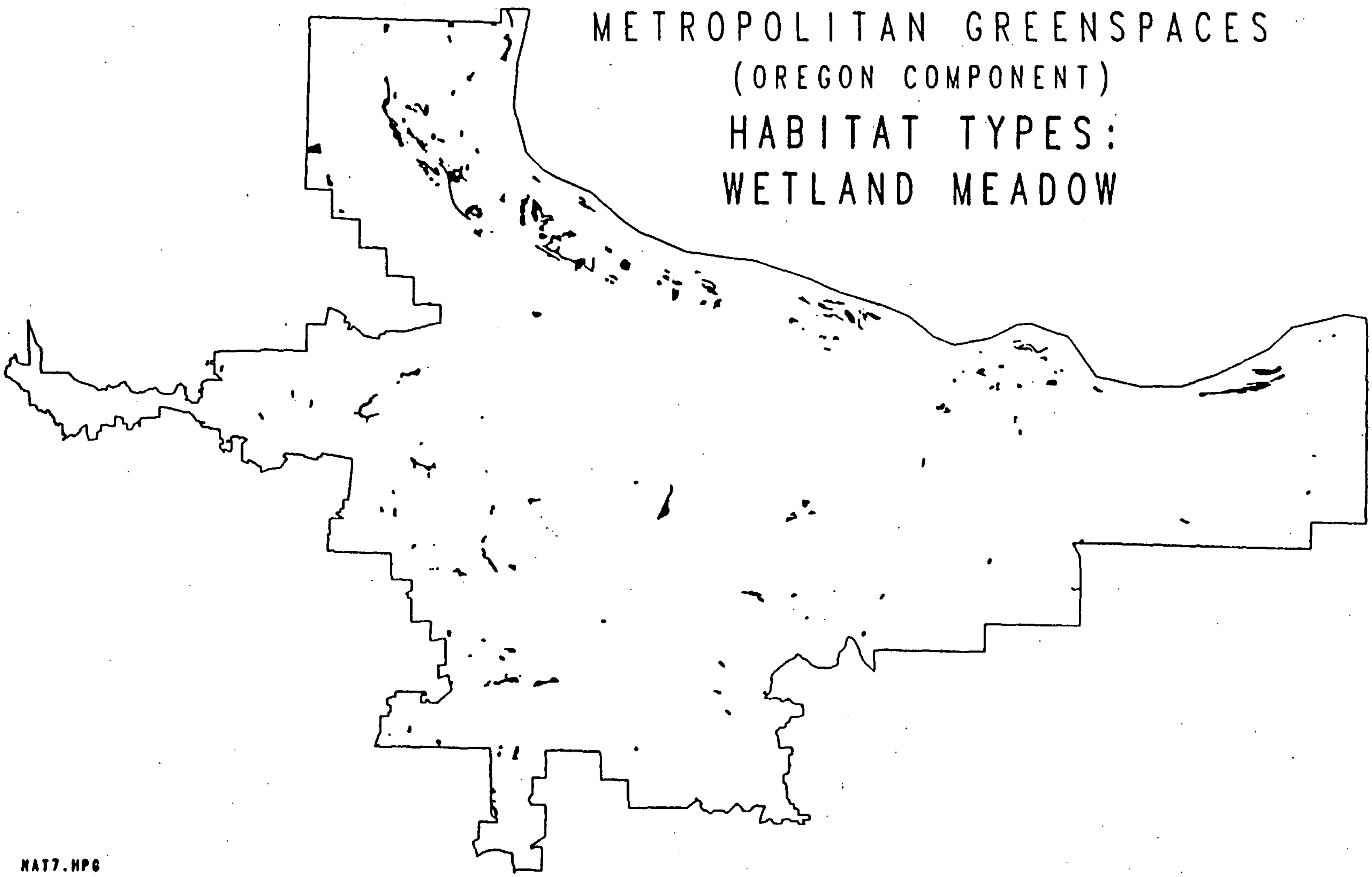

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
WETLAND MEADOW
NAT7.HPG

FIGURE 30

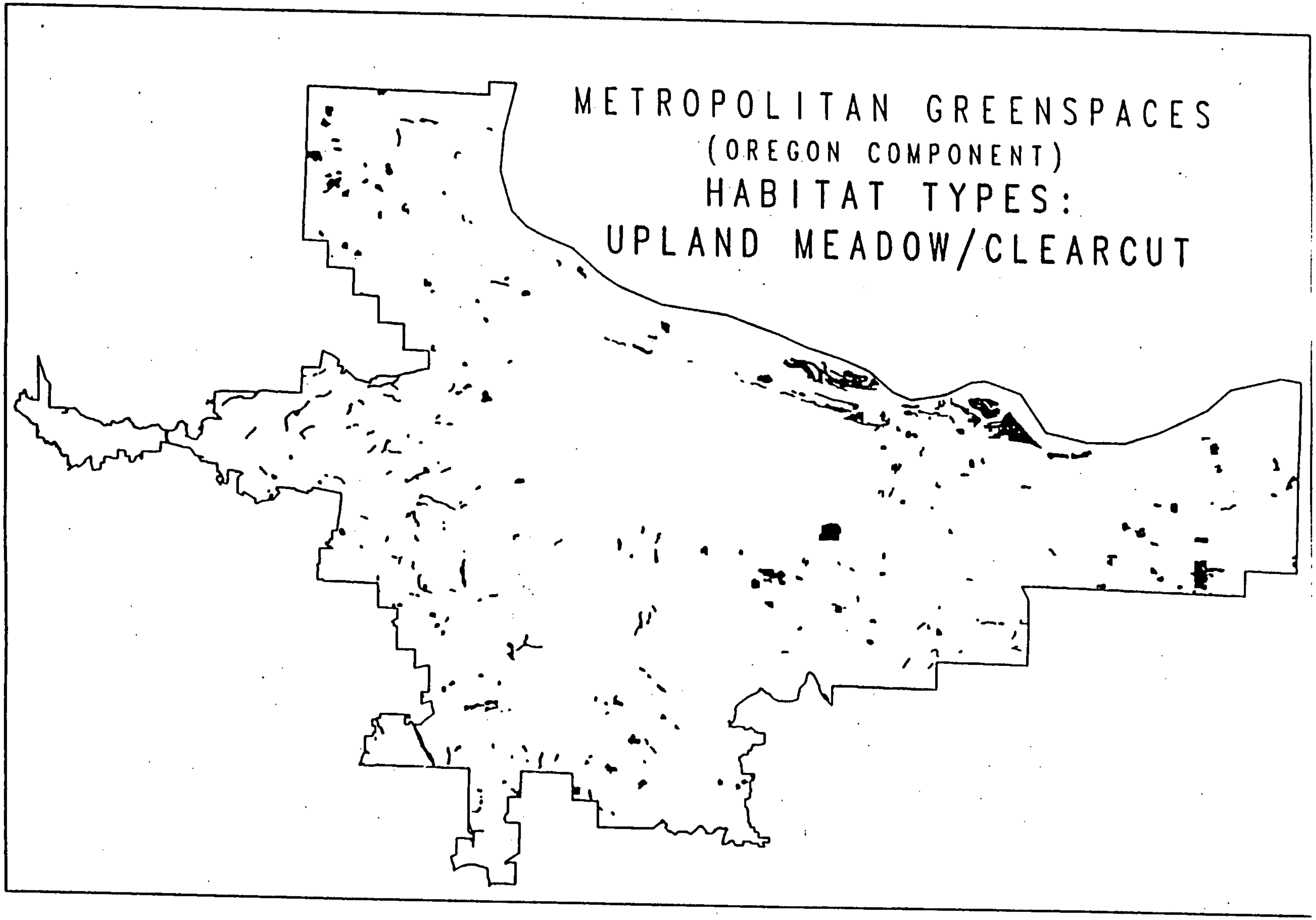

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
HABITAT TYPES:
UPLAND MEADOW/CLEARCUT

FIGURE 31

TABLE 6

STATISTICS ON THE EIGHT HABITAT TYPES WITHIN THE STUDY AREA

Habitat Type	Number of Sites	Percent of Total Sites	Total Acres	Percent of Total Acres	Maximum Size	Minumim Size	Mean Size
U Decid Forest	1,231	40.6	47,254	44.2	988.3	0.2	38.4
U Mixed Forest	532	17.6	29,066	27.2	759.3	0.5	54.6
U Conif Forest	252	8.3	10,791	10.1	880.9	1.8	42.8
U Mead/Clearcut	381	12.6	6,994	6.5	510.1	0.3	18.4
U Shrub Scrub	195	6.4	5,457	5.1	143.6	0.6	28.0
W Meadow	226	7.5	3,679	3.4	137.9	0.3	16.3
W Forest	127	4.2	2,126	2.0	118.7	0.9	16.7
W Shrub Scrub	46	1.5	798	0.7	90.6	0.6	17.4
Total	2,990	98.7	106,165	99.4	988.3	0.2	35.5

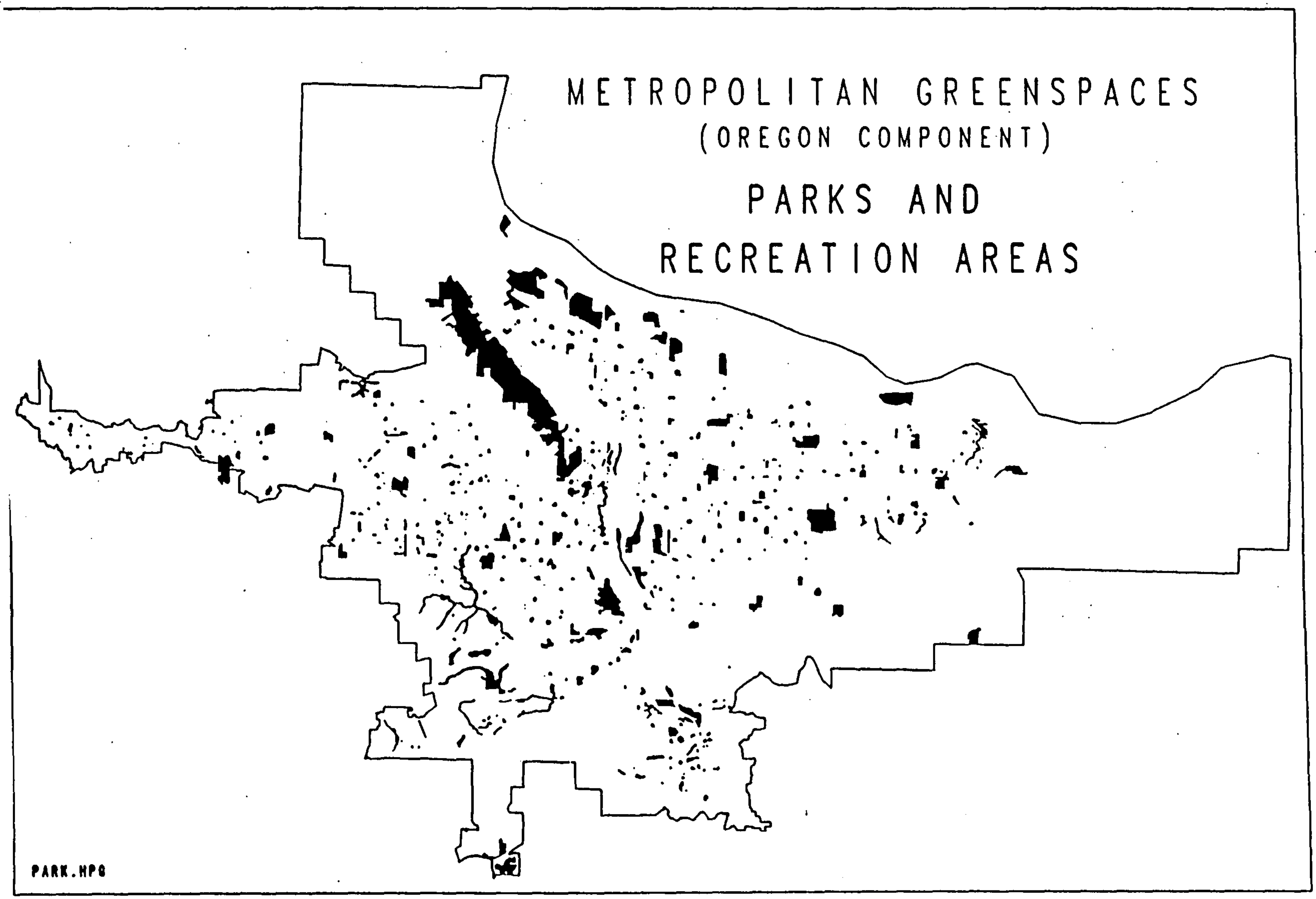

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
PARKS AND
RECREATION AREAS
PARK.HPG

FIGURE 32

a single park or recreation site. For example, the area that most people would commonly identify simply as Forest Park is made up of four different polygons, all called *Forest Park*, plus a number of additional polygons that have other names, such as *Linnton (FP)*, *Macleay (FP)* and *Clark & Wilson (FP)*. As an informal estimate, there may be 175 to 300 separate park and recreation sites if the multiple polygons were combined into sites. The resources were not available for sorting this information out for all sites, thus making it impossible to quote a precise figure for the total number of park or recreation areas.

Second, many of the individual polygons within the coverage are very small. Sizes range from less than one acre for 123 of the areas to 3,261 acres for the single largest area. The mean size is 26.4 acres and the median size is 4.6 acres. Again, this is due in part to the fact that many of the parks are listed by their polygonal components rather than by their commonly-known boundaries. It is likely that the mean and, especially, the median sizes for the actual parks is much larger.

Third, the coverage includes a variety of types of sites, ranging from natural areas through developed greenspaces to heavily-developed recreation facilities. Among the better-known natural areas are Oaks Bottom Wildlife Refuge, the several portions that comprise Forest Park, Elk Rock Island, Hedges Creek Marsh and Beggar's Tick Marsh. Examples of developed greenspaces include Mt. Tabor Park, Laurelhurst Park, the South Park Blocks, Gabriel Park and numerous golf courses. Heavily-developed recreation facilities include Oaks Amusement Park, Pioneer Square, numerous playgrounds and school parks, and a number of tennis courts, swim centers and community centers. These examples of park and recreation types are presented simply to provide some understanding of the variety of features included in this coverage. Time did not permit the identification of the park and recreation type of each of the 666 sites, though such an undertaking would provide valuable data for long-term park and natural areas planning.

Sites are included in this coverage because they are identified as park or recreation by their owners. In most cases, the sites are publicly-owned, but a lesser, indeterminate number are apparently privately-owned. By virtue of their assignment to the park or recreation area class, these sites are not viewed simply as *vacant land* and are not considered available for development.

Though sites designated as *parks* or *recreation areas* enjoy an implied protection, in many cases there is not necessarily any real protection. The level of protection for an individual site varies with the owner and the level of explicit long-term legal assurances that may have been provided to a site. Simply naming a site as *Park* is a different level of protection than developing and adopting a management plan for a publicly-owned site, and different than assigning a conservation easement to a piece of privately-owned natural area, and different than ownership by a land trust. In a number of cases, it is only the good will of the individual property owner that keeps the property from being developed, and, should the property change hands, development could occur without any legal impediments. Realizing that there is only limited data available, the Park and Recreation Areas coverage has been generally accepted as the best available indicator of natural areas protection in the study area.

By overlaying the Natural Areas coverage with the Parks and Recreation Areas coverage, it was determined that 9,319 acres, or 8.7 percent of the 106,822 acres of natural areas are protected from development by virtue of being designated as Park or Recreation Areas. Figure 33 portrays these protected areas. Put another way, 91.3 percent of the natural areas in the Oregon Component are currently available for development. These available-for-development natural areas are shown in Figure 34.

Included on the map of protected areas are the approximately 5,000 acres that constitute Forest Park. However, since Forest Park is such a large and unique component of the regional natural areas situation (Figure 35), it can be viewed as an anomaly. On this basis, an argument can be made to remove the acres assigned to Forest Park from the park statistics (and from the natural area statistics as well), in order to arrive at a more realistic view of natural areas protection throughout the study area. When this is done, only 4,319 acres or 4.2 percent of the natural areas in the Oregon Component enjoy the protection of designation as a Park or Recreation Area. This map is shown in Figure 36.

3.6 Tualatin River National Wildlife Refuge

The U.S. Fish and Wildlife Service has proposed a more than 3,000-acre area of agricultural wetlands and riparian woodlands on the Tualatin River near Sherwood for possible acquisition as a National Wildlife Refuge (Harrison, 1992). Should the refuge become a reality, it will be an important addition to the protected natural areas in the region. Anticipating the possible acquisition and refuge designation for the area and the importance of considering it as an element of the Metropolitan Greenspaces system, the U.S. Fish and Wildlife study area was digitized to produce a coverage.

Figure 37 portrays the location of the proposed Tualatin River National Wildlife Refuge relative to the Oregon Component study area. The refuge lies within the Tualatin Valley and straddles the southwestern edge of the Oregon component. The study area consists of three large patches oriented in a generally northwest-to-southeast pattern, most of which is just outside the Oregon component. The total size of the area, according to the Washington County Assessor's Office, is 3,058 acres. When digitized, the area was calculated to be 3,237 acres, a disparity that arises from the difference in detail between the large scale assessor's maps and the medium scale maps used for digitizing. About one-half of the southeastern patch, about one-seventh of the central patch, and none of the northwestern patch falls inside the Oregon component. Only 16 percent, or 523 of the 3,237 acres of the study area coverage, is within the Oregon Component.

Figure 38 is a map using shading patterns to portray the natural areas, and park and recreation areas within three miles of the refuge study area. The western and southern portions of the map are unshaded, indicating not necessarily a lack of natural areas, but a lack of data, since these areas are outside the Oregon component study area. However, within the Oregon component area of the map there is a great deal of shading, indicating potential for establishing linkages between

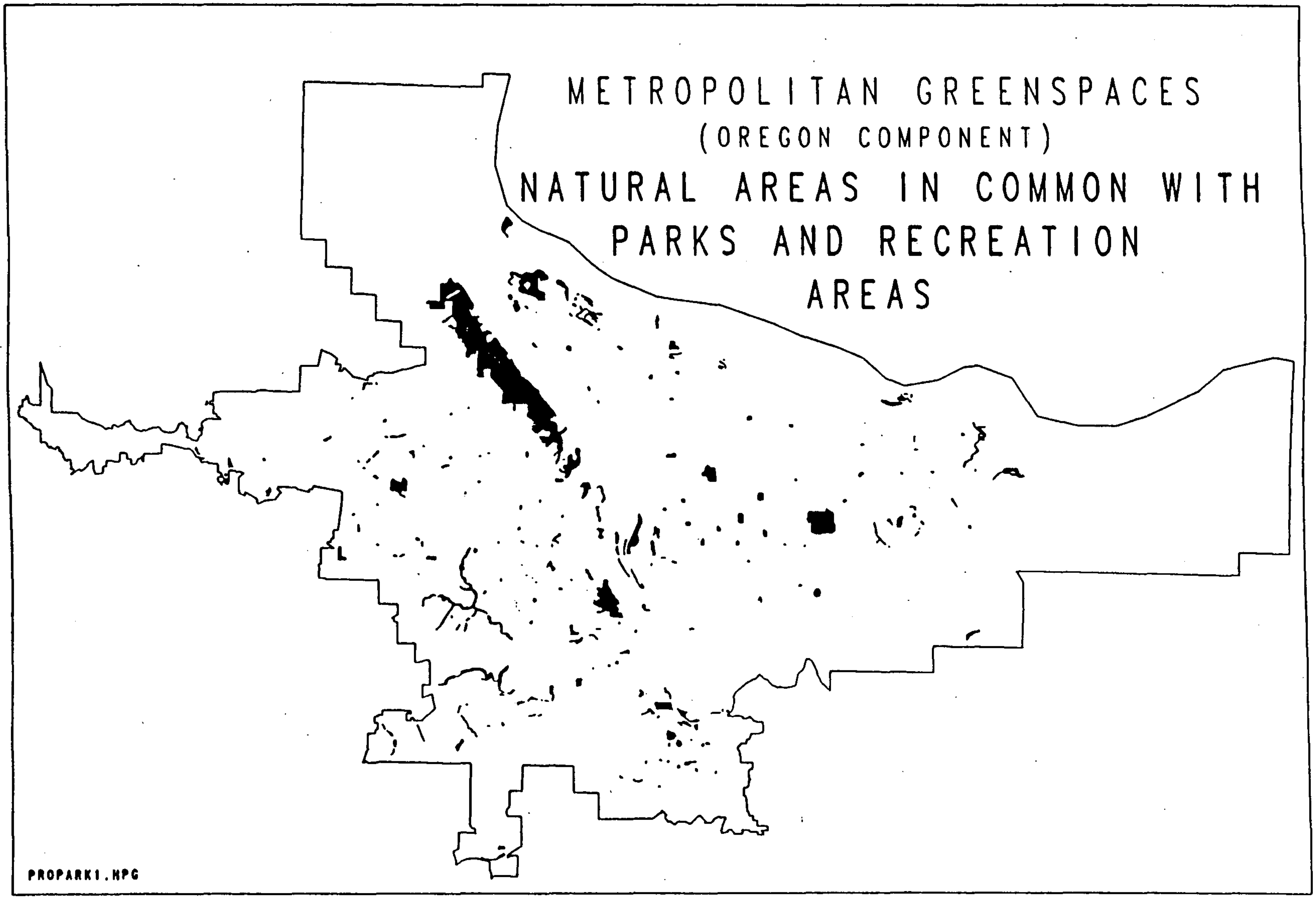

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS IN COMMON WITH PARKS AND RECREATION AREAS
PROPARK1.HPG

FIGURE 33

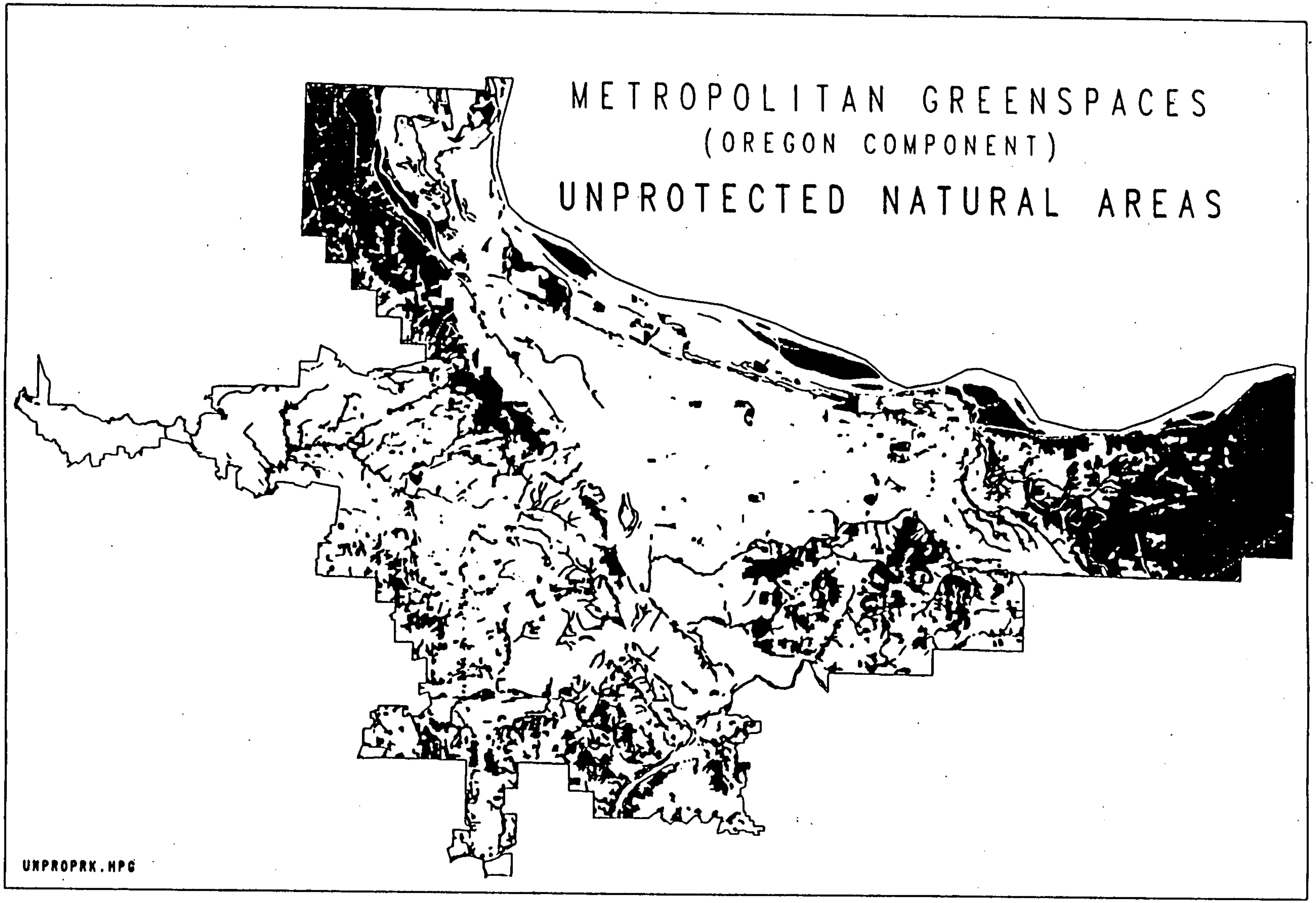

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
UNPROTECTED NATURAL AREAS
UNPROPRK.HPG

FIGURE 34

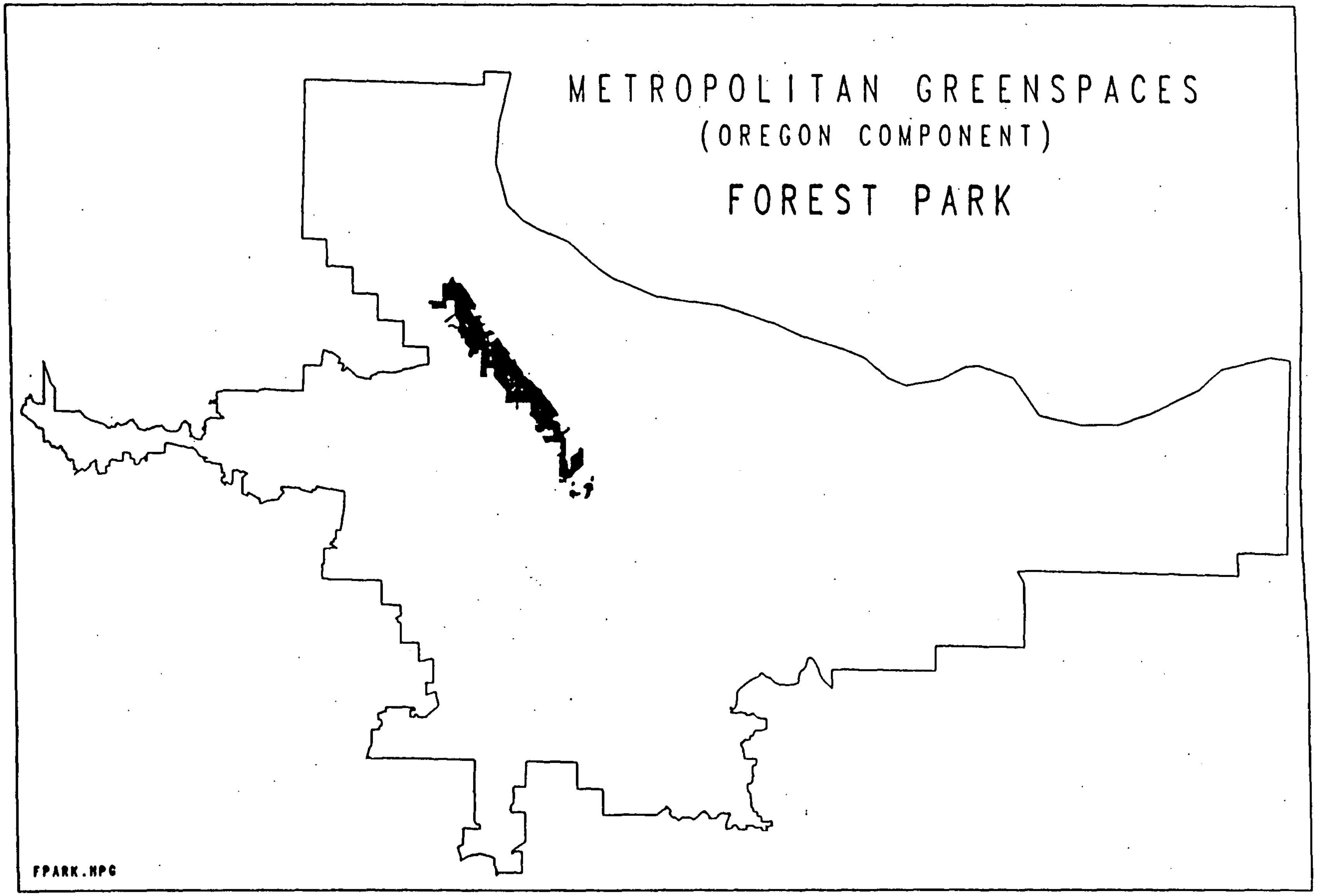

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
FOREST PARK
FPARK.HPG

FIGURE 35

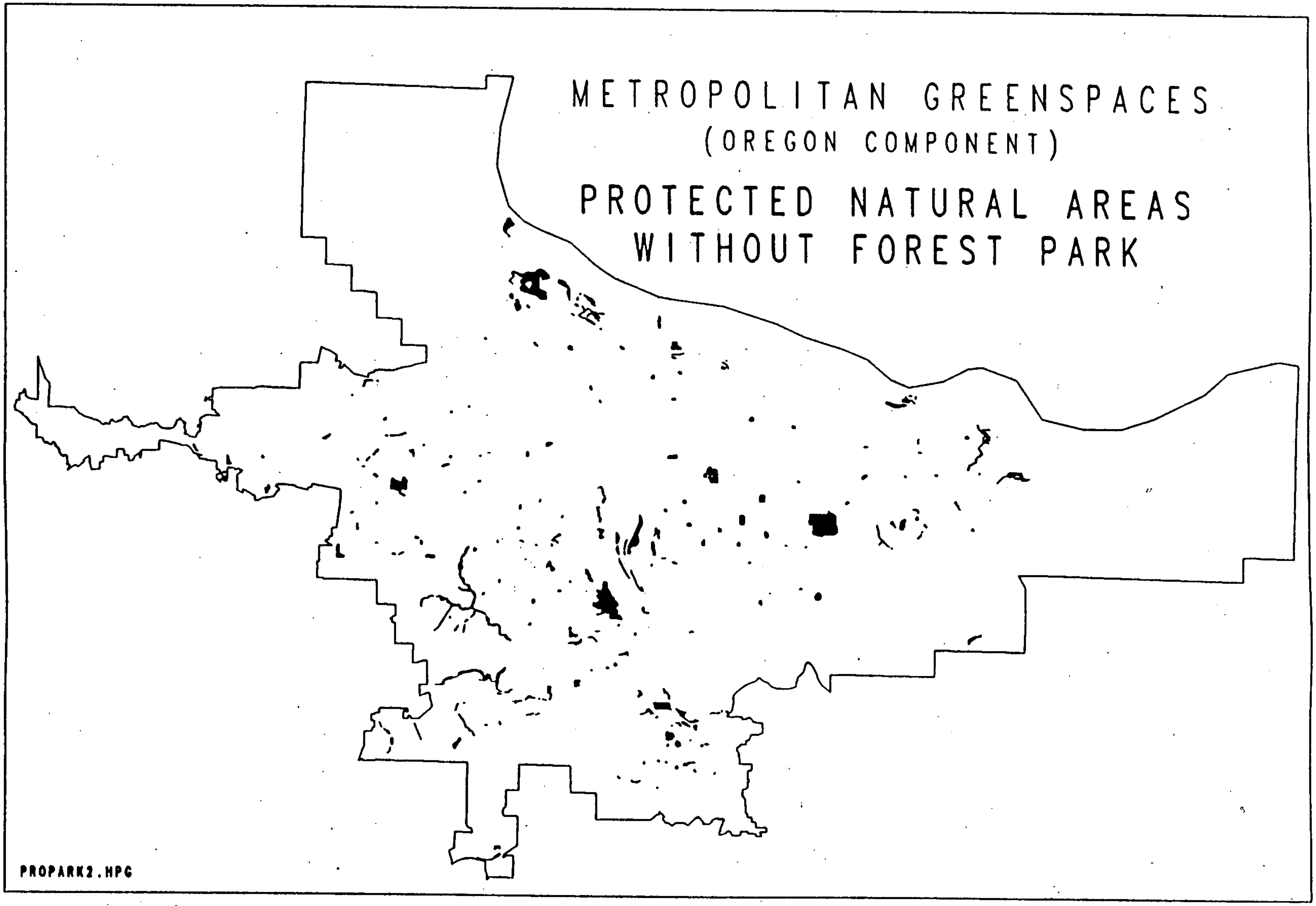

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
PROTECTED NATURAL AREAS
WITHOUT FOREST PARK
PROPARK2.HPG

FIGURE 36

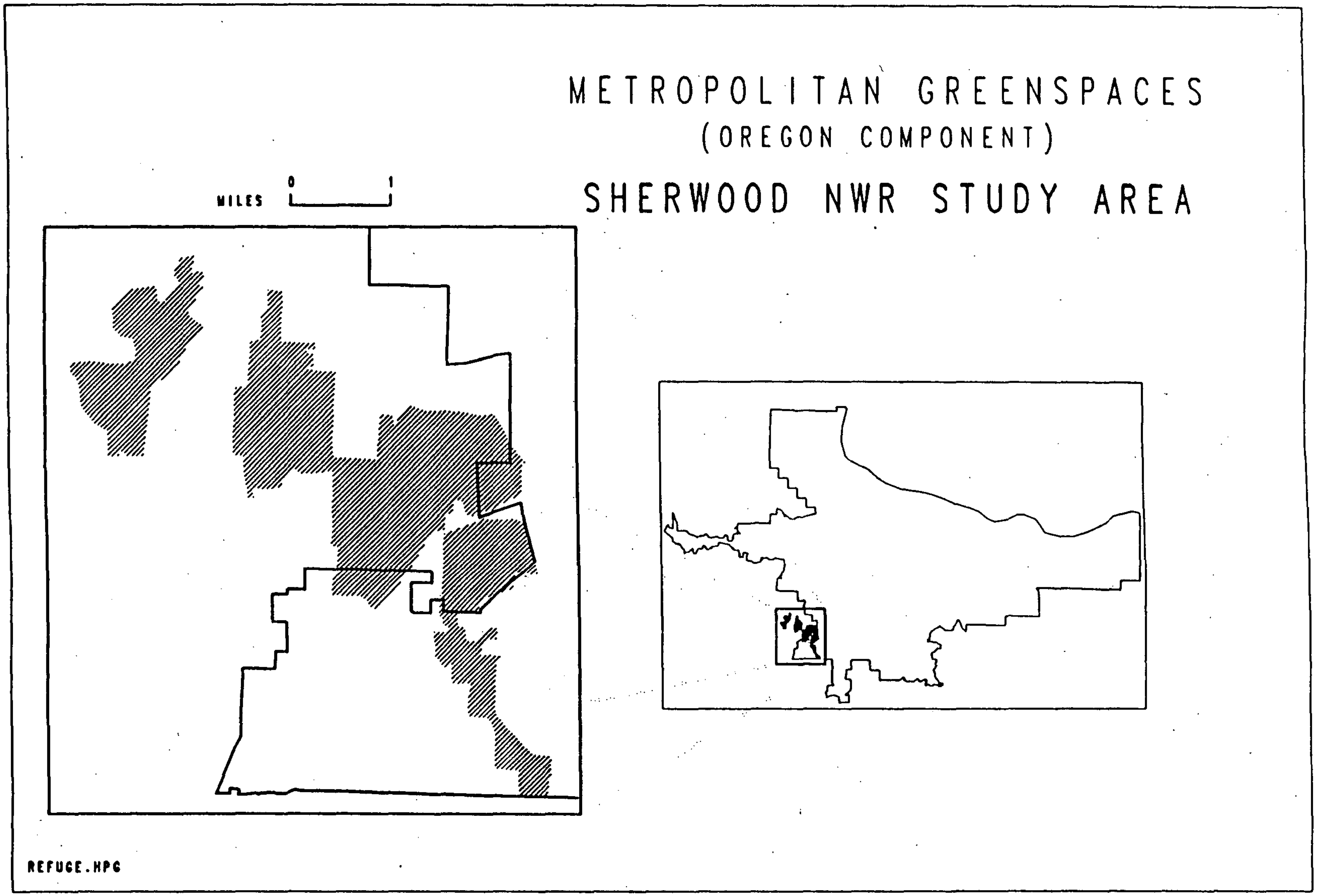

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
SHERWOOD NWR STUDY AREA
MILES
0
1
REFUGE.HPG

