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Title: Cartographic and Projective Techniques for a Corvallis Area Electrical Load Forecast

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The Corvallis area study is made to help evaluate the local need for additional system capacity ten years in the future. The product of the study is an areally detailed projection of electrical demand.

The demand is derived in two steps: the location, nature, and intensity of specific land uses are predicted, and usage indicators are applied to those activities. The usage indicators are not developed in this paper. The projections of land use are based in part on the capacities for and constraints on development as outlined in zoning ordinances and the Corvallis Comprehensive Plan. Other determinants of growth potential include location, ownership, available services, and an impression of the future rate and direction of urban expansion. The overall projection is the sum of 464 small-area projections. These are made with a limited use of extrapolation and an extensive use of informed opinion--contacts with planners, developers, and administrators being the primary external guidance.

The projections of housing units are converted to population figures and are compared with an existing population projection, and they are found to be in reasonable accord. The results of the project are presented cartographically, showing the expected growth in both population and electrical demand.

Cartographic and Projective Techniques for a Corvallis Area Electrical Load Forecast

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Cartographic and Projective Techniques for a Corvallis Area Electrical Load Forecast

I. INTRODUCTION

Load Forecasting in Utilities

The operation of devices which consume electricity is an electrical utility's raison d'être. The magnitude and distribution of the load created by these devices are the key elements which affect the organization and operation of a utility. Implications of load are most clear for engineering aspects such as design and placement of dynamos and delivery hardware, but no less affected are, for example, the matters of capital requirements, rate structures, and personnel. It follows that a utility cannot devise engineering and management strategies for a future date without being able to anticipate the load at that date. Thus, in the planning process for electrical utilities, load forecasting is the primary planning tool.

Load forecasting has become increasingly important in the electric power industry with the growth in size and complexity of its operational environment. In 1890, upon the completion of the first a.c. transmission line, a thirteen-mile span from Willamette Falls to Portland, Oregon (Stevenson, 1962), load forecasting was irrelevant. For the engineers and physical scientists who founded the industry, "planning" likely brought to mind wire and transformer stockpiles: econometrics and appliance saturation would have been foreign concepts with little applicability. In the last twenty to thirty years, however, the load forecasting portion of utility planning has steadily crept beyond the purview of the engineers,[1] who had managed it well enough in previous decades. Complicated economic and political interactions have made the utility industry ". . . a separate entity in the field of economics and business administration (Vennard, 1970, p. iii)." Burgeoning electrical demand and less direct and assured means of meeting it have combined with exhaustive reviews by regulatory bodies to place stringent requirements on the technical validity and judgmental credibility of load forecasts. Large-scale load forecasting has to be considered a specialization within a utility: it is no longer a sideline.

The need for a utility's system load forecast to stand up under regulatory scrutiny has recently clouded what is and always has been the primary aim of all load forecasts: to provide quantitative guideines for decision making within the utility. The range of decisions arising from a given forecast depends on the specific purpose of the forecast. The most visible forecasts relate to long-term generation requirements. Others address lower-level system components: transmission facilities, the placement and capacity of substations, or the routing and sizing of feeders--the low-voltage lines which emerge from distribution substations and carry the load to the customers. Most low-level forecasts serve only local purposes and, because whole-system

---

1. There are, of course, forecast engineers, but "engineers" above refers to those whose primary function is other than forecasting.

forecasts are not derived by summing the small-scale forecasts, the smaller ones receive only internal examination.

For all forecasting levels there is a deceptive simplicity in being able to sum up a study with a number--the number of watts in the expected load. Representing a large expenditure of time and resources, the forecasted number is the kernel around which utility management orchestrates its financial, political, and engineering activities. Any major organization shares the need to prognosticate, but the semi-public character of "private" power companies makes that task somewhat more demanding.

Load Forecasting in Pacific Power and Light Company

A marked trend in recent years has been for power companies to strengthen their load forecasting programs. Pacific Power and Light Company (henceforth Pacific or the Company) has done so by establishing, in June 1977, the Load Forecasting and Analysis Department at Company headquarters in Portland. The addition is not nominal--a new placard on an old door. The Department's head is from outside the Company (indeed, outside the industry); the forecasting procedure is reorganized; the technical capabilities are expanded.

In regard to total system load, previous forecasting was a diffuse activity. Several departments made independent forecasts and the one selected as the official statement may have had more judgmental appeal than analytical thoroughness. Presently, the knowledge of Pacific's system and territory, as well as the Company forecasting expertise, are focused by one department which can produce a more methodologically rigorous study. The first major product of the Load Forecasting Department is the System Load Forecast: 1978-1998 (Pacific Power and Light, 1977). The major steps and responsibilities in the forecast are shown in Figure 1.

Not all forecasts for the Company are prepared by the Load Forecasting and Analysis Department, however. The present and near-term emphasis of the Department relates to generation decisions. Usage analysis is also a primary responsibility of the Department, as its name implies. Further, there is a limited involvement in special forecasting projects of smaller scale, the first of which is the basis of this paper. Other local forecasts are commonly carried out by the district or area engineers to facilitate local distribution planning. In the Corvallis area, for example, the Area Engineer has made five-year forecasts by feeder line (Rhodes, 1978). The Load Forecasting Department is unlikely to supplant the local forecaster in the near future because of three factors: the limitation of manpower, the general adequacy of the present arrangement, and, as mentioned earlier, the independence of the local and the total system forecasts. Major changes in the Department's methodology are imminent, but major shifts in its responsibility appear not to be.

The Corvallis Area Forecast

ORGANIZATION. The Corvallis study was originated in Pacific's Electrical Engineering Department. The department had overseen a pilot study in Medford (before the Load Forecasting and Analysis Department

Pacific Power & Light Company: Organization of the 1977 20-Year System Load Forecast

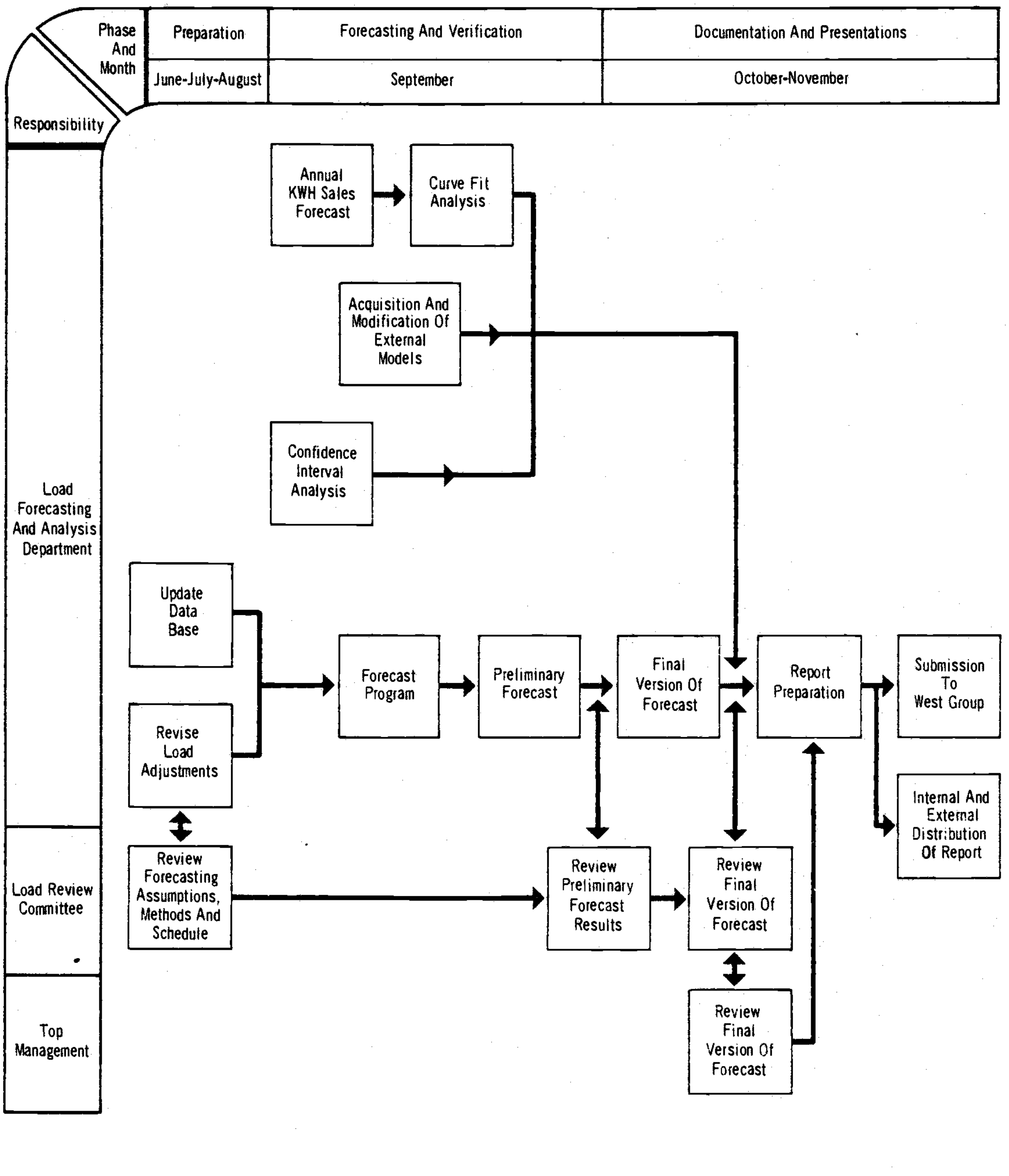

Figure 1. Source: Pacific Power & Light Company (1977), Exhibit B, p. II-3.

was established) during which a basic methodology and data management system were developed (Duncan and Toweill, 1977).

Major organizational differences between the two studies exist, however. The Medford study was supervised out of Portland as an Electrical Engineering project, and most field work was done through part-time work by Medford's Energy and Conservation staff. The Corvallis study was jointly run by the Load Forecasting and Electrical Engineering Departments. The field staff consisted of a Field Director from Load Forecasting, this writer as Graduate Assistant (later to become Acting Field Director), three full-time interns from Oregon State, and as many as twelve others from the University and community in part-time and full-time positions. Figure 2 outlines the general division of responsibilities. The Corvallis field operation was begun on November 1, 1977 and the final projections were in Portland for computer processing before May 1, 1978.

PURPOSE. Two subjects are addressed in this section. First, the reasons Pacific undertook the Corvallis study and the nature of the final products are discussed. Second, the emphasis of this paper is detailed.

(Because "forecast" has been used frequently and "projection" will be, their usage is distinguished here. As in Pittenger (1976), both a forecast and a projection provide speculative values for a future date. His definitions refer to changes in population, rather than load, but that has no effect on word usage. A <u>projection</u> is the conjectural description of the future based on a specific methodology and set of assumptions. By using different approaches, several

The Corvallis Project
Major Steps and Responsibilities

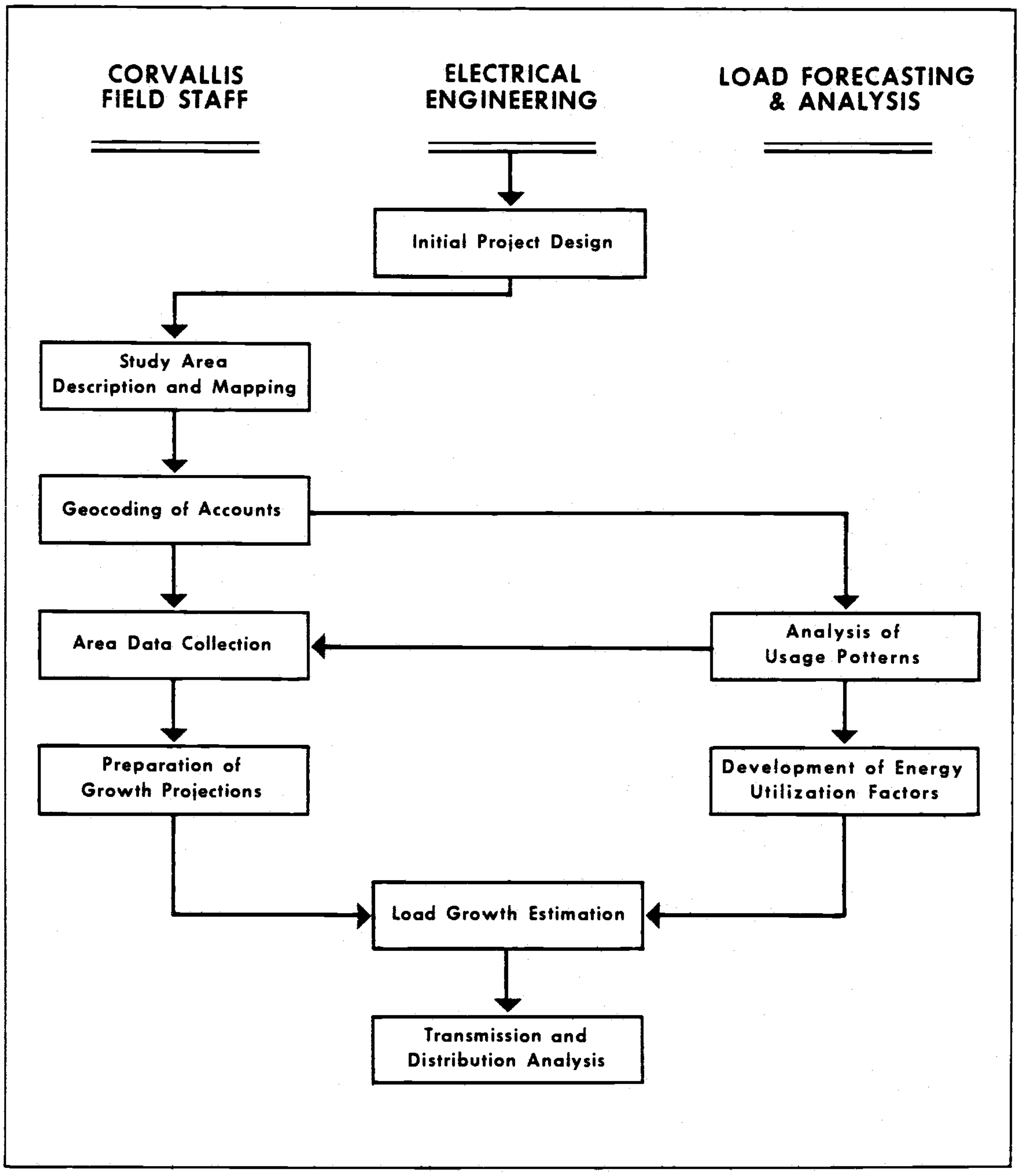

Figure 2

different projections may be made from the same situation. A forecast is the "best guess" projection, the one felt most likely to occur, in the opinion of whomever does the evaluation. Thus a forecast is always a projection, but a projection is not always a forecast.)

Pacific has two primary purposes in the Corvallis area load forecast: to provide data 1) to evaluate the adequacy and lifespan of the present system, and 2) to aid in assessing the suitability of different means of increasing the system capacity. Engineering decisions concern the capacity, placement, and timing of additions to the feeder and distribution substation systems. The Load Forecasting Department has the dual interests of deriving the forecasted load and developing a general methodology for small-scale forecasts.

To meet the above objectives there are four load projections. Two of them are ten-year projections, the most important difference between them being that one infers the influence of the Corvallis Comprehensive Plan (as proposed in 1977), and the other assumes that neither zoning changes nor any extension of city services beyond present city limits will occur. Additionally, there are two "ultimate" load projections. The first assumes that, mindful of present land-use and zoning constraints, all land will be fully utilized by the structures and characteristic consumptive devices of the allowable activities. The second, as above, assumes complete land occupation, but uses the guidelines of the Comprehensive Plan whenever it differs from present zoning. The projections are more fully detailed in Chapter III.

This paper focuses on two elements of the Corvallis load forecast: the development and implementation of the projection techniques, and the effort to facilitate the projection process and elucidate its outcome by cartographic means. Specifically, the emphasis in both cases is on the ten-year projection which incorporates the anticipated effects of the Corvallis Comprehensive Plan. Of the many topics related to load forecasting which are dealt with only minimally or not at all in this paper, some are included in Pacific's Corvallis study while most are not. Included in the Corvallis study report but not here are descriptions of the present electrical hardware system and the selection of coefficients for increasing the demand per customer. Included in neither this paper nor the report are such topics as weather normalization, the regulatory environment, price-demand elasticity, competitive fuels, sources of power for the added load, econometric modeling of the study area, and the various (social, ecological, political . . .) implications of a thoroughly electrified society.

II. BACKGROUND

Literature Review

An opening section on methods of projecting population growth is included because of its importance in load forecasting. Out of the many volumes available on the subject, Greenberg, et al. (1978) is chosen as the primary resource because nowhere else are the relevant topics so tidily presented.

Population Projections

> Demographic forecasting, it has been said, requires three qualities: historical perspective, current information, and a sense of humor.
>
> --Morrison, 1971, p. 44

Population changes result entirely from births, deaths, and migration. Those three simple items, however, can induce professional discomfiture in the population specialist who lacks the recommended sense of humor. Recent downward revisions in year 2000 projections for the World, the United States, and Corvallis reflect the tenuous nature of the discipline. Electrical load forecasters inherit or develop similar uncertainty in the demographic components of their forecasts. The general techniques for projecting population are discussed in this section. Also, the methods used by Portland State University's Center for Population Research and Census (CPRC) are identified because data from the Center's projections are used in a load forecast comparison in Chapter III.

The descriptions of population forecasting techniques are brief here because load forecasters typically use rather than make population projections. Tables 1 and 2 summarize the more common approaches.

Table 1. Comparison of population projection methods - I from Greenberg, et al. (1978, p. 11).

	Relative Complexity			Type of Data That Can Be Used		
Type of Model	Simple	Moderate	Complex	Historical Counts	Vital Components	Other Indices
(NONCOMPONENT)						
Trend extrapolation	X	X		X		X
Comparative forecast	X			X		
Ratio trend	X			X		
Density ceiling		X	X	X		
Housing unit		X	X	X		
Market force		X	X	X	X	X
GKM		X	X	X	X	X
(COMPONENT)						
Vital rates		X			X	
Cohort-survival		X	X		X	
Cohort-component		X	X		X	X
Composite		X	X	X	X	X

Table 2. Comparison of population projection methods - II from Greenberg, et al. (1978, p. 12).

	Appropriate Projection Period			Appropriate Projection Scale			
Type of Model	Short	Middle	Long	Nation	State	County	Local
(NONCOMPONENT)							
Trend extrapolation	X					X	X
Comparative forecast	X					X	X
Ratio Trend	X	X	X		X	X	X
Density celing		X	X			X	X
Housing unit	X	X				X	X
Market force	X	X	X	X	X	X	X
GKM	X	X	X		X	X	X
(COMPONENT)							
Vital rates	X				X	X	X
Cohort-survival	X	X	X	X	X	X	X
Cohort-component	X	X	X	X	X	X	X
Composite	X	X	X		X	X	X

In them, "component" models consider births and deaths (and sometimes migration) explicitly: "noncomponent" models do not. "Other indices" are commonly symptomatic data, such as building permits or utility connections. Under "appropriate projection period," less than ten years may be considered short term while long term is not less than twenty years.

The checks in Tables 1 and 2 represent the "collective judgment" of Greenberg, et al. (1978) and do not impart rigid credentials to any of the methods. The following sketches are abbreviations from the source of the tables (Greenberg, et al., 1978, pp. 11-23).

NONCOMPONENT METHODS. These methods produce population projections by less direct means than component methods.

Trend extrapolation is so familiar that little need be said except that its simplicity, economy, undemanding data requirements, and historical accuracy make it the most frequently used method.

Comparative forecasting is likewise simple and assumes that an area's growth pattern will mimic that of another area which is further developed but cast from a similar mold.

Ratio trending ". . . assumes that the relationship of a minor civil division to a larger geographic entity will prevail in the future (p. 17)." Thus, one works from the projection for the larger geographic entity, an item which must already exist.

The density ceiling model places restrictions on the ultimate population density of an area and can employ a variety of means to describe the growth pattern under which that density is approached.

The housing unit method projects household numbers, often with high spatial resolution, which convert to population by the appropriate household size factor.

Market force studies are not usually made with primary intent to project population, but the projections are among the results. A wide range of methodologies are applied in such studies, which ". . . are focused on economic growth, transportation, environment, and other concerns (pp. 21-2)."

The GKM (Greenberg-Krueckenberg-Mautner) chain model may be applied in the form of any of five separate models which project minor civil division population. Generally, national or state projections are stepped down to the MCD level, from which point one of the models (either extrapolative, ratio trend, or density ceiling) develops the small-scale projections.

COMPONENT METHODS. These focus directly on vital and social statistics and require detailed data of that type.

The vital rates method is the simplest of the component approaches. It uses a ratio technique and employs raw birth and death data; there is no age or sex breakdown. Migration gets only implicit treatment.

Cohort-survival models use and produce data which is age-and sex-specific. The model is driven by age-specific death rates for each age-sex category and by age-specific birth rates for each of the six fertile female categories. Migration is not addressed.

Cohort-component models (used by the Bureau of the Census) go further than the previous type by performing a migration analysis based on data for the school-age population.

Composite models apply the rationale that different projective techniques have varying effectiveness depending on the particular age-sex group in question. In principle, this is the optimal component method in that it selectively applies elements of the other methods, and may introduce other indicators as well.

The component methods do provide age-sex data, which may be highly desirable (e.g. for school planning), but White (1954) has found that they do not necessarily produce more accurate results than extrapolation, for example. Because of constraints in data, time, funds, and expertise, subcounty area projections are most commonly made by extrapolative means. Isserman (1977) has evaluated eight extrapolative techniques and proposed guidelines by which one can select the most suitable one for a particular situation. He points out that local insight may be of more value than strict adherence to his guidelines.

To describe the factors pertinent to choosing a projection method from those mentioned--there are others--would be an involved task and one not appropriate here.

PORTLAND STATE'S CPRC METHODS. The Center for Population Research and Census (CPRC) has chosen a cohort-survival technique with a migration component for its population projections. This choice suits the expertise of the staff, offers an alternative to the economically-based projections which exist for the State and its counties, and avoids the inexplicit nature of an extrapolative forecast (Portland State University, CPRC Projections, 1976).

Mortality statistics are based on the Oregon population because its structure differs significantly from the national average. Fertility data are likewise specific to Oregon, but rather than continuing the present (i.e. 1975) birth rate, one below replacement level, the rate rises to replacement level (2.11 children per woman) around 1980 and remains there for the projection period. The migration component, the most precarious one, has more assumptive breath than the birth and death components to better encompass the possible future trends. This flexibility is in the form of alternative migration assumptions which are termed "high," "medium," and "low." The high assumption continues Oregon's migration trend of 1970-75; the medium begins with the 1970-75 trend and then tapers to the 1960-70 level; the low migration assumption begins at the 1970-75 rate and arrives at a zero net gain rate by year 2000. Growth is allotted at the county level in a way which preserves the distinctive nature of each county's growth pattern (Portland State University, CPRC Projections, 1976).

Load Forecasting Techniques: Introduction

A population projection can provide vital data for a load projection, but load growth does not arise solely from reproduction and relocation. The following elements are highly generalized but offer an overview of load growth considerations. At the personal level, key factors are appliance saturation,[2] disposable income, and household size. Commercial growth may act as a function of population growth, both of which are influenced by industrial growth. Not only industrial output, but also the rates of consupmtion per unit output are important data. Residential, commercial, and industrial consumption may all

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2. Appliance saturation relates to electrical consumption in homes. The use of "appliance" (also "white goods") is very broad, including not only stoves, heaters, and dryers, but also such things as lights, fans, and radios. More intensive use of present appliances, net gains in their numbers, and the introduction of new appliances all contribute to an increasing appliance saturation.

be affected by conservation efforts, price changes, and interfuel competition. Governmental effects may be in the form of utility regulations, energy legislation, or consumption related to government functions and contracts. It is becoming clearer how even international relations can alter growth curves. And at the most encompassing level, electrical demand sways to the apparent whims of Rossby waves and pressure ridges.

How can one be certain of a load forecast when so many unpredictable elements may affect its accuracy? Clearly, one cannot. George Bernard Shaw said that there are always simple answers to complicated questions--and they are always wrong. In load forecasting, projective techniques are not always simple, but they are poor and incomplete models of reality, and the basic assumptions which guide forecasts are not fully correct. Although load forecasts have a history of being highly accurate, the techniques are a blend of science and art, and no matter what advances are made in the science, the art of making good judgment will always be an important part of them.

In a field enmeshed in social parameters, finely-tuned system models can be vitiated by a wide range of seemingly random events. Conflicting principles make choosing the desired level of complexity in a forecast a problem in itself. Brooks (1953) proposes to simplify the task, inasmuch as a forecasting framework is based in part on judgments and assumptions, and that these should be minimized. Hooke (1955) believes that information should be separated into as many clear subsets as possible. He feels that to directly estimate a whole is less reliable than to separately analyze and prognosticate its parts. In using Brooks's approach, one should consider that the use of a few massive assumptions may impair the credibility of a forecast more than the use of several specific and more reliable ones. In using Hooke's approach, one must take care to ". . . avoid being caught putting a micrometer on a mud puddle (D. H. Sterrett in "Load forecasting techniques . . .", 1976, p. 37). The clear trend, however, is toward using more and more complex forecasting methodologies, even to the point of making multiple projections prepared by different means. This approach provides checks and hopefully compensates for the inherent flaws in any given method (R. B. Comerford in "Load forecasting techniques . . .", 1976; N. A. Bord, 1978).

The primary effect of the more recent forecasting schemes is not a dramatic increase in forecasting accuracy--there is the continuing lack of knowledge as to the nature and timing of future events. Rather, most of them merely increase the ability to predict how certain events may affect an electrical system. The use of scenario analysis has been greatly aided by digital computers. They superceded the a.c. calculating boards, first used in load studies in 1929, which use small-scale electrical system replicas (Stevenson, 1962). After serving long and useful careers, these analogue computers are too massive and inflexible for the current large-scale operations. The digital computers facilitate both mathematical model-building and the simple number-crunching, needs of the bulk of load forecasts, which are not based on detailed models of system functions.[3]

General Load Forecasting Techniques

Load forecasting literature is not consistent when describing the common forecasting techniques. One source may evaluate three methods; another may reorganize those three methods, give them different names, and speak of five methods; a third may belabor two additional approaches, neither of which is in common use. In this section, forecasting techniques are grouped according to their emphasis: those primarily based on 1) extrapolation, 2) correlation, and 3) other techniques. It will be apparent that the techniques are not wholly isolated from one another. It should also be noted that a given forecasting project or department is likely to incorporate more than one basic methodology into its operation.

EXTRAPOLATION. Also called trending, this is the most pervasive and long-standing load forecasting technique. For example, in spite of the increasing attention paid to load forecasting and the genuine progress that has been made, the trending scheme used by the Detroit

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3. The most precise and deterministic forecasts <u>are</u> based on detailed system models. They are of very short term and integrate transitory weather effects on the systems. The detail of some of the forecasts are at the hourly level (for example, see Lijesen and Rosing, 1971; Gupta and Yamada, 1972). The influence of modern equipment on the forecaster's technique may be noted by comparing Dryar (1944) and Asbury (1975). For a more descriptive overview of a utility's daily load monitoring and forecasting system, see Clair and Einwechter (1962). Although short-term load fluctuations are an important part of load forecasting, this paper deals with forecasts on a scale of years, not days or hours.

Edison Company sixty years ago (Reyneau, 1918) is neither shallow nor anachronistic. Extrapolation is still an important component of virtually all of today's forecasts. In its favor are three basic attributes: 1) it is comparatively simple to devise; 2) it is not an expensive method to implement; 3) it has a history of making accurate forecasts.

The negative qualities become apparent by examining the necessary assumptions. One must assume that 1) a suitable trend line has been selected and 2) that the pattern of the past will continue in the future. The first point is made because a trend line need not be, and commonly is not, a straight line. The more common analytical functions besides the straight line ($y = a + bx$) are the parabola ($y = a + bx + cx^2$), the s-curve ($y = a + bx + cx^2 + dx^3$), the exponential curve ($y = ce^{dx}$), and the Gompertz curve $y = \ln^{-1}(a + ce^{dx})$ (Sullivan, 1977). Informed judgment or mathematical curve-fitting is usually applied to historical data to select the model which best describes the trend. It may even be reasonable, as Hooke (1955) suggests, to use separate extrapolative curves for different forecasting components: for example, a linear curve for population growth, a Gompertz curve for appliance saturation, and an exponential curve for industrial growth. The effectiveness of trending, however, depends less on finely honing a curve than on the rationale behind letting it loose into the future.

To assume that the pattern of the past will continue in the future may at first seem audacious. The past is, after all, always different than the future. But the alternative is to describe the state of the future and quantify its effects on load growth--an even bolder approach. By making no attempt to explain why the dependent variable, electrical load, behaves as it does, the trending method evades many costly and complicated analyses. It also, however, provides little intellectual satisfaction and gives no information on the workings of the system. Trending justifies itself with a rewording of its own premise: it has worked well before, therefore it should work well again.

CORRELATION. Correlative techniques have recently enjoyed a vigorous assimilation by the load forecasting community. They enable load growth to be viewed as one resultant of many complex interactions, rather than as a series of numbers generated by an isolated and self-governing entity (i.e. trending). The principle behind correlation in load forecasting is that growth in electrical load may be defined through values determined for other factors: projected population, employement, and GNP, for example. But problems appear on several fronts. There is the primary assumption that what has covaried in the past will covary in the future. Further assumptions include 1) that a suitable number of the most pertinent factors has been selected, 2) that the projected values for those factors prove valid, and 3) that the conversion of projected data into electrical demand is accurate. In general use, regression analysis helps to define the relationships to electrical demand. Some factors may relate directly to demand; others may have statistical rather than functional connections. System modeling and data manipulation have become elaborate but, as in trending, the most sorely lacking tool is prescience.

Econometric modeling is the most prominent method of applying correlation to load forecasts, and its wide use represents ". . . a rather abrupt departure from traditional methods of forecasting ("Load forecasting techniques . . .", 1976, p. 36)." The connection between economic indicators and load growth has not been a sudden revelation, rather there has been a rapidly increasing number of workable system models and a growing willingness to employ them. Brooks (1953) applied economic correlations to electrical demand long before "econometrics" was in vogue. A later study by Fisher and Kaysen (1962) became a prototype in the econometric field. Originally produced for General Electric and later turned into a book, their work was ". . . designed to show what modern econometric models could contribute to the understanding of the forces shaping the demand for electricity (Fisher and Kaysen, 1962, preface)." Edification is still the strong point of econometric load forecasts. They are not yet sufficiently precise to stand alone, and are commonly used in conjunction with other methods.

OTHER METHODS. Besides the extrapolative and correlative approaches to load forecasting, there are several less widely-used methods of varying practicability: 1) input-output, 2) causal analysis, 3) probabilistic modeling, 4) systems dynamics, 5) end-use, and 6) land-use. The end-use and land-use approaches are currently the most definitive and practiced of the six methods listed.

Input-output tables are familiar tools in economics and regional analysis. As in econometric modeling, the use of input-output compels one to discard any notions of autonomous phenomena at the industry level. The tables clearly show the quantitative interrelationships among industries[4] within a region, or between regions, and their greatest usefulness in load forecasting is for that function. This is because, as Isard (1960) and Devine (1975) point out, there is the need to continually modify the coefficients with time. (A two-year forecast which is modified periodically is not really a two-year forecast.) Thus input-output is of little practical value in load forecasting, which employs typical forecast periods of five, ten, and twenty years.[5]

Causal analysis "implies that the system can be modeled as an initial value problem (Devine, 1975, p. 10)." Although correlation may be used during analysis, this technique is functionally distinct from correlative ones. It has two elusive requirements: first, that the state of the system at the initial time can be described mathematically, and, second, that the system can be made to proceed into the future guided by valid and complete principles, expressed mathematically. The guidance of trend lines, however, is presently a source of much greater assurance to load forecasters.

Despite the precise appearance of twenty-year forecasts to five significant figures, forecasters recognize that defining a probable load range is their realistic objective. By applying probability

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4. The use of "industry" here is general and includes not only the obvious components such as iron and steel manufacturing, but also agriculture, educational services, and households, for example.

5. Although shorter forecasts of less than five years are frequently made, they are mostly on a local scale, for which suitably detailed data for input-output do not exist.

theory, they attempt to quantify the uncertainty of load forecasting. Probabilistic and stochastic models[6] both apply probability theory, but in different ways.

A typical probabilistic model might isolate several components of load growth, curve fit and extrapolate the data groups, and aggregate the separate forecasts into the total system forecast. The probability limits of the system forecast are derived from the probability limits of the component forecasts (Vemuri, et al.,1975). Defining the confidence intervals may entail making assumptions about the nature of the historical data's distribution. The overall effect of the probabilistic approach is not a sharpening of the forecasting resolution. Rather, the approach aids the forecaster by evaluating how reliable the forecast may be expected to be.

A stochastic process is "a statistical phenomenon (such as the future load demand on the utility) that evolves in time according to probabilistic laws . . . (Vemuri, et al., 1975, p. 31)." Stochastic models rely on a probabilistic foundation, but instead of producing a trend line as in the above description, the evolving electrical demand is the model output. Such models do not presently have long-range credibility because, without periodic adjustments to them, the random elements in the forecast soon make it uselessly murky.

Sytems dynamics is another of the peripheral approaches to load forecasting, more useful for investigating the nature of the system

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6. "Model" refers to a mathematical representation of a certain condition or thing. Even trend lines are included under that title because, although they may appear to be only slightly modified raw data, they are analytical tools which are nothing less than mathematical representations of load growth.

than for making forecasts. The technique, established by Jay W. Forrester (1961), is particularly suited to studying the effects of policy changes in an industrial system by the use of computer simulations. Its main principle is " . . . to treat all activities in a system in terms of levels and flows (Pachauri, 1975, p. 23)." Systems dynamics labors under the same difficulties as other methods which attempt to model the system that generates the load. Especially difficult is producing a functionally complete mathematical description of the system.