FIGURE 37

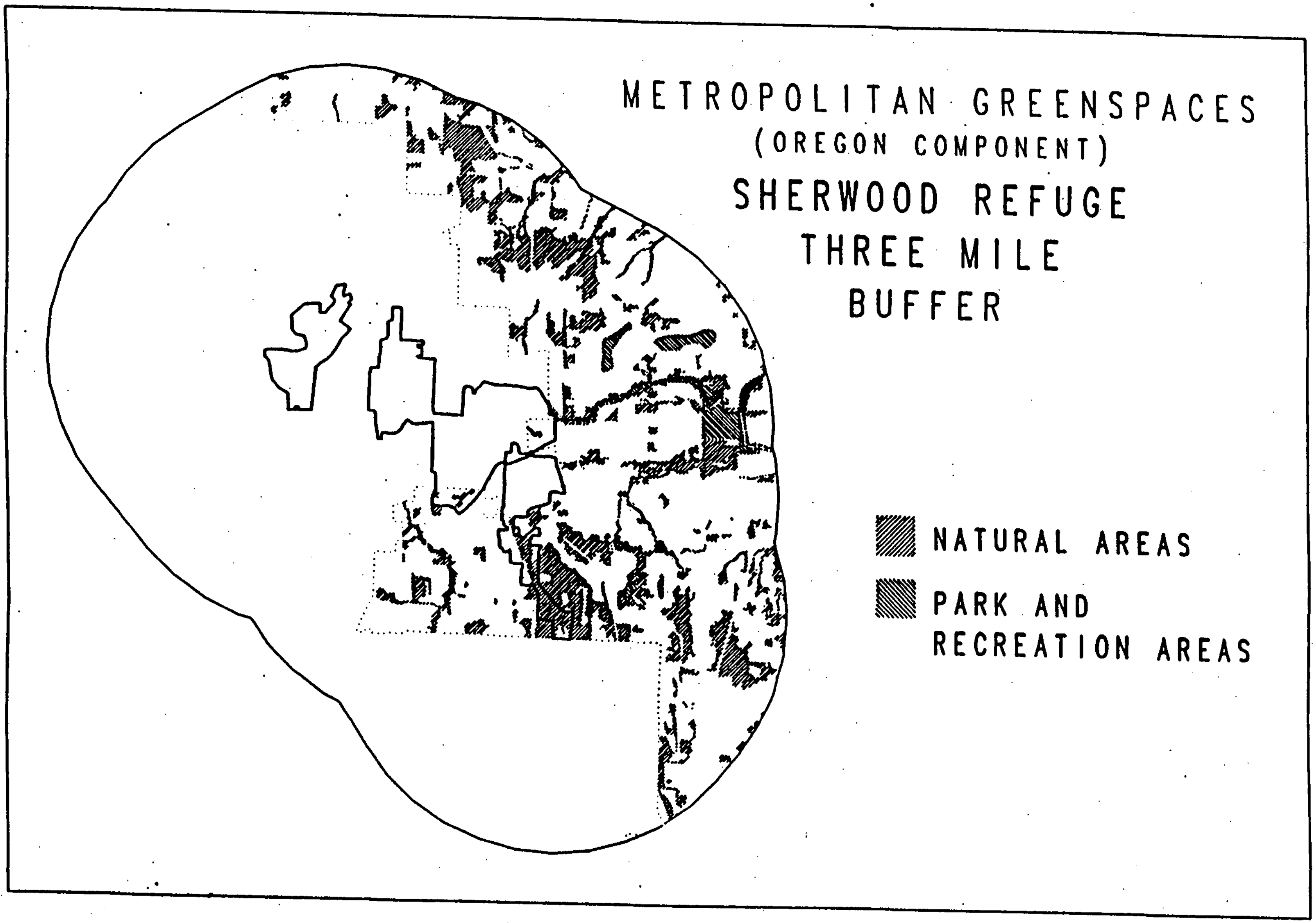

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
SHERWOOD REFUGE
THREE MILE
BUFFER
NATURAL AREAS
PARK AND
RECREATION AREAS

FIGURE 38

the proposed refuge and other natural areas within the Metropolitan Greenspaces system.

Table 7 is a tabulation of the acres of natural areas and park and recreation areas within the three mile buffer shown on Figure 38. There are 4,610 acres of natural area within the Oregon component that are within three miles of the proposed refuge. The formal designation and acquisition of even a part as a refuge will add substantially to the acreage of projected natural areas. The 765 acres of park & recreation area that already exist within three miles of the proposed refuge means that there are already a number of potential connecting pieces in place. The proposed refuge area has the potential to become a major anchor point within the Metropolitan Greenspaces system.

3.7 Hydrography

A coverage for hydrography was available from Metro's RLIS database. Since the RLIS coverage did not extend far enough eastward to include the entire study area, it was augmented in east Multnomah County with features digitized at PSU from 1:24,000 quad sheets. The augmented hydrography coverage was then clipped with the Oregon component boundary to produce the hydrography coverage for this analysis, shown in Figure 39.

The hydrography coverage consists of two classes of spatial features. One class is polygons, representing the outlines of rivers, lakes and other water bodies that cover extensive areas. The other class of features is arcs or single lines, representing smaller streams that may be almost any length, but are so narrow that it was not feasible to digitize them as anything other than a single line. Conceptually, each polygon can be assigned an area, but the single-line streams can only be assigned a length.

In recognition of the difference in attributes between polygons and line features, two variations of the hydrography were prepared. One coverage includes only the open water body polygons (Figure 40) and the other coverage includes only the single-line streams (Figure 41).

The polygon coverage includes 299 open water polygons covering a total area of 22,885.1 acres (35.8 square miles). Included as polygons are the Columbia and Willamette Rivers, major segments of the Clackamas, Tualatin and Sandy Rivers, all lakes and sloughs. The open water polygons range in size from 0.01 to 13,622.8 acres, with a mean size of 82.3 acres and a median size of 5.9 acres. The perimeters of all the polygons total 492.5 linear miles, providing a measurement of the total length of open water shoreline in the study area.

The total length of the arcs representing the single-line streams is 714.5 linear miles. However, since a stream has a bank on either side, the stream length may be doubled, to 1,429 linear miles, to indicate the potential total length of land fronting on stream banks. Adding the perimeters of the polygonal areas to the total stream bank length indicates that there are 1,921.5 linear miles of water edge, or potential riparian habitat, in the 582 square miles of the study area. This calculates to a mean

TABLE 7

NATURAL AREAS AND PARK & RECREATION AREAS WITHIN VARIOUS BUFFER ZONES AROUND THE PROPOSED TUALATIN RIVER NATIONAL WILDLIFE REFUGE

	Natural Areas		Park/Rec Areas	
Buffer Area	Number of Polygons	Acres	Number of Polygons	Acres
Study Area plus 0.5 mile	64	879	4	24
Study Area plus 1 mile	125	1,388	14	118
Study Area plus 2 miles	241	2,809	29	331
Study Area plus 3 miles	394	4,610	52	765

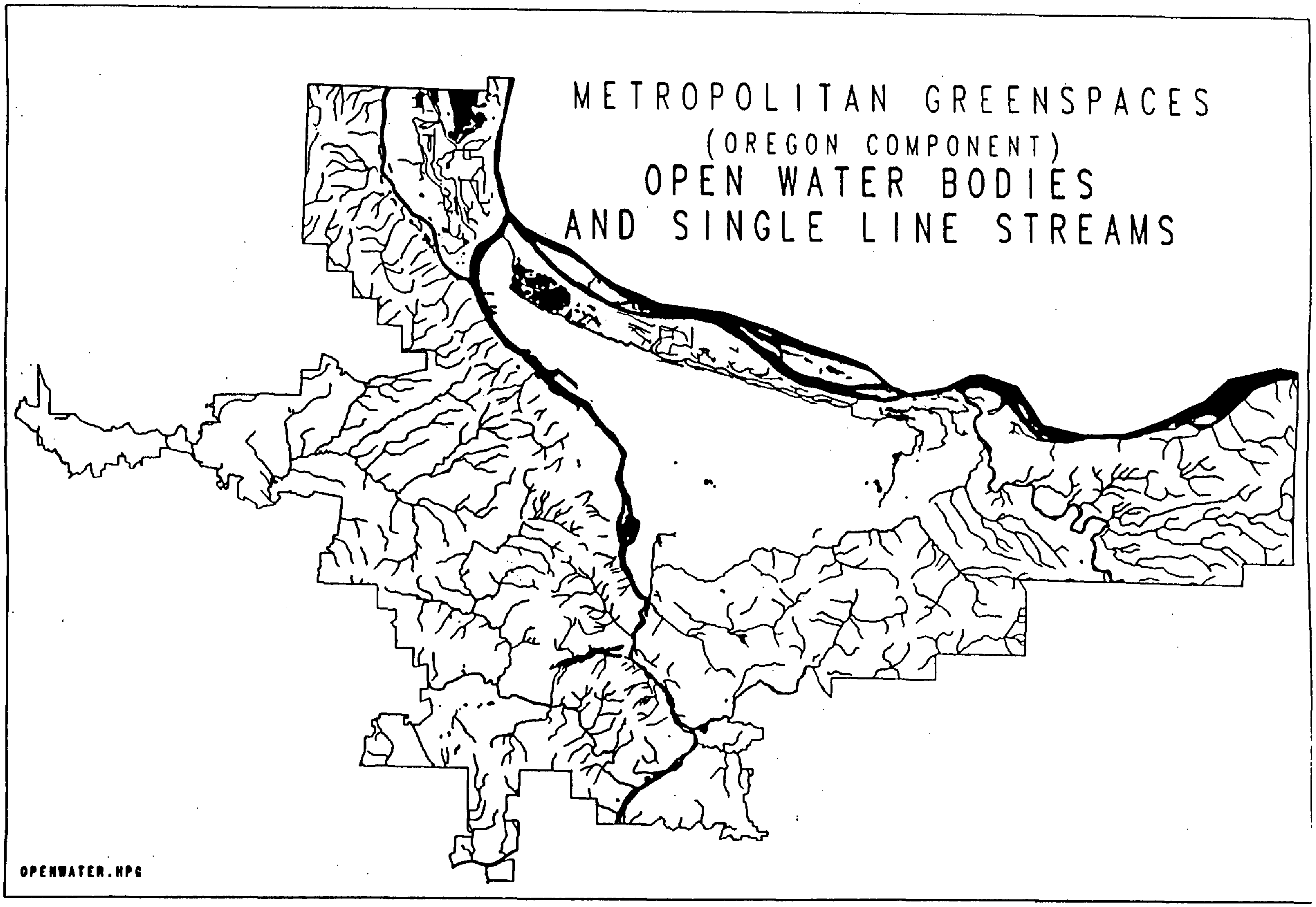

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
OPEN WATER BODIES
AND SINGLE LINE STREAMS
OPENWATER.HPG

FIGURE 39

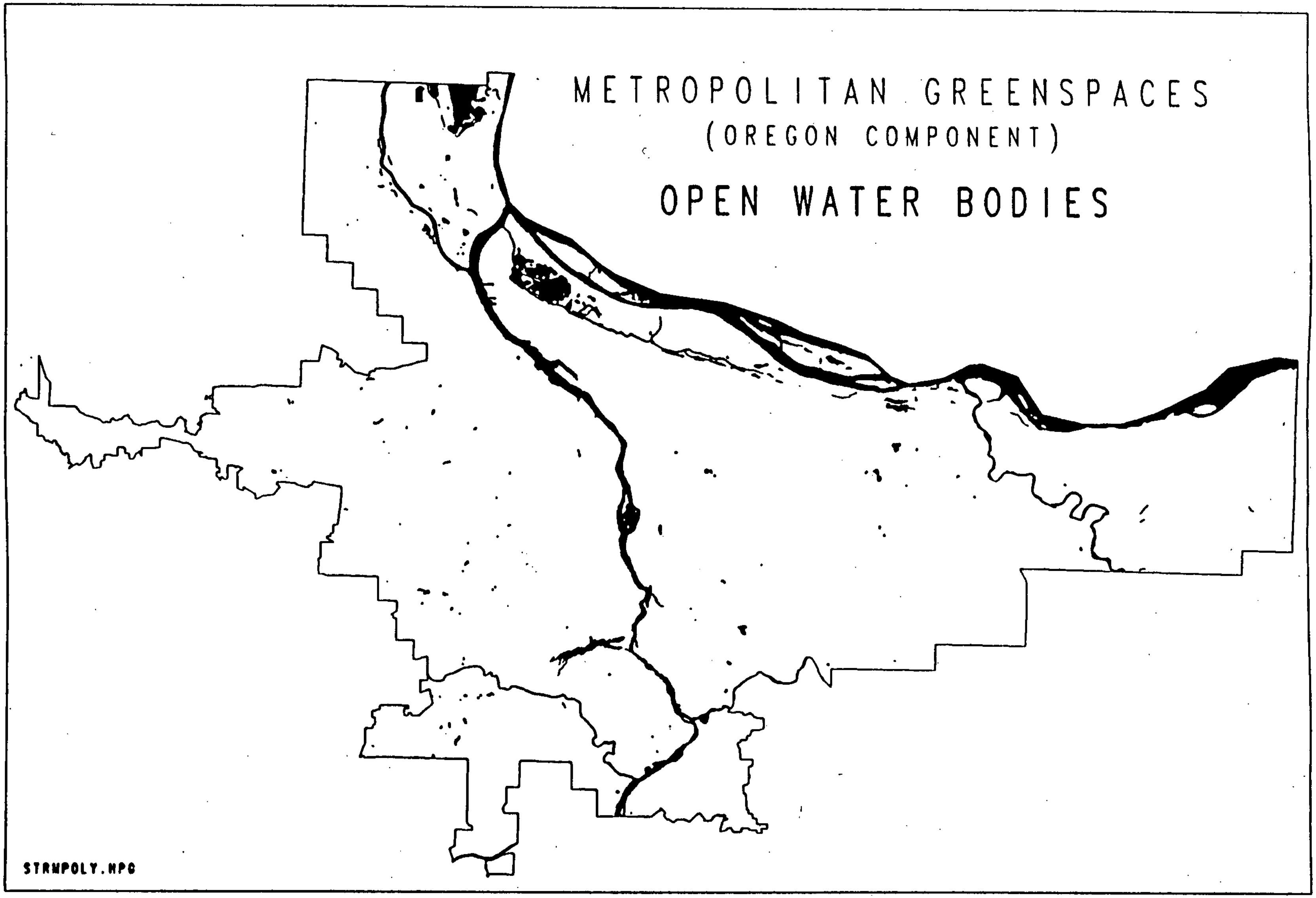

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
OPEN WATER BODIES
STRMPOLY.NPG

FIGURE 40

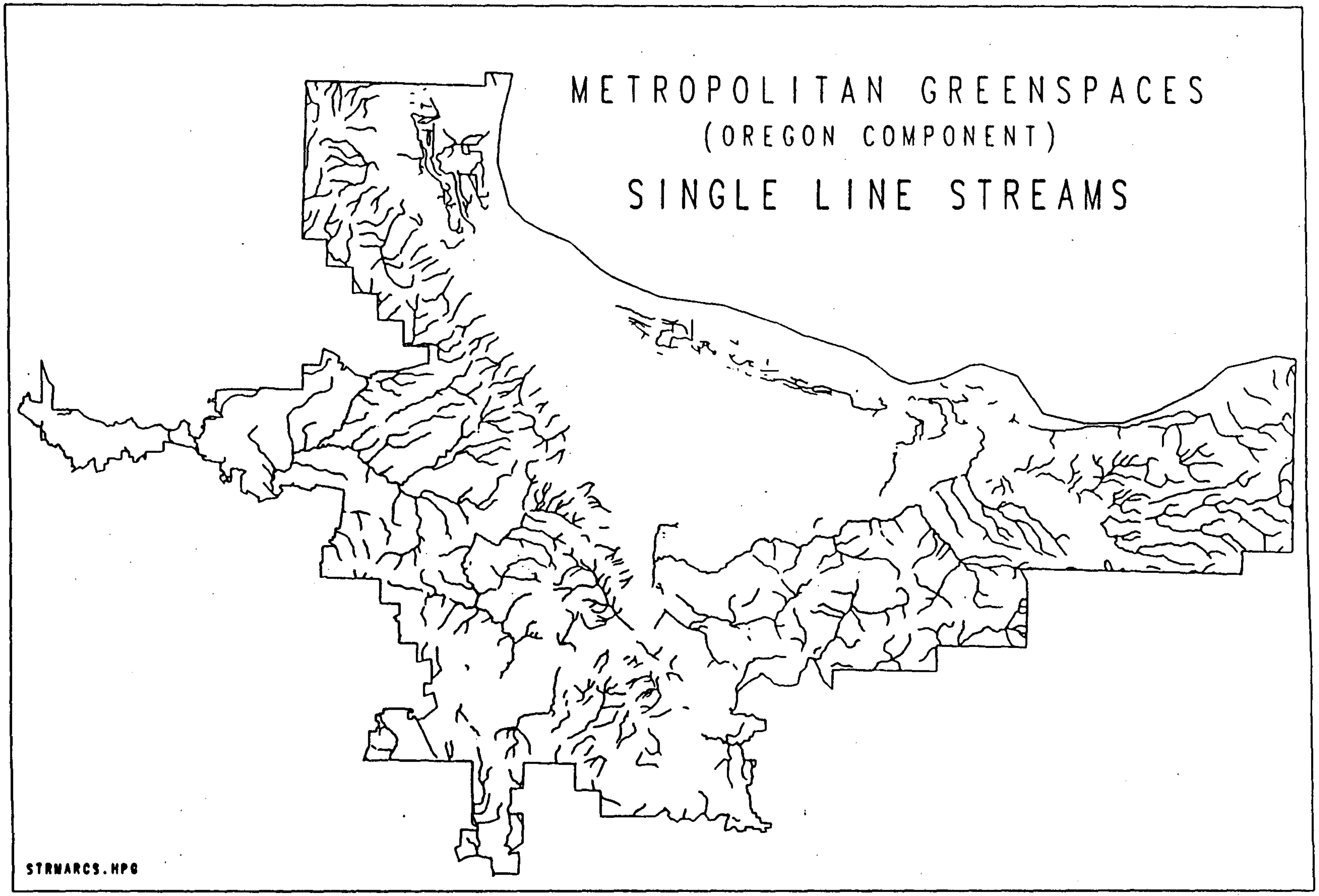

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
SINGLE LINE STREAMS
STRMARCS.HPG

FIGURE 41

value of 3.3 linear miles of potential riparian habitat within each square mile of the study area.

3.8 1990 Block Group Population

Data for current population within the Oregon Component were derived from 1990 census data. The data were acquired for block groups, a standard enumeration unit of Census data that is derived by aggregating data for individual blocks into larger, predefined, block group units. Each block group is identified by a unique numeric identifier within the census files, and clusters of block groups may be aggregated into the larger enumeration units of Census tracts. Block groups are, therefore, an intermediate-size reporting unit, larger than blocks but smaller than census tracts.

The block group data provides an appropriate level of spatial resolution for the 1990 data and thus was used in lieu of the much larger data set based on blocks (which would have provided higher spatial resolution) or the smaller data set based on census tracts (which would have provided lower resolution.) Block group data for an area somewhat larger than the Oregon component were acquired as an Arc/Info coverage from the Center for Population Research and Census at PSU. The polygonal outlines of the block groups contained in the coverage were derived from the U.S. Bureau of the Census' TIGER files.

Since the block groups vary in size, it is necessary to standardize the population data in order to identify population patterns. Population densities were calculated for each of the 929 block groups. Densities varied from 0 to 45.6 persons per acre, with a mean of 7.2 and a median of 6.8 persons per acre. The block group data was then clipped with the study boundary coverage and sliver polygons eliminated. The resulting 835 block groups, as shown in Figure 42, range in size from 27.5 acres to 23,909.6 acres, with a mean size of 444.4 acres and a median size of 139.5 acres.

The density figures were multiplied by the areas of the clipped block groups to calculate a new total population for each block group. Thus, for block groups that were truncated by the clip operation, a total population count was allocated to the remaining area of the block group in proportion to the amount of the original block group area remaining after the clip. For block groups that were not affected by the clip, the population remained the same. The total population of the study area in 1990 is 1,030,477, as calculated by adding up the populations of the individual block groups within the Oregon Component.

Though a good initial estimate, population densities based solely on block group population and block group areas are limited by the necessity of assuming homogeneous density throughout the block group. The spatial resolution of the density data may be refined and enhanced through use of a simple procedure. Within many of the block groups there is a mix of development levels, with some land heavily developed, some land moderately developed, and some land that is either undeveloped or, at least, only lightly developed. Undeveloped land has no population and including its area in density calculations tends to increase the denominator of the density equation, thereby reducing otherwise higher local densities and decreasing the overall range of density values. If these areas within

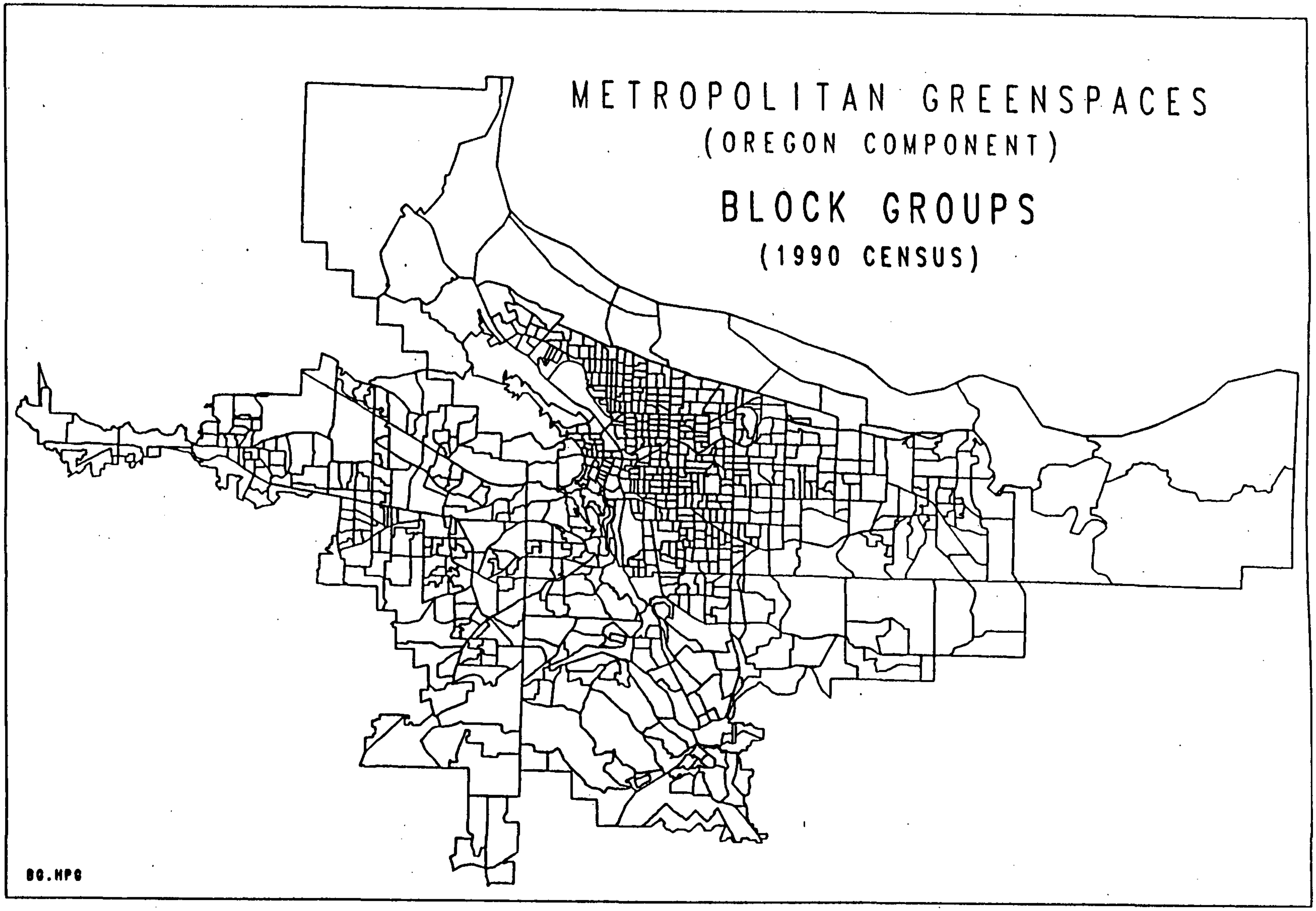

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
BLOCK GROUPS
(1990 CENSUS)
BG.HPG

FIGURE 42

the block groups can be identified, it is possible to identify more realistic denominators and to improve local population density estimates.

There are four major constituents of these unpopulated areas. Three of them -- natural areas, park and recreation areas, and open water bodies -- were available as coverages in the database. A fourth constituent of unpopulated area is agricultural land. Unfortunately, no data that identified agricultural land was available for the analysis.

In order to adjust the density figures to account for the unpopulated areas, the block group coverage was overlaid with the three available unpopulated area coverages -- natural areas, park and recreation areas, and open water bodies. The combined area of the three overlaid coverages was then subtracted from the area of the block group in which it was contained and the total block group population reassigned to the remaining *populated* portions of the block group.

Densities were then calculated for the remaining or *populated* portions of each block group. The resulting recalculated densities ranged from 0 to 45.6 people per acre, with a mean of 4.9 and a median of 3.6 people per acre. The maximum density remains the same after the reallocation since the highest density block group contained no unpopulated areas and was thus unaffected by the recalculation procedure. However, there are some shifts in the pattern of densities over small areas of the map.

The map of the recalculated densities is Figure 43. As would be expected, the densities tend to be highest in the urbanized center of the study area and tend to decline away from the center, though locally there are isolated clusters of very high density. Highest densities are found in downtown Portland, and in inner northeast and southeast Portland. Densities rivaling those of east Portland are also found in areas of Washington County, indicative of the rapid urbanization that is underway in that traditionally agricultural area. Lowest densities are found in northern and eastern Multnomah County. The rest of the map area indicates moderate densities interspersed with small moderate-to-high density patches. The densities along the edge of the map may be artificially low due to the averaging effect of having block groups along the periphery clipped by the study area boundary.

This coverage of the reallocated population represents the highest level of spatial resolution for 1990 population data. Subsequent analyses requiring 1990 population data should use this reallocated data rather than the original block group data.

3.9 Population Projections to 2010

Population levels as of 1990 are a useful starting point for evaluating and prioritizing human needs in natural areas acquisition. However, the greater Portland/Vancouver metropolitan region is forecast to undergo major population increases in the coming decades and it is necessary to consider future population patterns as a part of the long-range planning for natural area preservation.

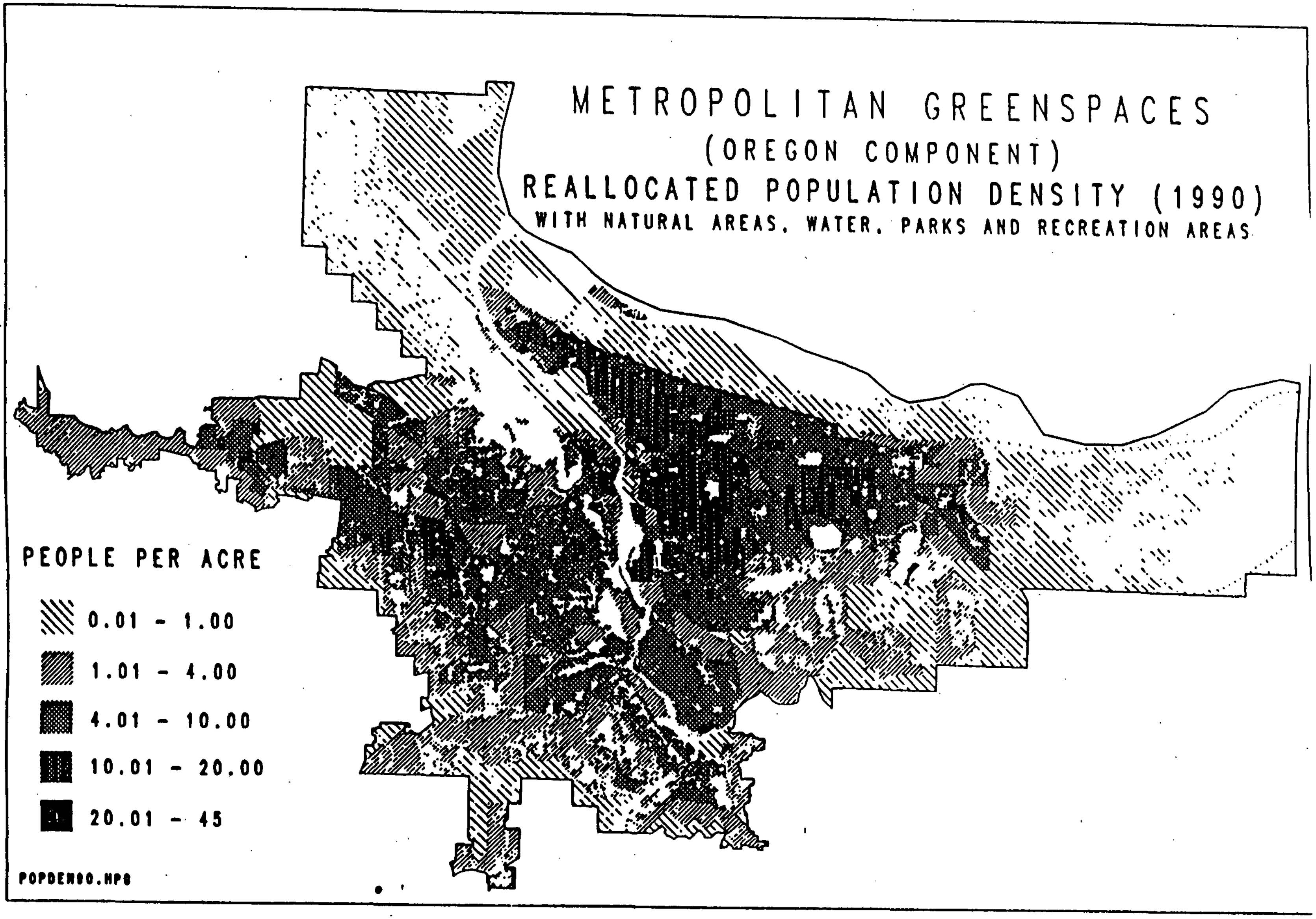

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
REALLOCATED POPULATION DENSITY (1990)
WITH NATURAL AREAS, WATER, PARKS AND RECREATION AREAS
PEOPLE PER ACRE
0.01 - 1.00
1.01 - 4.00
4.01 - 10.00
10.01 - 20.00
20.01 - 45
POPDEN90.HPG

FIGURE 43

Data from a recent *Regional Forecast* of population to 2010 (Metro, 1989) were provided from Metro's RLIS. These data are based on census tracts and are therefore spatially coarser than the 1990 block group population. However, given that these data represent projections rather than actual conditions, and are subject to the imprecision that is inherent in any kind of projection, the census tract level of spatial resolution is appropriate.

The 2010 projections were made based on 1980 census tract boundaries. Within the Oregon Component the 2010 population projections include 245 census tracts, as shown in Figure 44. The area of the census tracts are generally about two to five times the size of the 1990 block groups, and range in size from 83.6 acres to 44,440 acres, with a mean size of 8,111.7 acres and a median size of 544.4 acres. Using the individual census tract populations and the size of each census tract as calculated by the GIS software, population densities were calculated for each tract.

Densities varied from 0 to 29.1 persons per acre, with a mean of 6.4 and a median of 6.5 persons per acre. The total projected 2010 population for the Oregon component, calculated by summing up the populations of the individual tracts within the study area, is 1,210,065. This represents an increase of 179,588 people or 17.4 percent over the 1990 population of 1,030,477.

In order to allow direct comparison with the 1990 data, the 1990 block group boundaries were unioned with the 2010 census tract density map and the census tract densities assigned to their corresponding block group areas. As with the 1990 population data, an adjustment was made in the density figures to account for unpopulated areas. The same three unpopulated area coverages -- natural areas, park and recreation areas, and open water bodies -- were used and populations were reallocated to the remaining or *populated* portions of each census tract (Figure 45).

Based on the reallocated populations, densities ranged from 0 to 257.6 people per acre, with a mean of 6.5 and a median of 2.5 people per acre. Though the maximum density value increased, only five areas had densities greater than 100 people per acre. In comparison with the 1990 density pattern, the map has more contrast, with small local areas gaining population and appearing darker in relation to some adjacent areas that either remain the same tone or, in some cases, get lighter as population declines due to commercial or industrial development replacing housing. Highest densities continue to be found in inner city and east Portland but the darker tones expand outward, particularly to the south and southwest of the city. Lowest densities continue to be found in north and east Multnomah County, though the overall area of lighter tones on the map has declined somewhat.

It should be noted that the procedure of reallocating population from census tracts to block groups results in a spatial smoothing of the density data. The population total assigned to each census tract is a function of a variety of population densities within the tract, ranging from high to low. Calculation of a density for the entire tract from the total population represents an averaging of these high and low densities, a process that eliminates the extremes and produces a single central value. As a result, the high and low density information is lost. In reallocating the population back to the smaller block groups, that average density is used throughout the tract

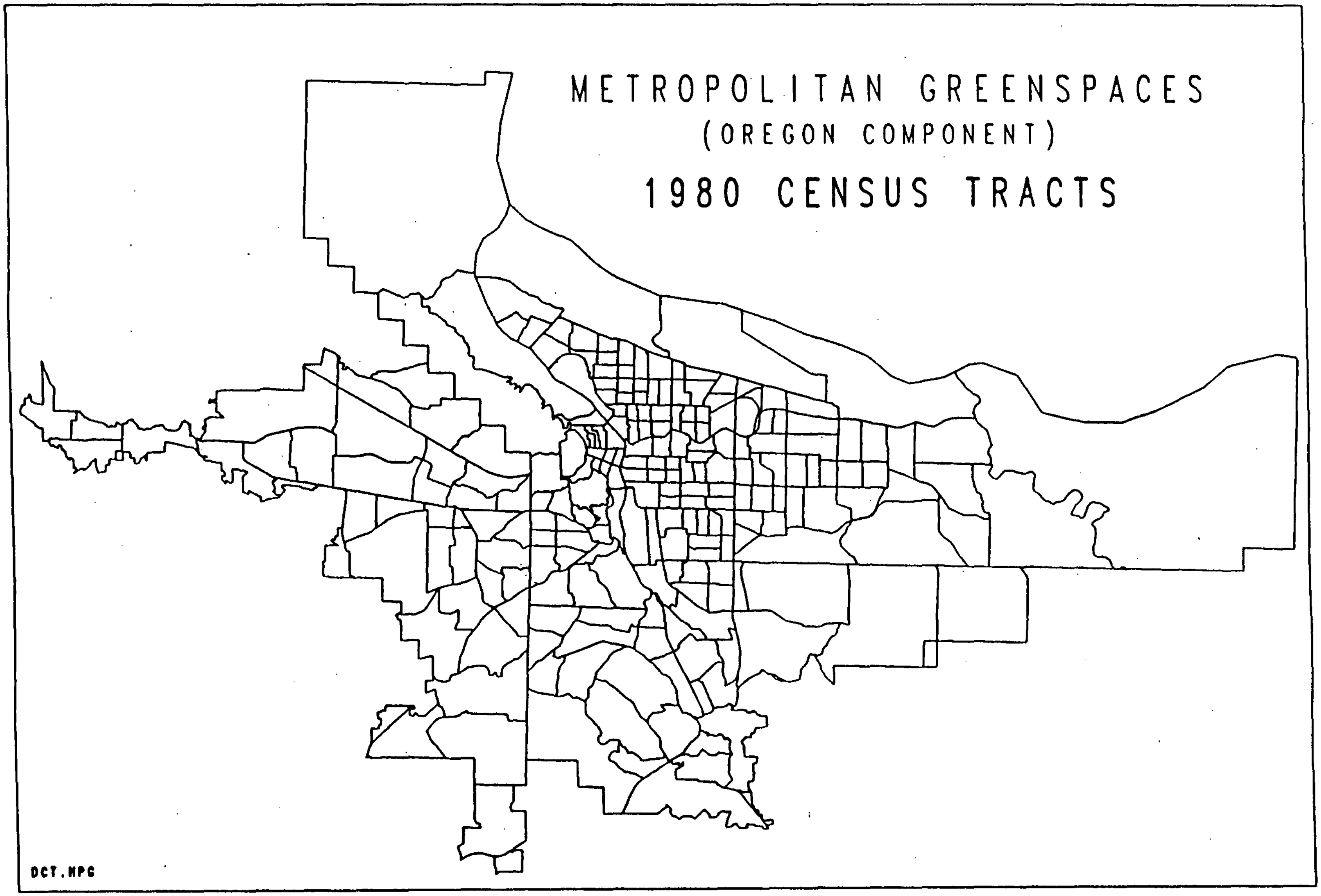

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
1980 CENSUS TRACTS
DCT.HPG

FIGURE 44

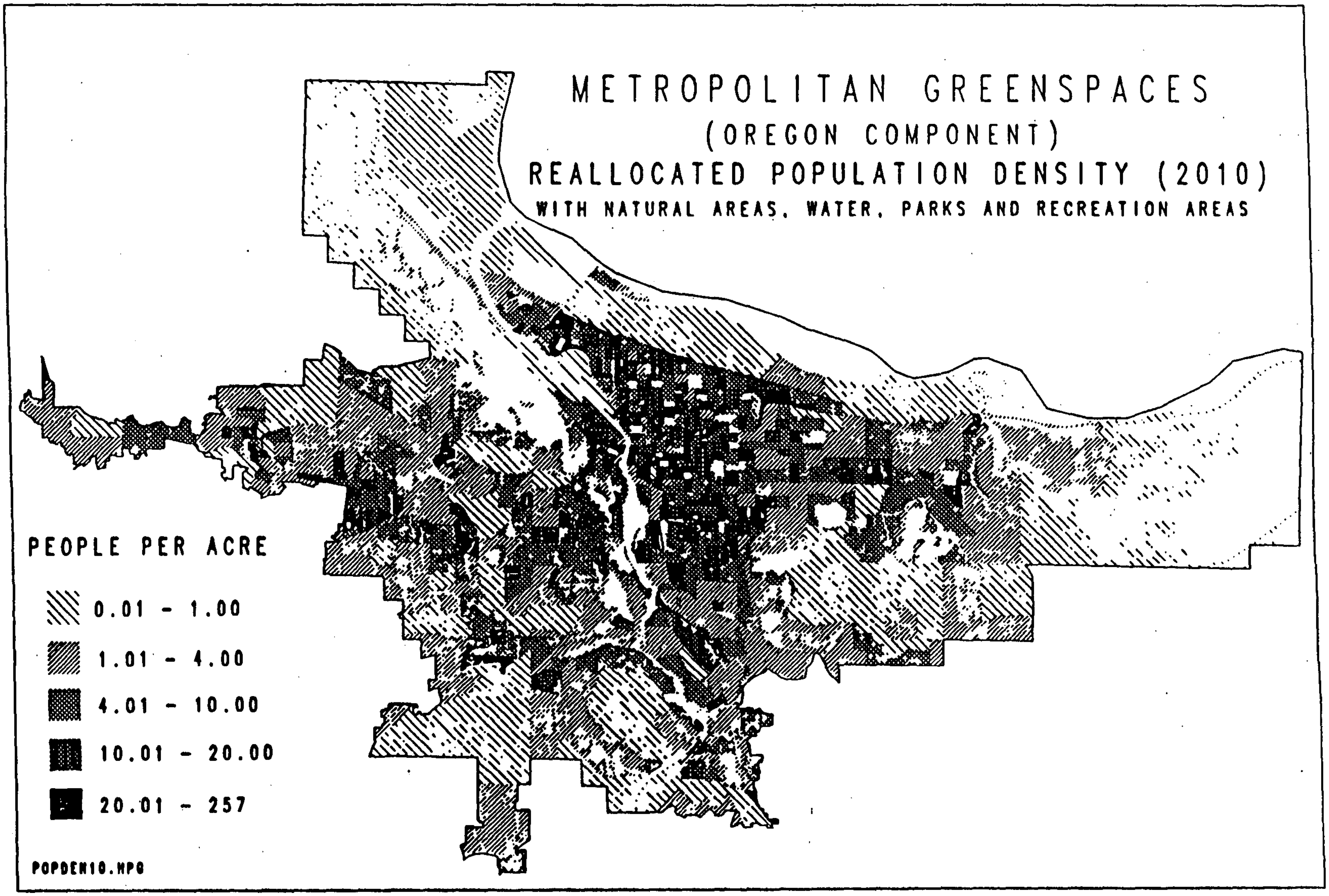

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
REALLOCATED POPULATION DENSITY (2010)
WITH NATURAL AREAS, WATER, PARKS AND RECREATION AREAS
PEOPLE PER ACRE
0.01 - 1.00
1.01 - 4.00
4.01 - 10.00
10.01 - 20.00
20.01 - 257
POPDEN10.HPG

FIGURE 45

area, resulting in a large area with identical densities and a dampening of the overall density variation.

The reallocation of population based on the three unpopulated area coverages is useful for comparison with the 1990 reallocated data. It is unrealistic, however, to assume that the 1990 natural areas will all exist in 2010. Thus, a second reallocation of population was performed, using only the open water, and parks and recreation coverages. The assumption here is that these types of areas will continue to not be developed and gain population. When this approach is used, the map in Figure 46 is the result. The pattern of densities is very similar, but the map has a *smoother* look since the fragmentation of the shading patterns that results from the white areas representing the natural areas on the other two maps is gone.

3.10 Watersheds and Polysheds

As part of the analysis of the various data sets, multiple coverages will be joined together to allow the interaction of their spatial patterns to be evaluated. The boundaries in one data set are generally very different from the boundaries in another, and the joining together of their outlines serves to produce a new set of polygons defined by the combination of both sets of boundaries. The result is a rapidly increasing fragmentation of the area into numerous smaller and smaller polygons.

The increasing fragmentation of the area and the swelling data sets create problems. Strictly from a data processing viewpoint, data sets rapidly get unwieldy when they grow from a few thousand polygons to 10,000 or 15,000 polygons. From an analytical viewpoint, it becomes difficult to recognize generalized patterns from highly fragmented data. And, from the viewpoint of understanding and applying the results of the analysis, clearly-defined and coherent areas must be distinguished in order to develop and implement plans.

It is necessary to identify an organizational structure for aggregating the multitude of small polygons back into reasonable-sized areal units. The spatial structure that is chosen will cast the outcome of the analysis within a particular framework and play an important role in shaping the application of the results into substantive action. Therefore, selection of an appropriate spatial structure for organizing the data is extremely important.

3.10.1 Rationale for Watershed-based Analysis

One spatial framework to be considered is administrative jurisdictions such as cities, counties and special districts. However, this framework has several characteristics that makes it inappropriate for natural resource applications. Jurisdictions vary greatly in size, they frequently overlap and they usually represent artificial units that have little correspondence to natural resource patterns.

On the other hand, watersheds as a spatial framework have a number of characteristics that make them especially attractive for this purpose.

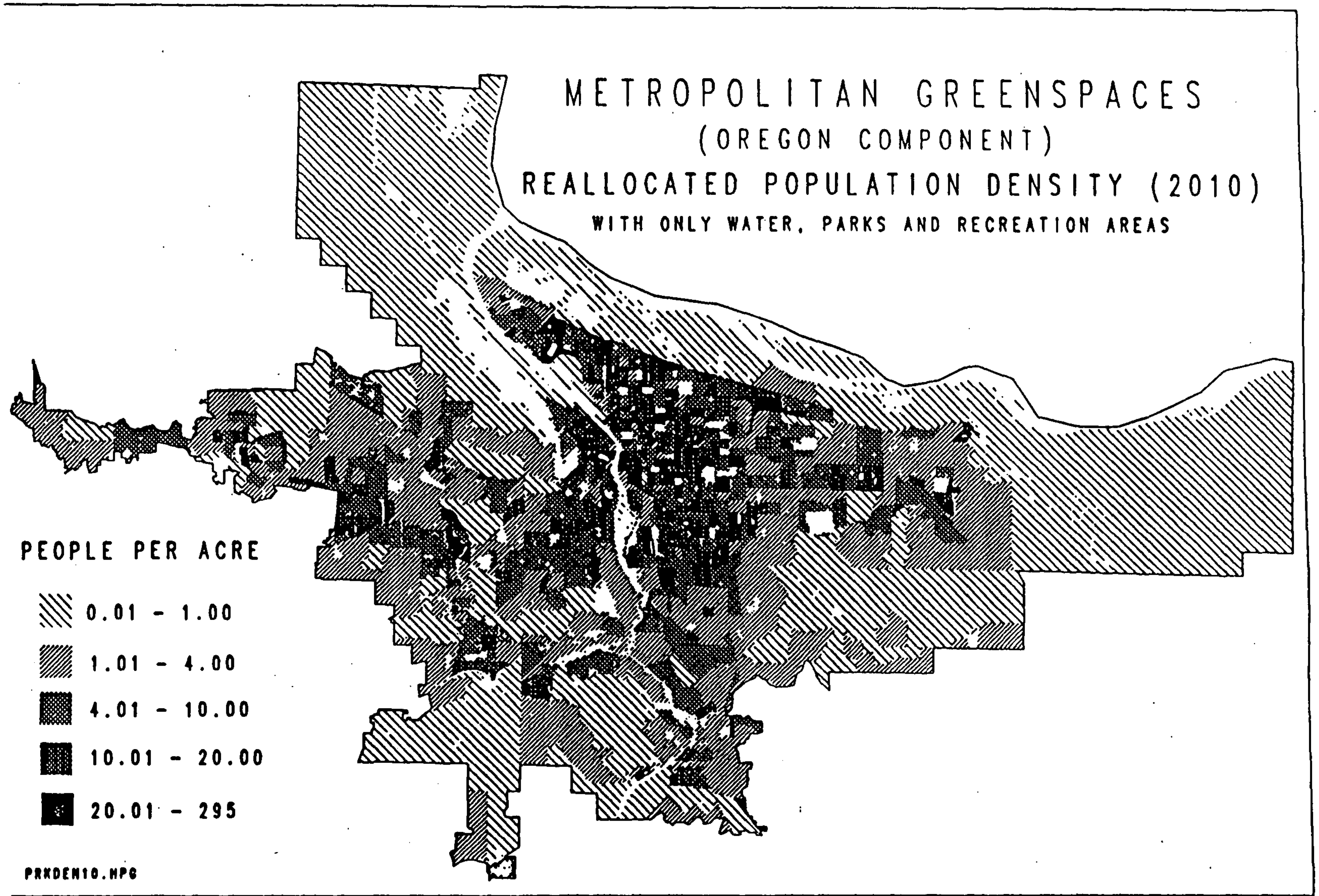

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
REALLOCATED POPULATION DENSITY (2010)
WITH ONLY WATER, PARKS AND RECREATION AREAS
PEOPLE PER ACRE
0.01 - 1.00
1.01 - 4.00
4.01 - 10.00
10.01 - 20.00
20.01 - 295
PRKDEN10.HPG

FIGURE 46

1) The watershed is a commonly accepted and easily understood landscape unit. It relates directly to landform and hydrology, representing the catchment area or collection area for precipitation entering a particular stream, river or lake.

2) Watersheds can be readily delineated from existing topographic data. The process simply involves the location of individual stream channels and the interpretation of slopes from contour lines. Slopes which incline downward to a stream are part of that watershed; slopes which incline away from a stream are part of another watershed; and the ridge lines or divides between slopes represent watershed boundaries.

3) There is no overlap of watershed areas as there often is with administrative jurisdictions. When overlap exists, any locations that are within the overlapping area may be assigned to either of the jurisdictions. With watersheds there is no ambiguity as to which area something belongs to; any specific location belongs to only a single watershed.

4) Since all water in the Oregon Component eventually flows into the Columbia River, the unity of the study area as part of a single natural landscape unit, the Columbia River watershed is recognized and serves as the basis for analysis.

5) Watershed units may be related to each other in a hierarchical fashion. There is thus a basis for viewing each unit not just in isolation, but within a regional structure, and for describing interactions and connectedness within that structure.

6) Each watershed has a readily-identifiable set of features in the form of a stream mouth, a stream channel, slopes leading into the channel, and other features about which data may be collected and organized to describe characteristics of the individual units. Since the list of features or characteristics is common to all watersheds, it provides a basis on which to make comparisons of situations and conditions between units.

7) Many other features of the natural environment may be connected with or correlated to the watershed. For example, patterns of geology play an important role in shaping the watershed and are reflected in the physical structure of the watershed landforms. Soils are often related to the general configuration of the watershed. Patterns of plant distribution relate to elevation and aspect differences within the watershed as well as to proximity to water. Wildlife densities and movement patterns can often be associated with watershed features.

8) Watershed boundaries are determined by natural processes and change so slowly, in terms of human time scale, that they may be considered permanent. This is in sharp contrast to administrative boundaries, which are defined on a political basis and are subject to relatively frequent changes.

Given these characteristics, watersheds would appear to provide a nearly ideal basis for subdividing the study area.

3.10.2 Delineation Strategy and Procedures

A large watershed, such as the Columbia River, may be subdivided hierarchically into smaller watersheds and they may, in turn, be subdivided into still smaller watersheds. The subdivision is based on stream patterns and the identification of associated drainage areas. Only the four or five very largest watersheds in the study area had been delineated and entered into a computerized mapping system. Since that level of delineation is not detailed enough for the goals of this project, it became necessary to perform original delineations of smaller watersheds.

Watershed delineation requires landform relief information in the form of contour maps. The most readily available maps having the necessary contour information are the U.S. Geological Survey 1:24,000 (1 inch = 2,000 feet) scale 7½-minute quadrangle sheets. Since the scale of these maps is the same as that at which the natural area mapping was performed, the spatial resolution of delineations from these maps represents a good match with the natural areas data.

The delineations were performed by visually examining stream patterns and contours on the 46 quad sheets required to cover the area. Watershed divides were identified, drawn on the quad sheets and then digitized into a single Arc/Info map coverage. A total of 95 watersheds were delineated. Three key rules were adopted for the delineations:

1) All streams named on the quad sheets were delineated. Unnamed tributaries of named streams were not delineated as separate watersheds, but were included as part of the named stream's watershed.

2) If a delineated watershed extended outside the study area, it was followed outside the study area and completely delineated. The two exceptions to this rule were the Columbia and Willamette River watersheds, which both extend so far outside the study area that full delineation was not feasible.

3) Sometimes, while continuing a delineation beyond the study area, a named tributary of the stream being delineated was encountered and the tributary fell entirely outside the study area. In such cases, the watershed of the tributary that fell

entirely outside the study area was not delineated separately, but was treated simply as an undifferentiated portion of the larger watershed.

3.10.3 Derivation of Polysheds

Since many of the delineations extended beyond the study area boundary, the problem of incongruence between natural (watershed) boundaries and human-defined (study area) boundaries arises once again. Though the 95 watersheds completely cover the study area, their boundaries do not correspond to the study area boundaries. Some are contained fully within the study area and a number of them extend outside the study area.

In order to match up the delineations with the study area, the watershed delineations were clipped by the Oregon Component boundary, resulting in the truncation of all the watersheds that extend outside the study area (Figure 47). In a number of cases, the proportion of the watershed outside the study area tends to be very large. Thus, though the total area encompassed by the extended watershed delineation was 2,947 square miles, only 582 square miles of that area, or 19.7 percent of the fully-delineated watershed area, was included within the clip area.

Most notable among the clipped watersheds are the larger ones -- the Tualatin, Sandy and Clackamas Rivers -- as well as the Columbia and Willamette, which were already only partially delineated. There were also 29 smaller watersheds that were affected by the clip, making a total of 34 watersheds that were truncated.

Though there are 95 watersheds that were delineated within the Oregon component, the addition of two factors resulted in a final coverage with a larger number of polygons. The first factor was the clipping of the watersheds by the study boundary, which resulted in a number of the truncated watersheds being split into two or more polygons on the map. For example, the Tualatin River watershed straddles a long segment of the southwest edge of the study boundary. However, after overlaying the study boundary, the watershed is truncated in several places and broken up into six distinct polygons within the study area. Other watersheds for which the same thing happens are the Willamette River, Rock Creek and Beaver Creek, which are all split into two polygons.

The second factor acting to produce a larger number of polygons was the large size of the Columbia and Willamette River watersheds. The Columbia River extends nearly the full length of the top edge of the study area and the Willamette River extends almost the entire distance from the bottom to the top of the study area. In order to provide differentiation of these relatively large areas, it was necessary to subdivide them into smaller units. The divisions were drawn at points where key streams enter and were chosen so as to subdivide the larger units into segments that are more in line with the mean size of the other basins. On the Columbia, an

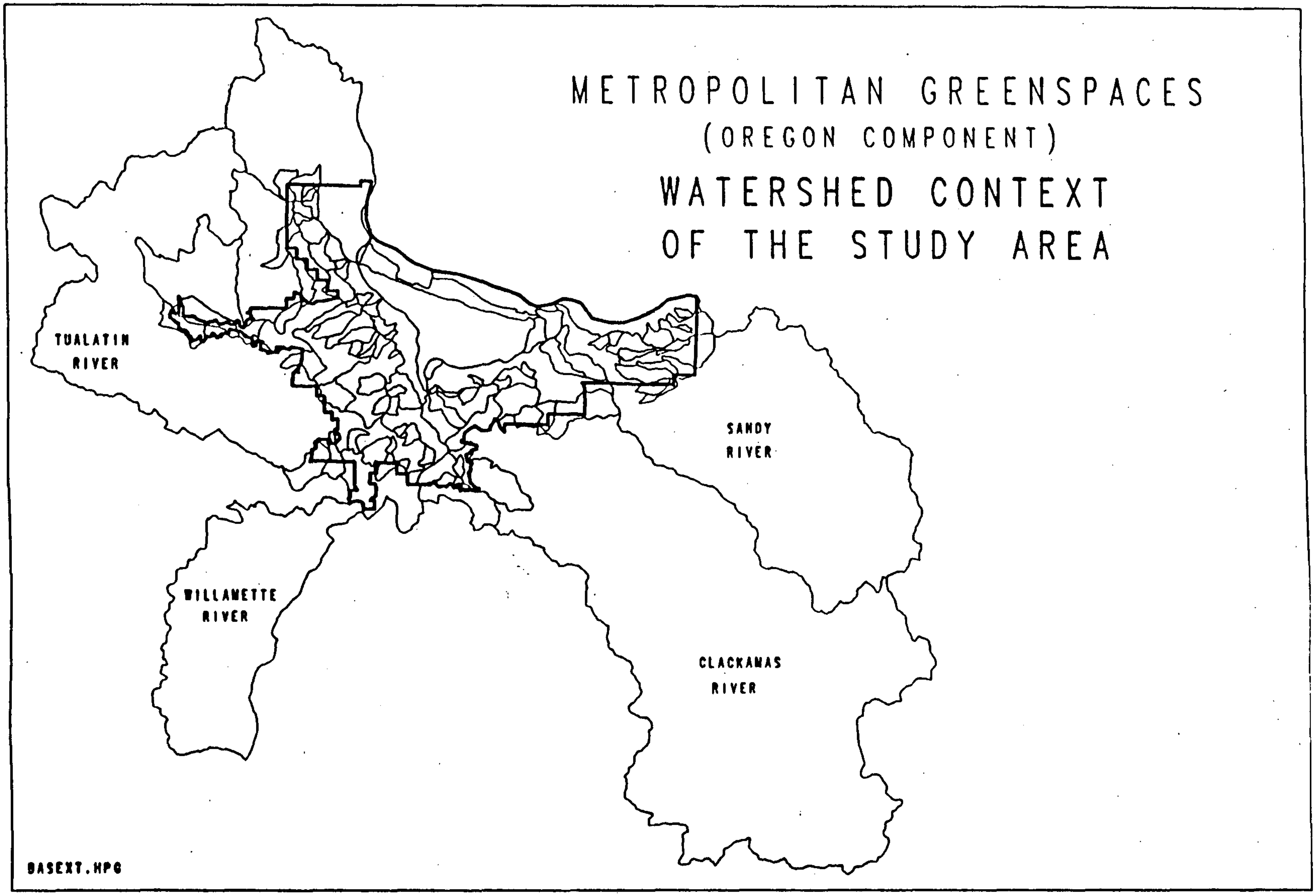

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
WATERSHED CONTEXT
OF THE STUDY AREA
TUALATIN RIVER
SANDY RIVER
WILLAMETTE RIVER
CLACKAMAS RIVER
BASEXT.HPG

FIGURE 47

additional set of lines were drawn in order to differentiate Hayden Island from the Columbia River shore. Also, a dividing line was drawn down the middle of the Willamette River, in recognition of the different conditions that often occur on either side of a river as wide as the Willamette. The Columbia was divided into five smaller units and the Willamette into nine units.

As a result of subdividing the two rivers and the subdivision of other watersheds along the study boundary, there are additional polygons produced on the map, bringing the total up from 95 to 119. Since these polygons have their origin in watershed delineations, they will be referred to as *polysheds* from here on in this text (Figure 48) to distinguish them from watersheds.

3.10.4 Characteristics of the Polysheds

The polysheds in the coverage range in size from 37.4 acres to 37,908 acres. The mean size of the polysheds is 3,131.8 acres and the median size is 1,564.5 acres (see Figure 49).

The largest single polyshed in the coverage is the 37,908-acre triangular area encompassing the heart of the City of Portland area. As a consequence of development, the original stream network in this *concrete triangle* has been diverted into pipes and buried beneath the ground. This unit is unique among the polysheds in that there is no above-ground stream associated with it. Thus, moving northward from Johnson Creek adjacent to the southern edge of the triangle, one does not encounter flowing water again until reaching the Columbia Slough, adjacent to the northern edge of the triangle. Though the triangle is large, there is no reasonable way to subdivide this unit into smaller polysheds.

The second largest polyshed is Johnson Creek at 26,552 acres and the third largest is Sauvie Island at 15,704 acres.

Each watershed divide represents a ridge or line of higher elevation than the surrounding area. Some divides are very prominent features on the landscape, others very subtle. Among the most prominent features visible from the area east of the Willamette River is the view back across the river to the West Hills, a continuous ridgeline running from McCarthy Creek in the north to Tryon Creek State Park in the south. Geologically, this represents a north-south trending escarpment, marking the eastern edge of the Columbia River Basalt which underlies Portland's West Hills.

Immediately west of the escarpment, following the moderately steep hillside, streams tend to be generally straight and have moderate gradients, down to their junction with Beaverton Creek and the Tualatin River. Delineated watersheds in this area tend to be somewhat narrow and elongated and are generally small.

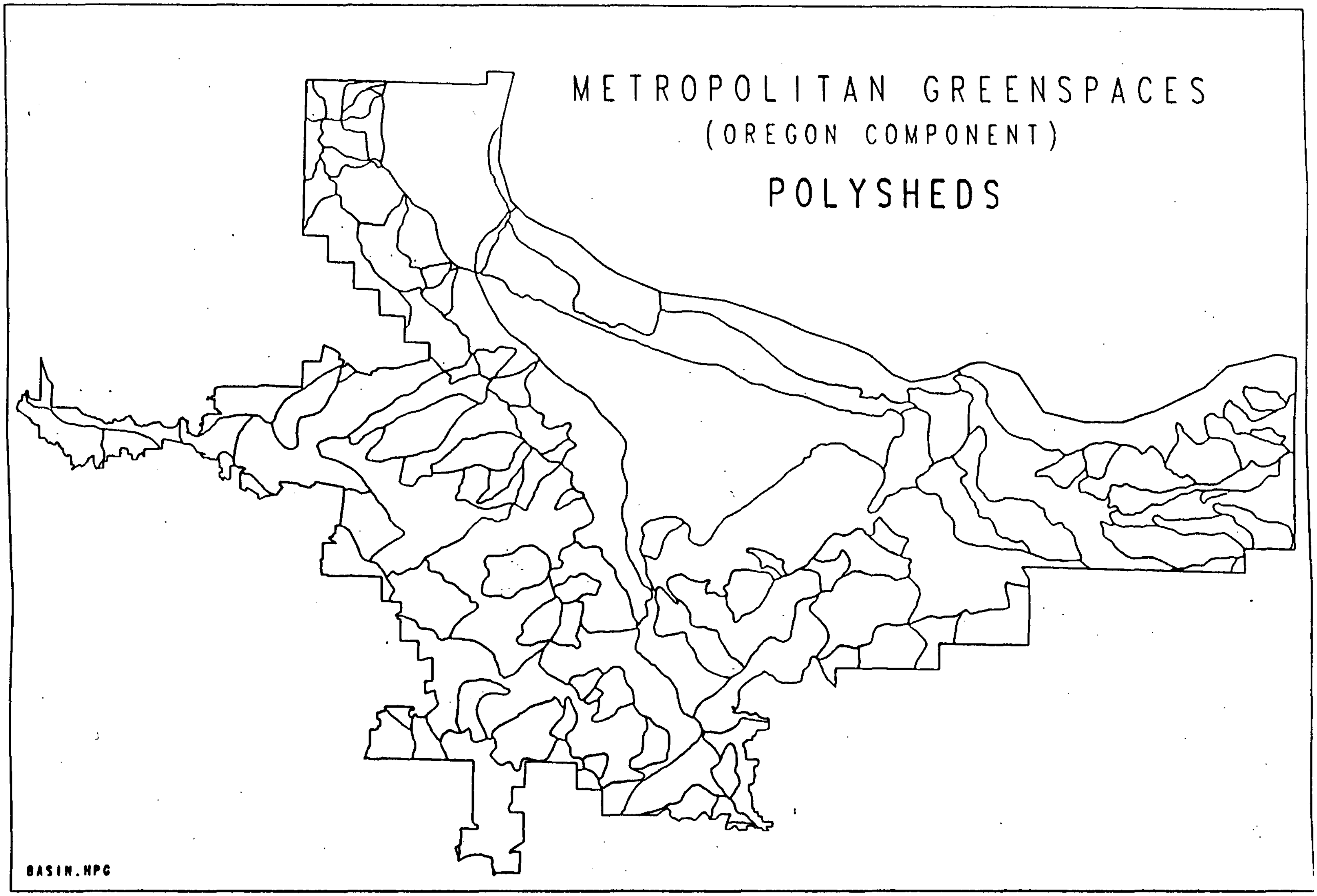
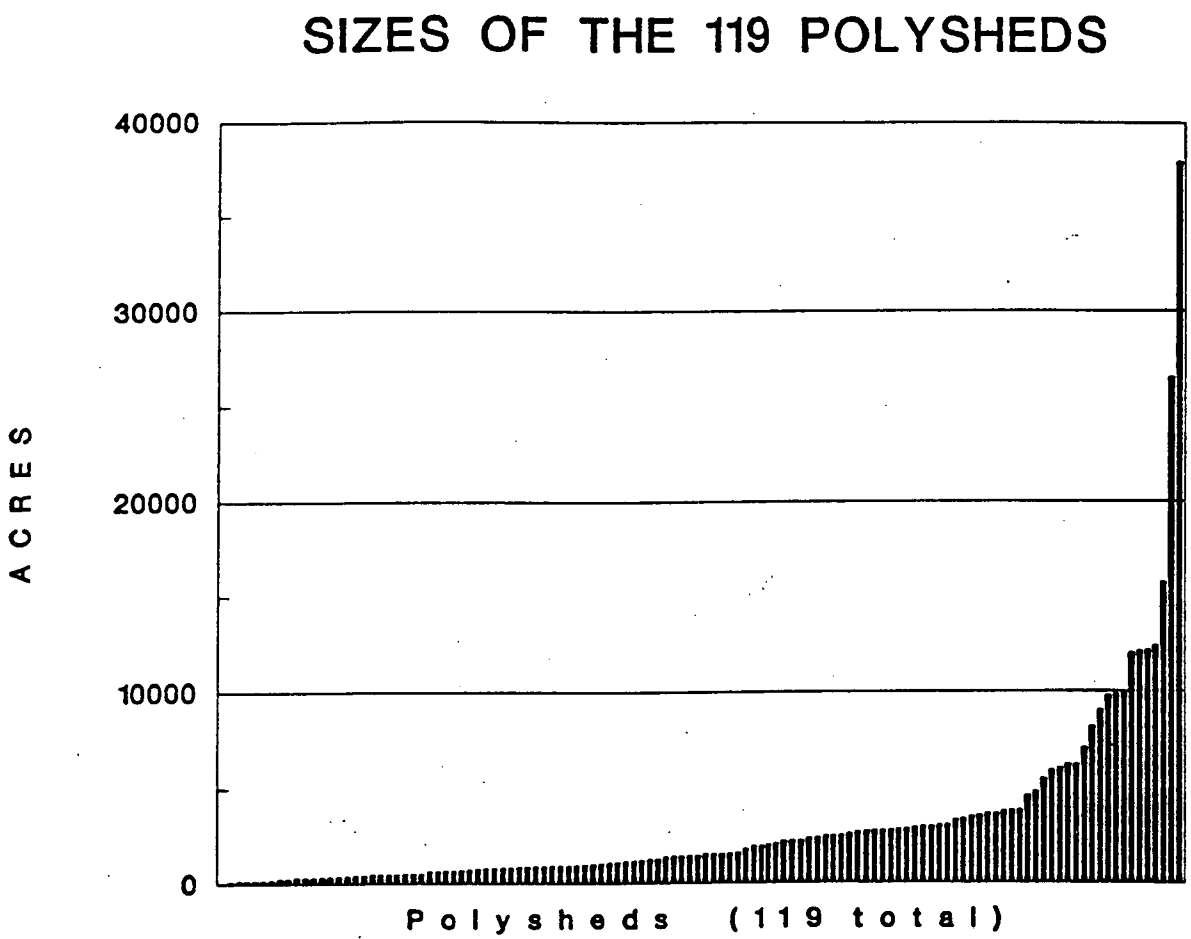

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
POLYSHEDS
BASIN.HPG

FIGURE 48

FIGURE 49



PSSizes

In the broad floor of the Tualatin Valley, the combination of the low gradient and the soft sedimentary substrate produces a meandering drainage system. Watersheds here tend to be compact or somewhat irregular in shape, rather than elongated, and of moderate size.