End-use forecasting has the outward appearance of being the most precise of all techniques. It seeks to determine the future load by forecasting the nature of, number of, and demand of all the devices in the system which consume electricity. There must, of course, be generalization involved because it is impossible to know even the present numbers of and usage patterns of every light bulb, dishwasher, and planer motor in a system. What must be evaluated are 1) the level of use of known stock, 2) the rate of growth of the stock of equipment, and 3) changes in types of equipment from the present stock.[7] The detail of end-use studies varies widely. As an example of a more involved system, Southern California Edison has used six major end-use classes, two of which are the residential and the industrial.

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7. In households, for example, nineteen appliances were in common use in 1930. In 1968 there were over sixty (Vennard, 1970). A factor for "phantom appliances" is usually included, explicitly or implicitly, in appliance saturation forecasts. Similar compensation may also be made for other customer classes. For instance, a hypothetical study may forecast an increase in office space of forty percent, but a reduction of four percent in the average consumption per square foot of office space due to advances in energy management systems.

In the residential, seventeen categories of end-use appliances are analyzed; in the industrial, the breakdown is to two-digit SIC system categories (Gupta in "Load forecasting techniques . . .," 1976). Although historical data is of uneven quality and detail, trending is commonly used in forecasting each load component. Further, demographic and economic trends must be considered in making the hardware forecasts. Thus the problems associated with extrapolation and correlation are not circumvented by the end-use scheme, although the perspective and subsequent insights do differ.

The land-use approach is not completely independent of other forecasting techniques, but it can be plainly distinguished. Its common use of trending does not make it an extrapolative method, just as the incorporation of land-use constants into a causal analysis does not make causal analysis a land-use method. Although details of any given land-use-based forecast are unique,[8] certain elements are common: 1) the areal distribution of several broad end-use categories is described, 2) present and future usage values for each category are assigned, and 3) the future occupance area of each category is forecasted, based upon the local policies, facilities, and growth prospects,

8. The following five sources provide a good cross-section of utilities' land-use strategies in forecasting. The evolution of Arizona Public Service Company's land-use method can be noted by comparing Lazzari (1962) and Lazzari (1965). The greater use of external information sources is apparent in the Memphis Gas, Light, and Water system (Turner, 1969). Barry and Nix (1977) present the development of Shreveport's distribution system model, which has great flexibility as a decision-making tool. Pacific's initial land-use-base forecast, designed by Duncan and Toweill (1977), focuses on zoning units.

and the natural capacity of the land. The land-use approach has a unique ability to accomodate study area singularities and to forecast load growth in great spatial detail. Its greatest problem, not at all uniquely, lies in the need to predict the future. In an attempt to do so with greater assurance, it is common practice to work closely with local plans and planners. Their causal influence on growth pattern is becoming stronger with the more pervasive effects of public planning.

The Study Area

The load forecast is not made for the entire Corvallis District, which includes area extending beyond Dallas and Independence. The study area can be called the Corvallis office area of the Corvallis District, and its extent and peculiar form are shown in Figure 3. Its area is just over eighty-three and a quarter square miles, or about 53,000 acres.[9] Lying primarily on poorly-drained alluvial soils, the study area is of low elevation and low relief. Over ninety-nine percent of the area is under 275 feet (85 meters), the range being 200 to 500 feet (60 to 150 meters). As a reflection of the local agricultural and urban activity, nearly all naturally occurring vegetation is riparian.

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9. The use of English units for linear and areal measurements is consistent throughout. This is not a protest against metric adoption, but rather an attempt to avoid an affected and unproductive intrusion of metric conversions into conventions which pervade this study's data. English conventions are reflected in 1) all zoning ordinances, 2) all local resource material, 3) the format of the study's computer program, 4) the land survey system, and thus 5) the geocoding process (described in Chapter III) and the seven maps of the study area.

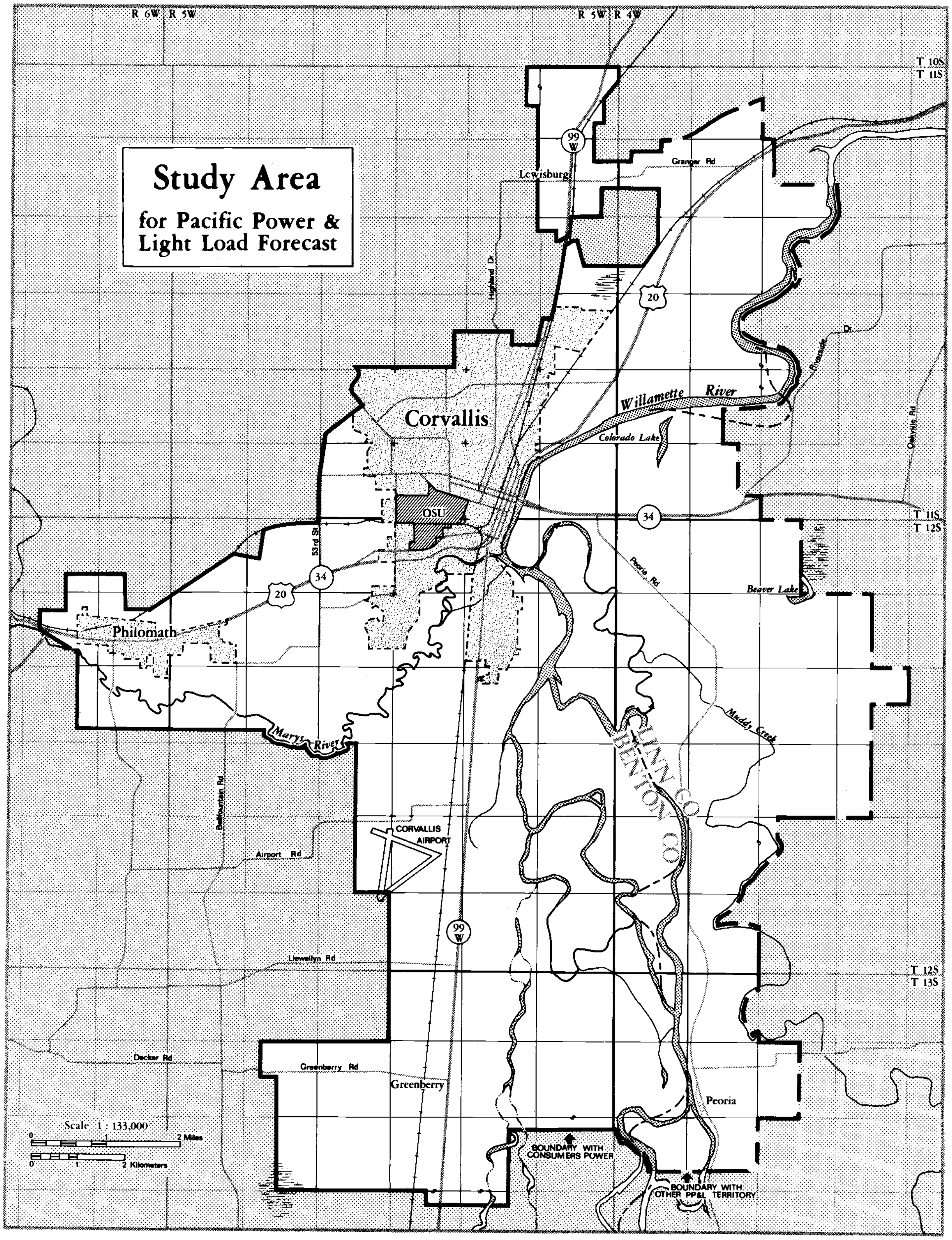
Study Area
for Pacific Power & Light Load Forecast
R 6W R 5W
R 5W R 4W
T 10S
T 11S
T 12S
T 13S
Lewisburg
Granger Rd
Highland Dr
Corvallis
OSU
Willamette River
Colorado Lake
Philomath
53rd St
Peoria Rd
Beaver Lake
Muddy Creek
Marys River
LINN CO
BENTON CO
Bellfountain Rd
Airport Rd
CORVALLIS AIRPORT
Llewellyn Rd
Decker Rd
Greenberry Rd
Greenberry
Peoria
Scale 1 : 133,000
2 Miles
2 Kilometers
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY

Figure 3

The designated land uses of the study area, according to city and county zoning, are briefly presented in Table 3. The data result from aggregating the forty-five zoning classifications which occur in the study area into six, more descriptive, classes. Data were derived by planimetry during the study.

Table 3. Designated land uses in the study area.

Land Use	Area (ac.)	Percentage of Total Area
Agricultural/resource	36,620	68.7
Residential	10,580	19.8
(rural)	(6,900)	(12.9)
(urban)	(3,680)	(6.9)
Public	2,810	5.3
Industrial	2,700	5.1
Commercial	580	1.1

General demographic and areal data, by political units, are shown in Table 4. The demographic data are derived in greater detail in Chapter III. The Benton County figures include Philomath and the portion of Corvallis within the study area (SA).

Table 4. Land and population distributions in the study area.

Political unit	Area within SA (ac.)	% of polit. unit	Population within SA	% of polit. unit
Benton Co.	39,340	9	46,480	69
Corvallis	5,030	92	37,500	97
Philomath	490	100	2,470	100
Linn Co.	13,950	1	2,330	3

III. THE CORVALLIS AREA PROJECTION

The Land-Use Approach

The techniques for data gathering and load projecting need to accomodate both the concept and the constraints of the Corvallis area forecast as initiated.

The concept is of a study which enables the future hardware needs of the Corvallis area to be evaluated. The study must maintain high areal resolution throughout its processes to be effective in doing so.

The constraints are mostly matters of form and time. The final output from the field staff is of a format developed during Pacific's Medford Study. This entails at least scores of individual projections based on zoning classes. Extrapolation by rote and the explicit guidance of existing projections of population or employment are not to be used in the load projections, which must be completed within six months. Company data and funding are limited but not particularly limiting.

The possibilities are further limited by the small size and unusual economic base of the study area, which make functional (versus descriptive) models virtually unworkable at the necessary level of detail. A study of the energy requirements for Linn and Benton Counties (Energy Patterns and Projections: An Econometric Analysis, Day and Sindlar, 1978) has a promising title, but is too general for use in this project and in no way validates the econometric approach to the load forecast. The data requirements, field staff expertise, time constraints, and prospects for success (in anybody's hands) speak strongly against adopting a correlative foundation of any kind. As Bartholomew (1967) points out, there are many unresolved measurement problems in the social sciences, even in ideal study areas, which limit the efficacy of otherwise sophisticated mathematical techniques.

The required methodology needs to apply readily available data specific to the study area to a highly detailed geographic framework. Input-output, casual analysis, probabilistic modeling, and systems dynamics can be summarily dismissed. An end-use approach is more plausible, but to compile data for the study area would be exceedingly time-consuming, and one could not confidently apply generalized data to a small and uncharacteristic sub-county unit. If one could, however, subsume all the consumptive devices in the study area under more inclusive categories for which specific data are available (households, commercial and industrial units), the problem of defining present end use no longer exists. That solution, made possible by the geocoding process discussed later, is the basis for the land-use method adopted for this study.

Factors besides having a finely detailed data base support a high resolution land-use approach. The field staff has a long-term familiarity with the area. The guidelines of the Corvallis Comprehensive Plan (a land-use product par excellence) provide much more insight than any historical analysis possibly could. The importance in population projections of the migration component, the one least amenable to standardized mathematical manipulation, varies inversely with the study area population. Thus interaction with local planners rather than with statistical journals is likely more fruitful. And insofar as theory is typically a surrogate for fact, and considering that microscale theory on the social dynamics of a particular small area is dubious or nonexistent, it is preferred to exploit all the available facts by having one's nose to the ground rather than up in the air.

Three elements of the previously discussed population projection techniques are applied in this land-use study: housing unit projections, density ceilings, and limited trend extrapolation. The overall method, compared with the land-use-based forecasts cited in Chapter II, is by far most similar to Pacific's Medford study (Duncan and Toweill, 1977). It uses aerial photography and trending, but in a much less encompassing way than in Lazzari (1962, 1965). It develops external contacts, but is less removed from them than in Turner (1969). It employs computer processing of data, though not as a continually-used analytical tool as in Barry and Nix (1977). It is more areally detailed than any of them. The means of making the ten-year projections are described in the two following sub-chapters.

Modeling the Present Situation

The Cartographic Component

Because the total load projection is the aggregate of many small-area projections, the first step in modeling the study area is the definition of the discrete geographic units. Three objectives are fulfilled in the fragmentation: 1) the projection criteria are standardized, 2) the desired spatial detail is attained, and 3) subsequent field work is facilitated. The first objective is met by using zoning maps and a transcribed Corvallis Comprehensive Plan map to outline areas in which certain designated uses may occur.[10] The second is met by dividing large or irregular areas of a single zoning type into smaller units for which a centroid geocode is a conformable description. The third objective entails selecting map boundaries which are discernible and convenient in field work.

A variety of maps, numbering over one thousand sheets, overflowed the file space. Informational overlays from several sources are needed because no single map or map series meets all project requirements. The following outlines the primary uses of the map types:

1) electrical distribution maps

   --locating all non-urban accounts for the geocoding process,

   --delimiting the service area precisely;

2) urban address maps

   --locating urban accounts during geocoding,

   --determining the most current lot lines and subdivisions;

3) composite topographic map

   --gives overall view of the study area,

   --serves as an index for maps required from other sources;

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10. The four sets of zoning ordinances provide for some flexibility within zoning classes, but are very specific. The Corvallis Comprehensive Plan outlines ranges within activity categories, and is very general.

4) air photo mosaic map

--provides "realistic" view of study area,

--allows location and measurement of area occupied by specific land uses;

5) urban growth boundary and Comprehensive Plan maps

--show in detail the UGB,

--aid in determining housing densities and the ultimate urban growth area population;

6) zoning maps

--serve as sources for field maps,

--serve as base for zone planimetry,

--serve as urban geocoding grid;

7) postal rural route maps

--help in locating rural customer accounts for geocoding;

8) field maps

--plotting vacant lots,

--plotting areas having specific activities,

--plotting areas having physical development constraints.

Compiling a coherent resource base on maps from 12 sources and at 13 scales presents a time-consuming task. Assistance from the Geography Department's Cartographic Service in delineation, transcription, and planimetry of zones[11] aided the effort, but much of the field staff's time

11. Henceforth, "zone" means one of the individual projection units, of which there are 464.

was spent in related map work. The outcome of the labor is an extremely dense data resource which obviates several weeks of field work and helps to provide key historical data.

Figure 4 charts the cartographic operations, and the maps involved in each, from the inception to the completion of the project. The maps or map sets indicated by the coding (L3; S1, 2, 3 . . .) are keyed to the map inventory in Tables 5, 6, and 7. For example, at the lower right of Figure 4, the plotting of all customer accounts is done on the electrical distribution maps (S1) and the Corvallis and Philomath address maps (C1 and P1), a total of 204 sheets.