East of the West Hills ridgeline the steepness of the escarpment means that streams draining into the Willamette River and Multnomah Channel tend to be short, generally straight and have high gradients. Reflecting the character of these streams, the delineated watersheds tend to be triangular or somewhat irregular in shape, and generally of small size.

In the area immediately south of the Columbia River and west from the Sandy River through Sauvie Island, drainage and watershed morphology are influenced by the sand-laden river deposits and low-relief that characterize the land surface. The stream network tends to be dense and the water slow-moving. The watersheds are generally elongated, irregular in shape and of moderate size.

From the Sandy River eastward, moderate to steep gradients down from the Cascades tend to predominate, producing moderate to fast-moving streams in moderately steep-sided, v-shaped valleys. Watershed are generally elongated and fairly narrow, and of small to moderate size.

In northern Clackamas County, stream patterns are influenced by the resistant geologic features known as the Boring Lava Hills. Streams have low to moderate gradients and somewhat irregular patterns. Here watersheds tend to take on a number of shapes from compact to somewhat linear and are generally of moderate size.

3.10.5 Clarifications Regarding Polysheds

While polysheds are appropriate units for bringing spatial organization to the analytical process, their nature and role should be clarified in order to prevent misunderstanding of their use and misapplication of the study results.

Although polysheds are derived from watersheds, in many cases they are only a small fraction of the total area of their parent watershed. Of the 95 watersheds delineated to cover the study area, 34 are truncated to varying degrees, losing from 0.2 percent of their area (Trout Creek) to 99 percent (Clackamas River) of their area. The Columbia River and Willamette River lose 68.1 percent and 70 percent of their areas, respectively, but both of these figures represent underestimates, since they are based on acres truncated from what was only a partial delineation of their total watershed areas. A list of the 34 truncated watersheds and the areas lost from them is presented in Table 8.

TABLE 8

Stream Name	Original Watershed Size (acres)	Clipped Watershed Size (acres)	Size Difference (acres)	Percent of Acres Lost
Trout Creek	3,805	3,797	8	.2
Joy Creek	461	459	2	.5
Cat Creek	1,501	1,476	25	1.7
Summer Creek	3,814	3,656	158	4.1
Richardson Creek	2,536	2,264	272	10.7
Abbey Creek	3,227	2,780	447	13.9
Thompson Creek	1,823	1,565	259	14.2
Rock Creek (West Multnomah County)	16,499	13,454	3,045	18.5
Canfield Creek	709	556	153	21.6
Butternut Creek	3,661	2,491	1,170	31.9
Noyer Creek	2,176	1,455	721	33.2
Gordon Creek	7,428	4,589	2,839	38.2
Gales Creek	4,779	2,391	2,387	50.0
Bridal Veil Creek	3,446	1,619	1,827	53.0
Jackson Creek (North Multnomah County)	2,685	892	1,793	66.8
Rock Creek (South Washington County)	3,004	976	2,028	67.5
Columbia River	134,772*	43,014	91,759*	68.1*
Newland Creek	1,705	528	1,177	69.0
Council Creek	6,523	1,981	4,542	69.6
Willamette River	246,842*	74,309	172,553*	69.9*
Deep Creek	9,674	2,862	6,812	70.4
Jackson Creek (West Multnomah County)	3,401	993	2,408	70.8
Walker Creek	1,847	524	1,323	71.6
Cedar Creek	5,778	1,899	4,212	72.9
Raymond Creek	2,609	560	2,049	78.5
Abernethy Creek	12,774	2,259	10,515	82.3
Deer Creek	1,276	172	1,103	86.5
Beaver Creek (South Clackamas County)	10,000	1,317	8,683	86.8
McKay Creek (North Multnomah County)	39,863	3,899	35,964	90.2
Tualatin River	277,145	16,059	261,087	94.2
Holcomb Creek	3,082	168	2,913	94.5
Dairy Creek	35,036	1,627	33,409	95.4
Sandy River	287,334	9,901	277,434	96.6
Clackamas River	589,148	6,038	583,110	99.0
All 95 Water Sheds	1,885,473	372,681	1,518,168	80.5
Only 34 Truncated WSs	1,730,364	212,196	1,518,168	87.7

*These figures are underestimates, since the full watershed was not delineated.

Truncation does not impact the amount of data concerning any of the 61 polysheds that have their entire watershed within the study area. However, the polysheds which are truncated have data available for only a portion of a watershed.

It might be argued that truncating the delineations of the watersheds and utilizing polysheds dilutes the value of the watershed approach, since the truncation process reduces the natural integrity of the watershed units. This would be true if the concern of this study was with the watersheds themselves. Since many of the polysheds represent something less than a total watershed, no generalizations or conclusions should be made from the data about watersheds.

However, what is of interest in this study is not the watersheds as units, but the fact that their boundaries represent dividing lines that have environmental meaning. The objective in using the watersheds is to identify boundaries that have not been arbitrarily chosen. The watershed boundaries that lie entirely within the study area clearly meet these criteria and it is these lines that form the foundation for delineating the polysheds and constitute the majority of polyshed lines. The few additional lines that were added to further subdivide the Columbia and Willamette watersheds were all selected because of they correspond with readily-identifiable physical features. And the study area boundary, which truncates many of the watersheds, is not used to delimit polysheds from each other, but to separate polyshed from *not-polyshed* (i.e., non-study areas).

Overall, polysheds have a great deal of utility as an organizational framework. This is true whether they are judged from the perspective of environmental system considerations, spatial analytical applicability, landscape planning, or the implementation of plans for the management and acquisition of greenspaces.

4. WATERSHED-BASED ANALYSIS

The data sets discussed in Section 3 individually represent a great deal of useful information about various features in the Oregon component. A still greater amount of information can be generated by blending and relating various combinations of features and examining the patterns of interaction between the features.

This section will focus on various combinations of data at the polyshed level, with the goal of drawing some conclusions about the overall pattern of polyshed characteristics. Discussion will then be presented about some of the alternatives available for developing general strategies of natural area protection and acquisition.

4.1 Hydrography of the Polysheds

A basic parameter for dealing with the polysheds and natural areas is variation in the occurrence of water. In order to examine this, the GIS-based hydrology data concerning linear streams and open water bodies were tabulated for each of the 119 polysheds.

There are a total of 749 miles of streams within the study area. The total length of streams within the polysheds varies from 0 to 43.28 miles, with a mean of 6.29 and a median of 3.47 miles (Figure 51). Twelve polysheds had no linear streams. Ten of these anomalies are instances of radical truncation of the parent watershed by the study boundary, resulting in the areas of the watershed containing streams to fall outside the study area. The other two cases are developed inner city polysheds in which the streams have been buried in pipes.

Since the polysheds are of various sizes, simple data on miles of streams within each polyshed are not very revealing. A better measure of stream occurrence is derived by dividing the total length of streams within a polyshed by the polyshed area. The resulting stream densities vary from 0 to 8.12 linear miles of stream per square mile, with a mean of 1.68 miles and a median of 1.66 miles. Figure 52 summarizes these data, and, from that graph, five categories of stream density can be identified.

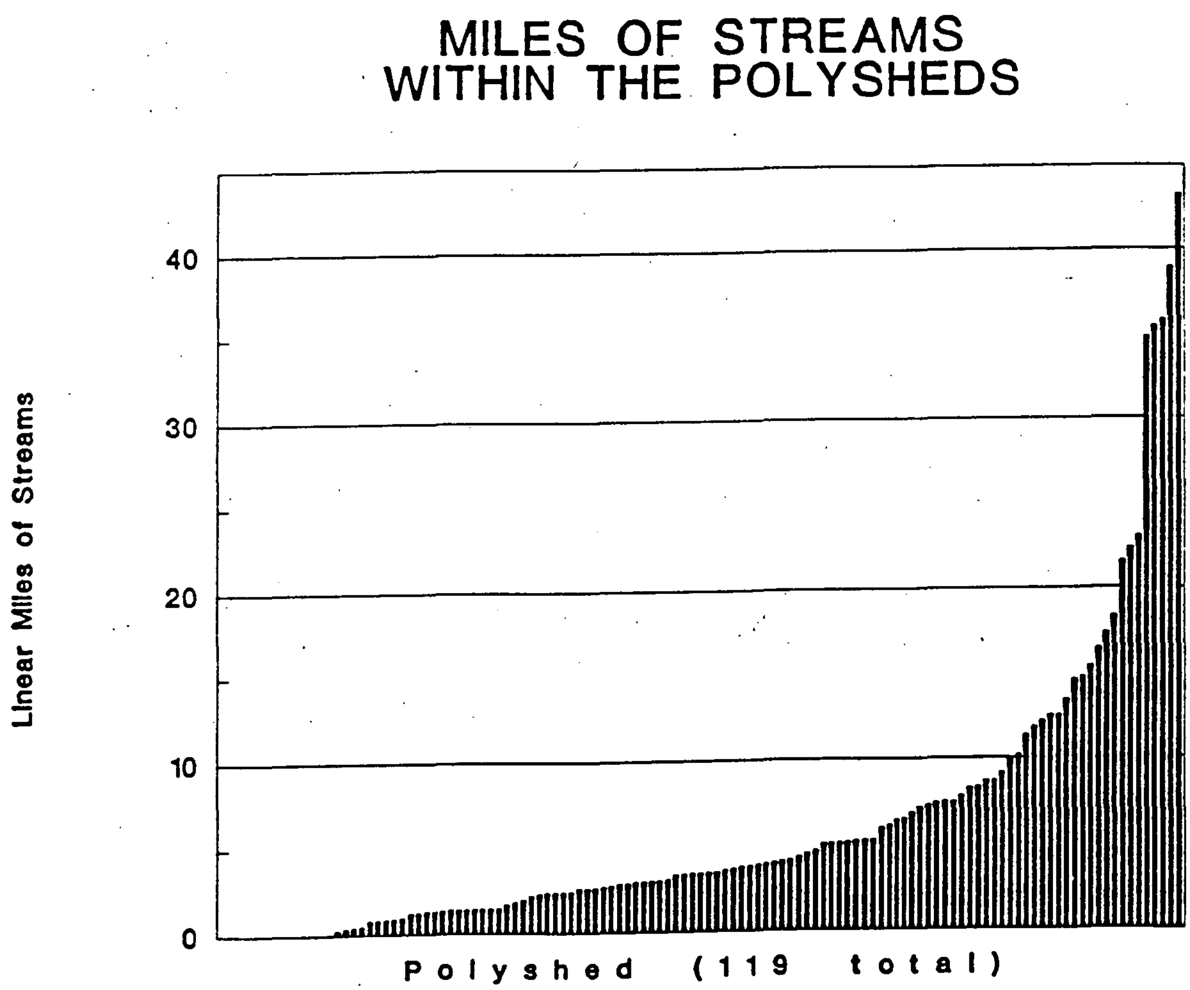
The pattern of stream densities, as portrayed on the map in Figure 53, would indicate that the three polysheds of very high density are probably products of the truncation process, as is also likely for some of the *no stream* polysheds. The most striking feature is the lack of streams in the large triangular polyshed of the City of Portland. In addition, it would appear that the highest densities tend to be associated with higher gradient streams in smaller, narrow watersheds that drain steeper hillslopes.

Open water bodies, consisting of lakes, sloughs and portions of rivers included in the database as polygons, cover 22,886 acres (35.76 square miles) of the study area. There are from 0 to 5,694 acres of open water within each polyshed, with a mean of 192.3 acres and a median of 0. The median of 0 is understood better when it is recognized that there are a total of 70 polysheds that contain no open water. The smallest area of open water in the polysheds is 1.2 acres. Of the 12 polysheds that contain no streams, only two contain open water bodies.

The open water body data is more meaningful when it is considered as a percentage of area. For the study area as a whole, 6.1 percent of the 372,682 acres consist of water bodies. For individual polysheds the figures vary from 0 to 69.4 percent, with a mean of 6.14 percent and a median of 0. Again the median is the result of more than half of the polysheds not having any open water. From the graph of open water percentages in Figure 54, five categories of open water percentage were identified and mapped to produce Figure 55. The pattern on the map suggests a close association of open water with areas of relatively lower elevation, while polysheds representing higher elevations and greater relief fall almost exclusively within the *no open water* category.

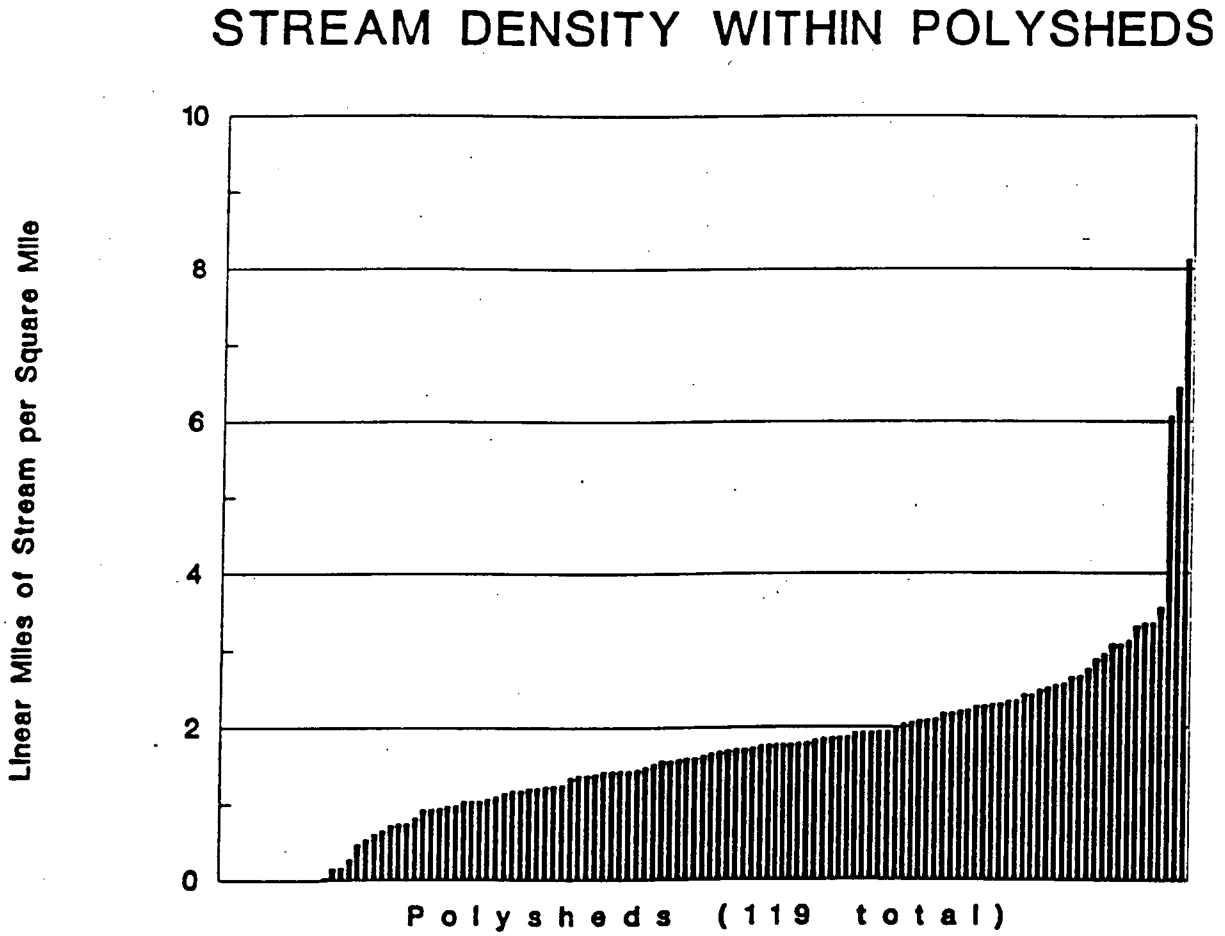
The distinctive map pattern suggests that the data-introduced dichotomy between open water and linear streams may reflect a very real difference between the water characteristics of polysheds. Those polysheds with a relatively large amount of open water may be viewed as a separate category from polysheds with little or no open

FIGURE 51



MLStrmInPS

FIGURE 52



strmden

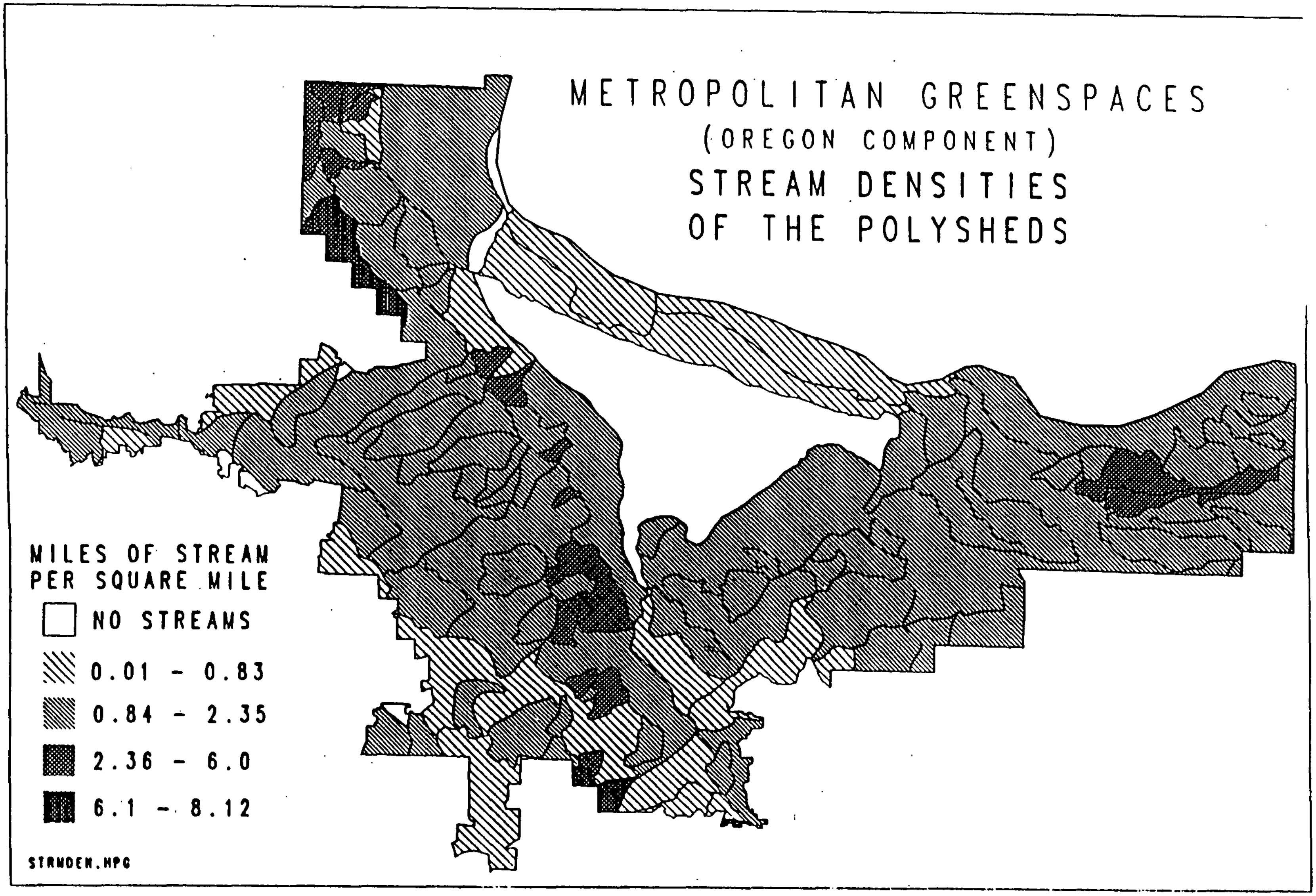
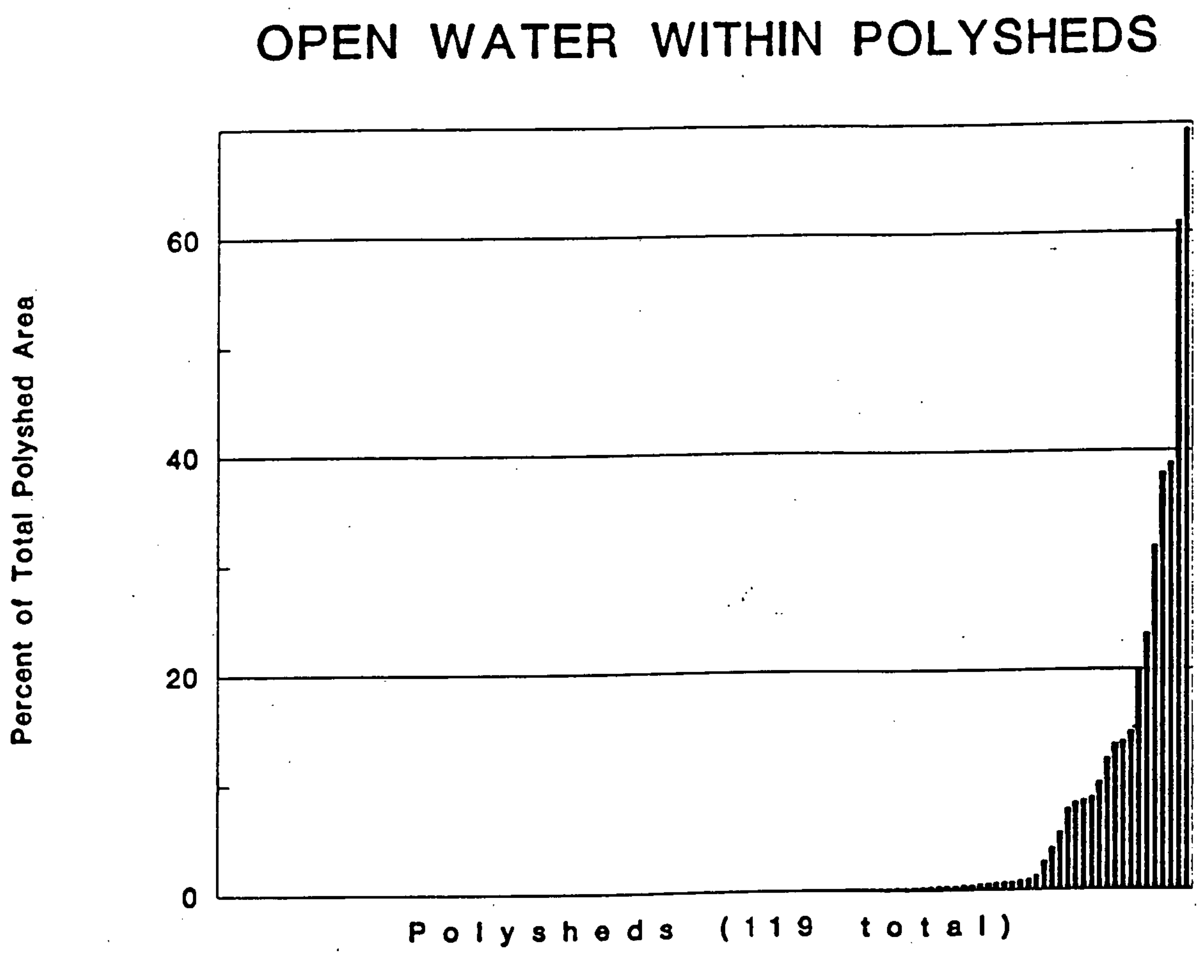

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
STREAM DENSITIES
OF THE POLYSHEDS
MILES OF STREAM
PER SQUARE MILE
NO STREAMS
0.01 - 0.83
0.84 - 2.35
2.36 - 6.0
6.1 - 8.12
STRMDEN.HPG

FIGURE 53

FIGURE 54



ovpct.ps

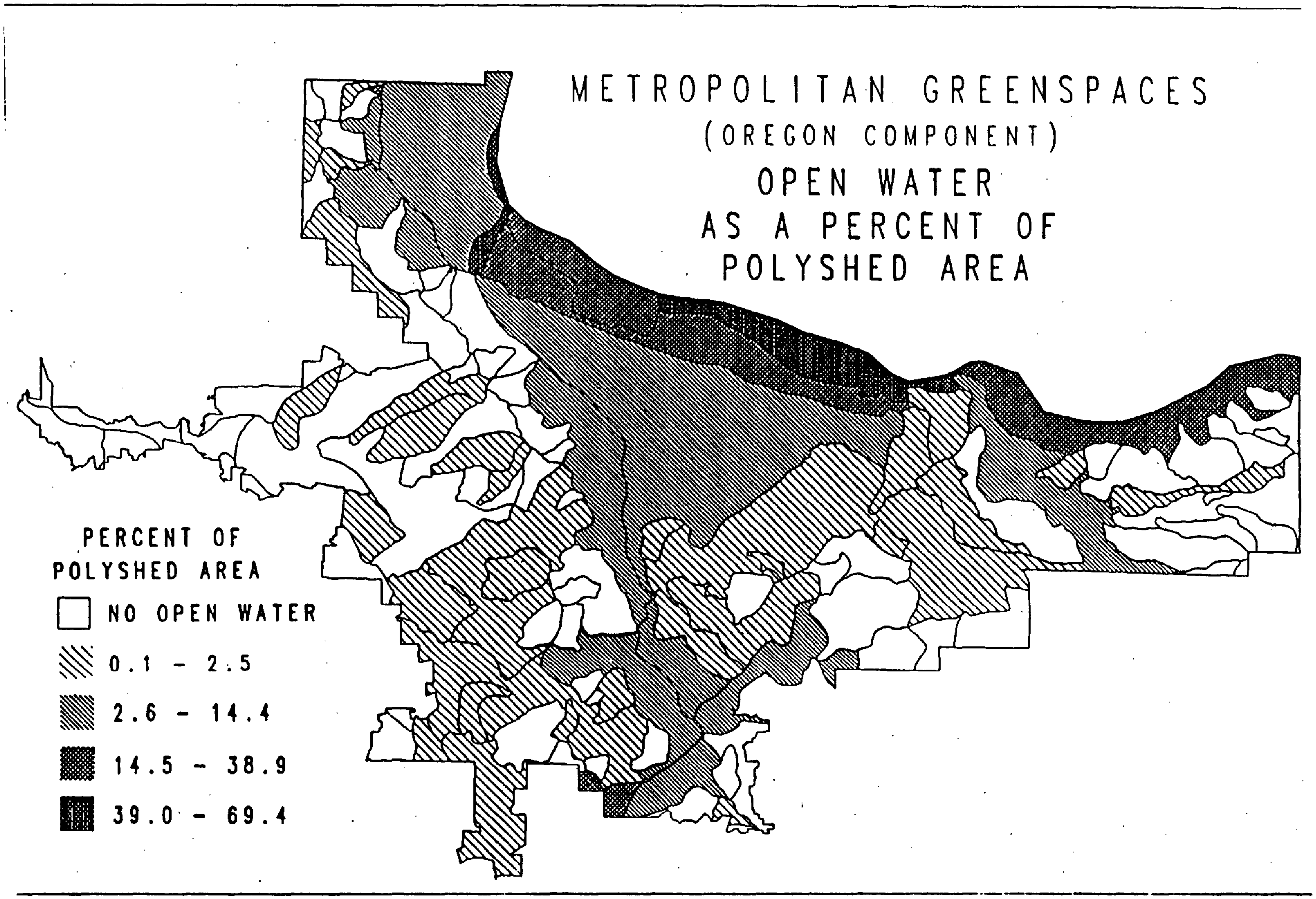

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
OPEN WATER
AS A PERCENT OF
POLYSHED AREA
PERCENT OF
POLYSHED AREA
NO OPEN WATER
0.1 - 2.5
2.6 - 14.4
14.5 - 38.9
39.0 - 69.4

FIGURE 55

water. The graph in Figure 54 would suggest a value of 2.5 percent of the polyshed area as a reasonable cutoff point, and could be used to identify the 19 polysheds above that level as *open-water-dominated* polysheds. These open-water-dominated polysheds are shown in Figure 56. These 19 polysheds represent segments of only five hydrologic units -- the Columbia, Willamette, Clackamas and Sandy Rivers, and the Multnomah Channel.

The argument can be made to view these open-water-dominated polysheds as distinct from the others and to deal with them differently when considering protection strategies. Support for this viewpoint is based on a combination of factors, including not only the statistical percent of the polyshed area that is in open water, but also that the water bodies involved are all very high on the hydrologic hierarchy. In addition, open water bodies tend to be viewed and used differently by people than smaller linear streams. For example, small streams are not as likely to be used for boating as are open water bodies. There may also be differences in the kinds and numbers of wildlife that might be associated with each. Planning for natural areas should consider these kinds of potential differences.

<u>Conclusions About Hydrography</u>

1) The polysheds with the highest stream densities tend to be smaller, higher elevation polysheds that have deeper, narrower configurations and higher gradient streams.

2) Open water areas seems to be associated with lower elevation areas and are virtually absent from higher elevation areas.

3) Streams are more widely dispersed than open water bodies, occurring in 107 of the 119 polysheds while open water bodies occur in only 49 polysheds. Consideration could be given to this factor in developing planning strategies for these polysheds (e.g., stream-dominated polysheds might have a higher priority for trail development than open-water-dominated due to the linear pattern of riparian areas).

4.2 Polyshed Natural Areas Parameters

<u>Natural Areas</u>

The portion of each polyshed that is natural areas ranges from 0 to 100 percent (Figure 57), with a mean of 39.8 percent and a median of 26.2 percent. Figure 58 suggests that the polysheds having the highest percentages of natural area seem to be related to higher elevation/greater relief areas. This is consistent with the fact that the most common natural areas are forests, which tend to be associated with these same factors.

<u>Wetlands</u>

Figure 59 portrays the total acres of wetland in each polyshed, as interpreted from aerial photography; these wetlands were not identified from a regulatory perspective.

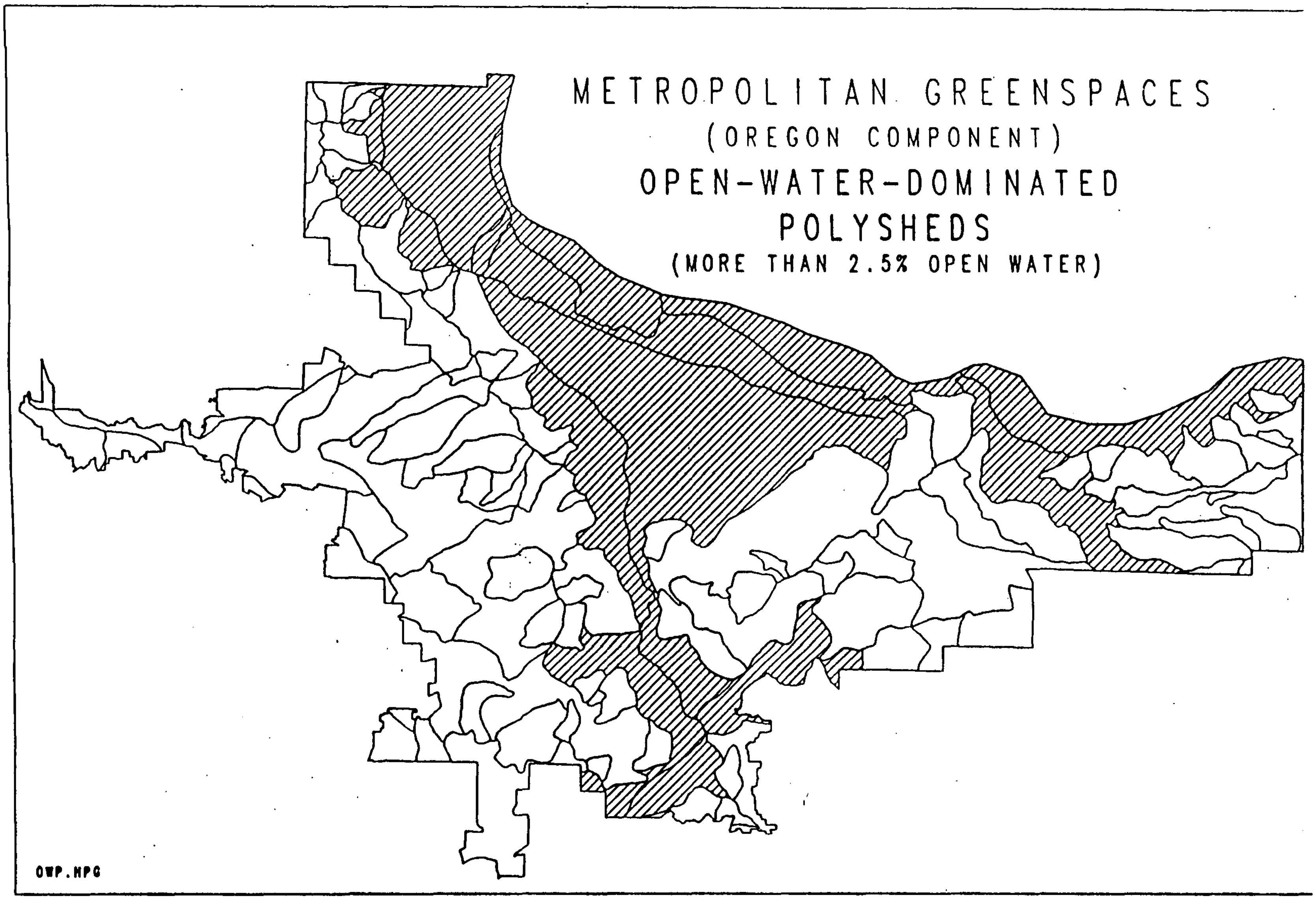
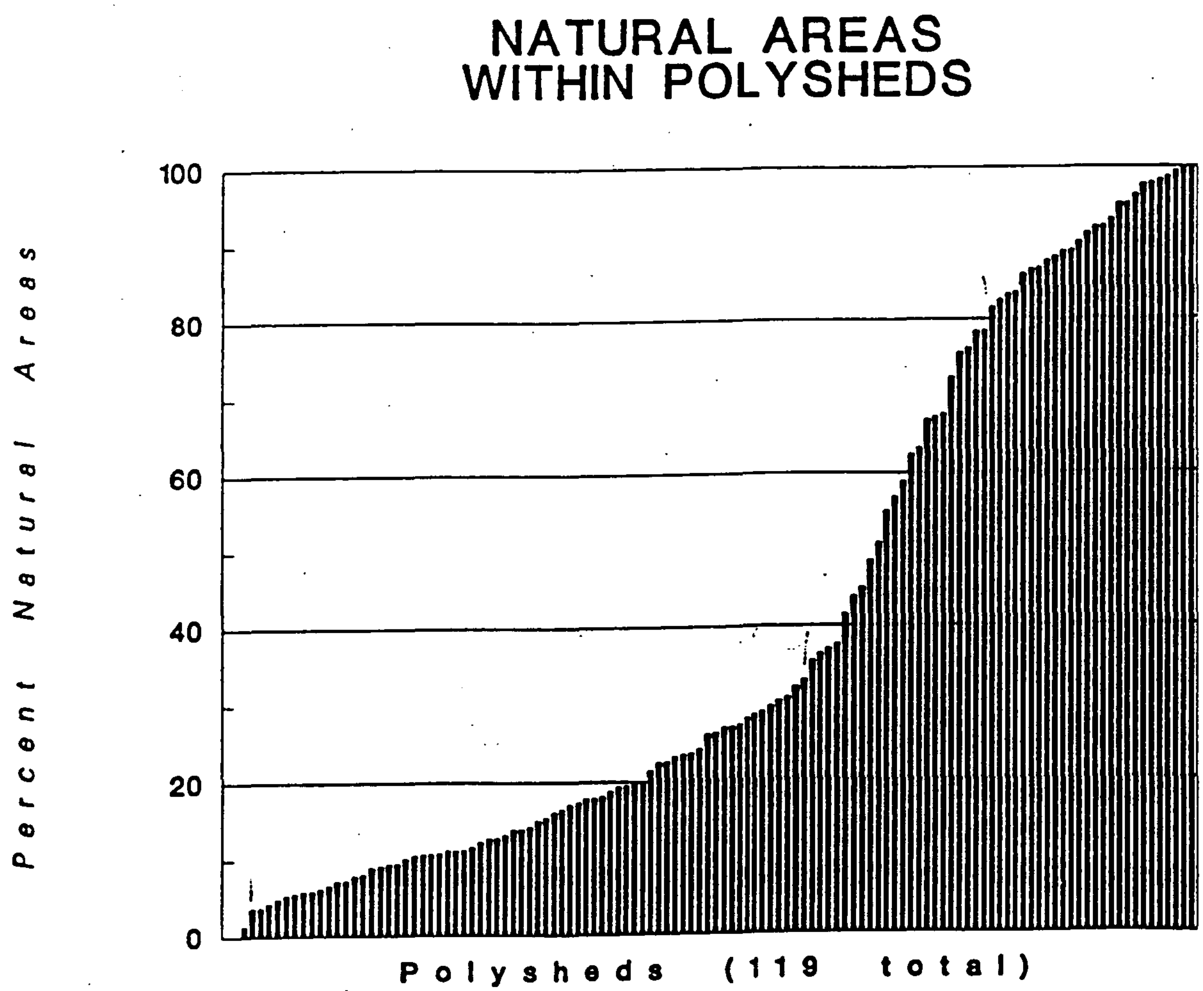

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
OPEN-WATER-DOMINATED
POLYSHEDS
(MORE THAN 2.5% OPEN WATER)
OWP.HPG

FIGURE 56

FIGURE 57



NATURAL AREAS
WITHIN POLYSHEDS
100
80
60
40
20
0
Percent Natural Areas
Polysheds (119 total)

FIGURE 58

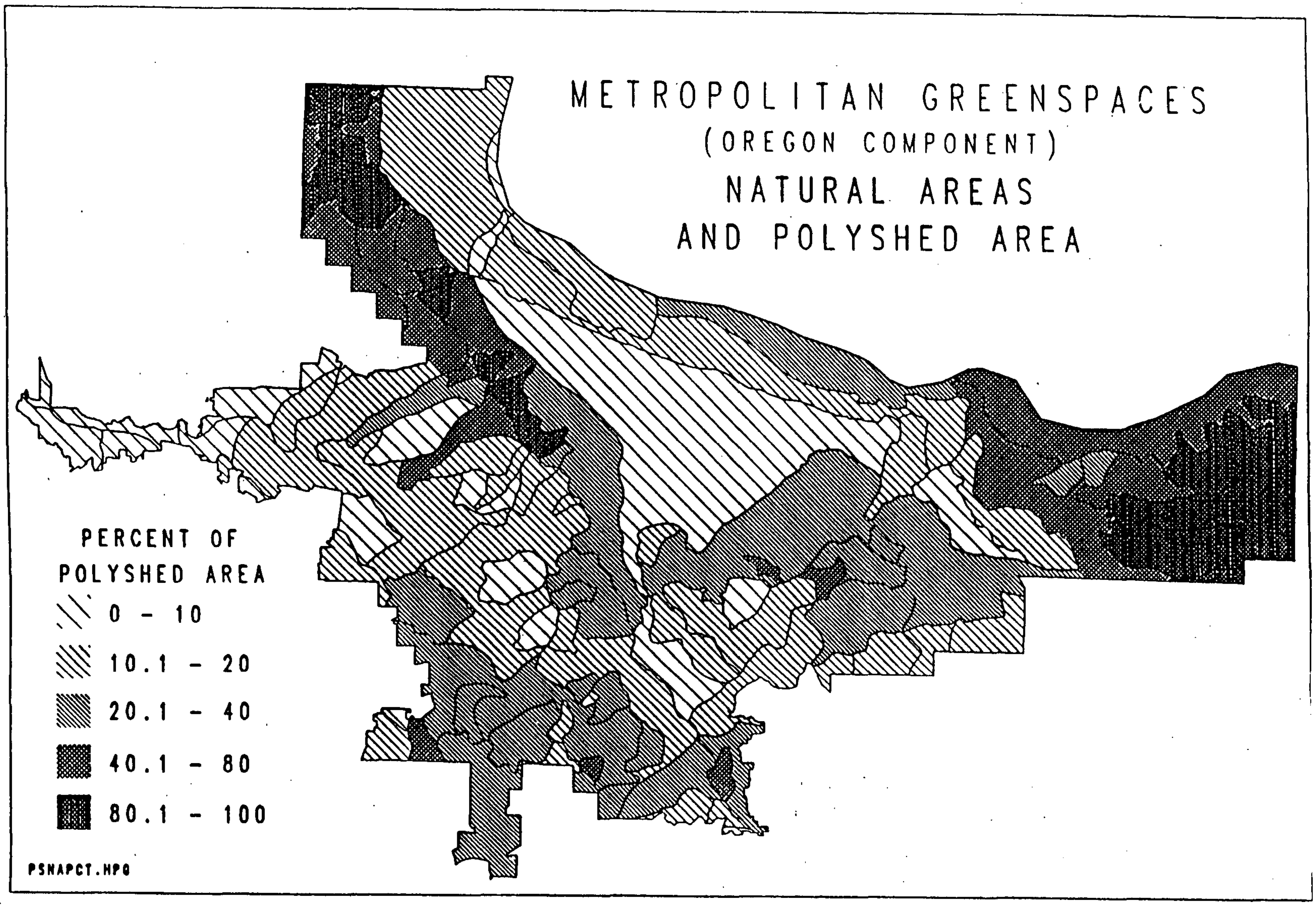
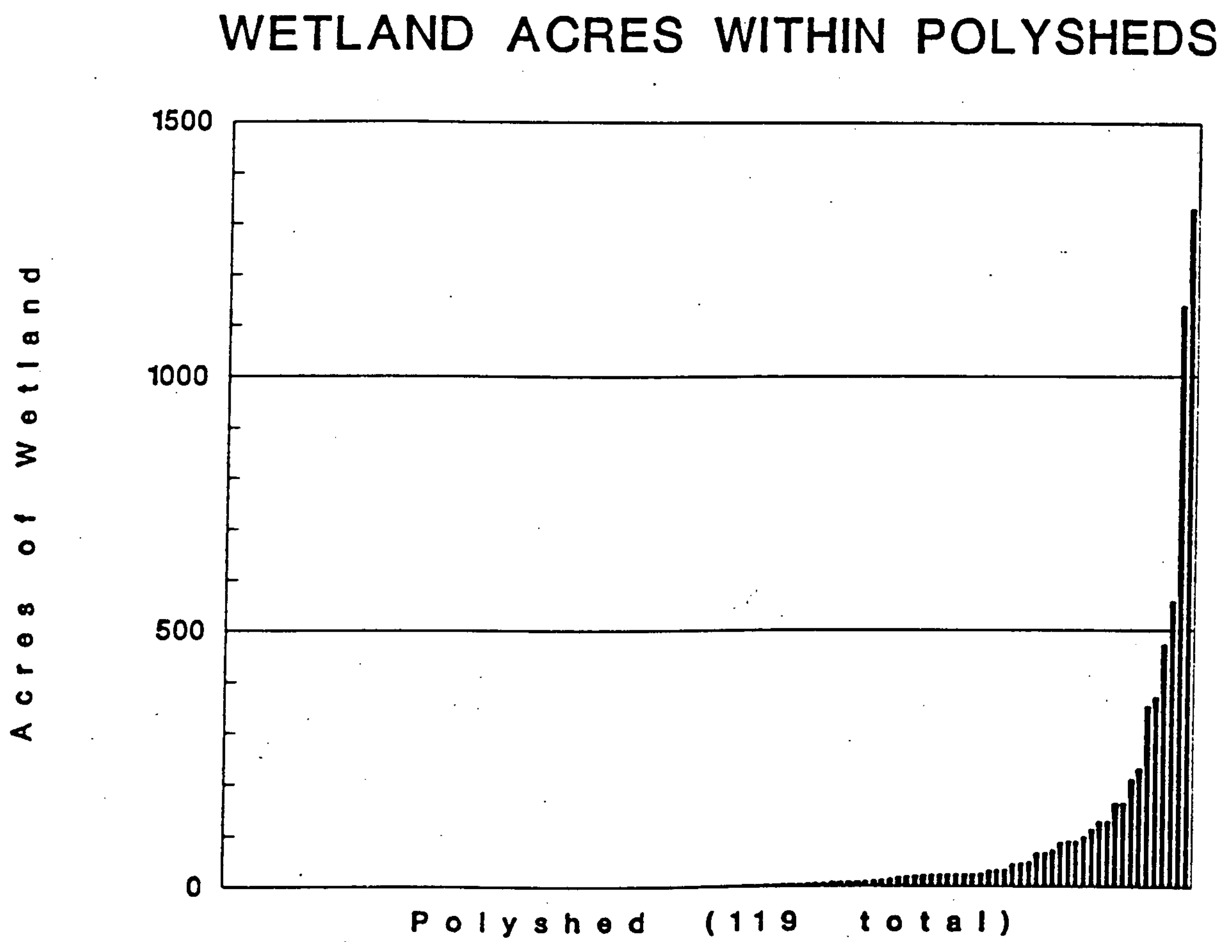

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS
AND POLYSHED AREA
PERCENT OF
POLYSHED AREA
0 - 10
10.1 - 20
20.1 - 40
40.1 - 80
80.1 - 100
PSNAPCT.HPG

FIGURE 59



%PSinWL

Based on the photo interpretation, there are a total of 6,588 acres of wetland within the Oregon component. Within individual polysheds the wetland areas range from 0 to 1,330 acres, with a mean of 55.4 and a median of 1.1 acres. A total of 55 of the 119 polysheds contain no wetlands. This would suggest that wetlands tend to be localized, generally occurring only in particular polysheds, and that there are large differences in the amount of wetlands that are found in polysheds where wetlands do occur.

The percentage of the natural areas in each polyshed that is in wetlands, as presented in Figure 60, ranges from 0 to 83.2 percent, with a mean of 5.7 percent and a median of 0.1 percent. The very low median is indicative of the large number of polysheds with no wetlands. The J-shaped curve on the graph was divided into five segments, based on changes in slope and the associated ranges of percentages used as shading classes on the map in Figure 61.

The map indicates that the five polysheds with the highest percentages of their areas in wetlands (39 to 83 percent) are all located along the Columbia River South Shore and Sauvie Island areas. Another 25 polysheds have between 6 and 29 percent of their natural areas in wetlands and 90 have less than 6 percent in wetland. The 6 percent figure is meaningful because it represents the mean value for the study area as a whole. Thus, only 30 of 119, or 25 percent of the polysheds, have a percentage of their natural area that is equal to or greater than the study-area-wide percentage. In all but the five highest category polysheds, wetlands are a very small percentage of the total natural area.

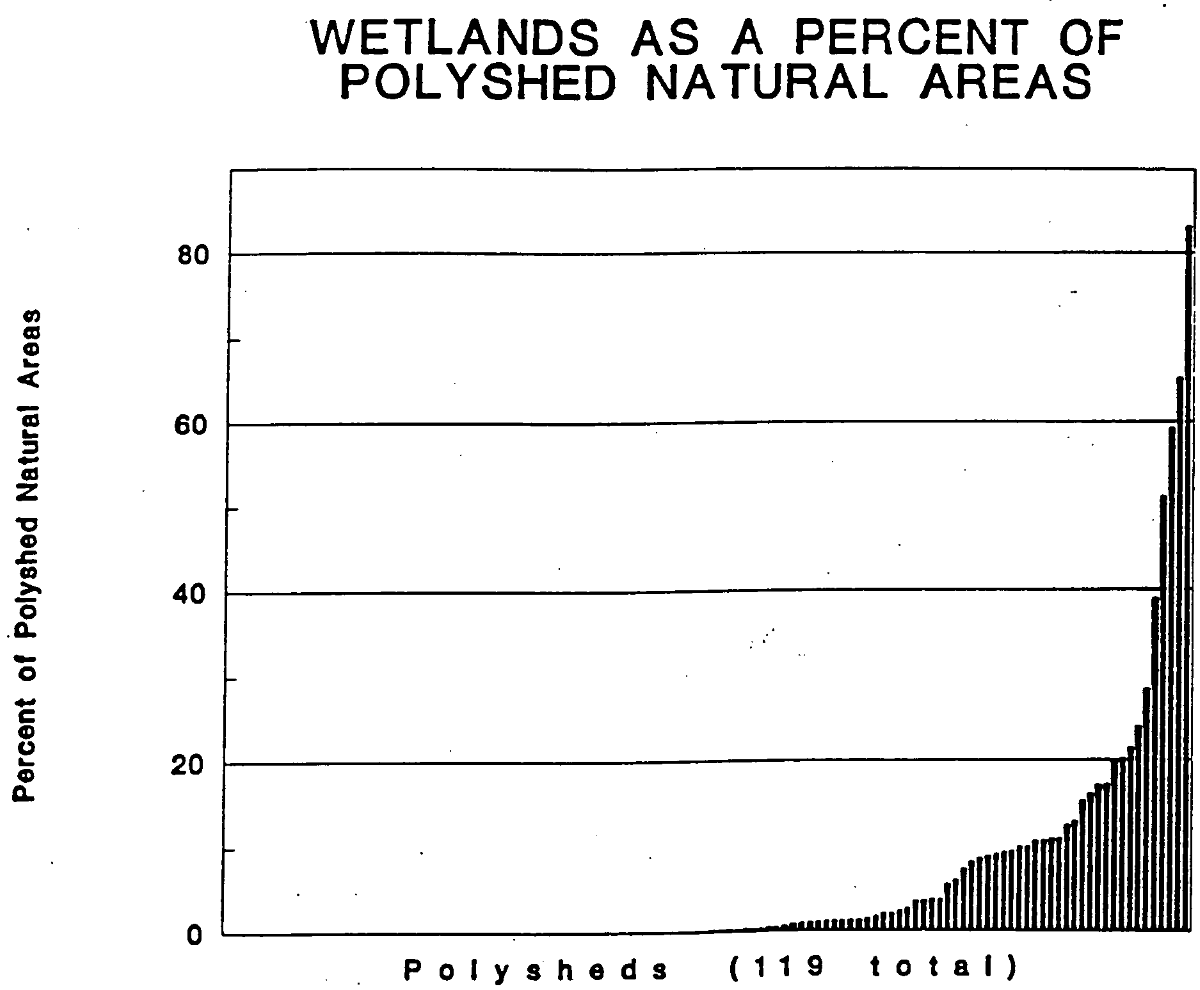
Riparian Areas

One approach to understanding the riparian data is to relate the actual amount of riparian natural area to the potential maximum extent of the riparian area. The area of potential riparian corridor within each polyshed was determined through use of the GIS buffer function. Each linear stream and open water polygon was buffered to identify the area within 100 feet of the streamline, in the case of linear streams, and within 100 feet of the edge of open water areas, in the case of the open water polygons. The result is a band 100 feet wide around each open water polygon, and 200 feet wide (100 feet on either side) around the streams.

The selection of 100 feet as a buffer width for the riparian areas was made to correspond with the distance used to delineate riparian areas during the photo interpretation and mapping of the natural areas. Obviously, the actual width of riparian corridors can vary widely within a very short distance, depending on topography, soils, stream dynamics and other factors. Lacking information concerning the numerous variables that would allow a more detailed delineation, the 100 feet figure was felt to be a good average width that would include most ecological situations and serve landscape aesthetic goals as well.

The sum of the buffered hydrography areas constituted the potential riparian area of the study area, and this totals 15,362.4 acres. Figure 62 portrays acres of potential riparian areas within the individual polysheds in graphic form. These figures range

FIGURE 60



psvpct.no

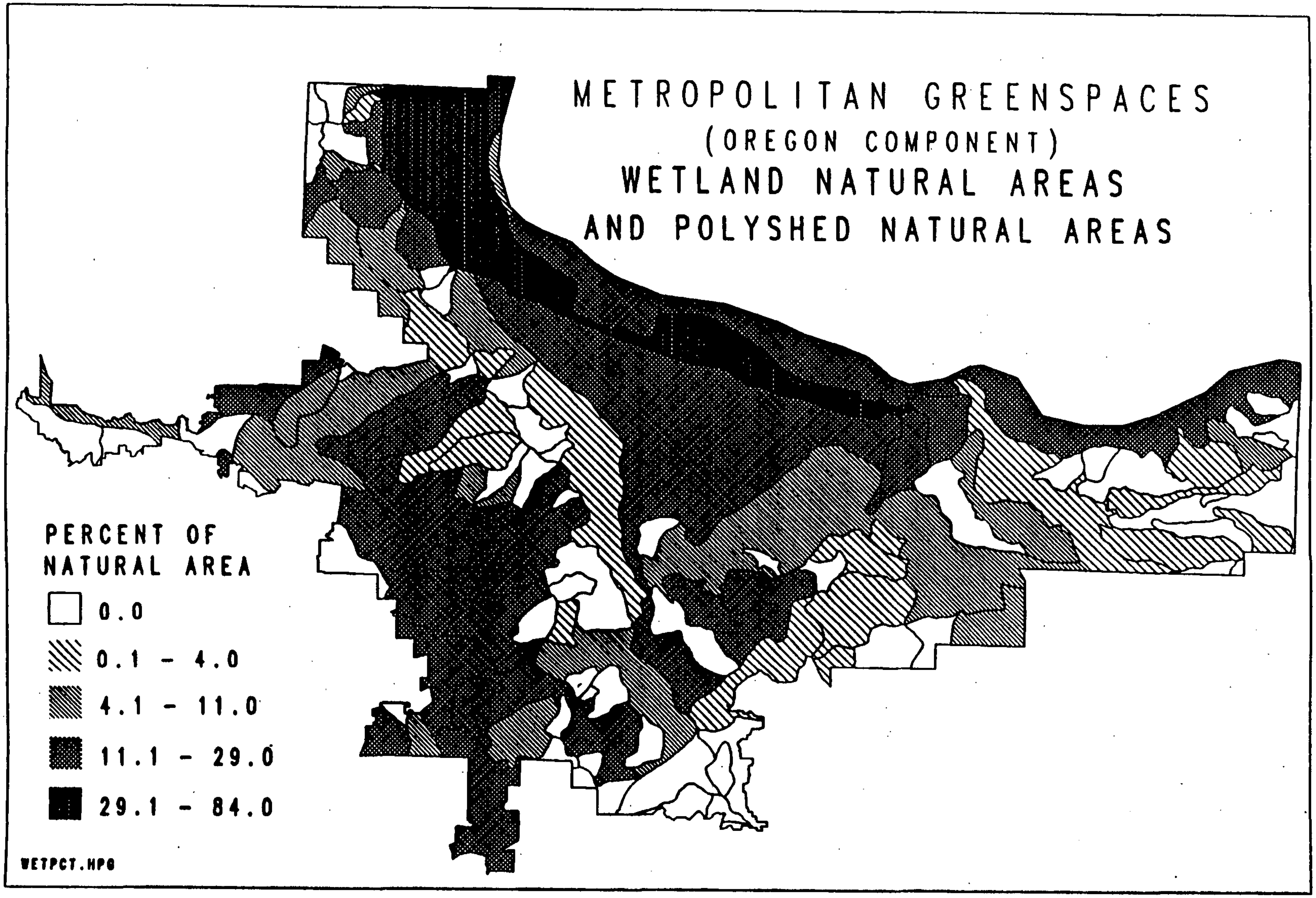
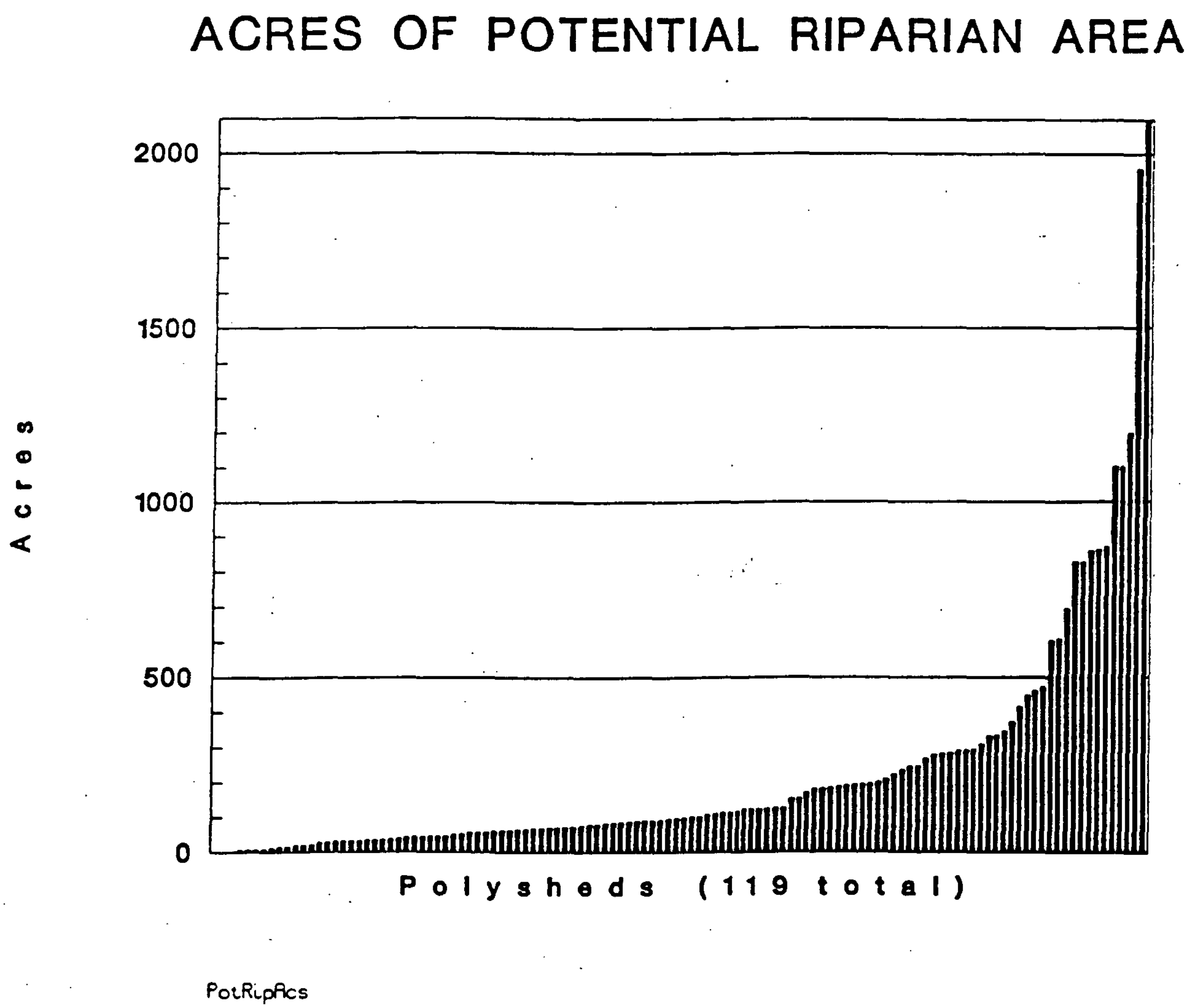

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
WETLAND NATURAL AREAS
AND POLYSHED NATURAL AREAS
PERCENT OF
NATURAL AREA
0.0
0.1 - 4.0
4.1 - 11.0
11.1 - 29.0
29.1 - 84.0
WETPCT.HPG

FIGURE 61

FIGURE 62


ACRES OF POTENTIAL RIPARIAN AREA
2000
1500
1000
500
0
Acres
Polysheds (119 total)
PotRipAcs

from 0 (two polysheds) to 2,095 acres, with a mean of 227.6 and a median of 100.8.

The potential riparian acres are portrayed as percentages of the total polyshed area in Figure 63. The values range from a minimum of 0 percent to a maximum of 22.5 percent, with a mean of 7.6 percent and a median of 7.1 percent. Figure 64 presents this data as five classes in map form. The map indicates that the polysheds with the greatest riparian potential lie on the Columbia River, the Sandy River and in several locations along the ridges west of the Willamette River.

The potential riparian natural areas were compared with the actual pattern of natural areas, resulting in the data illustrated in Figure 65. The percent of the potential riparian natural areas that actually occur in each polyshed ranges from 0 to 100 percent, with a mean of 64 percent and a median of 66.1 percent. This is the only distribution dealt with in this portion of the analysis in which the median exceeds the mean. Both are also very high, given the range of the data, indicating a dominance of large values rather than of small values, as in most other distributions. This prevalence of large values is also indicated by the concave-downward shape of the curve, very unlike the J-shaped curves of most of the other distributions. This suggests that overall there is a great deal of potential riparian area still intact, a fact that is very encouraging to the possibilities for riparian corridor protection as part of a natural area acquisition and protection strategy.

The map in Figure 66 portrays the actual riparian area as a percent of the potential (i.e., the percent of the buffer zone that contains natural area). The map is generally very dark, reflecting the preponderance of high percentages on it. The exception to this is the generally light, low percentage areas along the Columbia River and over the Portland City Triangle. The low values along the Columbia River/Sauvie Island area are doubly significant, for not only do they represent low percentages is terms of the values on this map, but these are the same areas that in Figure 64 showed up as the highest percentages in terms of the importance of potential riparian areas to the polyshed sizes. What this says is that these areas are among the most heavily impacted in the study area in terms of the loss of riparian habitat.

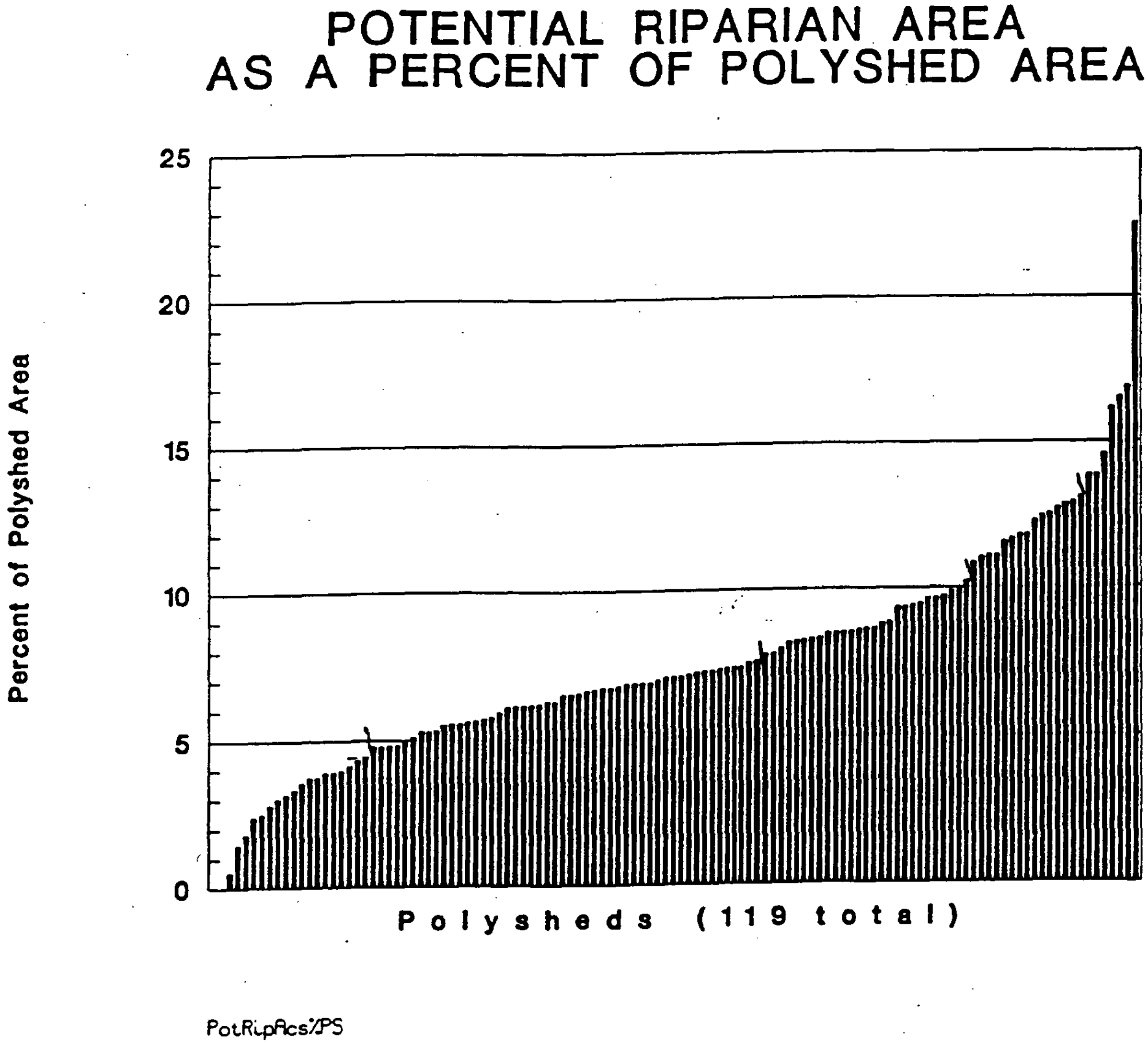
<u>Conclusions About Polyshed Natural Areas Parameters</u>

1) The polysheds with the largest percentages of natural areas seem to occur in higher elevation/greater relief areas and are generally dominated by forests.

2) There are large differences in the amount of wetland area found in polysheds, ranging from 55 polysheds having no mapped wetlands to one polyshed with 83 percent of its natural areas consisting of mapped wetlands.

3) In general, a great deal of the potential riparian natural areas remain, meaning that there are potentially good opportunities to preserve riparian corridors.