The Geocoding Process

All geocodes are ten-digit numbers which specify either a customer location or the centroid of a zone by identifying the hundreth of a section in which it lies. The identification is made by using ten-by-ten grids of appropriate scale which overlay maps' section lines. Pacific's distribution maps already have the grid superimposed. Modeled after the Company's pole-numbering system, the code translates as follows:

first digit--identifies the state whose coordinate system is being used;

second digit--identifies the quadrant of the coordinate system;

third and fourth digits--the township;

fifth and sixth digits--the range;

Development of Cartographic Resources

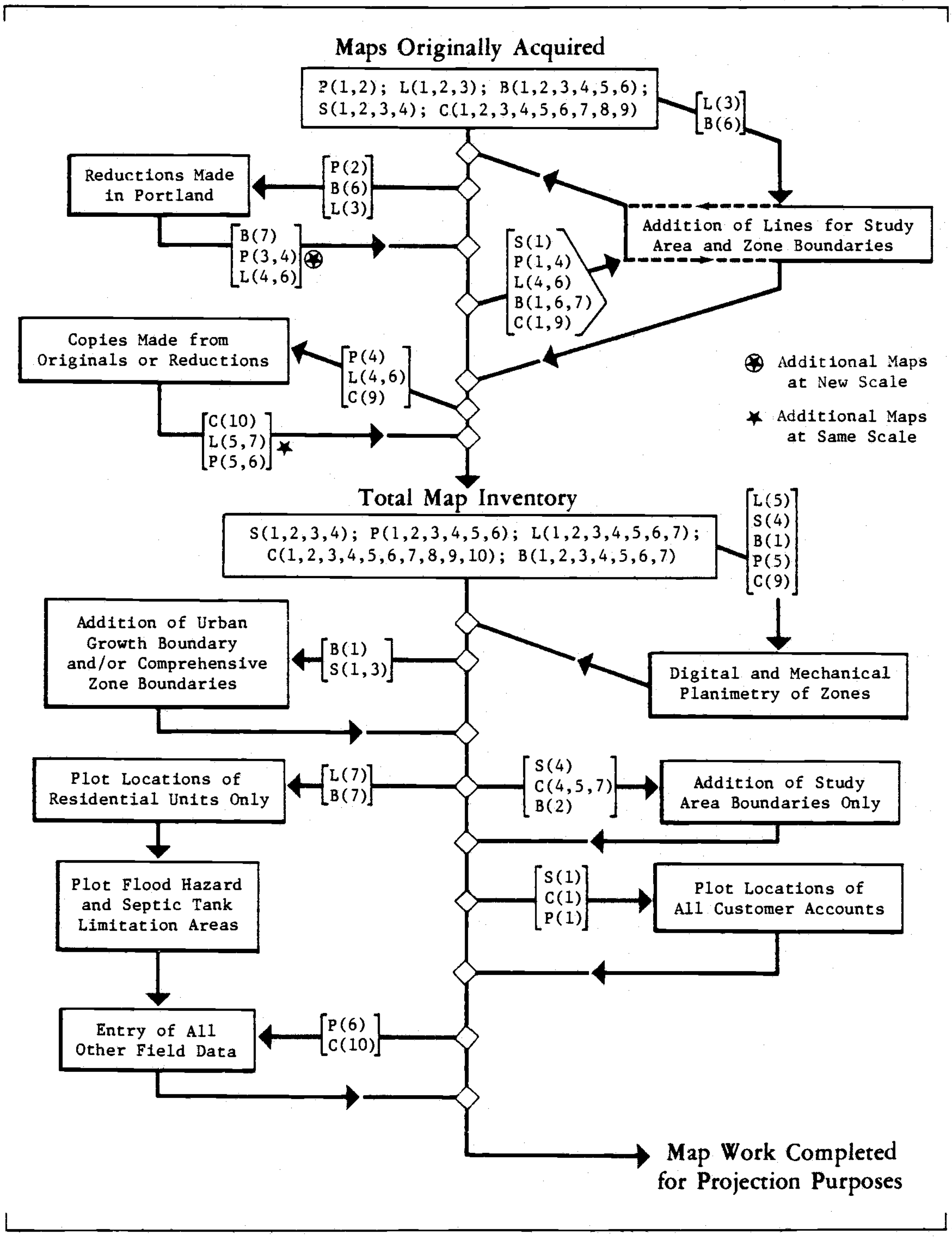

Figure 4

Table 5. Corvallis map inventory.

Quantity (and scale)	Description and source
1 set, 71/set (1" to 100')	<u>C1</u> - Corvallis Street Address Maps. Corvallis Dept. of Public Works.
1 (1" to 1,000')	<u>C2</u> - Corvallis Street Address Index Map. Corvallis Dept. of Public Works.
2 (1" to 600')	<u>C3</u> - Corvallis Large Load Maps. PP & L.
2 (1" to 1,200')	<u>C4</u> - Index to Zoning Maps with Study Area Boundaries. Corvallis Planning Dept.
1 (1:62,600)	<u>C5</u> - Topographic Composite of Study Area. USGS.
1 (1:62,500)	<u>C6</u> - Corvallis 15' Quadrangle. USGS.
1 (1" to 1,600')	<u>C7</u> - Urban Growth Boundary Map with Proposed Comprehensive Plan Elements. Corvallis Planning Dept.
1 (1" to 1,200')	<u>C8</u> - Index to City Streets. Corvallis Dept. of Public Works.
2 sets, 12/set (1" to 400')	<u>C9</u> - Zoning Maps with Zone Type and Specific Descriptions. Corvallis Planning Dept.
1 set, 222 zones (1" to 400)	<u>C10</u> - Field Maps. Reproductions of <u>C9</u>.

Table 6. Study Area and Benton County map inventories.

Quantity (and scale)	
1 set, 132/set (1" to 400', 1" to 200' 1" to 100')	S1 - Electrical Distribution Maps--Corvallis District. PP&L.
1 (1:145,000)	S2 - Electrical Distribution Index Map--Corvallis District. PP&L.
1 (1" to 800')	S3 - Air Photo Mosaic of Study Area. Western Ways, Inc., Corvallis.
1 (1:56,000)	S4 - Corvallis Comprehensive Plan Map. Corvallis Planning Dept.
1 set, 5/set (1" to 800')	B1 - Zoning Maps with Individual Zone Descriptions. Benton County Public Works Dept.
1 set, 2/set (1: to 2,000')	B2 - Zoning Maps of Benton County. Benton County Public Works Dept.
1 set, 8/set (1" to 1 mile)	B3 - Postal Rural Route Maps. Corvallis Post Office.
2 (1" to 2,000')	B4 - Large Load Maps for Benton County and Portions of Linn County. PP&L.
1 (1" to 2 miles)	B5 - County Road Map. Benton County Public Works Dept.
1 set, 179/set (1" to 400', 1" to 100')	B6 - Master Benton County Assessor's Maps. Benton County Assessor's Office.
1 set, 147 zones (1" to 800', 1" to 200')	B7 - Field Maps. Reductions from B6.

Table 7. Linn County and Philomath map inventories.

Quantity (and scale)	Description and Source
1 (1" to 400')	P1 - Philomath Address Map. Philomath Public Works Dept.
1 (1" to 200')	P2 - Master Zoning Map. Benton County Assessor's Office.
2 (1" to 800')	P3 - Zoning Map Copies. Reductions from P4.
2 (1" to 400')	P4 - Zoning Map Copies. Reductions from P2.
1 (1" to 400')	P5 - Zoning Map with Zone Type and Specific Descriptions. Reduction from P2.
1 set, 21 zones (1" to 400')	P6 - Field Maps. Reductions from P2.
1 set, 51/set (1" to 1 mile)	L1 - Postal Rural Route Maps. Albany Post Office.
1 (1" to 1 mile)	L2 - Postal Rural Route Map. Tangent Post Office.
1 set, 34/set (1"to 400', 1" to 100')	L3 - Master Zoning Maps. Linn County Assessor's Office.
1 (1" to 1,600')	L4 - Zoning Map. Reduced Mosaic of L3.
1 (1" to 1,600')	L5 - Zoning Map with Individual Zone Descriptions. Reduced Mosaic of L3.
1 set, 34/set (1" to 800')	L6 - Zoning Maps with Individual Zone Descriptions. Reductions from L3.
1 set, 29 zones (1" to 800')	L7 - Field Maps. Reductions from L3.

seventh and eighth digits--the section;

ninth and tenth digits--the absissa and ordinate, respectively, of the ten-by-ten grid: (0,0) to (9, 9).

The geocodes of zone centroids and major customer (large load) locations serve as their primary identification, thus each of the 464 projection units must have a discrete geocode. In addition, <u>every</u> customer account in the study area is also geocoded. It is both unnecessary and impossible for the 18,000 accounts to have unique codes. To describe the intricacies and labor intensity of the customer coding invites hyperbole, but let it suffice to say that the instructions developed for the geocoding process are 25 pages long.

It is natural to inquire about the need for all this busy work. It must justify itself by producing something worthwhile that could not have been gained by less rigorous means, or could not otherwise have been gained at all. The two main resultants of the geocoding meet these criteria. First, a perfect accounting is made of the existence and location of all customers--a task which, by field methods, would require combing the routes of every meter reader in the area. A cursory field check would miss many of the "non-visible" accounts--laundry rooms in apartments, farm shops, water pumps, residences in commercial buildings, multiple accounts at one location, and so on. Second, by compiling the coded accounts into the zones in which they occur, the use of Pacific's computerized record system provides the following data:

1) the number of accounts, by customer schedule, in each zone;

2) the average peak month consumption per account, by schedule, in each zone;

3) the number of accounts gained, by schedule, in the previous five years in each zone.

The gained accounts are discerned by matching the current account file (which is customer locations, not names) with that from five years previous. Unmatched accounts are gains.

The Projection Process

To aid the discussion of the projection process, descriptions of the relevant terminology and the data-handling format are included.

Terminology

The total study area demand is derived from peak month values for 1) large load demand, 2) industrial and public zone load densities, and 3) schedule 04 and schedule 025 consumption. For a zone using energy data, units and equivalent units convert to demand by means of the zone's area, minimum or empirical lot size, large load adjustment, street adjustment factor, saturation factor, use per unit, and the appropriate load and coincidence factors. What does this mean?

Demand is an expression for the average rate at which energy is delivered during a specified continuous period of time. To avoid delving into phase angles, apparent power, etc., the kilowatt (kw or 1,000 joules per second, equal to about 1.34 horsepower) is used here as the demand unit.

Load density (LD) is the demand per unit area. Load density times area equals demand.

Consumption, use, and energy all may be expressed in kilowatt hours (kw-hr, 3.6 x 10^6 joules), a unit of work or energy provied equivalent to one kilowatt of power applied for one hour. Thus energy is used, or consumed, and the rate at which this occurs is the demand.[12]

The load factor and the coincidence factor are the engineering means by which consumption is converted to demand, as is necessary in a peak load forecast. The conversion is not perfect but, as noted by Sullivan (1977), a direct demand projection is considered harder to pin down than is a projection of energy, converted to demand. The load factor (LF) is the ratio of the average demand over a designated period to the maximum demand occuring in that period. The coincidence factor (CF) is the ratio of the maximum demand of a class as a whole to the sum of the individual maximum demands of the several components of the class. For the residential and commercial loads in this study area

$$\text{demand} = \frac{(\text{peak month consumption})\ \ (\text{CF})}{(\text{LF})\ \ (720\ \text{hr.})}$$

$$= \frac{\text{peak month consumption}}{504\ \text{hr.}}$$

A complete rundown of Pacific's rate scheduling is not warranted here; it is sufficient to note that residential accounts are called schedule 04's and commercial and industrial accounts are called schedule 025's. These accounts have consumption meters only.

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12. From this point, all references to demand and consumption imply peak month figures.

Another customer group consists of large loads. They have demands over 100 kw and are wired with demand meters in addition to consumption meters. As a comparison, an average three-bedroom, all-electric house in Corvallis may generate a demand of about three or four kw. There are 81 large loads in the study area.

A unit in the projection process is a schedule 04 or a schedule 025. An equivalent unit is the number of schedule 04's or schedule 025's which has the equivalent consumption of one unit of the other schedule in a given zone. The need for the equivalency concept is explained in the worksheet development section.

The minimum lot size (MLS) for a given zone is as defined by the concerned zoning authority. In cases for which a minimum lot size is either undefined or deemed inappropriate, field data determine an empirical lot size to be used in its place.

Because large loads are treated separately in the projection process, they are mathematically removed from zones in which they occur by a large load adjustment (LLA). The effect is that a 40-acre zone which includes ten acres of large load activity is functionally a 30-acre zone.

In a similar manner, the street adjustment factor (SAF) eliminates street area (existing or expected) from a zone's load considerations.

Finally, a zone's saturation factor (SF) identifies its present or projected level of occupancy as a percentage of complete occupancy, as defined by a realistic integration of land-use designations and the characteristics of the zone. The number of units possible in an uncomplicated zone equals

$$\frac{\text{area (SAF) (LLA)}}{\text{MLS}}.$$

Full occupation of a hypothetical 120-acre R-1 zone in Corvallis which includes 20 acres of large load use (a school, for instance) consists of 462 units--

$$\frac{120\ (0.85)\ (0.83)}{0.184} = 462.$$

It is possible, in fact common, for a zone's saturation factor to exceed 100 percent. This usually results from a land-use pattern which predates either all zoning or the current zoning's minimum lot size. An extreme case, one exclusive-farm-use zone in Linn County (40 acre MLS) is currently 621 percent saturated and can increase to 668 percent under present zoning.

Format

The projection format facilitates computer processing of the field data. The data must eventually take the form of electrical demand and, because of the nature of the consuming system, three means of arriving at present demand are employed:

1) for large loads, which have demand meters,
   demand = (metered demand) (CF);
2) for public and industrial zones,
   demand = (zone area) (LLA) (SAF) (CF) (SF) (present LD);

3) for commercial and residential zones,

$$\text{demand} = \frac{\text{(zone area)(LLA)(SAF)(CF)(SF)(consumption/unit)}}{\text{(LF)(MLS)(720 hr.)}}$$

The projected demand calculations are slightly different:

1) for large loads,

demand = (projected demand)(CF);

2) for public and industrial zones, demand equals present demand + (projected SF - present SF)(LLA)(SAF)(CF) (projected LD);

3) for commercial and residential zones, demand equals

$$\frac{\text{(zone area)(LLA)(SAF)(CF)(projected SF) (projected consumption/unit)}}{\text{(LF)(MLS)(720 hr.)}}$$

It is apparent that most of the data required come from the compliation of a preliminary data base. The essence of the load projections, however, is in the values for projected large load demand, the per-unit consumption in residential and commercial zones, the projected saturation levels, and, of less importance, the projected industrial load densities. The field staff work and this paper focus on the derivation of saturation values which, when processed, represent 1) specific numbers of residential and commercial units and 2) the area of land engaged in industrial activity. The large load growth, increases in residential and commercial per-unit consumption, and the projected industrial load densities are all determined by other than field staff and are not discussed in any detail here as they are separate topics of research.

Table 8 shows the field data required for each zone projection, with information from Electrical Engineering entered parenthetically.

Examples include each of the three means of deriving demand. Except for the omission of the large load customer's identity, the data are as used in the projections.

The data are keypunched and input to the computer, wherein the factors for the increased consumption per unit, projected load density, and large load demand are introduced.

Table 8. Data input sheet.

	Residential Zone	Industrial Zone	Large Load
Location	1311051028	1311052696	13--------
Description	R1-18-C	M1-1-C	Customer A
Large load area	4%	0%	--
Map area	33.21 in^2	13.66 in^2	--
Map factor	1" to 400'	1" to 400'	--
Min. lot size	0.184	--	--
Pres. saturation	47%	22%	--
Proj. saturation	56%	38%	--
Street adj. factor	85%	75%	--
Load factor	(0.21)	(0.21)	--
Coincidence factor	(0.30)	(0.90)	(0.90)
Load density	--	20.6 kw/ac.	--
Large load demand	--	--	(204.3 kw)
Consumption/unit	1,424 kwh/mo.	--	--

The Future Image

The predictive dichotomy between the field staff and the Portland staff can be plainly stated: the field staff determines the future number of units and where they will be; the Portland staff determines the usage values for them. This section discusses the former task.

As a prelude to any kind of unit projection, population projection, economic forecast, and the like, a preliminary set of assumptions is adopted, often implicitly. The assumptions are typically of a sweeping nature and include such standbys as: the country will not become engaged in a major war; no natural catastrophe will befall the concerned system; our democratic institutions will continue to operate. One can go on at great length describing the assumed conditions of the forecast period, but the intent is most often to establish an untainted canvas upon which the forecaster applies his strokes and dabs of logic and judgment. It is possible, of course, that the forecaster does not wish to assume business as usual, in which case the aberrations must be clearly specified. In this study it is business, world affairs, geology, etc., as usual.

The entry of a saturation value on a data input sheet represents a precise prediction of the state of a small geographic unit in 1987. In the six-month study of the Corvallis area, the field staff produced 383 zone saturation values (the Portland office forecasted the 81 large loads). How are these values arrived at?

RESOURCES. Saturation factors evolve in various ways depending on the particular zone involved. The major inputs are from the following:

1) the data base from Pacific's records;
2) field staff expertise;
3) current zoning ordinances and the proposed Corvallis Comprehensive Plan;
4) local planners;
5) local developers, administrators, and engineers;
6) special studies of the area;
7) the physical attributes of the zones.

The data base from Pacific's records has already been discussed. The ability of the field staff to apply and further develop its factual foundation results in part from interactions with the Company's local staff and management and the open access they provided to all relevant records.

The initial expertise of the field staff, aside from the original Field Coordinator, consisted primarily of native intelligence, familiarity with geographic principles, and a net long-term residence in the study area. Crash courses in local planning processes, specialized geographic data management, load forecasting, and the Company systems stripped the veil of mystery from all levels of the forecasting procedure and produced an effective research group.

The current zoning ordinances[13] and the proposed Corvallis Comprehensive Plan[14] lay the groundwork for defining zone capacities.

13. Four political units are involved (Corvallis, Philomath, Linn County, and Benton County), but all are compatible with the projection format.

14. At the time of the study only the proposed plan was available. Now there is a very slightly altered final plan, but it is still subject to approval at the state level.

Through them can one model what is possible in the study area.[15] The range of possibilities for a given point in time is fairly wide, however, partly as a function of flexibility in the land-use specifications, but especially as a result of the uncertainty over when and at what rate a zone will be developed.

The local planners are a vital link between the planning paperwork and the future. Their opinions can be worth a pound of Citizen's Advisory Committee reports. The planners offer not only speculation, of course, but also help to interpret plans and ordinances, and can provide data available through no other sources.

The developers are called on more for specific details about developments either planned or in progress, rather than for their general conceptualizations of urban growth. The same is true for the administrators and engineers contacted: what is the floor area of the veterinary science building?; is construction of the city pool imminent?; is the experiment station going to expand?; is the sewer extension limited to gravity flow or are lift pumps anticipated?