FIGURE 63


POTENTIAL RIPARIAN AREA
AS A PERCENT OF POLYSHED AREA
25
20
15
10
5
0
Percent of Polyshed Area
Polysheds (119 total)
PotRipAcs%PS

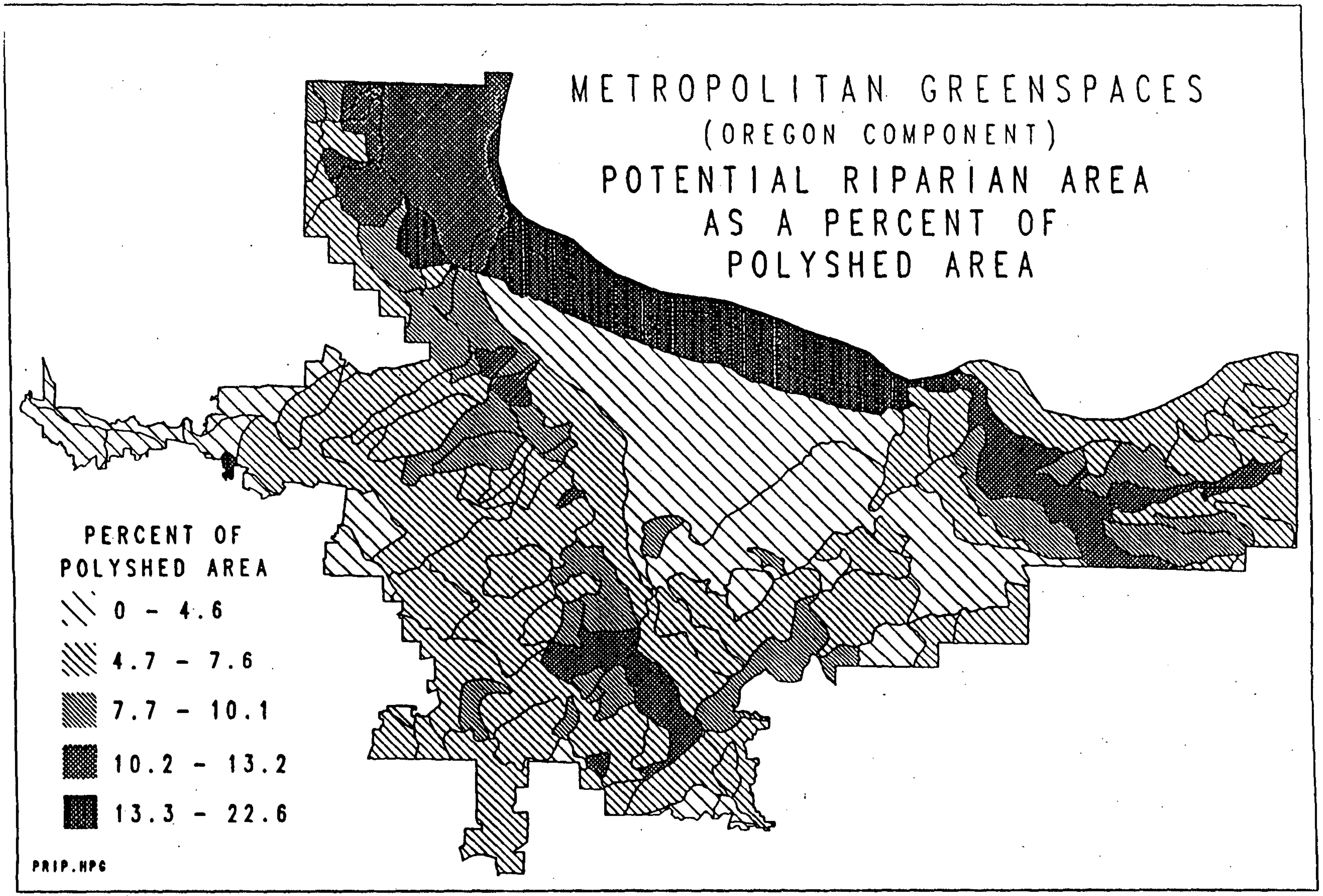
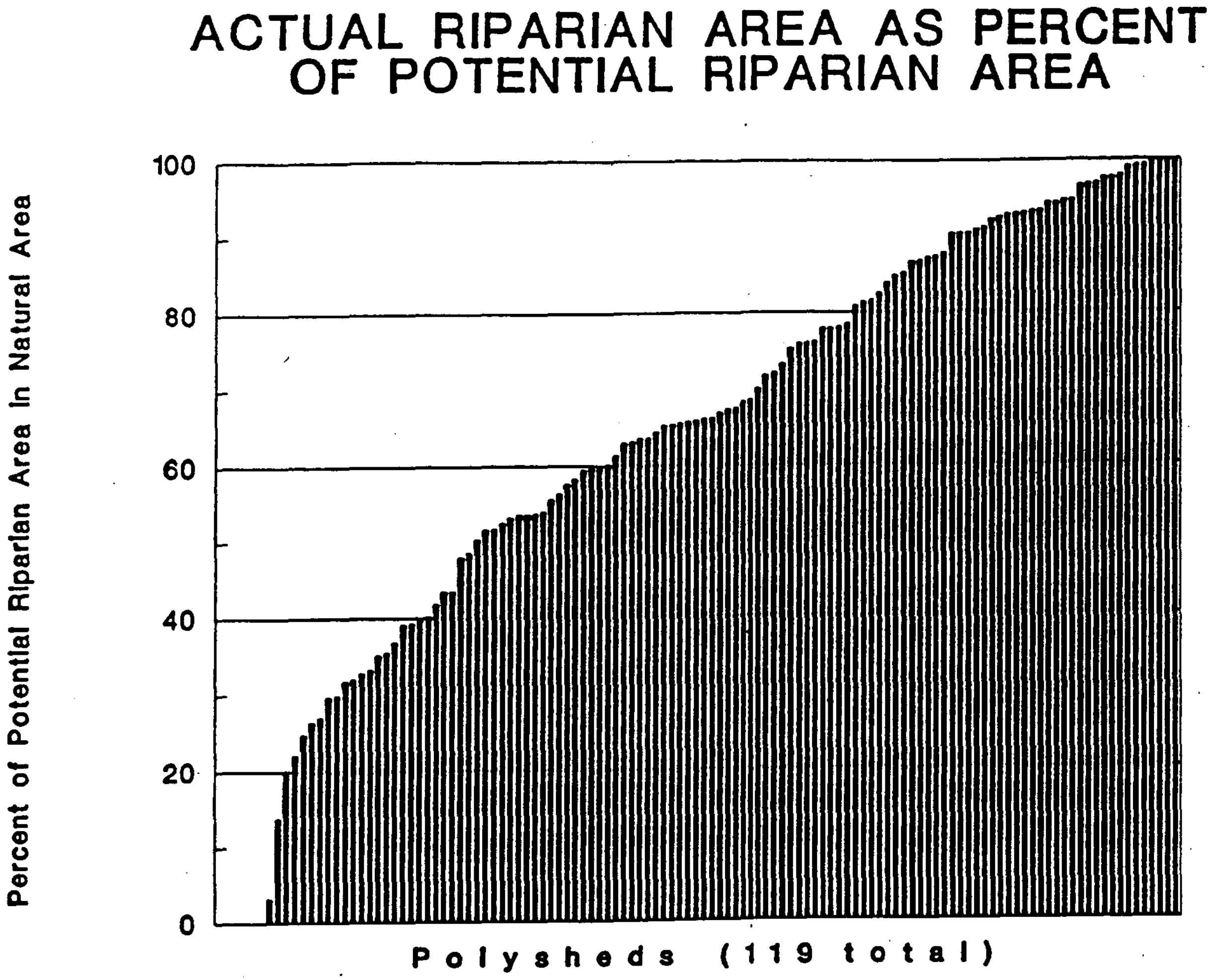

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
POTENTIAL RIPARIAN AREA
AS A PERCENT OF
POLYSHED AREA
PERCENT OF
POLYSHED AREA
0 - 4.6
4.7 - 7.6
7.7 - 10.1
10.2 - 13.2
13.3 - 22.6
PRIP.HPG

FIGURE 64

FIGURE 65



%RipBufInNA

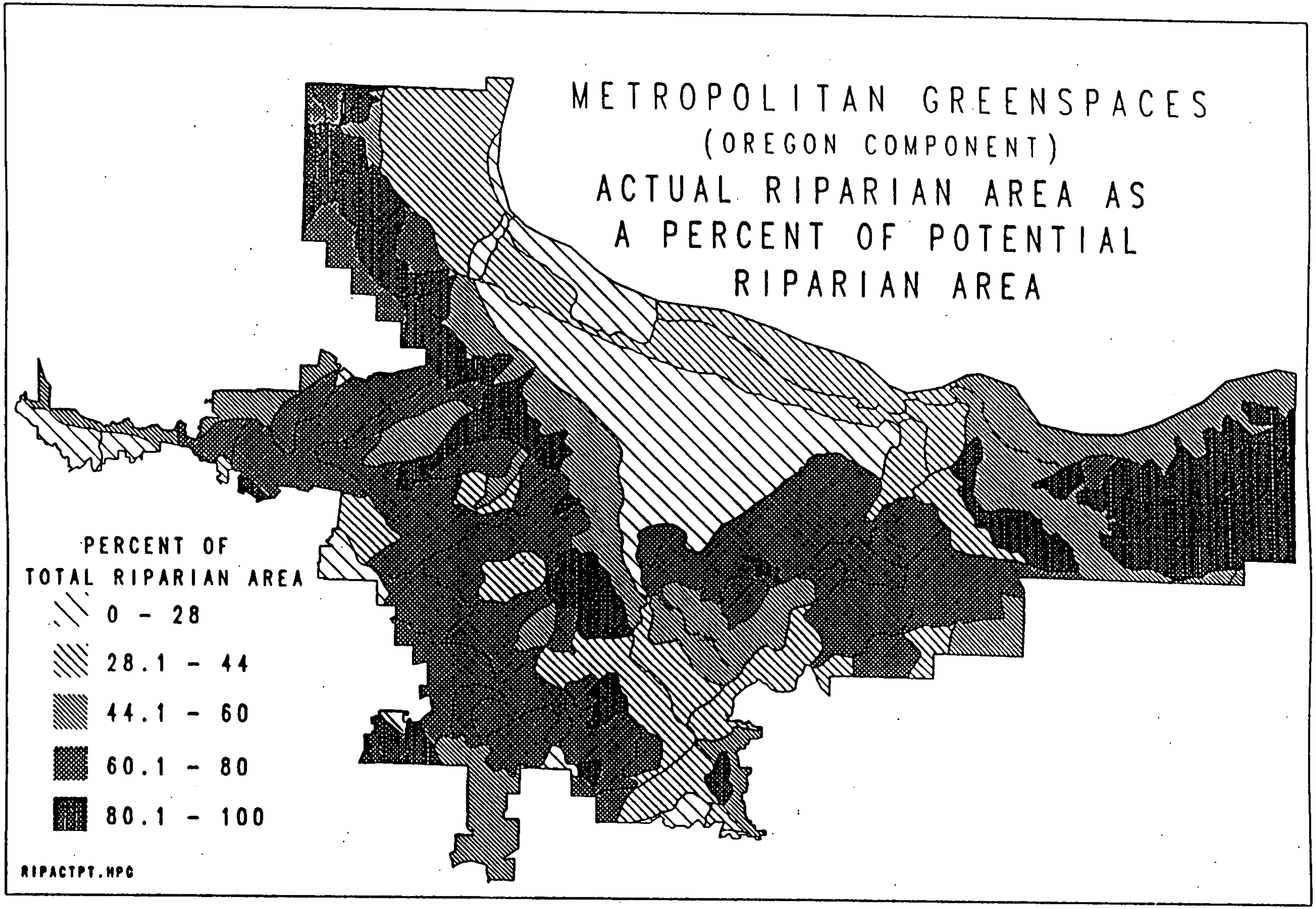

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
ACTUAL RIPARIAN AREA AS
A PERCENT OF POTENTIAL
RIPARIAN AREA
PERCENT OF
TOTAL RIPARIAN AREA
0 - 28
28.1 - 44
44.1 - 60
60.1 - 80
80.1 - 100
RIPACTPT.HPG

FIGURE 66

4.3 Polysheds and Habitat Types

For each of the eight habitat types of the study area, data were tabulated on the acres that occur in each polyshed. These data are presented in Figure 67A-67H. The bars in each graph represent the percent of the polyshed in the indicated habitat type. The curve on each graph portrays the total percent of the polyshed that is in natural area and the polysheds are sorted along the X-axis of each graph according to the curve. If all the bars on the eight graphs are added together, they represent the total area under the curve. Since the bars on each graph are sorted according to the same data -- the percent of total natural area within the polyshed -- direct comparison of the pattern of one habitat type to another is simplified. The graphs are arranged from the most common habitat type, upland deciduous forest, having the largest number of total acres, to the least common habitat type, wetland shrub-scrub, having the smallest number of total acres. Thus, the height and density of the bars decreases from Graph A through Graph H.

The general form of the bars portrayed in graphs A and B closely follows the form of the curve, reflecting the widespread character of these two forest types. On Graph A there is somewhat of a gap at the very highest end, but this is accounted for by the generally greater height of the bars in Graphs C and E at the highest end. Graphs A, B, C and E are the only ones that consistently have a high density of tall bars on the right side of the graph, reflecting the fact that polysheds with high percentages of natural area tend to be uplands and be dominated by woody (forest and shrub-scrub) categories. In general, the bars in Graphs D and F are short and evenly distributed in small quantities over the entire width of their graphs, indicating that meadows are generally widespread throughout polysheds of various sizes, but do not usually occupy very large areas.

Maps portraying this information are presented in Figures 68-75. Their sequence is the same as in graphs A-H and they do not present any surprising patterns. The first map is, overall, relatively dark and the others get rapidly very light, indicating the rapid drop-off in the percentages being portrayed.

<u>Conclusions Concerning Habitat Types</u>

1) Polysheds with high percentages of natural areas tend to be uplands and their natural areas are generally dominated by forest and shrub-scrub habitat types.

2) The woody habitat types are the most widespread, occurring in virtually every polyshed and generally representing high percentages of the natural areas.

3) Though not as widespread as the forests, meadows tend to be moderately widespread throughout the range of polyshed sizes, but generally do not occupy very large areas.

4) The three wetland habitat types occur in the fewest polysheds and at the smallest percentages of total natural area of all the habitat types.

FIGURE 67A-67D

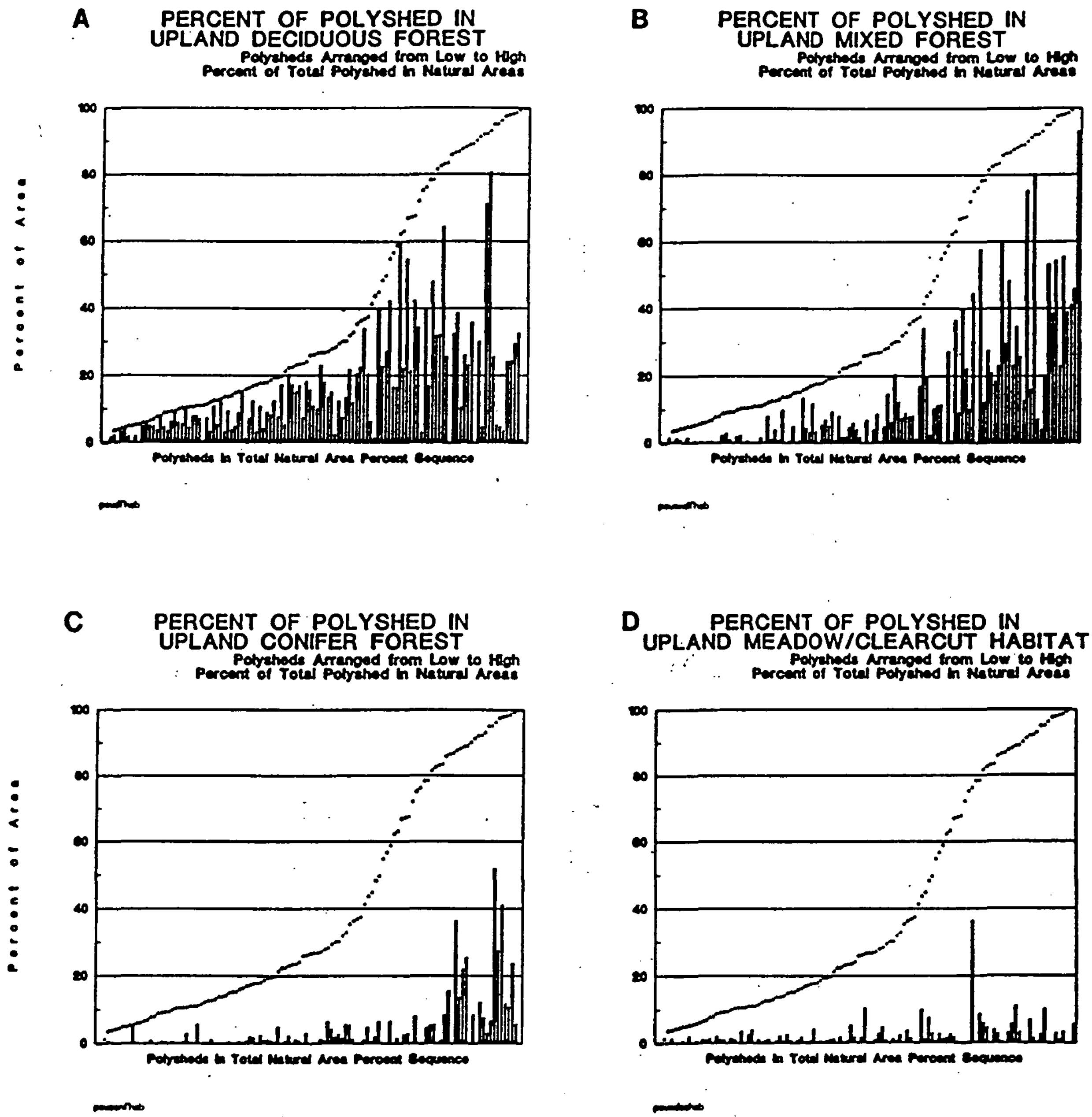
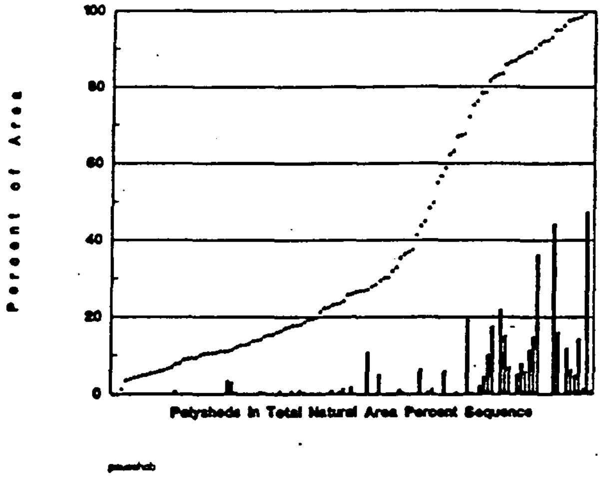
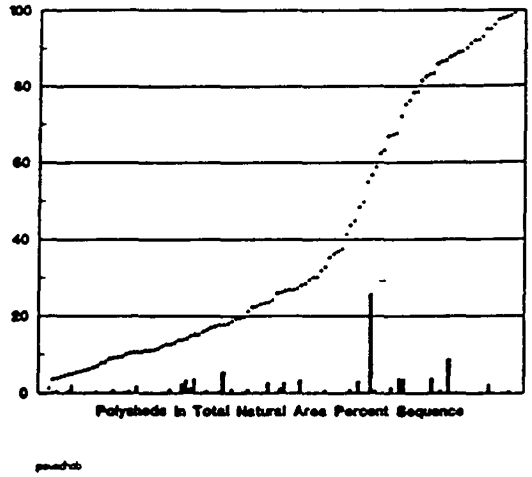


FIGURE 67E-67H

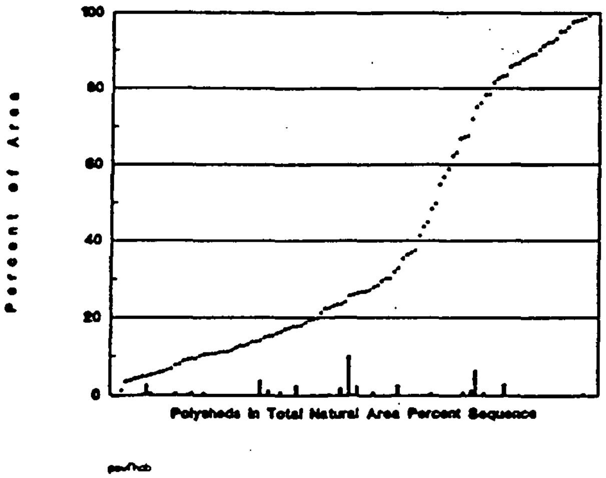
E **PERCENT OF POLYSHED IN UPLAND SHRUB-SCRUB HABITAT**
Polysheds Arranged from Low to High Percent of Total Polyshed in Natural Areas



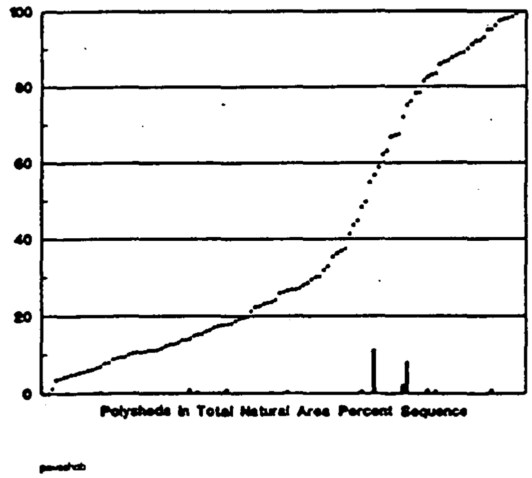
F **PERCENT OF POLYSHED IN WETLAND MEADOW HABITAT**
Polysheds Arranged from Low to High Percent of Total Polyshed in Natural Areas



G **PERCENT OF POLYSHED IN WETLAND FOREST HABITAT**
Polysheds Arranged from Low to High Percent of Total Polyshed in Natural Areas



H **PERCENT OF POLYSHED IN WETLAND SHRUB-SCRUB HABITAT**
Polysheds Arranged from Low to High Percent of Total Polyshed in Natural Areas



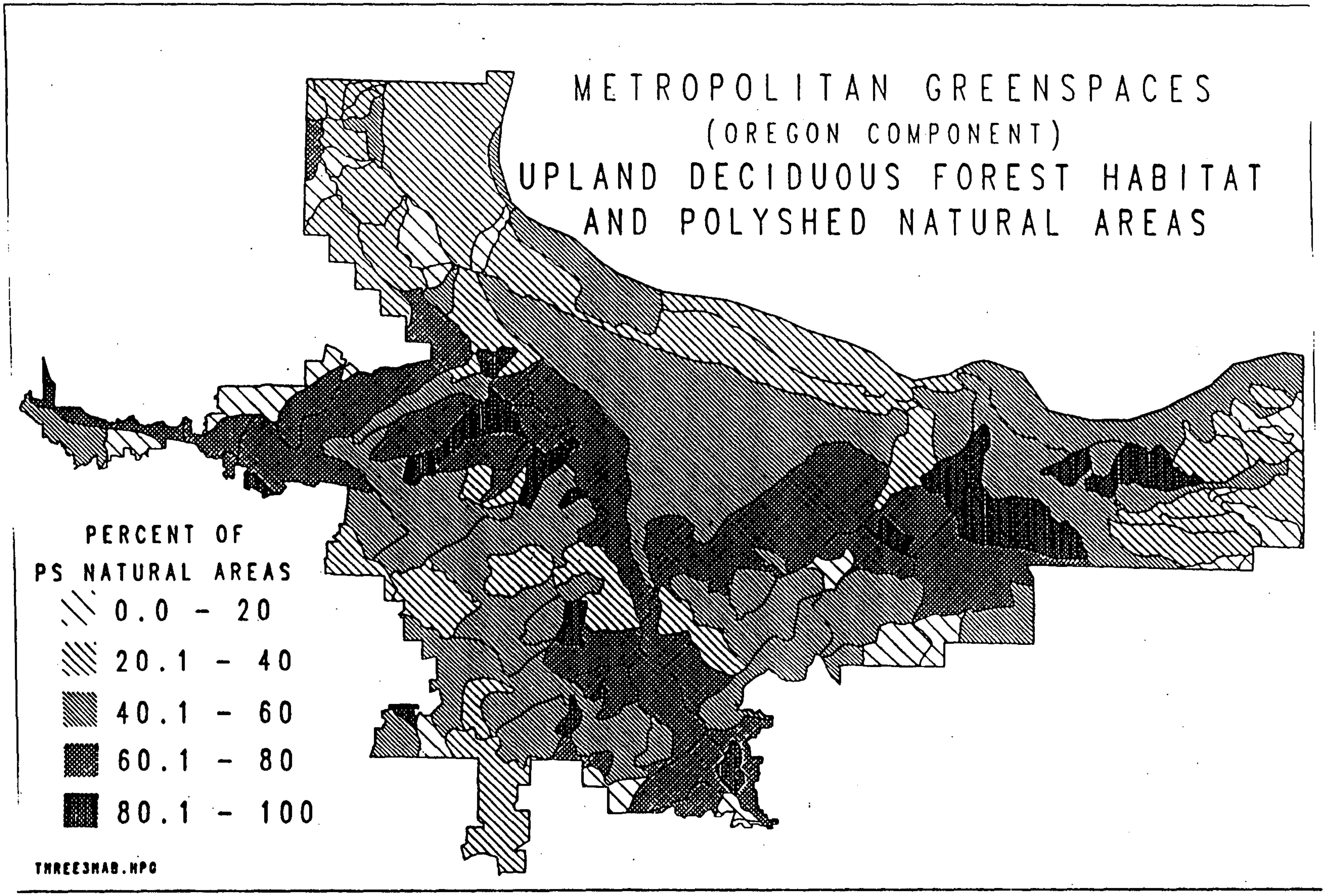

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
UPLAND DECIDUOUS FOREST HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
THREE3HAB.HPG

FIGURE 68

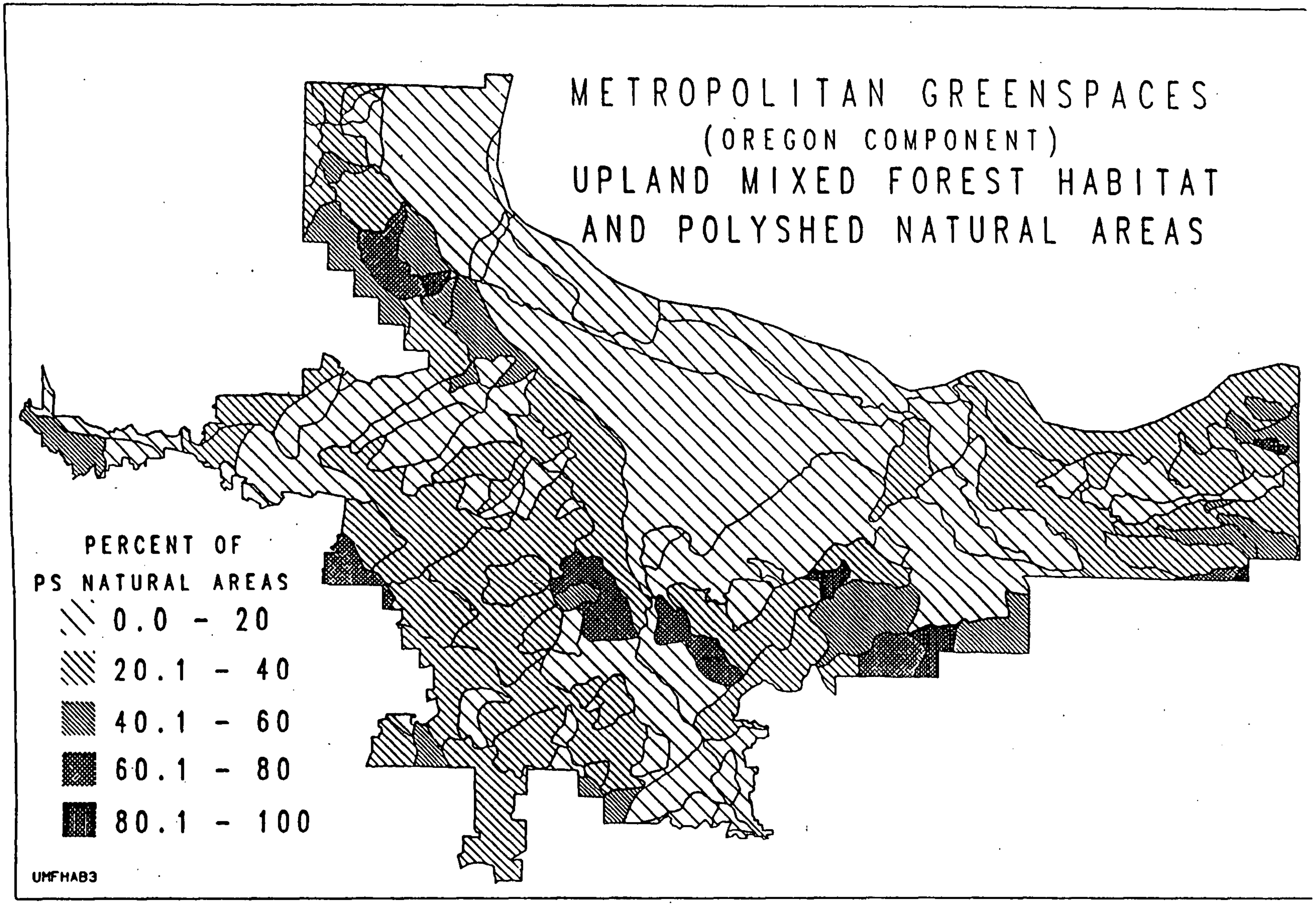

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
UPLAND MIXED FOREST HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
UMFHAB3

FIGURE 69

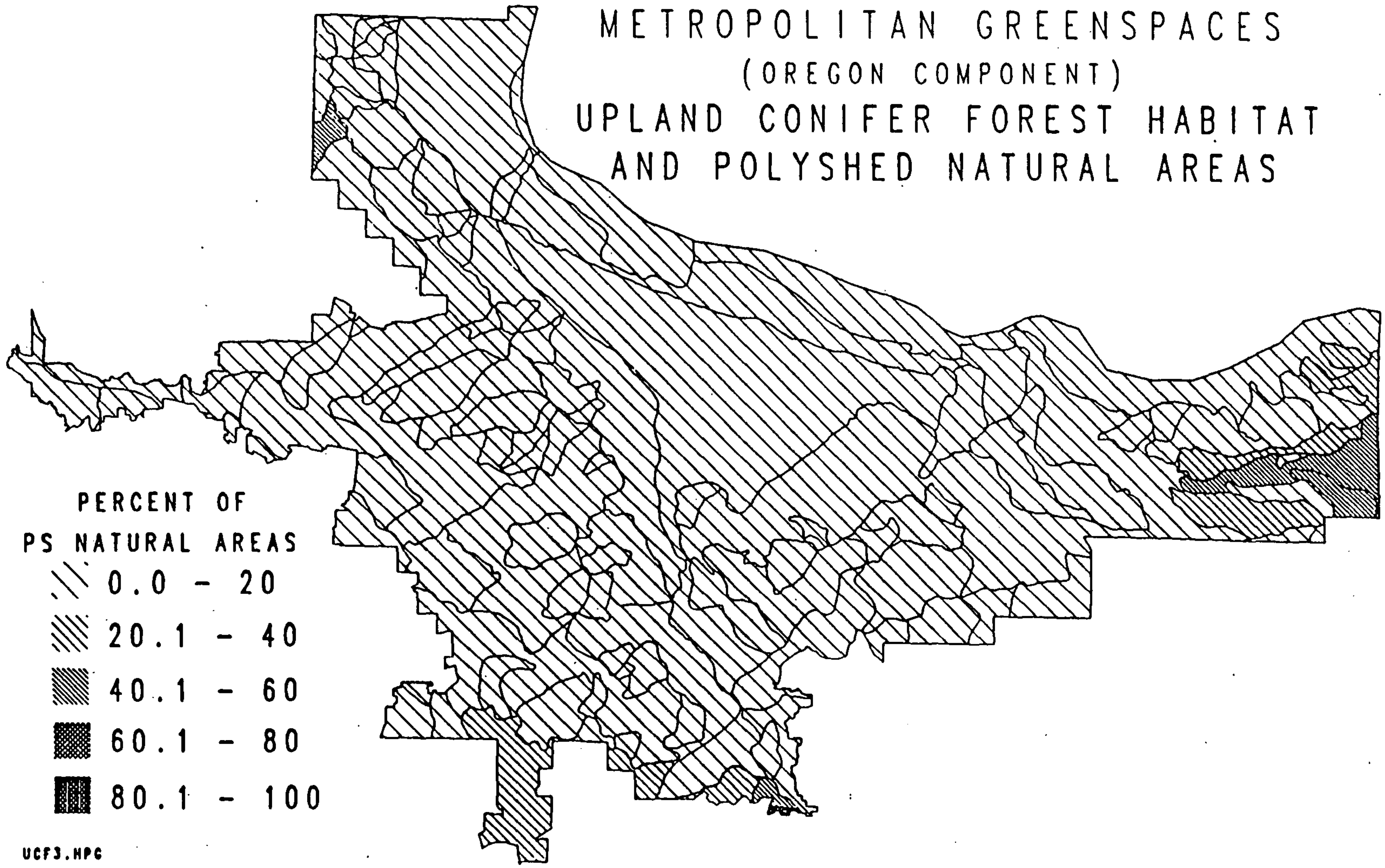

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
UPLAND CONIFER FOREST HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
UCF3.HPC

FIGURE 70

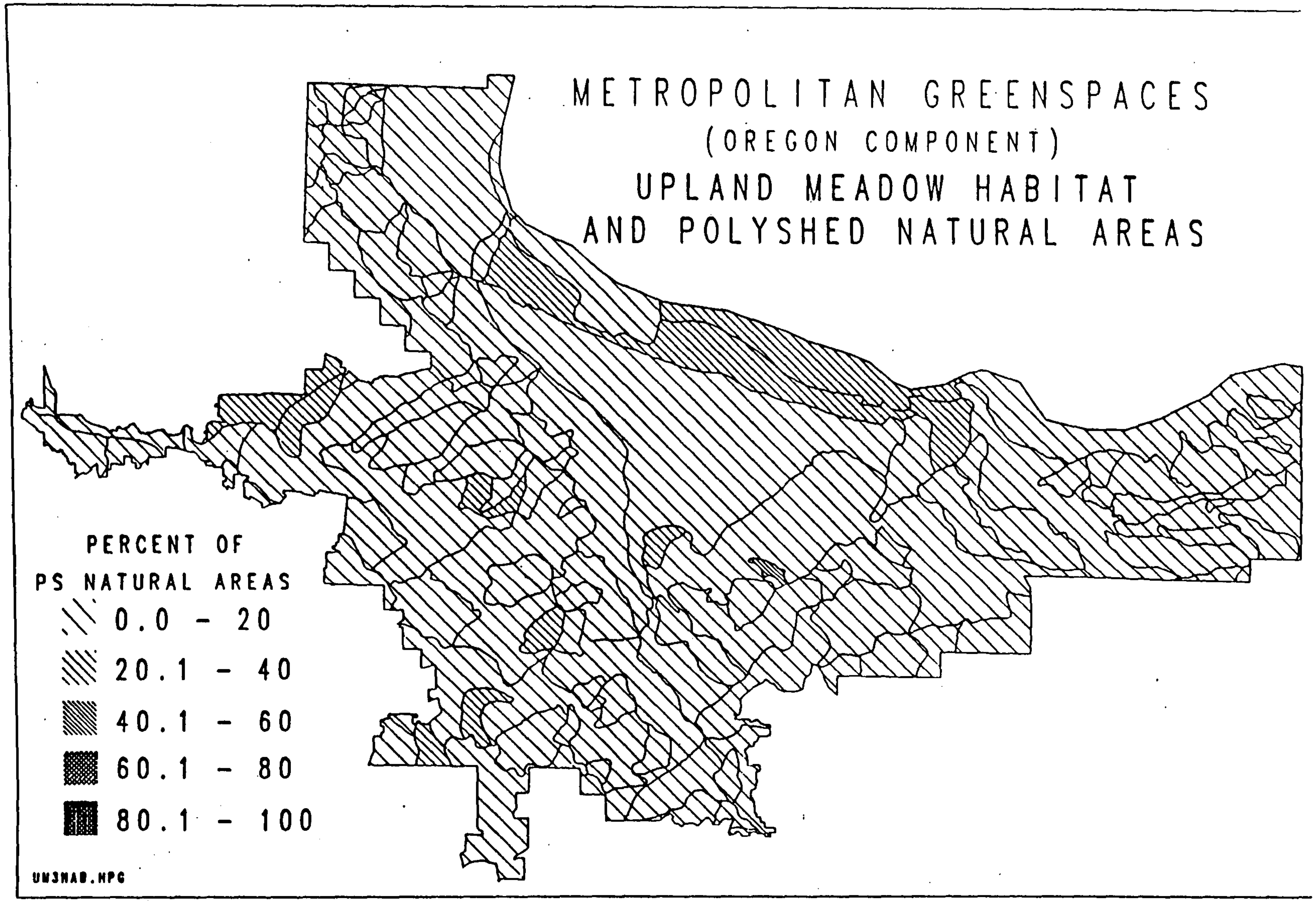

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
UPLAND MEADOW HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
UM3HAB.HPG