In many cases, discussions with the above people serve to clarify or reinforce impressions gained from reports on special planning studies. Findings in them often become official policy. A venerable

15. The three other comprehensive plans were felt to be too early in their development to be integrated into the study. The Corvallis Plan is fortunately the most influential of the group.

(1970) sewer system study is still referred to as "the bible" by utility management. Such reports are valuable not only for their findings, but sometimes even more so for their raw data.[16] Some reports are in fact, nothing more than raw data.[17]

More raw yet than data is the land itself. Its qualities have variable influences on its future prospects. Impermeable soils may proscribe development in western Squaw Creek basin, but be inconsequential inside the city limits because of sewer service. The attractiveness of the industrial park is dulled by the low flow rate of its well system. Elevation can be too high (above projected service levels) or too low (in a flood hazard area). A location may be too close in or too far out. Surrounding uses may be attractive or repulsive. For analysis, all of these factors must be evaluated in concert with the land's key non-physical attributes: zoning, ownership, and the demand for it.

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16. The most useful of all is something of a local monograph: Toward the Year 2000: Preliminary Plan Elements for the Corvallis Comprehensive Plan (Corvallis Planning Department, 1975). To select from the many other reports, two come from the City of Corvallis (1978): Growth Managment Study Inventory Phase: City Facilities and Services and Growth Management Study Inventory Phase: Land Resources. The Corvallis Goals Steering Committee (1975) provides Corvallis Community Goals for 1985. From the consulting firm of Cornell, Howland, Hayes and Merrifield come Housing Study (1976), Sanitary Sewer Plan for the Corvallis Urbanized Area (1970), and Water System Plan for the Corvallis Comprehensive Urban Area (1970). The Oregon Administrative District Four Office of the Council of Governments produced District Four Overall Economic Development Program (1977).

17. Both are from Oregon Administrative Distric Four: Housing: Census Data Analysis (1973), and Statistical Data Base (1976).

THE MENTAL MODEL. The projections in this study do not result from built-in, systematic decision-making processes. In Lazzari (1965), for example, the forecasts do, and the more mechanical analysis used there greatly reduces the study's time requirements.[18] But it also reduces the analyst's ability to address the unique qualities of his study area. The Corvallis area projections are based first on as much factual detail as possible, and second on a composite image of the area's growth prospects garnered by a process which resembles an unstructured cousin of the Delphi method.

The Delphi method was developed by the Rand Corporation in the late 1940's as " . . . a systematic way of eliciting expert opinion on a variety of topics, including technological forecasting (Rand, 1974, p. iii)." This is usually done with carefully designed questionnaires and controlled opinion feedback. The approach is most useful " . . . when accurate information is unavailable or expensive to obtain, or evaluation models require subjective inputs to the point where they become the dominating parameters (Linstone and Turoff, 1975, p. 10)." Whereas this study makes no attempt to incorporate the Delphi method as such, the goals of the method and the objective behind the field staff's continual contacts among over 40 local "experts" are

18. The forecast units, square miles, have two-point historical trends and their own saturation levels and ultimate capacities. These three inputs are used to define a specific s-shaped growth curve for each forecast unit. For a given year in the future, the forecasted load is quite simply the y-value of the curve for that year. Once the data are assembled, only one result is possible (Lazzari, 1965).

the same: to derive a reliable consensus of expert opinion. The inquiries help to create a model based on a legal framework and informed opinion which is applicable to individual zone projections. This model takes the form of an isoplethic overview of the study area: a Z value is a locality's growth potential--a concept which integrates available space and its tendency to become occupied. Explicit quantification of the model takes place with the completion of the projection worksheets, which are discussed in the following section.

As might be expected, there can be a higher level of confidence in assigning relative growth potential than in predicting the exact number of units the zones will have ten years down the road. Most of the fundamental sources and determinants of growth cannot be readily analyzed:

1) will the voters continue to reject annexation proposals?;
2) will the study area eventually absorb a greater proportion of the impact from Hewlett-Packard?;
3) will the University enrollement level remain stabilized--will its research facilities expand?;
4) are there going to be major new entries into the basic sector of the Corvallis economy?;
5) is the nonbasic sector going to meet more of the local demands?;
6) how long can Philomath continue to grow at seven percent per year?;
7) should the inviolate nature of the EFU zones be expected to continue indefinitely?;

8) will the projected decline in wood products industry employment be reflected in the study area?;

9) can the proposed Corvallis Comprehensive Plan get approval at the state level without being significantly altered?;

10) will the rate of natural increase change markedly?

All of these questions must be reckoned with. To summarize the field staff viewpoint (that is, to elicit responses from the model) on the above ten questions:

1) in the short run, yes--in the long run resistance will lessen or the electorate may lose their say by the retraction of the City's singular ordinance requiring voter approval of all annexations;

2) yes, resulting in part from urban expansion;

3) yes and yes;

4) yes, but nothing as large as Hewlett-Packard;

5) yes;

6) no more than another two years;

7) yes, at least for the projection period;

8) not dramatically or not at all;

9) yes;

10) no.

The answers to these and other similar questions, however, are insufficient to identify <u>where</u> growth will occur. That problem is also approached with detailed background reading and a pseudo-Delphi effort to sharpen a consensus of external opinion. Needing none of this brainstorming, some zones cannot grow because they are full;

Figure 5 gives an idea how often this is the case. Most zones, however, require some thought to project. Because water and sewer system extensions largely dictate the pattern of urban expansion, it is important to develop a scenario of the process for projection purposes. Local planners, the Comprehensive Plan, and utility system studies help one to visualize the spread of city services, but the annexation referenda do, of course, make this more difficult. There can be a more direct market analysis in the less transitional areas--those within city limits or outside the urban growth area. The type of analysis used is not the spearhead of economic theory, but the results are practical, for example:

--activity will soon resume at the site of the abandoned Consumers Power headquarters;

--the infilling of vacant land in southeast Corvallis will continue apace;

--Timberhill will employ a steady, moderate development program;

--Peoria is inert.

At the finer levels of detail subjectivity swells: microscale accountability is favored over a strictly deterministic methodology. That is to say, the field staff can offer reasonable explanations for every one of its projections, whereas more abstract (less subjective) methods may have ludicrous implications in some of its small, isolated components.

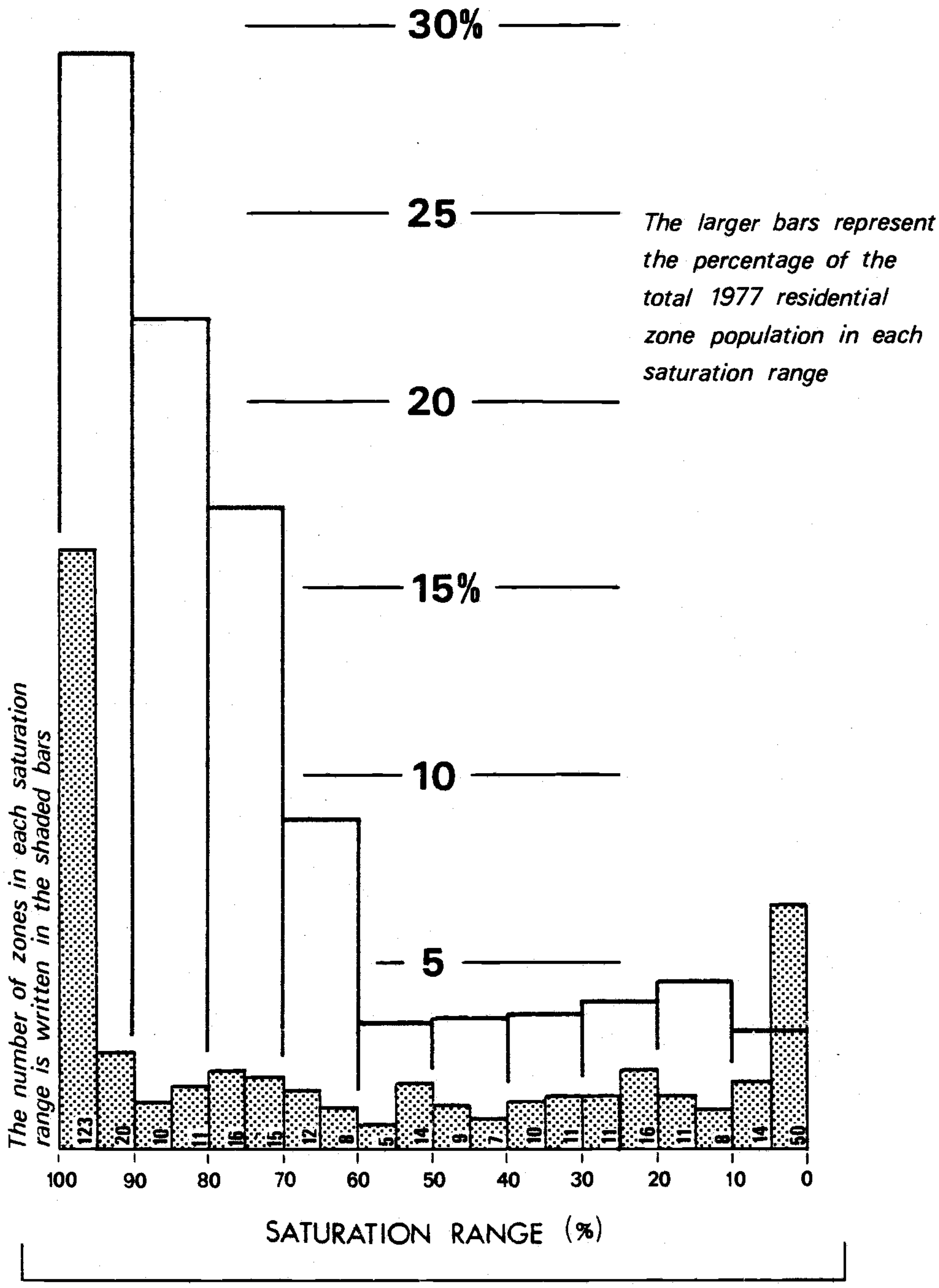

Figure 5. Present population and zone distributions by saturation range.

Worksheet Development

The mental models of the previous section have no value in this study unless they can be put into hard copy. Projection worksheets are the primary means by which field knowledge is transformed into a projected 1987 electrical demand. Worksheets are filled out for each zone, and their design is influenced by the functions and qualities outlined for them:

1) to document data collection,
2) to minimize and document subjective entries,
3) to be compatible with the data input format,
4) to produce results which are as replicable as possible,
5) to address zones' special circumstances,
6) to require explicit examination of each zone, and
7) to meet the above requirements while being simple to complete.

The effort to comply with item five above, without creating just one oversized Federal form, yields projection worksheets for six classes of zones:

1) residential,
2) multiple-family residential,
3) commercial,
4) industrial,
5) public, and
6) comprehensive.

The objective of every worksheet is to produce a zone's present and projected saturation values. In Appendix A are samples of the worksheets used; Appendix B provides notes on their use. The few items which pertain to the Company report but not this paper are edited.

(1) RESIDENTIAL ZONE WORKSHEET DEVELOPMENT. Residential worksheets are applicable to both urban and rural residential zones which allow development of only single-family units. Zone demand is based on the effective number of units (that is, units and equivalent units) and the consumption per unit. In the computer program, a coefficient representing increasing usage per unit is inserted.

Zone capacity. Every zone has unique qualities including its own holding capacity. The capacity is calculated by filling every available lot in conformance with the applicable zoning specifications. Large lots are divided into lots of the minimum size unless approved plans call for lower-density development. Among lots not considered available are those with severe physical constraints and ones which can legally be partitioned but because of the prevailing neighborhood character are not likely to be. Lots with units on them are identified during geocoding so that vacant land compilation is virtually all map work rather than field work. The somewhat grainy air photo mosaic is also useful in reducing field work.

The geocoding results also reveal the significance of schedule 025 consumption in single-family residential zones (which include exclusive-farm-use zones). Excluding large loads, they presently amount to an equivalent of about 450 units, and whenever an increase in their numbers or consumption is expected the zone capacity is enlarged accordingly.

Load projection. Beyond defining the zone capacity, the object of completing the worksheet is to arrive at a number which states how near to saturation a given zone will be in ten years. In light of development economics and the local housing climate, it is assumed that all platted subdivisions will be completed within the projection period. Other vacant land is evaluated for its location, physical attributes, likely market, available facilities, and ownership. For instance, farmer S's field off Plymouth Road will be verdant in ten years; developer D's land in Southeast Corvallis will have sprouted with houses on minimum-size lots. In general, reliance on the historical trend diminishes with increasing insight into a zone's prospects. In practice, urban zone projections frequently ignore the historical data whereas many rural zone projections are quite naked without the trending option. The overall contribution from external contacts is indispensable, but their role is not usually one of individual zone analysis.

(2) MULTIPLE-FAMILY RESIDENTIAL ZONE WORKSHEET DEVELOPMENT. Load projections for all residential zones which permit multi-family units are made on this worksheet. Zone demand is based on the number of units and the consumption per unit, with the same usage coefficient as before. Differences between this and the previous residential worksheet are discussed below.

Zone capacity. Unlike single-family zones, multi-family zones do not approach their designated minimum lot size densities. In fact, it is rare that even individual apartment complexes do so. To make more realistic estimates of zone capacities, field samples of the densities of recently-built complexes are used to calculate the empirical lot size at which development is most likely to occur in specific zoning categories.[19]

Another distinction is that demolition of detached schedule 04's is addressed for these residential zones but not the single-family zones. The reasoning is that the replacement structures in multi-family zones are likely to be of much higher load density, whereas to replace one single-family structure with another can be overlooked. The future rate of demolition is speculative, but the activity will no doubt localize in the R-M and R-H zones peripheral to the OSU campus, which are often characterized as the "student ghetto."

Schedule 025's are highly significant in multi-family zones, being equivalent to about 550 schedule 04's. They usually represent laundry rooms and as such are expected to grow in numbers along with apartment construction.

Load projection. The multi-family zone projections are less enlightened than the single-family ones, and the impact of the possibilities is more dynamic. In an R-1 zone (single-family), one unit can be built on a 13,000-square-foot lot; in an R-H zone (multi-family)

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19. To illustrate, R-L zones in Corvallis have a designated minimum lot size (that is, number of units ÷ site area) of 0.019 acres, or 52 units per acre. The field samples of eight late-model R-L complexes show an empirical density of 28 units per acre, with a standard deviation of 5.4 units per acre. Therefore, multi-family development in R-L zones is projected to occur at 28 units per acre.

there can be 35. The effects of demolition and University enrollment ceilings are uncertain. Development will necessarily occur in smaller, disjointed blocks rather than large tracts. External contacts are less helpful than before because most of the currently planned development is toward the urban fringes, while most multi-family zones are toward the core.

Fortunately, the occupation level of most multi-family zones is already high and the demolition rate is historically low. This greatly narrows the possible load range and makes the seat-of-the-pants approach (with historical perspective) less tenuous than it might otherwise be.

(3) COMMERCIAL ZONE WORKSHEET DEVELOPMENT. Urban and suburban commercial zones use this worksheet. In addition, planned developments, public zones, and industrial zones, which are now or are planned to be of commercial nature, also use it. The "unit" concept is somewhat blurred in commercial zones, but the demand can nonetheless be said to arise as before from the number of units and the consumption per unit. A different, lower coefficient for increased usage per unit applies to these zones. Large loads are sometimes dominant in commercial zones but, to repeat an earlier comment, they are handled separately by the Portland staff and have their own increasing demand coefficients.

Zone capacity. An empirical lot size is used on all commercial worksheets because 1) some zones have no area specifications whatsoever, 2) for some zoning types the area specified is for the entire commercial zone rather than its commercial units, and 3) great variations exist in the sizes of commercial accounts. A commercial unit is defined uniquely for each zone and has consumption equal to

$$\frac{\text{total schedule 025 consumption}}{\text{total number of schedule 025's}}$$

and an area equal to

$$\frac{\text{total area in commercial activity}}{\text{total number of schedule 025's.}}$$

Complete zone saturation implies that the area is fully occupied by units having the empirical size and consumption. Allowance is made for the possible demolition of residential units in commercial zones, as there is usually a greater consumption per unit area in commercial activity. The addition of residential units is permissible only in the CB zones of Corvallis.

In some cases planned commercial construction is specified by floor area. A field sample of existing schedule 025's provides an average demand per square foot of floor space of two watts even. This value is then 1) multipled by the specified floor area, 2) converted to a consumption value, and 3) divided by the average consumption per schedule 025 for the given zone. The result is the effective number of units in the zone concerned.

Load projection. As a characteristic of the data processing format, new load (stated as increased areal saturation) is expressed as a function of present load. For instance, consider a zone which has six schedule 025's and is 50 percent saturated. One hundred percent saturation of that zone implies the addition of six more units just like the first six; the addition of one load-intensive customer which uses three times more energy than the existing six combined produces a projected saturation of 200 percent, which implies that there will be 24 schedule 025's in the zone rather than the actual seven. The actual or implied number of units in the projected load is immaterial as long as the output is the intended demand. But this is format.