FIGURE 71

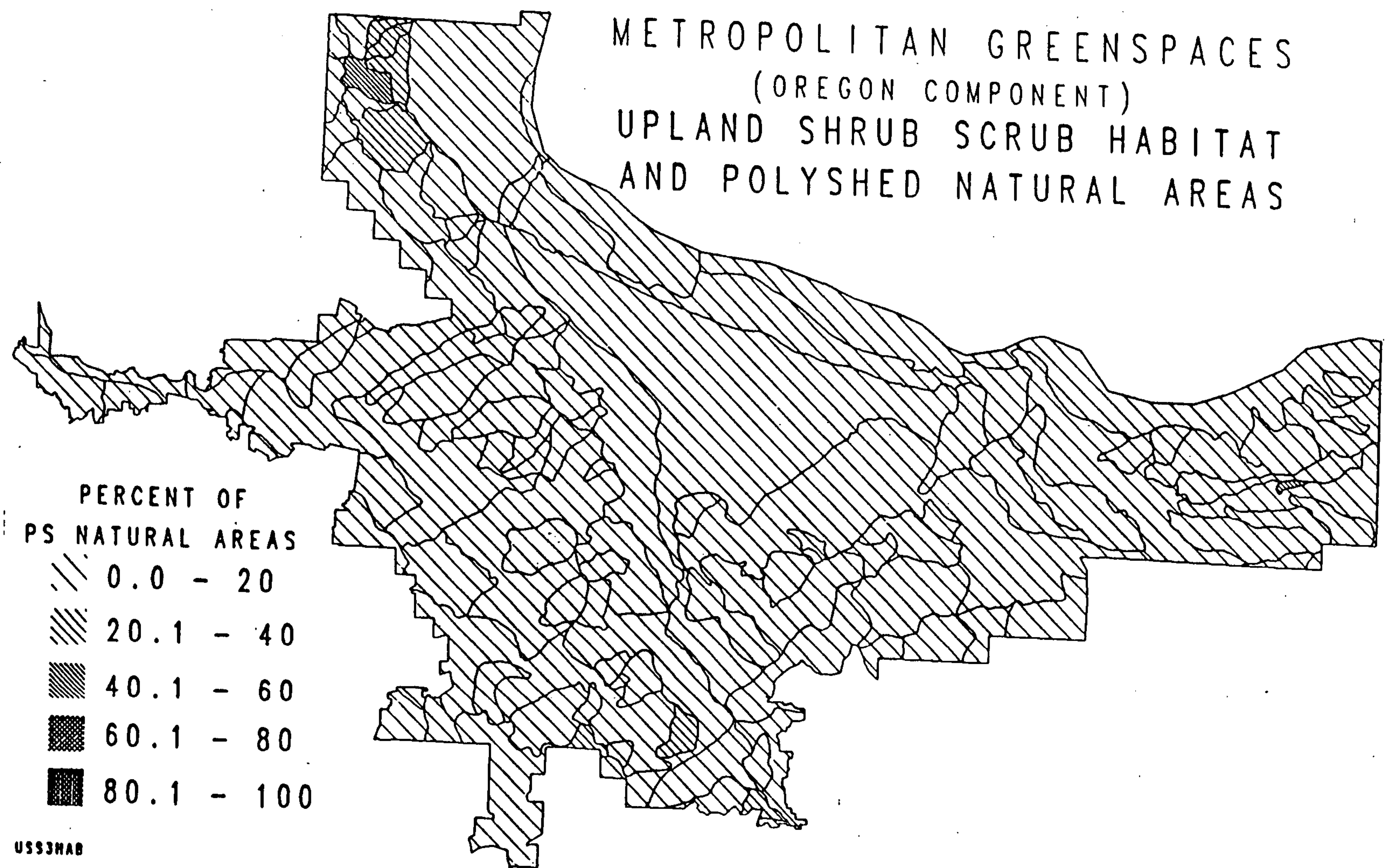

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
UPLAND SHRUB SCRUB HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
USS3HAB

FIGURE 72

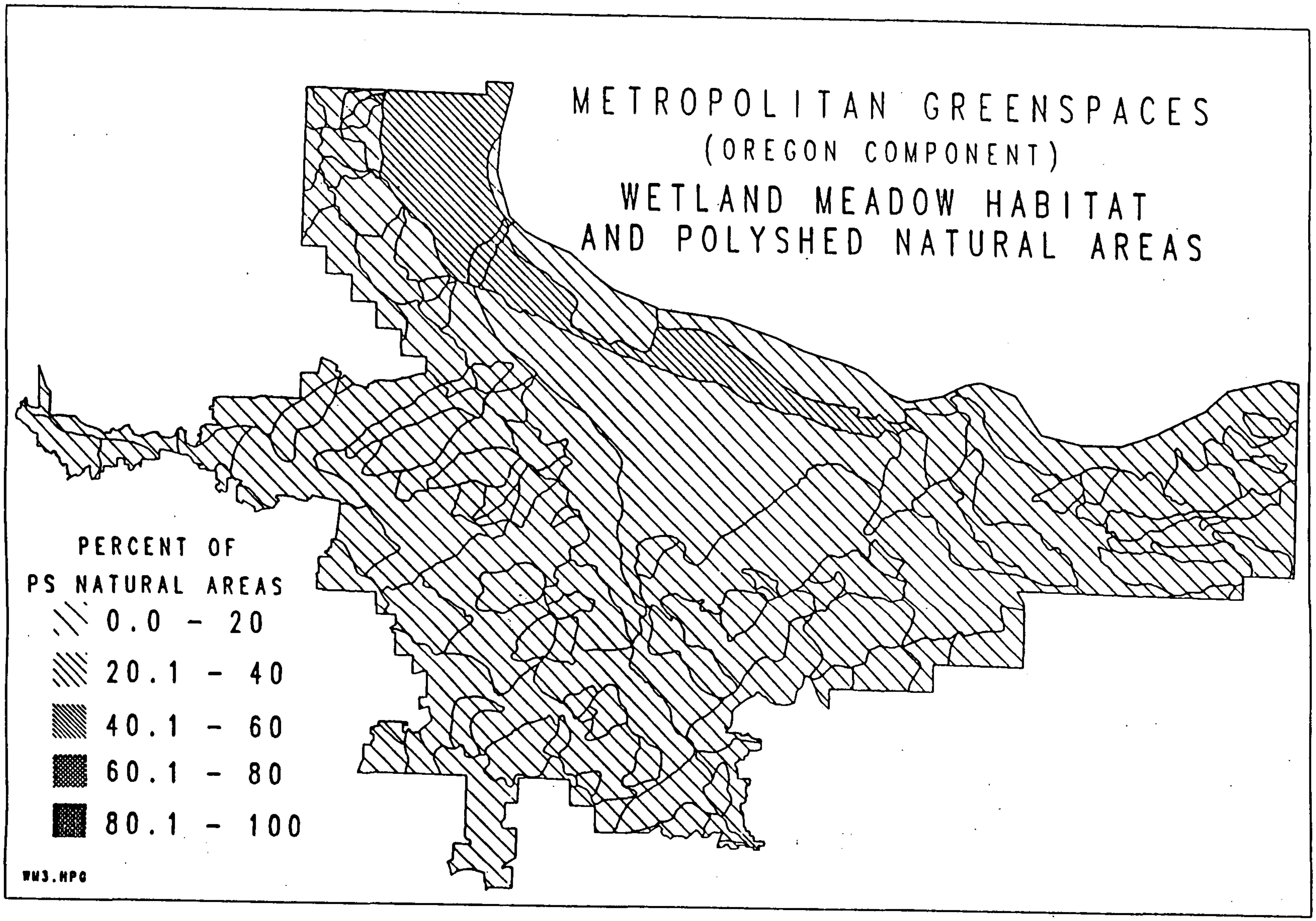

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
WETLAND MEADOW HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
WM3.HPG

FIGURE 73

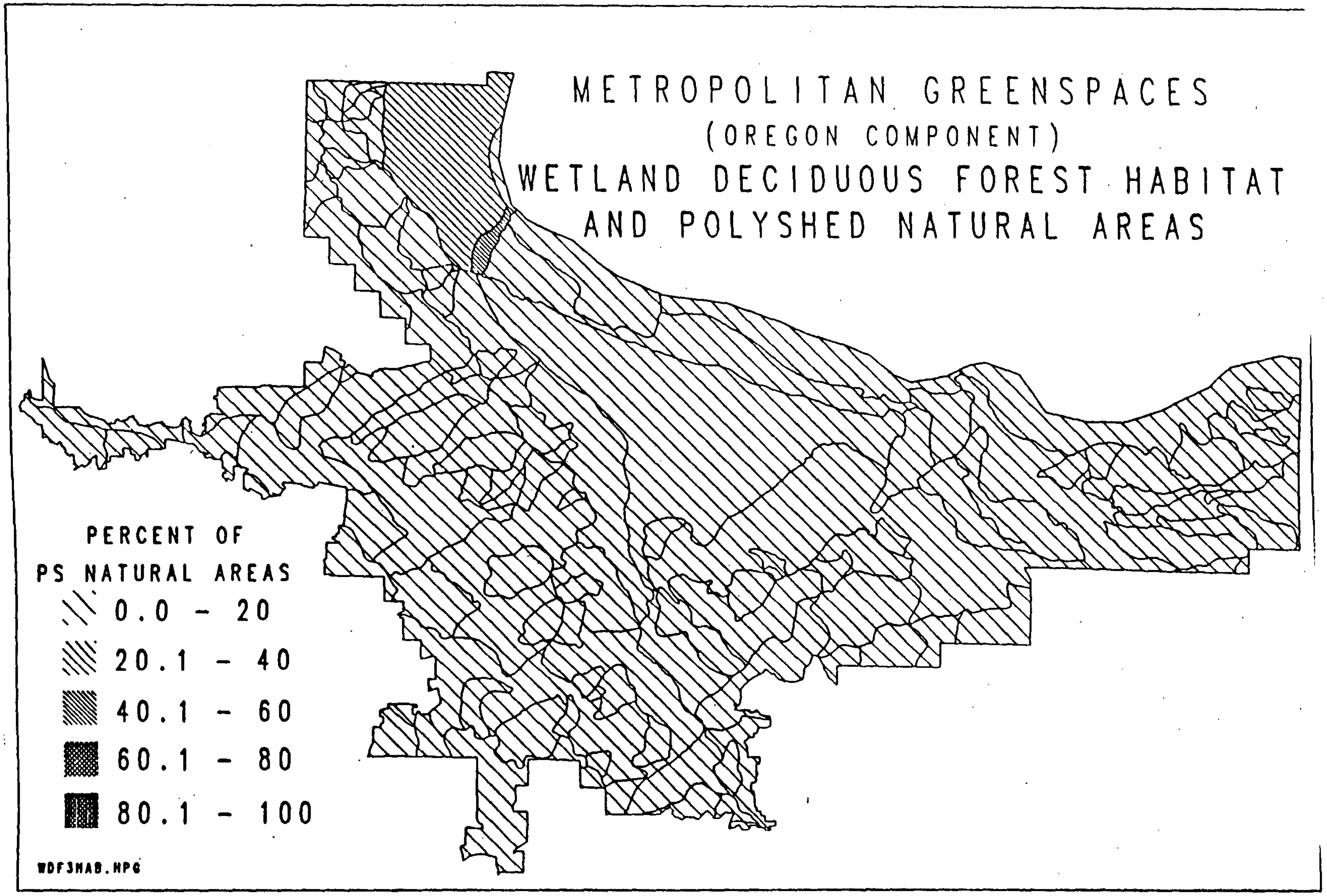

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
WETLAND DECIDUOUS FOREST HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
WDF3HAB.HPG

FIGURE 74

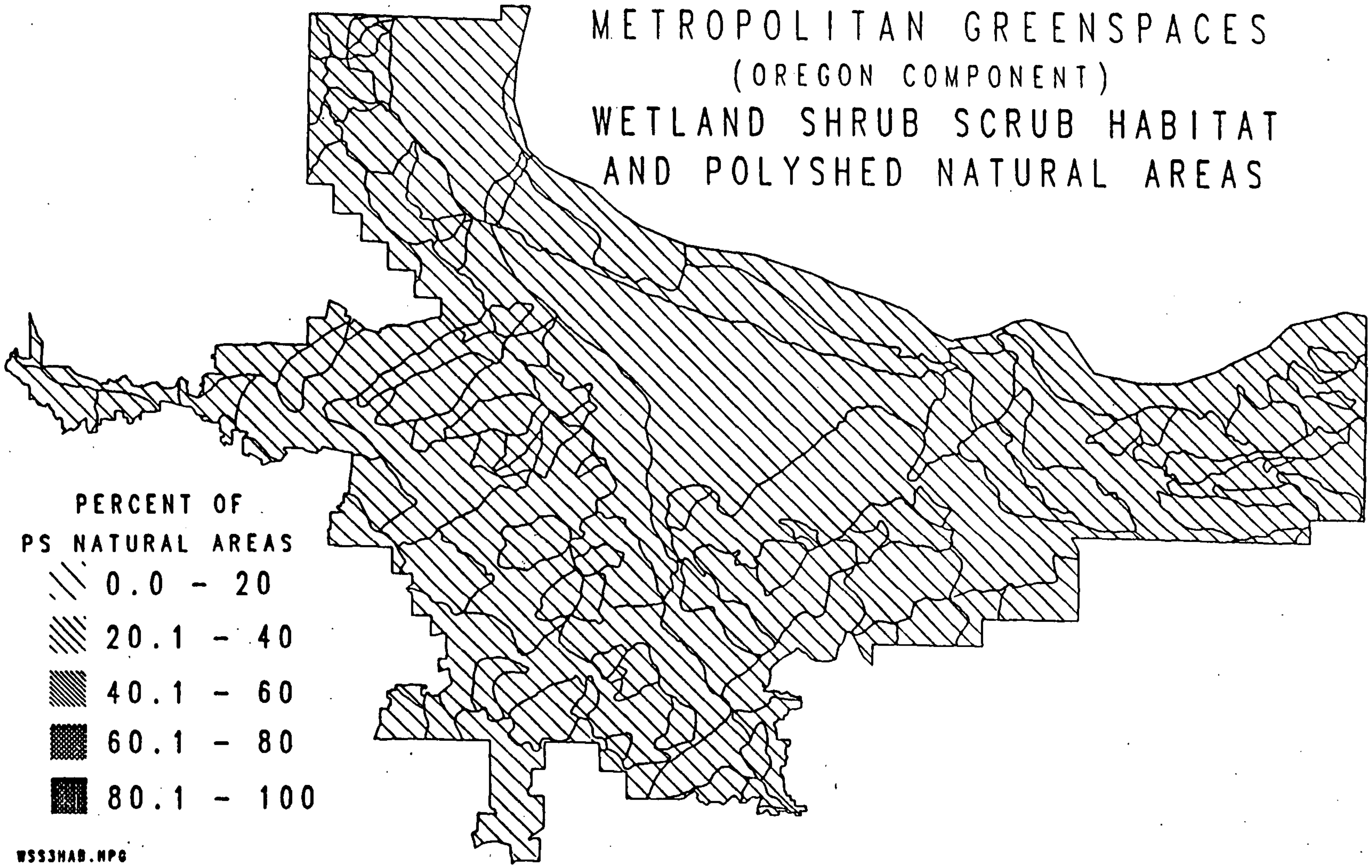

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
WETLAND SHRUB SCRUB HABITAT
AND POLYSHED NATURAL AREAS
PERCENT OF
PS NATURAL AREAS
0.0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
WSS3HAB.MPG

FIGURE 75

5) There are great differences between polysheds in both the amount of area available in each habitat type and the proportions of natural area in each habitat type. Since wildlife is tied to habitat, these differences indicate varying levels of potential for protection of particular wildlife species through natural areas preservation.

4.4 Topography and Polysheds

For a number of reasons, identification and protection of natural areas along ridges is an important consideration. The ridgeline zone is the uppermost source of water for streams and the preservation of natural areas in this zone is critical to protecting the quality of headwaters. The upland forests that naturally occupy many ridgelines are important habitat to particular species of wildlife. The ridgeline habitat zone serves as a connecting belt or zone of interaction and elimination of ridgeline vegetation can retard wildlife movement between watersheds, serving to isolate and genetically weaken local species. And ridgeline protection is critical from a visual standpoint (Whyte, 1970), since the ridgeline is likely to be one of the most prominent landscape features within a watershed and greatly affect people's perception of the greenness of a landscape.

Since watershed outlines represent topographic divides, they also represent ridgeline locations. In many cases, the topographic divide may be a relatively minor landscape feature, representing only a slight rise in the landscape rather than a major elevation difference with the surrounding area. However, in relative terms, the divide will represent the highest area within a watershed, except for an occasional isolated hill or butte within the watershed.

If the assumption is made that all ridges have some degree of visual prominence and no attempt is made to prioritize the relative importance of ridges, it is reasonable to use watershed outlines as the indicator of ridgeline locations. Note that it must be the watershed outline and not the polyshed outline that is used for this purpose. Watershed outlines represent topographic ridges. Polyshed outlines, on the other hand, include not only watershed boundaries, but also lines representing the study boundary and lines added to subdivide some of the larger watersheds, and neither of these other polyshed lines necessarily have topographic significance.

Watershed outlines were buffered with a 100-foot (on either side, 200 feet total) buffer. For a number of reasons, selection of the ridgeline buffer zone is not a straightforward issue. First, no attempt is made to associate the buffer zone with either the protection of a particular type of value or a particular level of protection. This discussion is concerned merely with the concept of a generic protection zone and the methodology for applying the concept to selection criteria for natural areas protection.

Second, the actual width simply represents one gauge of the minimum size of protected area potentially necessary to preserve the ridgeline resources and the selection of the 100-foot width is somewhat conservative. A divide that consists of only a slight rise might be adequately protected by a 100-foot buffer. However, higher ridges, such as along the West Hills, would likely require a green buffer several times that size.

Third, given the appropriate elevation data, it would be useful to attempt to vary the width of the buffer as a function of the slope, elevation and areal extent of the ridge. Lacking this data, a single buffer width was utilized.

The resulting buffer zone map was clipped to include only the area within the Oregon component and the total area of buffer tabulated for each polyshed. Sizes of the buffer area within each polyshed, as illustrated in Figure 76, vary from 0 to 684 acres, with a mean of 109.6 and a median of 73.9 acres.

Figure 77 depicts these data in the form of buffer area as a percent of total polyshed area. The percentages range from 0 to 30.8 percent, with a mean of 6.1 percent and a median of 5.2 percent. Figure 78 portrays the percentage data as a five-class map. The map illustrates what might be expected -- there is generally an inverse relationship between the size of the polyshed area and the percent of polyshed area included within the ridge buffer. Thus, the highest percentages are usually found in the smallest polysheds and the lowest percentages in the largest polysheds.

The buffer areas represent potentially desirable areas for greenspace protection but do not tell how much actual green buffer remains. To arrive at this, the natural areas coverage was combined with the ridge buffer and the acres of natural area habitat within the buffer zone tabulated for each polyshed. The percentages range from 0 to 100 percent (Figure 79), with a mean of 32.7 percent and a median of 18.3 percent.

Figure 80 illustrates the pattern through shadings on the polysheds; shading only the buffer areas would not work at this scale since the buffer zones are narrow bands just slightly wider than the linewidths on the map. The pattern on the map suggests that the highest percentages occur in the polysheds of greatest local relief and in the polysheds farthest from the developed core of the study area. The relief factor is probably the result of the higher property costs and greater construction costs associated with building on steeper slopes. The distance factor simply relates to less intense levels of development with increasing distance from the central urban area.

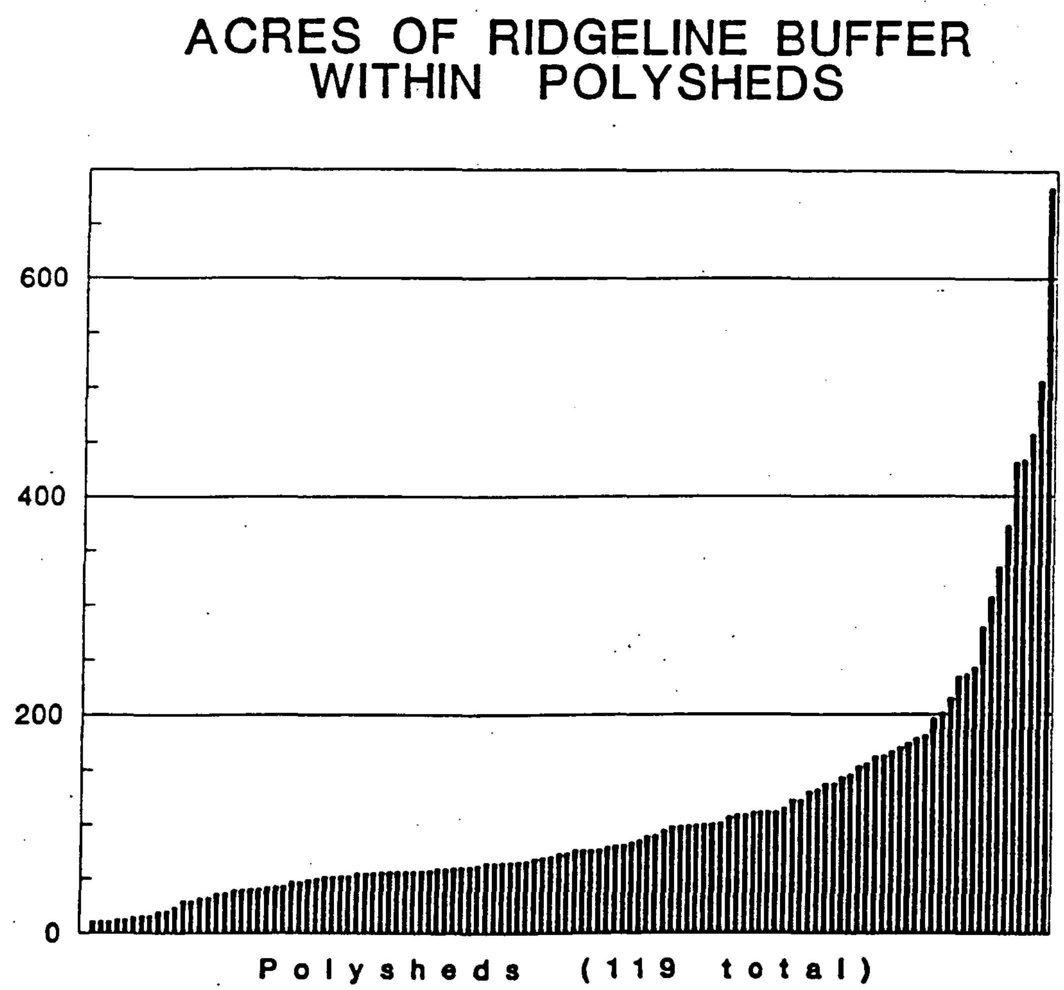
Conclusions Concerning Ridgelines

1) There is an inverse relationship between polysheds area and the percent of polyshed area in ridgeline buffer. This would suggest that ridgeline protection would involve a smaller percentage of total polyshed area in a large polyshed than in a small one.

2) There is a wide-range in the percentage of potential ridgeline buffers that are composed of natural areas, running from 0 to 100 percent.

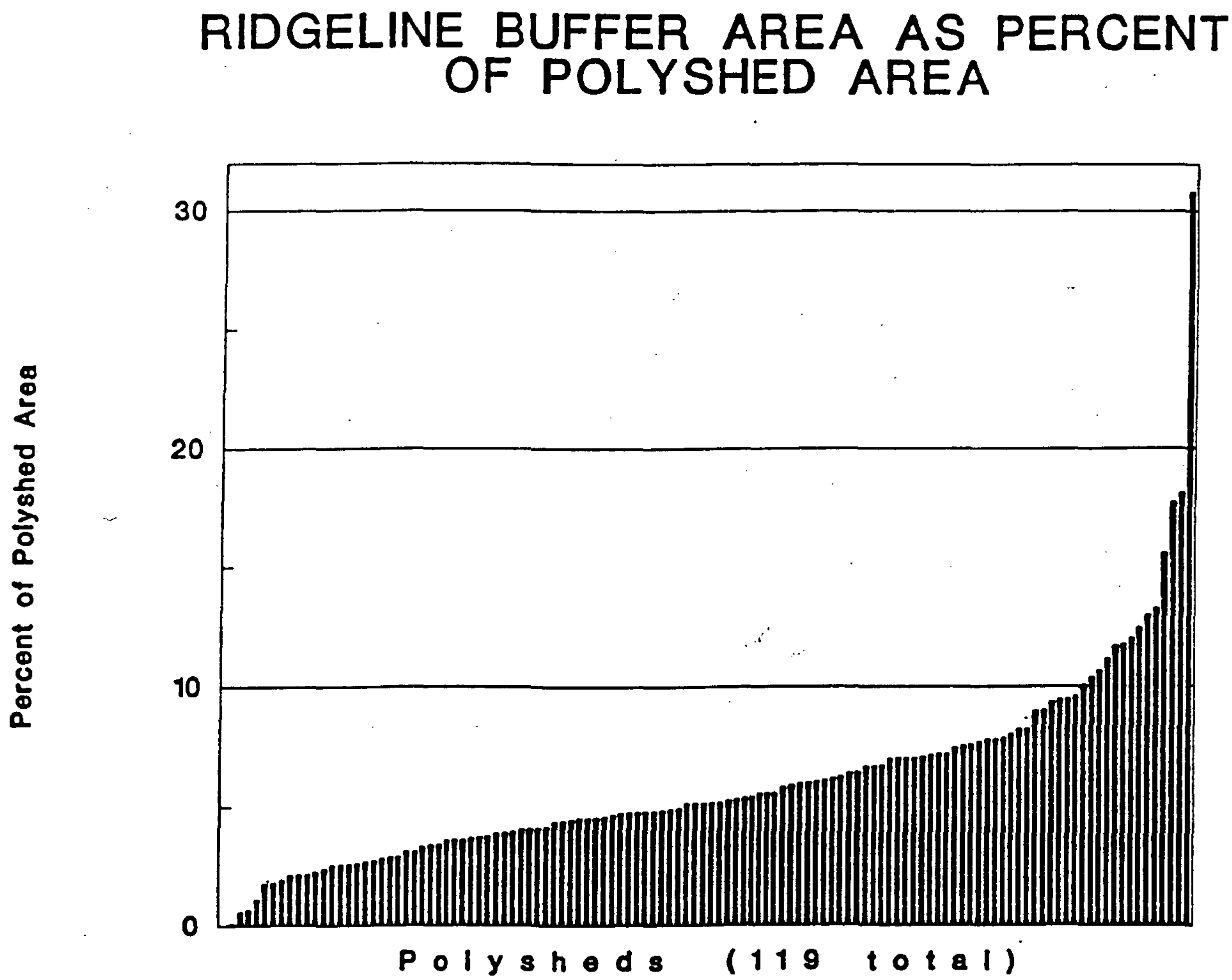
3) More than one-fourth of the polysheds (32) have 50 percent or more of their ridgeline buffer zone in natural area, indicating that there are some good potential opportunities for protecting ridge vegetation.

FIGURE 76



RdgBAcs

FIGURE 77



RdgB%PS

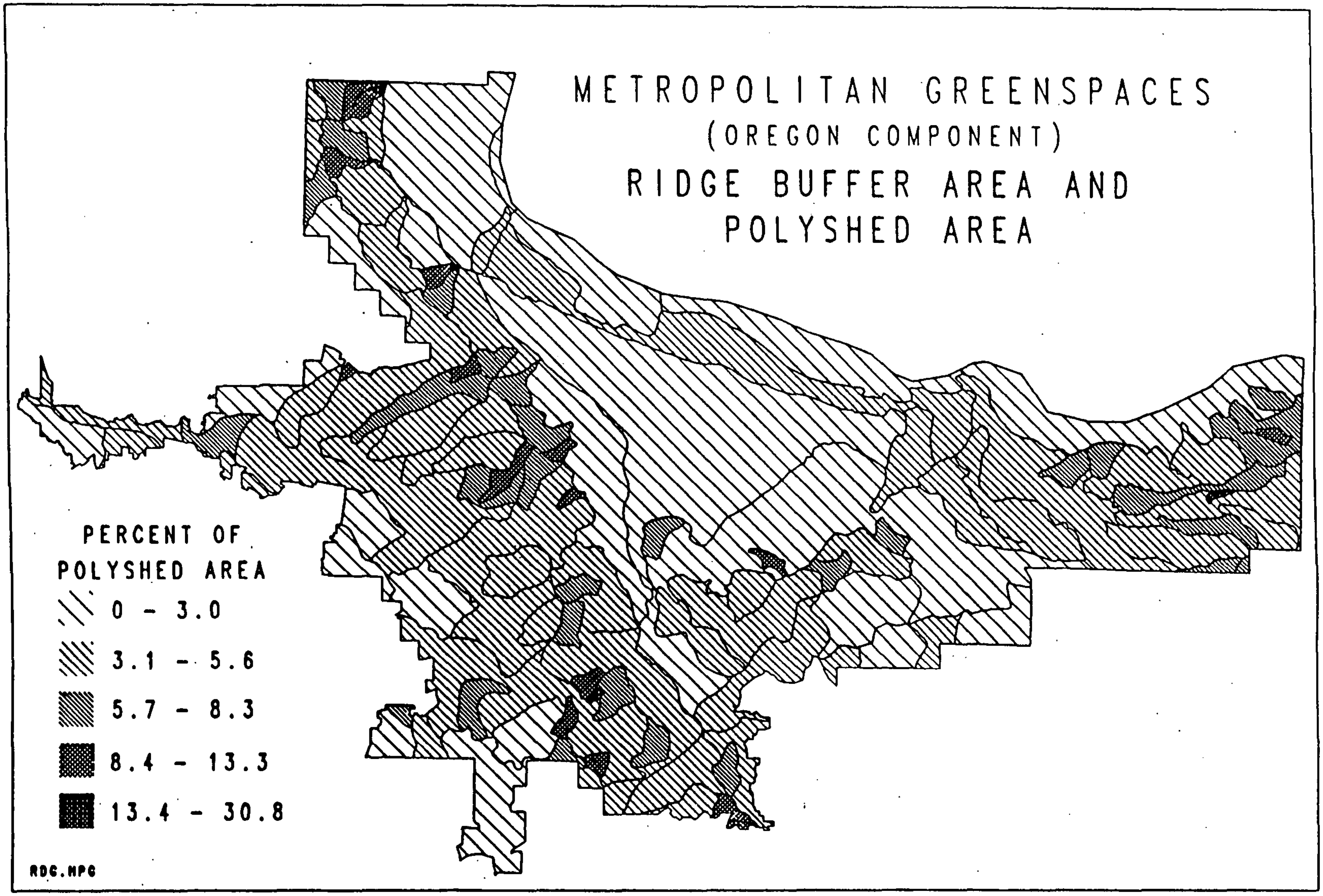
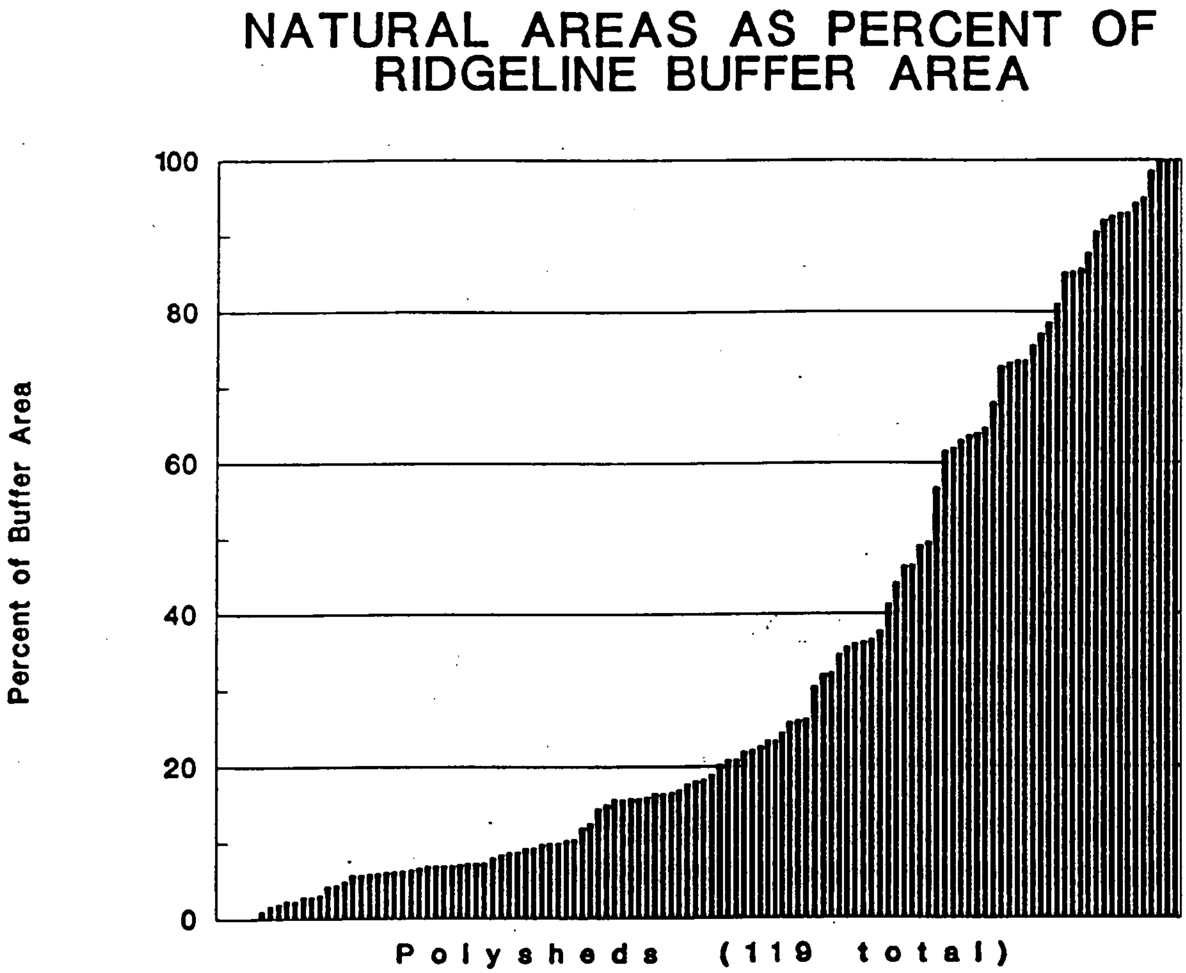

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
RIDGE BUFFER AREA AND
POLYSHED AREA
PERCENT OF
POLYSHED AREA
0 - 3.0
3.1 - 5.6
5.7 - 8.3
8.4 - 13.3
13.4 - 30.8
RDG.MPG

FIGURE 78

FIGURE 79



PctNARdgBu

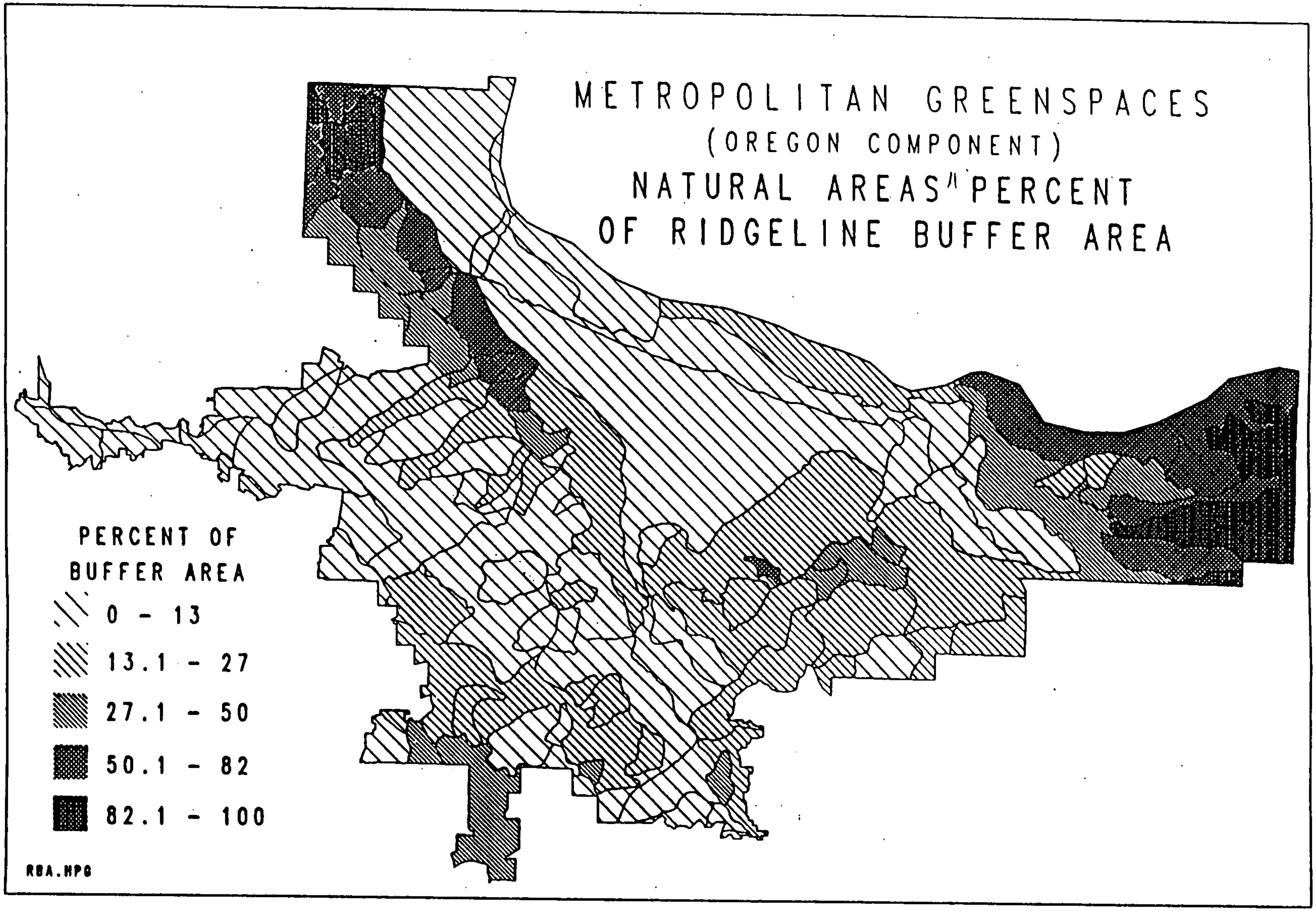

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
NATURAL AREAS" PERCENT
OF RIDGELINE BUFFER AREA
PERCENT OF
BUFFER AREA
0 - 13
13.1 - 27
27.1 - 50
50.1 - 82
82.1 - 100
RBA.HPG

FIGURE 80

4) The higher percentage areas tend not to be located in the densely developed central portion of the study area, but on the fringes, in northern and eastern Multnomah County.

4.5 Population By Polyshed

The current population for each watershed was determined using the reallocated 1990 population data, which assigned population to areas which were not identified as natural areas, water, or park and recreation areas. Polyshed densities ranged from less than .01 to 9.4 persons per acre, with a mean of 2.5 and a median of 1.6 people per acre (Figure 81). This maximum density is noticeably lower than the maximum of 45 that occurred with the block group data, reflecting the effect of averaging relatively high resolution data like the block group densities over areas as large as polysheds.

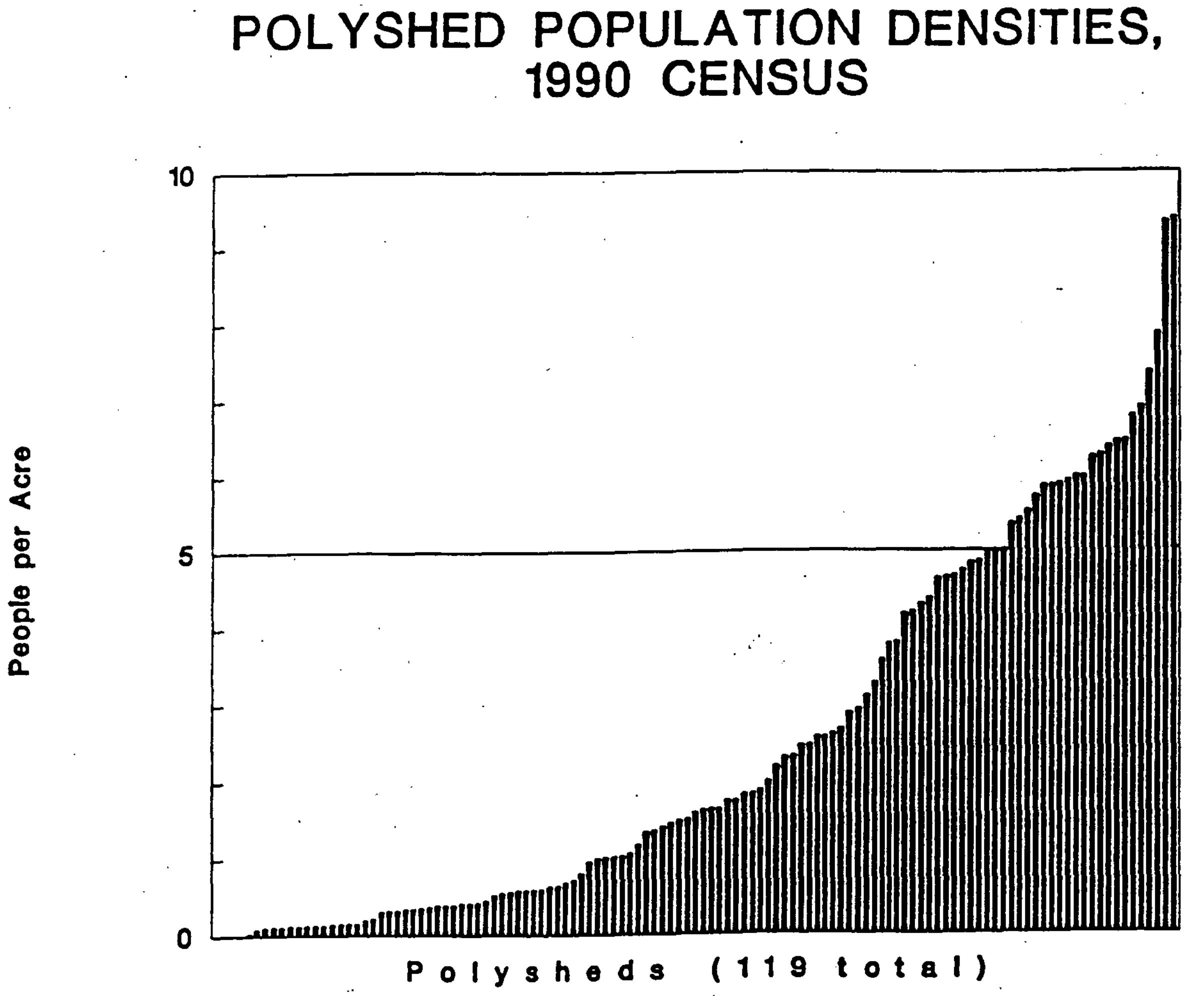
Using these densities, Figure 82 was prepared. This map very clearly shows the heavy urbanization of central and eastern Multnomah County and the rapidly-increasing population areas of eastern Washington County and northern Clackamas County. The impact of the West Hills topography on development is apparent, with a distinct band of medium and lighter grays separating large areas of darker tones on either side. Also apparent is the concentration of lighter tones in the area of the Boring Lava Hills.

Using the population projection data based on census tracts, the population density for each polyshed was estimated for 2010. This was also performed using the reallocated population data, which assigned population to areas which were not identified as natural areas, water, or park and recreation areas. Projected polyshed densities (Figure 83) ranged from less than .01 to 17.5 persons per acre, with a mean of 2.5 and a median of 1.6 people per acre. Though the maximum density is higher than the 1990 data, the mean density is only 0.2 higher and the median is only 0.2 higher.

The very low increases in density occur despite the fact that the data were prepared working from the unrealistic assumption that all natural areas that existed as of the inventory were still in place in 2010. This assumption should produce high densities of population, since it allows for no conversion of natural areas and forces already developed areas to become even more intensively developed. However, it is interesting to note that even with the relative high densities of development that this assumption would require, there is not as widespread and dramatic an absolute change in population densities than might be expected. In fact, if the graphs in Figures 81 and 83 are compared, it is only in the portion of data above five people per acre that there is a major change in densities. The portion of the curve for less than five people per acre is nearly identical on both graphs.

The projected 2010 population data is shown in map form in Figure 84. Comparing it with the 1990 population density map indicates two different aspects to the change in spatial pattern. First, there is a general density increase for a number of the already dense areas in the central area of the map and a general *growing together* of the urban areas of Portland, Beaverton and Tigard, replacing the

FIGURE 81



PSPopDn90

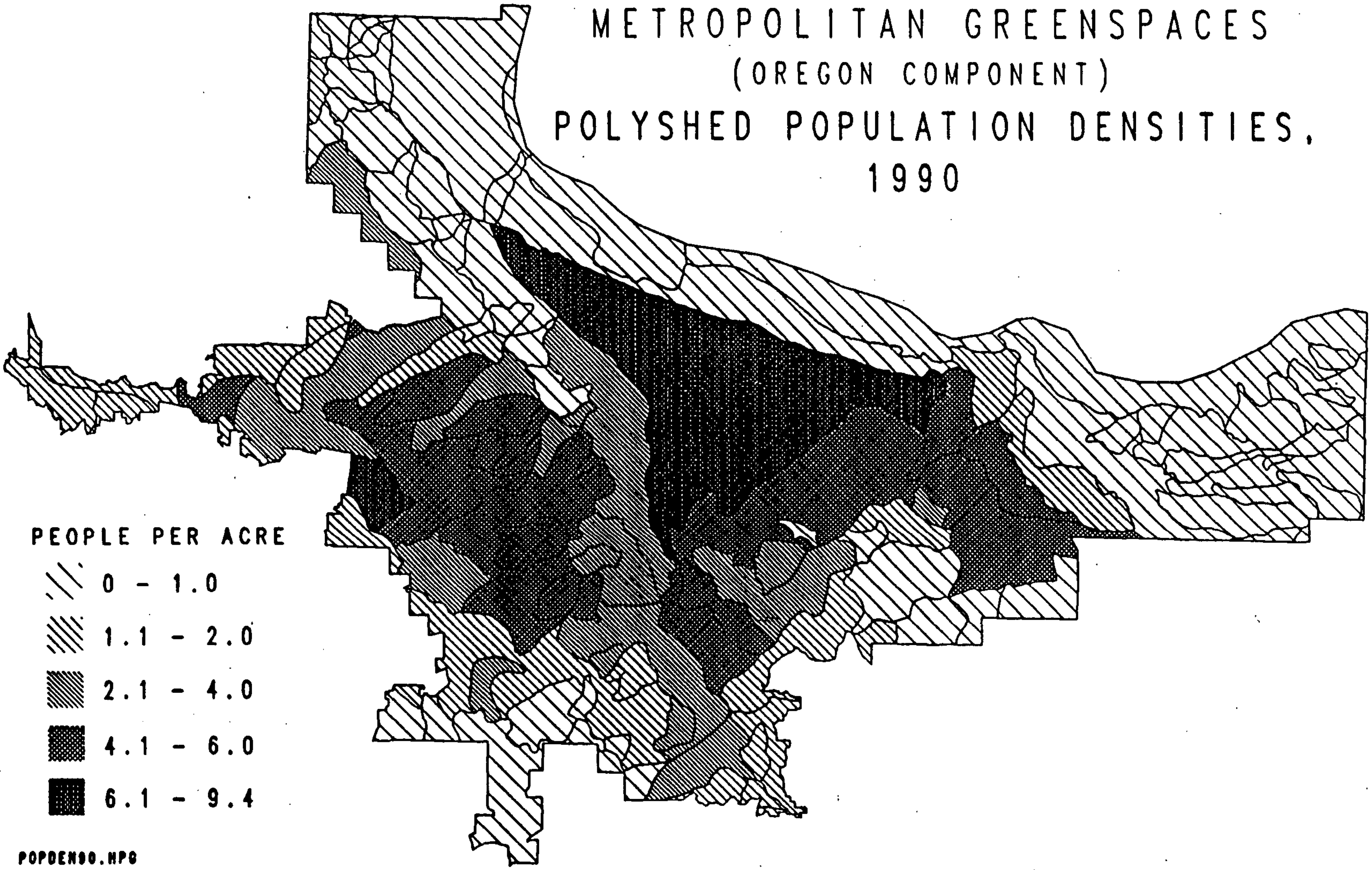
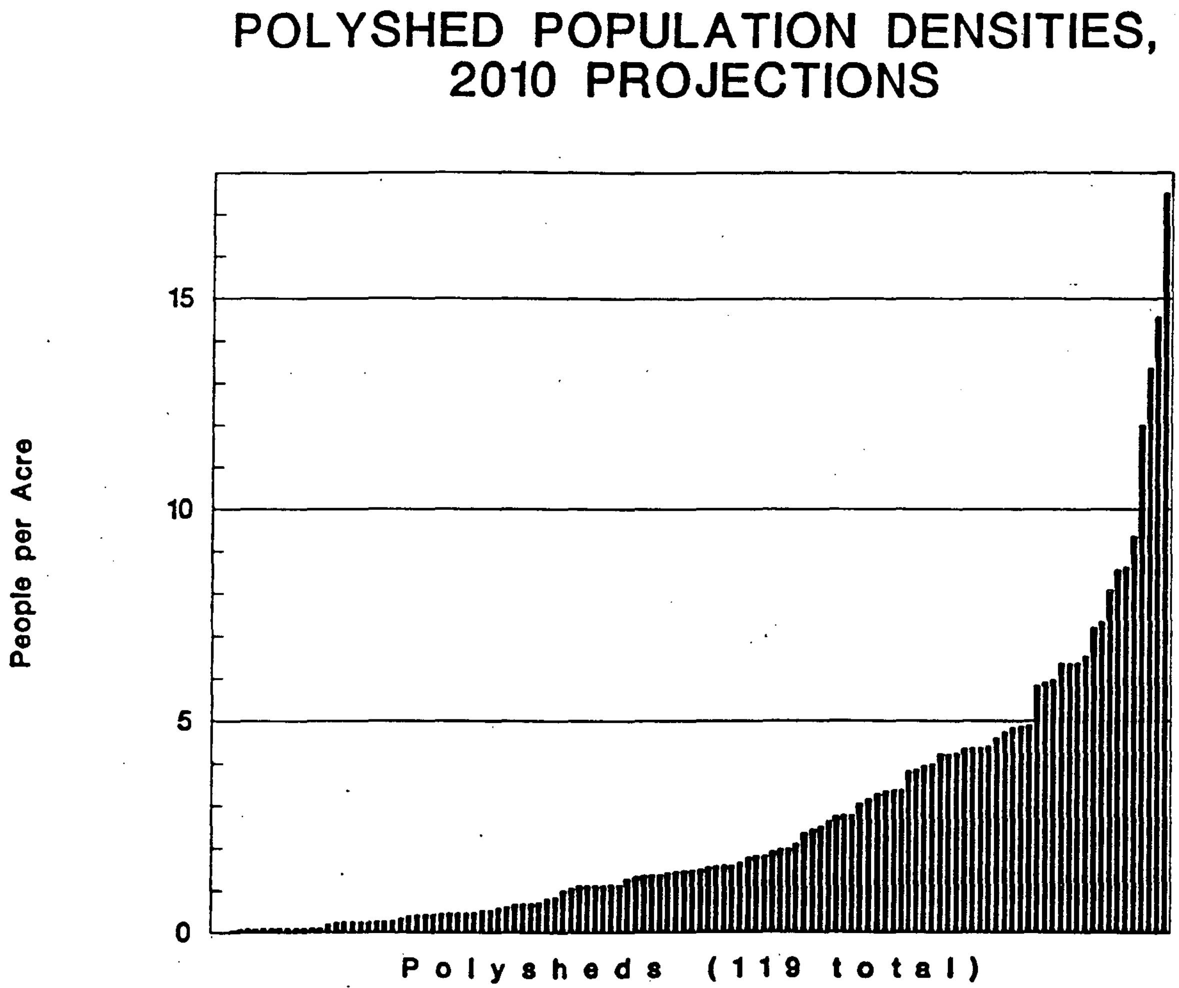

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
POLYSHED POPULATION DENSITIES, 1990
PEOPLE PER ACRE
0 - 1.0
1.1 - 2.0
2.1 - 4.0
4.1 - 6.0
6.1 - 9.4
POPDEN90.HPG

FIGURE 82

FIGURE 83



PSPopDn10PrNA

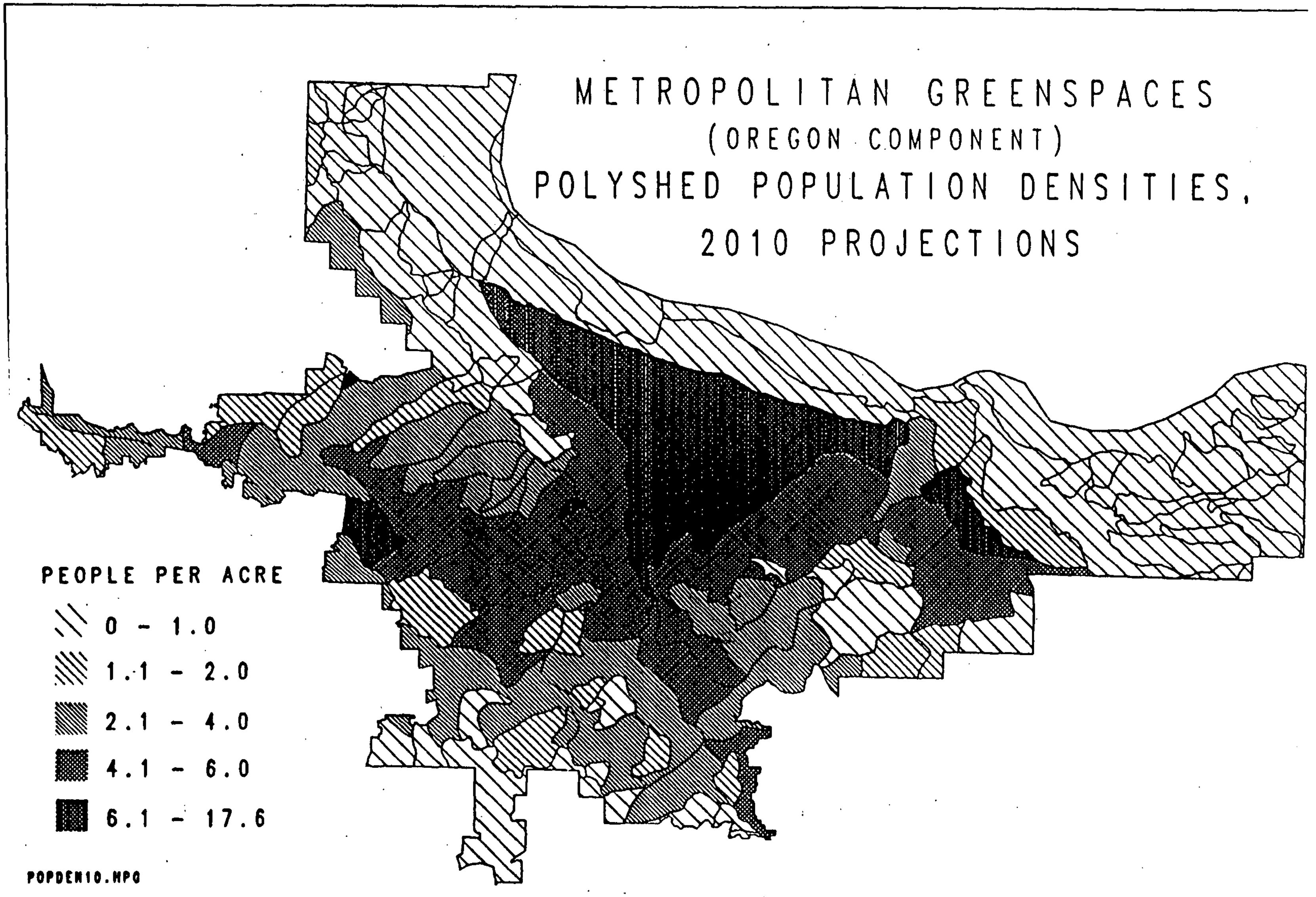

METROPOLITAN GREENSPACES
(OREGON COMPONENT)
POLYSHED POPULATION DENSITIES,
2010 PROJECTIONS
PEOPLE PER ACRE
0 - 1.0
1.1 - 2.0
2.1 - 4.0
4.1 - 6.0
6.1 - 17.6
POPDEN10.MPG

FIGURE 84

generally moderate 1990 densities of the West Hills with a continuation of the higher densities that now exist on either side of this area.

Second, there are some fluctuations in densities almost randomly distributed over the map, indicated by changes in tone between the two dates. Though there are a number of areas that show increases, there are also a number of areas that show a decline in density. Some of this decline may be due to the replacement of housing units by commercial or industrial uses, resulting in an overall decrease of population within an area and therefore decreased population density. A greater portion of the decline is probably due to the random smoothing effect of calculating population densities from census tracts, which are relatively large units.

Conclusions Concerning Population

1) Projected population density increases between 1990 and 2010 are less dramatic than might be expected, even using the assumption of no population growth in natural areas.

2) Population increases would appear to be focussed in areas that already have some moderate to high levels of density (i.e., generally within the Urban Growth Boundary (UGB)).

3) There is probably some smoothing and dampening of extreme values on the growth pattern as portrayed on the maps, due to the generalization of population variation that results from the use of census tract projections.

4.6 Population Unserved By Natural Areas

Using the buffered natural areas coverage, it is possible to make estimates of the number of people more than a specified distance from a natural area. If the buffer distance is taken to be a maximum distance that people will travel to utilize a natural area, then the unshaded portions of the map may be interpreted as areas that are *unserved* by natural areas. Anyone further away than that distance could be identified as *unserved* by a natural area. This approach is similar to the line of reasoning used in market area analysis problems, such as determination of shopping center market areas or identifying bus service areas.

The natural area coverages buffered at 325, 975 and 2,340 feet were each overlaid with the 1990 population coverage. For the 325-foot buffer there are 860,191 people, or 83.4 percent of the population unserved by natural areas. For the 975-foot buffer there are 543,400 people, or 52.7 percent of the population unserved by natural areas. For the 2,340-foot buffer there are 222,458 people, or 21.6 percent of the population unserved by natural areas. The 325-foot buffer leaves some people unserved in 98 of the 119 polysheds, while the 975-foot buffer involves people in 83 polysheds and the 2,340-foot buffer involves people in 43 polysheds.

The selection of buffer distances used for this *service* analysis is subjective and somewhat opportunistic, since the buffer coverage was readily available from another part of the analysis. No research was conducted to identify how close people might need to be to a natural area in order to *patronize* it and feel that they have access to a natural area. However, though the buffer distances employed are subjective, they do provide a reasonable range of options of ground distances that people can relate to: a) about 100 yards or the length of a football field, b) about three football field lengths, and c) a distance of about one-half mile. This *service area* strategy is suggested as a possible approach to further refinement of the prioritization process for natural areas acquisition. If natural areas are to be available for people, it is useful to consider what *available* means in terms of distance and ease of access.

Conclusions Concerning Unserved Population

1) A *service area* approach to natural areas shows that as of 1990 nearly 22 percent of the study area population is more than one-half mile from a natural area.

2) As natural areas are lost and population grows, the percentage of *unserved* population (i.e., people more than one-half mile from a natural area) will likely increase.

5. DISCUSSION AND RECOMMENDATIONS

This portion of the study has attempted to suggest some of the ways that both ecological and human parameters can be incorporated into natural areas decision making. The polyshed framework employed in this analysis provides the basis for a four-step model of greenspace protection planning:

Step 1. Examine the data at the polyshed level. Dealing with smaller segments of the region makes it possible to consider the polysheds in comparison with each other and to explore the interactions of various combinations of characteristics.

Step 2. Draw conclusions about the pattern of polyshed characteristics. Regularities and anomalies in the data lead to generalizations about the overall patterns of features. Based on the patterns, polysheds may then be grouped into categories having similar characteristics or combinations of features.

Step 3. Develop a general strategy for action. Once the regional mosaic of characteristics is identified, it is possible to make decisions about the kinds of actions or approaches that might be most appropriate to consider for each group of polysheds.

Step 4. Develop and implement the details of the desired actions at the polyshed level. This is a detailed action stage that involves consideration of a wide array of environmental, social, economic and political factors relevant to individual sites.

The purpose of the analysis in this section has been to deal with Steps 1 and 2 and to make suggestions about some of the alternatives available in Step 3. Metro and the other members of the Metropolitan Greenspaces coalition will then consider these options, as well as others, and make final decisions in regard to Steps 3 and 4.

Although the data used for this analysis were the best available at the time, there are a number of improvements that could and, in fact, should be made, if the Greenspaces Program is to improve its database capabilities. In general, there is a need for three things in the area of mapped data.

1) Higher resolution mapped data is needed. Both spatial detail and the amount of information need to be improved in order to provide a comprehensive database that will allow more detailed description of features and environmental situations.

2) Mapped data needs to be collected in a consistent fashion over the entire area. Much of the data on the region that might be of potential use is incomplete or discontinuous over the study area, limiting or negating its utility. In addition, consideration should be given to extending data collection beyond the Metro boundaries in the form of some natural units such as watershed boundaries.

3) Map data must represent current conditions, not historical situations. This necessitates an ongoing data collection program to ensure that data is up-to-date. This is not to say that historical data is not of great utility in identifying kinds and amounts of change and in tracking trends. However, in a dynamic area like the Portland/Vancouver region, change occurs rapidly and a major part of the environmental planning process is responding to that change. Without up-to-date data it is impossible to respond effectively to a need brought on by change.

In addition to these three general recommendations, the following specific recommendations are made:

1) Update and maintain the natural areas inventory on a regular basis. Loss of natural areas does not occur everywhere throughout the Oregon component at the same rate. Monitoring the areas and rates of change is important in assessing where and when to expend acquisition efforts.

2) Expand the natural areas inventory beyond the study area and perform it on a watershed basis rather than on the basis of purely administrative boundaries. While this is not likely to be possible for all the watersheds that fall within the Oregon component and are truncated by the administrative boundary, there are a number of watersheds slightly truncated by the boundary which would make good sense to include in any further analysis of Greenspaces.

3) Work to have future expansion of the UGB be coordinated to correspond with watershed boundaries rather than with traditional

administrative units. This kind of expansion could be preceded by development of a natural resource protection plan for the proposed expansion area that plans for natural areas and other greenspaces earlier, rather than later.

4) Update and improve the hydrography coverage for the study area and somewhat beyond it as well. The basis for this should be, at least, the 95 watersheds within the metropolitan region. There are a number of questions that have arisen concerning the completeness and accuracy of the hydrography data when compared with USGS 7½-minute quadrangles and recent aerial photography. Because of these questions, more detailed watershed analyses were not attempted. The watershed-based approach is a very powerful tool for the planning process, but better hydrographic data is critical in order to make full use of the approach.

5) The watersheds of many of the tributary streams within the already delineated watersheds should also be delineated, providing the basis for finer resolution studies. The 95 watersheds that were delineated for this study were chosen simply because their streams were named on the USGS quad sheets. Additional watersheds should be selected relying on criteria of local area importance.

6) Expand and update the Parks and Recreation Areas coverage. Presently the parks and recreation database is dated and covers only the Metro region. Furthermore, each site could be described in more detail as to: a) the identity of the category of park/recreation area, which is not always explicit in the name of each facility, b) the identity of the owners of each site, and c) the level of protection afforded each site. Add all this information to the database and update on a regular basis.

7) Digitize the 40 Mile Loop and other trails, whether existing or planned, on a scale compatible with other coverages. Information should include trail names, type of trail surface, approximate travel times/rates, location of rest stops, sites and feature of special interest, and information on access points.

8) Incorporate an agricultural component into the database and work to include a strong farmland protection component in the planning process. Agricultural land serves multiple functions within a greenspace system, acting as aesthetic amenity, open space, seasonal wildlife habitat and a functioning part of the local economy. A fully-integrated greenspace planning process needs to consider this important component.

9) Metro, based on U.S. Fish and Wildlife Service support, has instituted a program of restoration demonstrations and one requirement of the funding is that the restored sites be protected. The location of the restoration sites should be digitized for inclusion in the database and added to the list of *protected* sites.

10) Perform study to identify acceptable user *travel distance* to a natural area. This analysis has incorporated three buffer distances as an example of the use of a *market area analysis* approach that has great potential in assisting efforts to insure that people have access to natural areas. Identification of an acceptable user travel distance is a critical piece of information to this approach.

11) Monitor and support the progress of the Tualatin River National Wildlife Refuge designation process and include the area, where appropriate, as a component of detailed Metropolitan Greenspaces system planning. The proposed Refuge could serve as the major natural area anchor in the southwestern part of the study area and could connect with several wildlife habitat corridors to other parts of the Oregon component. In addition, the refuge is potentially an important link in the developing system of regional trails.

12) The suggested parameters and approaches to evaluating natural areas and site selection based on map data are only a starting point. Any acquisition process must include field survey of each potential acquisition site to verify and amplify data on its ecological characteristics.

13) Expand the streets coverage outside the Metro region. Include unimproved roads such as logging roads, since they are critical components of access to natural areas.

14) Initiate a study of natural areas protection techniques that would: a) identify the categories and levels of protection that can be applied to natural areas, and b) evaluate the strengths, weaknesses, advantages and disadvantages of each. The results should be utilized as the basis for an inventory of protected natural area sites in the metropolitan region and the identification of the level of protection currently afforded to each.

15) The digitization of the National Wetlands Inventory (NWI) map data which has been undertaken by Metro should be completed for the entire study area and that data compared with and, probably, substituted for, the photo interpreted wetlands data. It was recognized when the photo interpretation was being planned that there would likely be an underestimation of the wetlands in the mapping and the NWI data can be used to correct this.

16) There is a need to develop a high resolution digital topographic database suitable for use with the data at the level of detail of this study and, probably, at higher levels of resolution as well. The higher levels of resolution will be invaluable as more localized and site-specific planning is undertaken.

17) The issue of both riparian and ridgeline vegetation zones needs to be evaluated and some guidelines developed for appropriate widths of these areas. It is likely that widths need to be related to the type(s) of values that protection is aiming to achieve (e.g., wildlife habitat, water quality, hiking/recreational trails, aesthetic amenities) with different widths necessary to meet the minimum requirements of each type of value. It is possible that certain limited levels and kinds of fragmentation of these zones might be acceptable within the constraints of the chosen values. It is also likely that a mandated constant width is not the best approach, and guidelines need to be developed for determining appropriate widths based on local factors, including but not limited to: topographic, ecologic, hydrologic, social and aesthetic considerations. In most cases, the guidelines will likely be different for ridgelines and riparian zones.

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