What is the future of Corvallis' commercial zones? Many commercial construction plans are known and are included in the projections. Several commercial zones are fully occupied. Beyond such clear-cut cases the crystal ball is decidedly obscure. The present situation is that Corvallis does not satisfy the local market. Depending on, among other things, the recurring but uncertain prospect of a regional shopping center landing somewhere in town, the CBD may be on the verge of withering, blooming, or continuing as is. The regional center idea provokes an intense ambivalence in the business community and, in its presently unresolved state, helps not at all in pinning down the load projection. Further, because most commercial zones are so small, the historical trend is largely of marginal interest. The local planners' and developers' impressions are the most useful means of penetrating the fog.

(4) PUBLIC ZONE WORKSHEET DEVELOPMENT. Public parks and other public zones which have a nominal present demand and are not likely to change their nature in the future are projected on this worksheet. Other types of public zones (the industrial park, the University, the Court House . . .) are projected on other worksheets. A load density approach is used to produce zone demands. Increased load is solely a

function of increased areal saturation; no new load density is introduced during computer processing.

Zone capacity. Because the present and future loads concerned are nearly non-existent, zone capacity calculations are not critical. If no load is expected to be added, the present load is the zone capacity. If an increased load is expected, the new total load is called the zone capacity.

Load projection. The historical trend is ignored on public zone worksheets. Personal contacts with the heads of the organizations most directly concerned with managing the zones provide the projection background. Estimates are made for the consumption of the new load. In a manner similar to the commercial projections, new load is stated in terms of existing load as an unbounded saturation value. Schedule 025's are explicit in the present load but "units" are not literal in the projections.

(5) INDUSTRIAL ZONE WORKSHEET DEVELOPMENT. The eight zoning classifications which allow light or heavy industrial activity use the industrial zone worksheet. The present demand is derived from a zone's area and its calculated load density. The projected demand is the present demand plus the product of the area of new industrial activity times a new load density, which is uniform for all zones. The new load density is derived empirically from present industrial large load data.

Zone capacity. A presently empty industrial zone is considered, at capacity, to be fully occupied by activity having the load density of the average industrial large load in the study area. Call it density L. Partially occupied zones have the capacity of the present load plus the product of density L times the area of the unoccupied balance of the zone. Allowance is made in the worksheet for the demolition of residential or commercial units in industrial zones and the replacement of their area with new industry.

Load projection. The consensus from the local external contacts is that the Corvallis area industrial climate, cool to conservatively mild, will not change much in the near future. Keeping in mind that present large loads are analyzed separately, it seems reasonable to let the rate of historical growth continue through the projection period. But rather than extrapolate the individual trend of each zone, the following is preferred: 1) calculate the total consumption of all gained accounts (5 years) and double it, 2) convert the consumption to demand, and 3) divide the demand by density L. The quotient is the number of acres expected to come into use, at density L, in the next ten years.

The problem then is to distribute the computed number of acres into the zones most likely to develop. The zones' growth is represented by increased saturation values. Through a synthesis of field staff impressions, facts and opinions from planners and others, the historical trend, and the zones' locations and available services, the load units are doled out.

(6) COMPREHENSIVE ZONE WORKSHEET DEVELOPMENT. "Comprehensive zone" is shorthand for those zones lying in the area between present Corvallis city limits and its Urban Growth Boundary (UGB). Future development there is expected to follow the guidelines of the Comprehensive Plan rather than current county zoning. For projection purposes, there are 45 zones in the area described: 28 of these are foreseen to

undergo residential or commercial development while the other 17 are pegged for industry, agriculture, conservation, or public use. The latter group can readily be processed with the worksheets already discussed. The former group is processed on comprehensive zone worksheets and consists of low-, medium-, and high-density residential zones as well as two intensive development sectors (IDS's). The intensive development sectors include both residential and commercial development. To suit the generality of the Plan, new approaches are taken in assigning zone capacity and in making projections. Demand is once again a product of units, consumption per unit, and a usage coefficient.

Housing densities. In "Density Ranges in the Comprehensive Plan" (Hart, 1977), it is estimated that 45,000 people can be added to the area between present city limits and the UGB. In the Comprehensive Plan (1977), broad housing density ranges are defined for the urban growth area and the extent of each range is presented in very general graphical form. A sizable amount of the urban growth area lies outside the study area. Measurement of the area of each density range allows one to approximate the proportion of the additional population which will ultimately fall within the study area portion of the urban growth area. Calculations indicate that just under 54 percent, or about 24,275 people, are allotted to Pacific's territory.

The general density ranges are then replaced with specific ultimate housing densities for each of the 28 zones, based in particular on qualities of location and input from planners. The capacity of each zone is the product of its area and its housing density. Ultimate density designations are guided by the equation:

$$\sum_{i=1}^{i=28} (A_i)(UD_i)(2.38) = 24,275$$

in which A and UD are, respectively, the area (in acres) and the ultimate density (in units/acre) of zone i, and 2.38 is the average household size (from the 1977 census of Corvallis conducted by the Center for Population Research and Census).

Residential equivalent units. The intensive development sectors are the only zones dealt with on comprehensive zone worksheets which will experience significant commercial sector expansion. To make reasonable projections of this growth it is necessary to determine both the approximate acreage of the commercial activity and the electrical consumption stemming from it.

The areal extent of IDS commercial activity is not defined in the Comprehensive Plan, nor can one get consistent estimates among planners. The intent of the IDS's, however, is that they provide goods and services for the immediate locality, much in the way that Corvallis serves its limited hinterland. Therefore, the proportion of Corvallis zoned for commercial use (9.1 percent) is also the proportion of the IDS's assumed to become commercial.

The electrical consumption of the IDS commercial activity is also derived empirically from Corvallis data. Excluding the CBD, which is considered uncharacteristic with respect to outlying commercial activity, sampling from six commercial zones provides data to approximate the anticipated load. This peak month load of 13,200 kwh per acre is then converted to residential equivalent units (step ten of the worksheet example in Appendix A shows the method). A concluding assumption, both reasonable and expeditious, is that the residential and commercial growth in the IDS's will be proportional to each other with time, so that a single growth factor applies to both the residential and commercial components of growth in a given zone.

Growth factors. Within the time frame of the ten year projection, only a fraction of the 10,200 units (24,275 people ÷ 2.38 people/unit) will be added to the urban growth area. Of the total number of units that can be added to a given zone, the growth factor describes the projected proportion. The maximum number that can be added is the difference between the ultimate number of units and the present number of units. If all the possible growth in a zone is expected to occur within ten years, the growth factor equals one. If no growth is expected, GF equals zero. A value for each zone is arrived at by assessing, with insight from all available resources, the magnitude, direction, and timing of Corvallis' anticipated growth. The outcome is that just under thirty percent of the ultimate growth is expected to occur in the next ten years, or

$$\sum_{i=1}^{i=28} (\mathrm{UNU-PNU})_i (\mathrm{GF})_i = 0.296\ (\mathrm{UNU-PNU})_T$$

where $(\mathrm{UNU-PNU})_i$ and $(\mathrm{GF})_i$ are, respectively, the total possible number of units added and the growth factor for zone i, and $(\mathrm{UNU-PNU})_T$ is the total possible growth in the urban growth portion of the study area. This means that the weighted mean growth factor turns out to be about 0.3--the range is from 0.05 to 0.9.

Projection Results

These six houses will be torn down and replaced by commercial activity. There will be new field lights in the park, but they will not be used in the peak month. Septic tank applications from this part of the basin are getting blanket denials, and the city services are not going to reach the area for another five years. Owner C has plans for 70 units, but his expertise as a developer is questioned by Planner A. Village Green will complete its development after the next construction phase of the Cresent Valley Interceptor. Thousands of decisions are quantified and codified. The computer hums, and the definitive appearance of ten solid pages of output belies the pliant nature of many of the individual projections. Table 9 is a three-percent sample of the final output, with modified large load entries to preserve their proprietary nature. "SF" is the saturation factor.

The bottom line of the project is, of course, the projected 1987 load. What can be done with the information? Pacific might 1) run the data through its substation optimization program, 2) revise its construction priorities, 3) perform similar studies elsewhere, or 4) dismiss the study because it does not look right.

In this paper two main tasks remain: to perform a credibility exercise using the projected data, and to present the project results cartographically.

Comparison of the Load Projection with a Population Projection

The idea of comparing an external index with this load projection becomes complicated before it can be developed because nobody makes

Table 9. Sample from computer output.

Location	Description	Area (ac.)	1977 Units	1977 SF	1977 Demand	1987 Units	1987 SF	1987 Demand
1311050594	IDS-1	506	203	10	591	709	35	3,014
1311051262	RCL-17	37.6	144	59	558	234	96	1,321
1312051197	AGR-2	152	5	100	10	5	100	15
13--------	Large load A	0	1	0	236	1	0	191
13--------	Large load B	0	1	0	662	1	0	1,131
13--------	Large load C	0	1	0	223	1	0	381
1312050220	CH-3-C	28.9	32	80	173	37	92	220
1313051424	EFU-20-B	648	3	20	19	3	20	27
1311052402	PD-7-C	1.5	0	0	0	7	100	44
1311052353	R1-10-C	35.4	54	33	182	100	61	488
1311052424	R3-2-C	4.4	33	63	155	33	63	225
1311053475	RM-6-C	53.0	388	16	1,096	411	17	1,696
1312041633	SR-5-L	20.6	82	227	274	82	227	399
1311052411	M2-1-C	46.7	1	22	91	1	58	353

suitably detailed electrical load forecasts and nobody makes forecasts of any kind for this particular study area. A reasonable compromise exists in a population projection made in February, 1976 by the Center for Population Research and Census at Portland State University.

The bulletin from the CPRC addresses the whole of Benton County and lists population estimates in five-year increments from 1975 to 2000. The load projection covers an area which includes approximately 70 percent of the Benton County population and about 2,300 in Linn County, and its time frame is 1977 to 1987. Although the figures from Portland State are based on neither the exact time frame nor the identical geographic data base of the load projection, the bulletin's annual growth rate for the period 1975 to 1985 is used as a reference value. Using the high migration assumption, the growth rate is 3.15 percent. Figures from the CPRC, even current population estimates, cannot be labeled "the truth,"[20] but they are widely regarded as the best population information available.

POPULATION FIGURES FROM THE LOAD PROJECTION. The load projection is not a population projection. A portion of it, however, consists of the addition of residential units (schedule 04's). A running tabulation of all present and projected schedule 04's was made for the purpose of making population comparisons.

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20. The July, 1976 population estimate by the CPRC for Corvallis is 40,180. In a 100-percent-sample census conducted by the CPRC in October, 1977, the population figure is 38,538. The implication is not that Corvallis is losing people--it is not--but that current estimates, and certainly long-range projections, are imperfect.

The major problems with sifting a population figure out of schedule 04 data are that one schedule does not represent any fixed number of people, and that many people are not represented by schedule 04's at all. In the following sections these problems are dealt with and population figures are calcualted for the study area portions of Corvallis, Philomath, unincorporated Benton County, Linn County, and the entire study area.

Present Corvallis Population. Corvallis contains over three-fourths of the people in the study area and, fortunately, the city has the most recent, accurate, and detailed data of any portion of it. Population figures for Corvallis as of late Octorber, 1977 have been published and are based on the previously cited field census by the CPRC. It is useful to establish with these data that a schedule 04 is a practical analogue to a non-group residential unit. To do so, three categories are analyzed:

1) schedule 04 customers, some of which may be associated with group housing;
2) group housing, most of which is not associated with schedule 04's;
3) those units which lie within Corvallis but are outside the study area.

As of December 1, 1977 there were 12,459 schedule 04's within both Corvallis and the study area. Since the CPRC census data predate that tabulation by about one month, a closer correspondence may be attained by subtracting one month's gained customers from the total. Customer records show that 2,988 schedule 04's have been added in the last five years, so if one assumes that the November, 1977 growth rate is similar to the five-year trend, then 50 units fewer (2,988/60), or 12,409 units, existed at the time of the census. Each housing unit is determined by the census to average 2.38 occupants. Housing units with six or more unrelated individuals are considered group housing and are not included in the per-unit calculation.

The group housing population is determined largely by CPRC census data and was augmented by field work and a phone survey by the load forecast's field staff. Table 10 is a breakdown of group housing in Corvallis, none of which is outside the study area. Because there are approximately 58 schedule 04's associated with common meter situations, fraternities, and sororities, 138 people (58 x 2.38) are subtracted from the total of this group to avoid duplicative tabulation with the above 12,409 schedule 04's.

Table 10. Corvallis group housing.

Category	Population
Dormitory	3,819
Fraternity, sorority	2,221
Co-operatives	496
Nursing and retirement homes	463
College Inn	409
Misc. apartments, common meter	345
Hotels, motels	170
Public (fire stations, work release, etc.)	62
	7,985 - 138 = 7,847

A small portion of Corvallis is outside the PP&L service area. Field checks show the number of units not served to be 448 (329 single-family, 8 x 2-unit, 16 x 4-unit, and 3 x 13-unit). Given the figure of 2.38 people per unit, the Corvallis population outside the study area is approximately 1,066 (2.38 x 448).

Possible sources of error in comparing the CPRC population with that based on Pacific's data include:

1) the count made during the census is not correct,
2) the people per unit, 2.38, is a rounded number,
3) not all group housing population is accounted for,
4) the added accounts in November do not equal 50,
5) the tabulation of schedule 04's for December is not exact,
6) there are other than 448 units outside the study area, and
7) the above 448 units do not average 2.38 people per unit.

The effect of all these items, despite the length of the list, is likely to be offsetting and slight overall. The following compares the CPRC census figure with the customer-based calculation, both for late October, 1977:

Corvallis population (CPRC) = 38,538;

Corvallis population (PP&L) = (12,459 - 2,988/60) (2.38) + 7,847 + 1,066
= 38,446

It appears that schedule 04's may subsequently be taken to represent nongroup residential units. The population of the study area within Corvallis for December 1, 1977, assuming no change in group population or household size, is estimated as

$$12{,}459\ (2.38) + 7{,}847 = \underline{37{,}499}\ .$$

Present Philomath Population. The most recent and credible estimate of population for Philomath is the CPRC estimate of 2,400 made for July 1, 1977. A current (December 1, 1977) estimate for population and household size can be made if one accepts 1) the CPRC estimate of 2,400, 2) the use of schedule 04's as the number of households (group housing is insignificant) and 3) that the trend in schedule 04's gained in Philomath from 1972 to 1977 is representative of the trend from July 1 to December 1, 1977. Given these assumptions, one can use the following data:

--schedule 04 gains, 1972 to 1977 311

--estimated population on July 1, 1977 2,400

--number of households December 1, 1977 ..... 995.

The estimated number of households on July 1, 1977 then becomes

$$995 - 5/60(311) = \underline{969}.$$

Considering that no significant group housing exists in Philomath, it follows that the number of people per household is

$$2{,}400/969 = \underline{2.48}.$$

Assuming that the household size is unchanged over the five-month period between July and December, the December 1, 1977 Philomath population is estimated as

$$995(2.48) = \underline{2{,}468}.$$

Present Unincorporated Benton County Population. The figures for the Benton and Linn County areas are less assured than those for

Corvallis and Philomath because 1) the areas do not even approximately conform to county, county census division, or corporate boundaries, therefore 2) no population estimates exist for the areas, so that 3) the number of people per household must be estimated with less insight than in the previous cases.

The number of people per household is declining at a slow but uncertain and geographically variable rate. Rather than rely on speculation concerning the trend, the following population estimates are based on the latest known data from the smallest applicable data units. Of the seven CCD's in Benton county, three (South Corvallis, Philomath, and Lewisburg) encompass the rural portion of the study area. The data is from the 1970 Census; in Table 11 the Philomath CCD is adjusted to exclude households and people within the Philomath city limits.

Table 11. Benton County CCD data.

		1970 Population	1970 Households
Lewisburg CCD		3,562	1,057
S. Corvallis CCD		2,392	740
Philomath CCD		4,313	1,395
Philomath, City		(-1,688)	(-588)
	Totals	8,579	2,604

The household size for the three CCD's, as adjusted, is

8,579/2,604 = 3.29.

The group housing population in these areas is infinitesimal, so the Benton County portion of the study area can now be estimated as the number of schedule 04's (Dec. 1, 1977 tabulation) times the population per unit, or

$$1,980\ (3.29) = \underline{6,514}.$$

Present Linn County Population. As developed under the Benton County section, the method for calculating rural population is based on the number of schedule 04's and the household size in the applicable CCD, as listed in the 1970 Census. In this case, only the Tangent CCD applies. For December 1, 1977, the population of the Linn County portion is estimated to be

$$757\ (3.08) = \underline{2,332}.$$

Study Area Population. Inasmuch as the great majority of the study area's population is very firmly established (i.e. Corvallis' and Philomath's), and the balance is slightly less so, the total study area population estimate can be significantly improved upon only through extensive field sampling. The estimated study area population for December 1, 1977 is shown in Table 12.

Table 12. Current study area population.

	Number of Households	Household Size	Group Population	Total
Corvallis	12,459	2.38	7,847	37,499
Philomath	995	2.48	---	2,468
Benton Co.	1,980	3.29	---	6,514
Linn Co.	757	3.08	---	2,332
			Total	48,813

PROJECTION OF FUTURE POPULATION. The growth of Corvallis and Philomath will occur both within present corporate boundaries and within newly annexed areas. To avoid statistical inconsistencies, four units (i.e. the portions of which lie in the study area) are defined for calculating the 1987 population:

1) Corvallis and the area within the Comprehensive Plan's urban growth boundary;
2) Philomath and an adjacent portion of Benton County, presently zoned RU-2, in which a 360-unit phased development is planned and approved;
3) unincorporated Benton County which lies outside both the UGB and the above RU-2 zone, and
4) Linn County.

In reference to Table 13, present population estimates are already established for Corvallis, Philomath, and Linn County. For the UGB area, the RU-2 zone, and remaining Benton County, each current unit is multiplied by 3.29.

Table 13. Households projected by component area.

	Number of Households	Household Size	Population	Added Households
Corvallis	---	---	37,499	3,679
Philomath	---	---	2,468	378
Linn Co.	---	---	2,332	44
UGB area	1,029	3.29	3,385	3,021
RU-2 zone	69	3.29	227	165
Benton	882	3.29	2,902	241
		Total	48,813	

As with the present population, the projected population gain is the product of households and appropriate multipliers: 2.38 for Corvallis and the UGB area, 2.48 for Philomath and the RU-2 zone, 3.08 for Linn County, and 3.29 for remaining Benton County. The projected 1987 population is derived in Table 14.

Table 14. Projected 1987 population.

	Present Pop.	Added Units	Pop/ Unit	Added Pop.	Annual Growth	1987 Pop.
Corvallis & UGB	40,884	6,700	2.38	15,946	3.35%	56,830
Philomath & RU-2	2,695	543	2.48	1,347	4.14%	4,042
Benton Co.	2,902	241	3.29	793	2.44%	3,695
Linn Co.	2,332	44	3.08	136	0.57%	2,468
	48,813	7,528		18,222	3.22%	67,035

The study area is thus projected to grow at a rate of 3.22 percent per year over ten years (1977-1987). Compared to the CPRC figure of 3.15 percent per year for Benton County (1975-1985), the rate from the load projection is 2.4 percent higher.

COMMENTS ON THE POPULATION PROJECTION. The close agreement of the growth rates does not, of course, validate the load projection. The time frames and geographic data bases are not identical. The projections made by the CPRC are not correct, anyway. There are also the matters of large load projections and increased usage factors for residential and commercial customers. These are of about the same importance in the total load as is the unit projection, but they are not part of this paper nor can they be evaluated by the kind of comparison just made. What can be said is that the CPRC's methodology is reasonable, and that the independent projection of residential units in this study is probably reasonable too.

Speculation on changing household size helps to put the splitting of hairs into perspective. The projection just derived assumes no changes in component area household sizes (but counts added units inside the UGB as having Corvallis household size, and likewise for the Philomath household size in the RU-2 zone). Or, beginning in 1977, one could introduce a declining household size--the projected rate of decline for the Portland SMSA, which is the only available projection of household size yet made by the CPRC (Portland State University, CPCR Projections, 1977). As a third alternative, one might begin with the official 1970 household sizes for all component areas, and then have them decline until the end of the projection period at the rate of Corvallis' decline from 1970 to its 1977 census. In all three cases the calculations are based on a group population of 7,487 and 23,719 residential units in 1987. The surprising results are in Table 15.

Table 15. Projections based on different household sizes.

Household size assumption	1987 population	Growth rate, 1977-1987
Freeze at latest known figure	67,035	3.22%
Decline at CPRC's rate for Portland SMSA	64,487	2.99%
Decline at Corvallis' 1970-77 rate	54,291	1.07%

Although Corvallis' decline in household size from 2.76 to 2.38 in seven years is considered anomalous (if not incredible) by the local experts, it is also a fact--if 100-percent-sample censuses are taken seriously. The frailty of demographic forecasting is most plainly revealed in small study areas, where subjectivity increases in value. A subjective evaluation of this load projection is that the annual population growth rate it represents actually lies between two-and-one-half and three percent.

Cartographic Representation

The results of the projection can be stated as a load growth rate or an implied population growth rate, but neither of these figures addresses the two-dimensional nature of the study area--an attribute of central importance in the project design. In this section are presented the two themes of the study: first, because the primary responsibility of the field staff is for the <u>unit projections</u>, they are isolated from the other determinants of load and displayed graphically; second, the overall focus of the study, <u>electrical load</u>, is mapped.

The data as portrayed in Figures 9, 10, 11, 15, 16, and 17 do fairly represent the present and projected circumstances, but the data units do <u>not</u> represent the conformation or resolution of the projected zones. Figure 6 shows a sample of zones in Corvallis. The numbers on the map refer to the specific occurrence of a given zone type, that is, the "6" means that the area indicated is the sixth designated M-1 zone in Corvallis. The border of the map corresponds to the rectangle with an asterisk in its northwest corner in Figures 15, 16, and 17. As their notations specify, the "Study Area Detail" covers a quarter section, or 160 acres.

THE UNIT PROJECTION FIGURES. Because of the non-standardized and equivocal nature of industrial, commercial, and public zone "units," Figures 8, 9, 10, and 11 deal only with residential units or population.

The increasing saturation of residential zones is shown in Figure 7. A single symbol is used to represent the present and projected saturation levels, the projected gain in saturation, the projected 1987 population, and the urban/rural population ratio of zones having one of the 66 growth characteristics discernible on the triangular lattice. The data for the figure, compiled from 256 residential zones, do not include the people living in industrial, commercial, or public zones. Presently there are about 3,500 such people.

The circle graduations in Figure 7 are based on the scaling method suggested by Flannery (1971), which employs the psychological perception of circular areas rather than strict metrical proportion. The size of each circle represents the projected 1987 population of all zones which have the growth characteristics of the particular three-line intersection. For example, 43 zones with a total of over 6,300 people are represented at the apex, however, at 55 of the other 65 intersections five or fewer zones are combined.

If the <u>potential</u> population of the residential zones is of interest, the ultimate capacity of the zones at each intersection may be readily calculated. Given an indicated 1987 population, the ultimate capacity is the 1987 figure times the reciprocal of the 1987

Study Area Detail

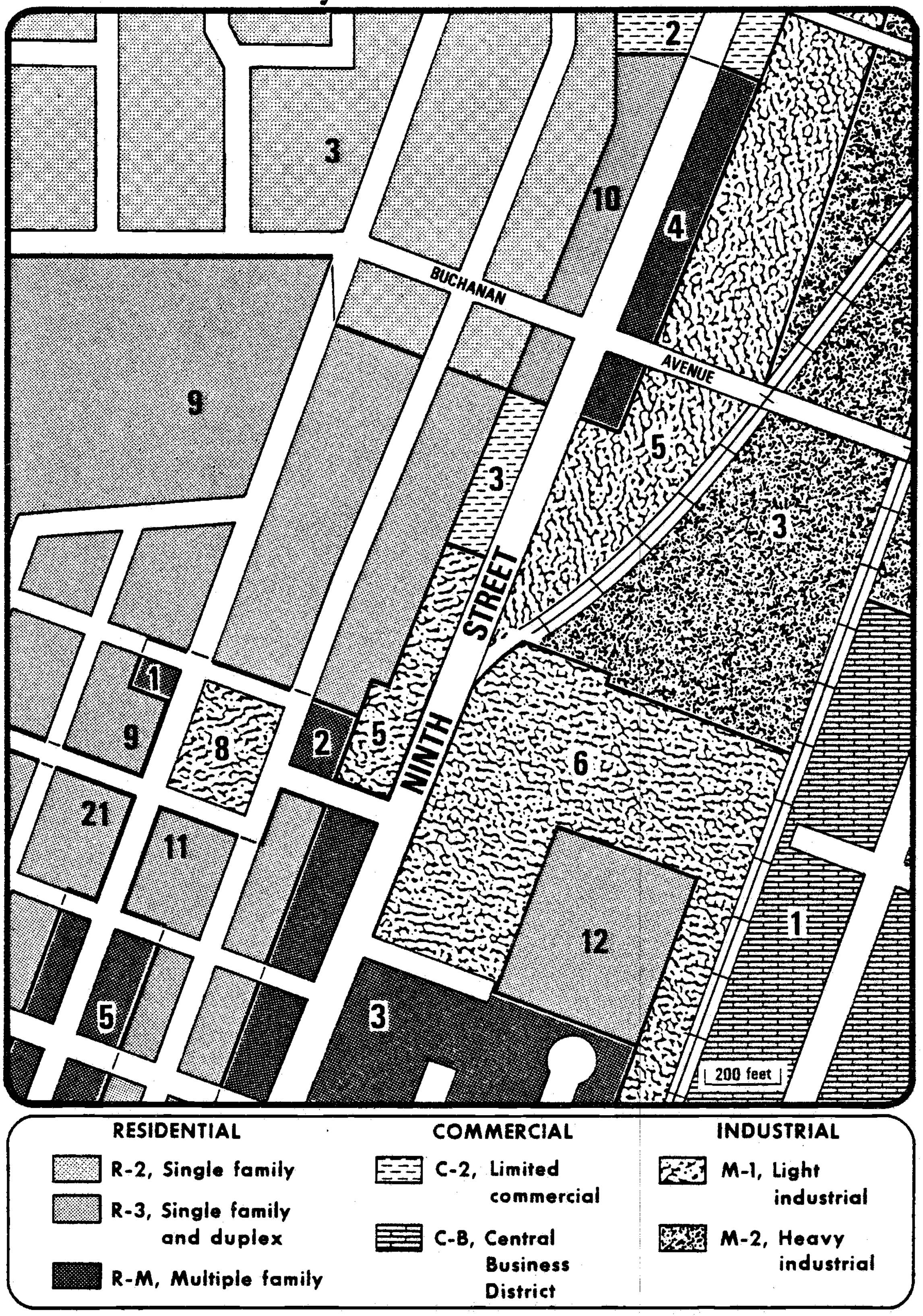

Figure 6

saturation factor. Thus, zones which in 1987 are 20 percent saturated with a projected population of 4,000 have a potential to hold 20,000 people (4,000)(1/0.2). Figure 8 offers some interpretive diagrams relating to Figure 7.

Figures 9, 10, and 11 put the unit projections into their geographic relationships. These maps, unlike Figure 8, account for all the people in the study area rather than selecting only those in residential zones. They employ sections as data units, in keeping with the format of the load density maps, which are discussed later. The population is distributed in two steps: 1) the group population is assigned to the sections in which it occurs,[21] and 2) the schedule 04's are assigned to the sections where they occur and are multiplied by the appropriate household size.

In the process of compiling zone-by-zone data into sectional data, a few people are misplaced, but none are "lost." In both urban and rural situations, any zone which falls fully within a section has its population given to that section. In the case of a zone straddling two or more sections, the urban and rural approaches differ. For urban zones which are fairly uniformly occupied and are expected to remain so, their population is distributed to the sections in proportion to their zone area in each section. For some urban zones there may be a present

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21. This is usually clear-cut, however, the University's group population occurs in three sections. For this circumstance, the separate living unit populations go to their appropriate sections, a process which in one instance entails separating adjacent dormitories.

Growth Pattern for Residential Zones

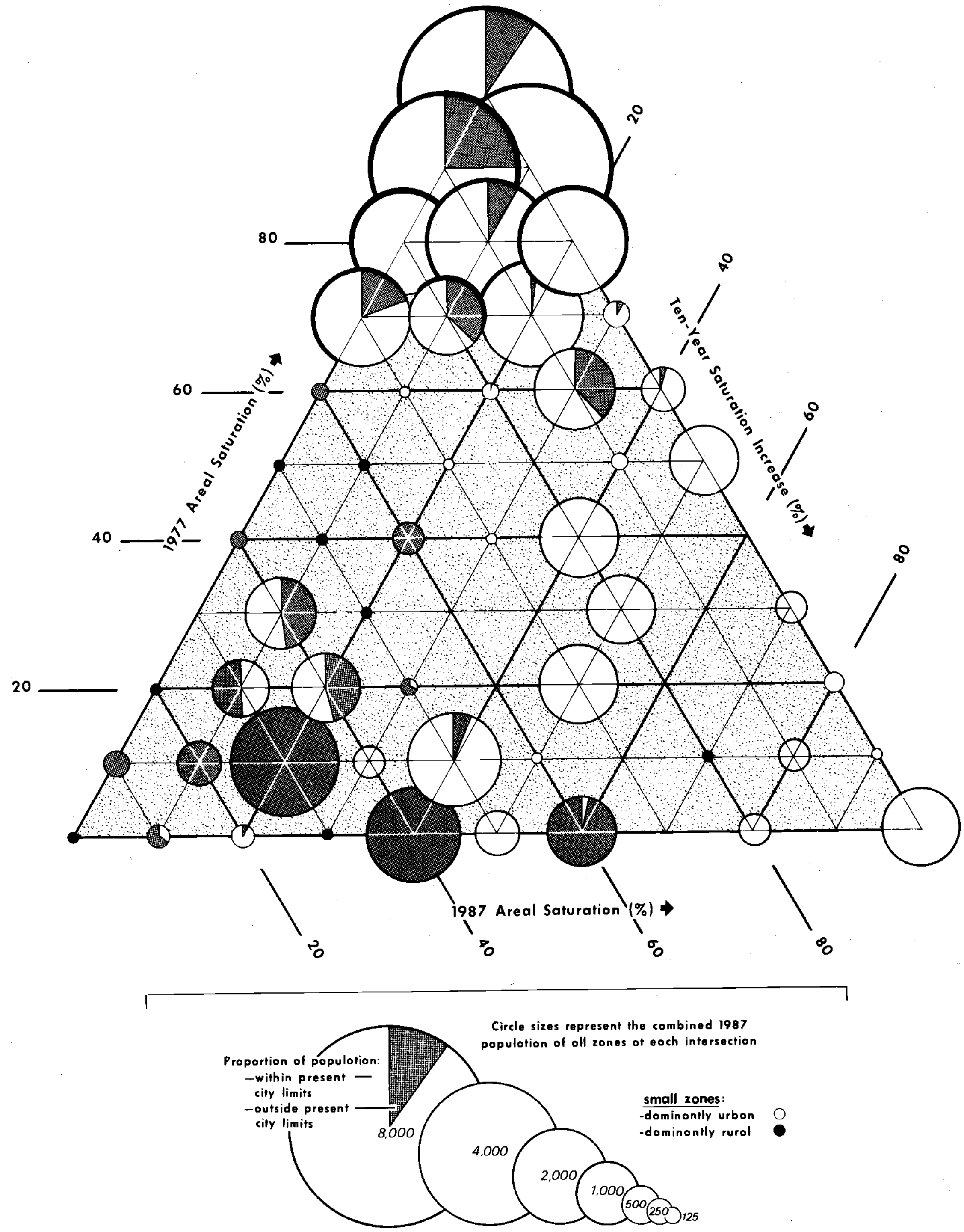


Figure 7

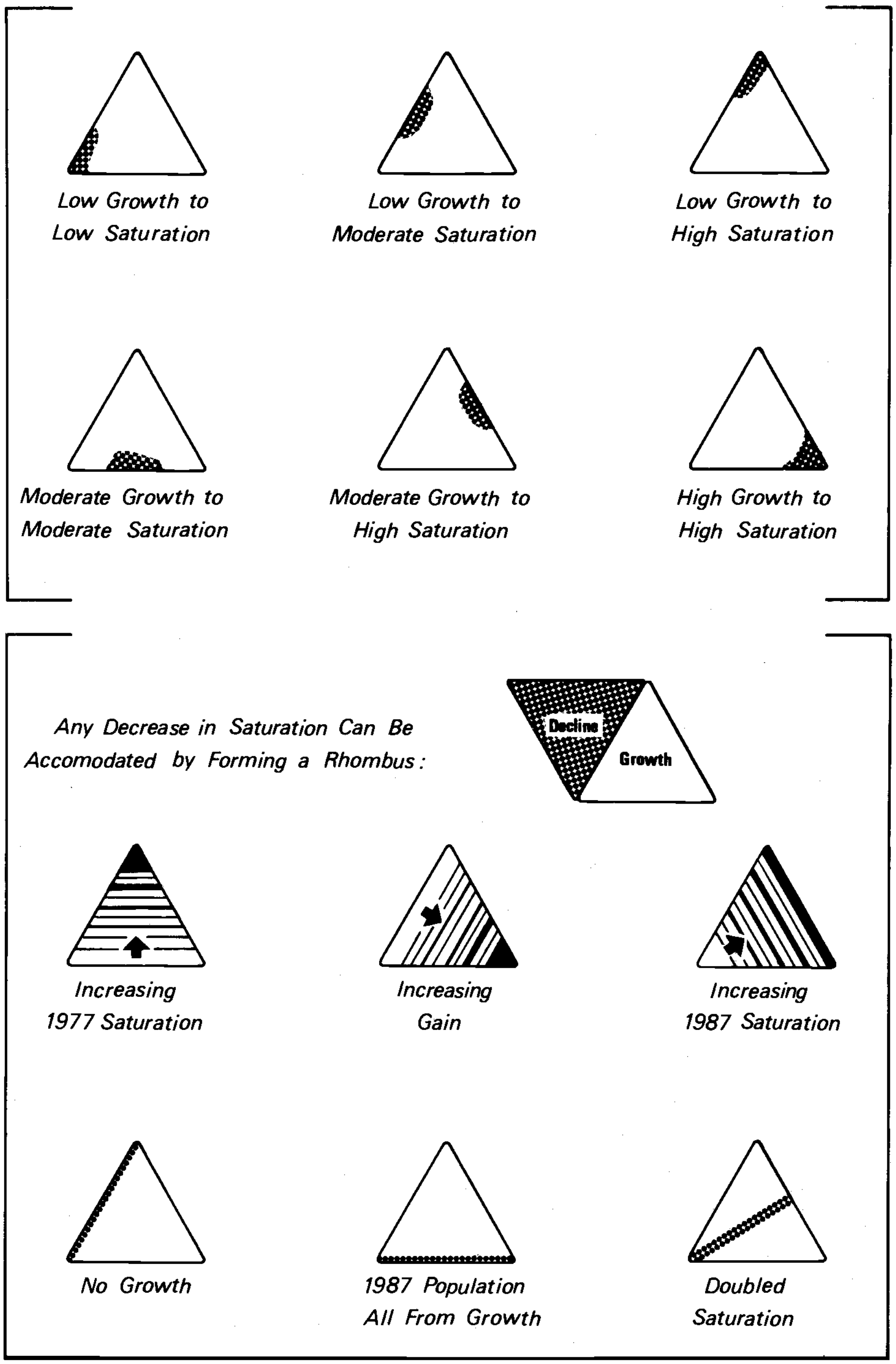


Figure 8. Graphical outlines of residential zone growth patterns in Figure 7.

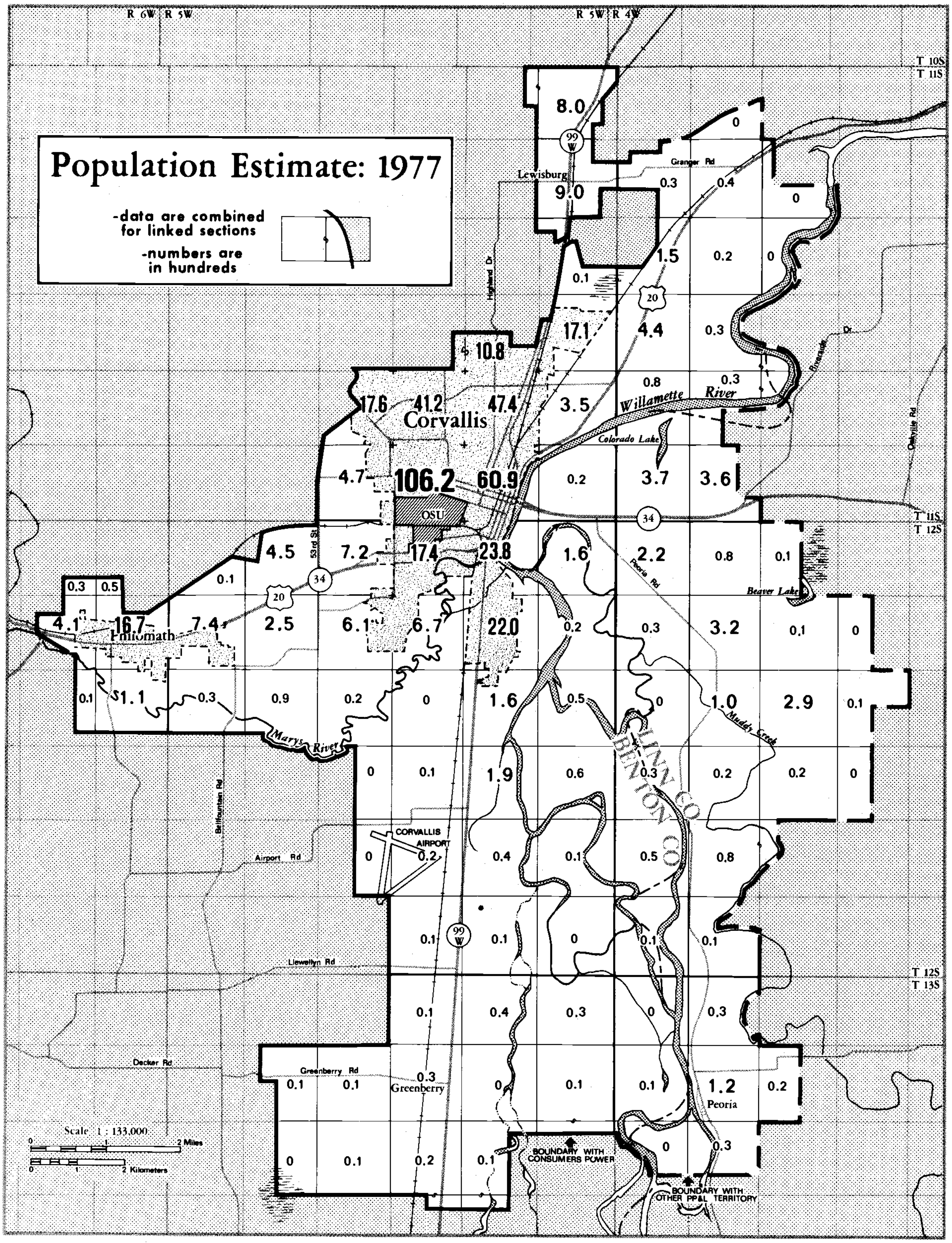
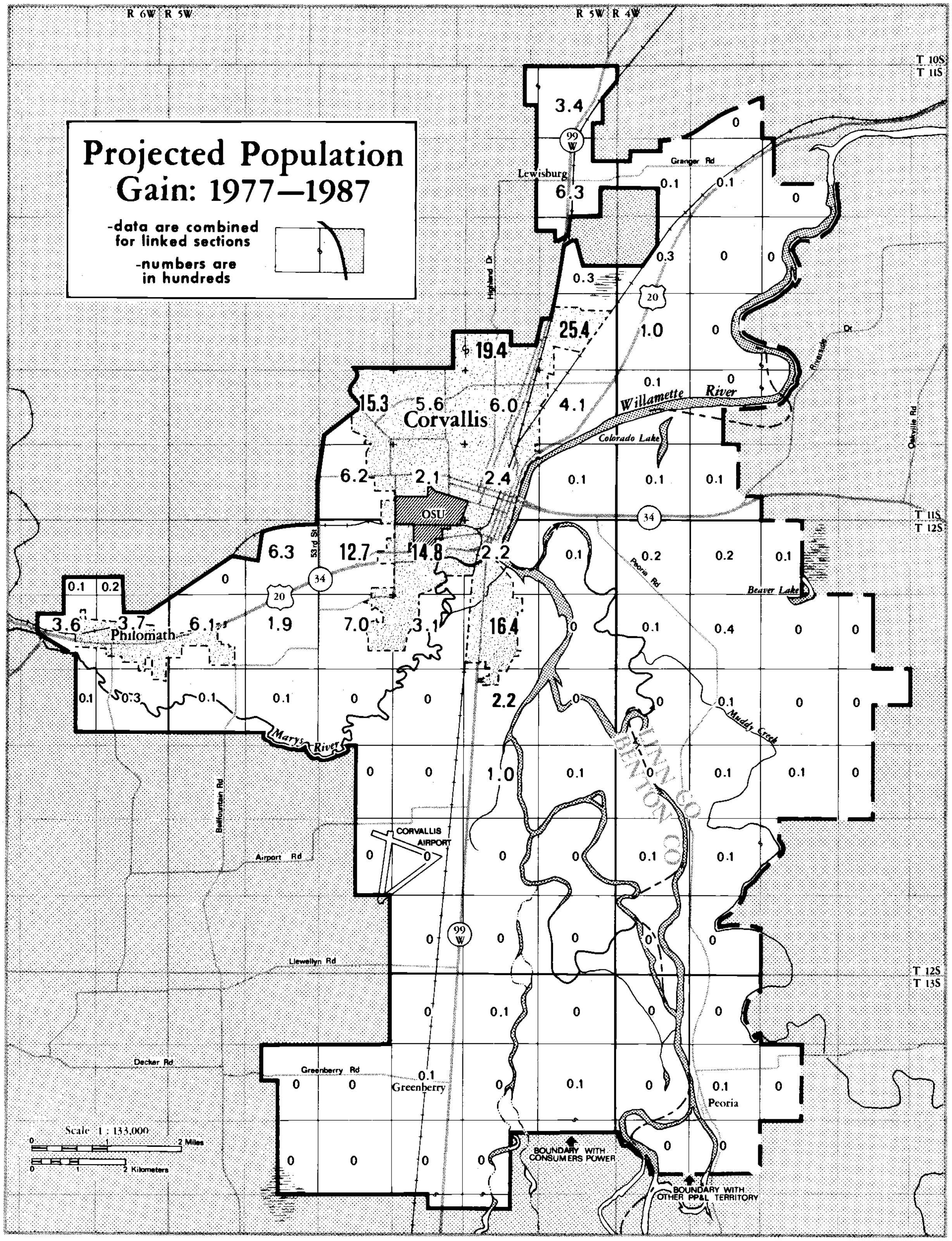

Population Estimate: 1977
-data are combined for linked sections
-numbers are in hundreds
R 6W R 5W
R 5W R 4W
T 10S
T 11S
T 12S
T 13S
Lewisburg
Granger Rd
Highland Dr
Corvallis
OSU
Willamette River
Colorado Lake
Philomath
53rd St
Peoria Rd
Beaver Lake
Marys River
Muddy Creek
LINN CO
BENTON CO
Bellfountain Rd
CORVALLIS AIRPORT
Airport Rd
Llewellyn Rd
Decker Rd
Greenberry Rd
Greenberry
Peoria
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY
Scale 1 : 133,000
2 Miles
2 Kilometers

Figure 9



Projected Population Gain: 1977—1987
-data are combined for linked sections
-numbers are in hundreds
Corvallis
Philomath
Lewisburg
Greenberry
Peoria
OSU
Willamette River
Marys River
Colorado Lake
Beaver Lake
Muddy Creek
CORVALLIS AIRPORT
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY
LINN CO
BENTON CO
Scale 1 : 133,000

Figure 10

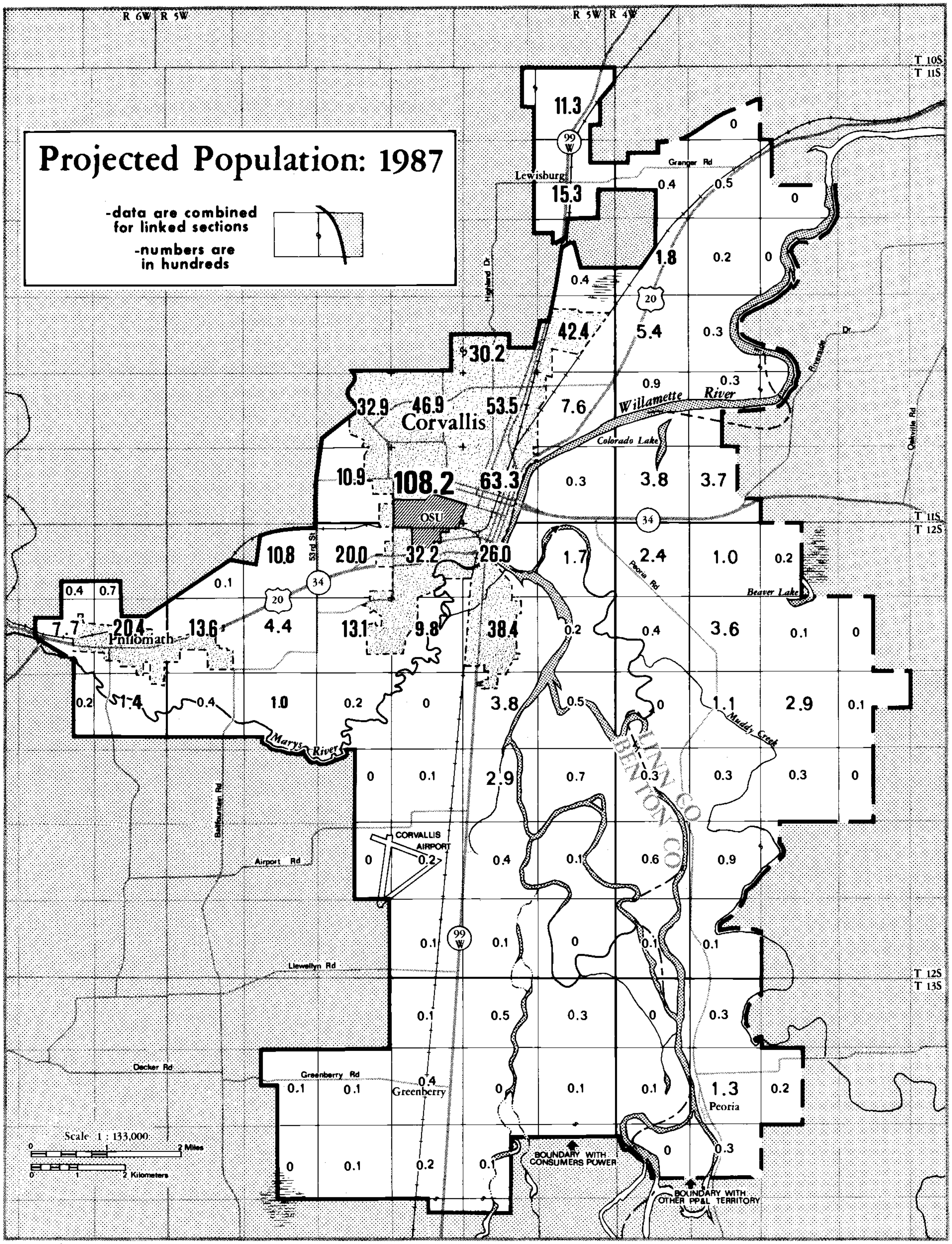

Projected Population: 1987
-data are combined for linked sections
-numbers are in hundreds
Corvallis
Philomath
Lewisburg
OSU
Willamette River
Marys River
Colorado Lake
Beaver Lake
Muddy Creek
LINN CO
BENTON CO
CORVALLIS AIRPORT
Greenberry
Peoria
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY
Granger Rd
Highland Dr
53rd St
Peoria Rd
Airport Rd
Bellfountain Rd
Llewellyn Rd
Decker Rd
Greenberry Rd
Riverside Dr
Oakville Rd
R 6W R 5W
R 5W R 4W
T 10S T 11S
T 11S T 12S
T 12S T 13S
Scale 1 : 133,000
2 Miles
2 Kilometers

Figure 11

or expected imbalance of occupation. The concentrations or shifts are taken into account in such cases.[22]

For the rural zones straddling section lines, the use of the field maps, which have all schedule 04's plotted, enables the present population to be distributed to sections on a unit-by-unit basis. The present ratio of zone population per section is retained unless there is a well-grounded insight on the distribution of future development.

THE LOAD PROJECTION MAPS. Figures 15, 16, and 17 include data from all determinants of load:

1) residential units and their present and projected consumption per unit;
2) commercial units and their present and projected consumption per unit;
3) industrial zone saturation levels and the present and projected load densities of occupied areas;
4) public zone saturation levels and their load densities;
5) the present and projected demand of existing large loads.

Data Compilation. The load for each section is calculated in a manner analogous to the above description of distributing residential units and group housing. Each residential unit is assumed to have the average per-unit consumption of the zone in which it lies. The projected units are assumed to have a specified higher usage per unit.

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22. As an example, one large residential zone is evenly divided between two sections. The present population distribution between them, however, is 80 percent-20 percent. Because virtually all future development will occur at higher than present densities in the sparsely occupied portion, the 1987 population reverses the sectional dominance to 40 percent-60 percent.

Commercial units are handled in the same way, except that the increasing usage per unit infers a slower growth rate than for residential units. The load from public and industrial zones is also assigned to sections in the manner described for the residential unit projections. The large loads are somewhat like the previous sections's group population: every large load except one, the University, falls entirely within one section. The University receives current in the form of a high-voltage input at its Beaver substation south of Parker Stadium and distributes the load on its own underground system. Rather than show all the load being delivered to one point, the substation, the load is assigned to three different sections in proportion to the size and estimated electrical intensity of the University facilities which lie in them.

Section 26 of Township 11 South, Range 5 West is used as an illustration of load compilation. It contains the "S" in "Corvallis" on the load maps. Its demand is derived from 22 complete zones and eight partial zones which have a total present demand of 7,548 kw and a projected demand of 13,646 kw. Additionally, there are 11 large loads with a present demand of 2,108 kw and a projected demand of 3,599 kw. Thus, for section 26, the load density maps show a 1977 demand of 9,656 kw, an added demand of 7,589 kw, and a 1987 demand of 17,245 kw.

<u>Map design</u>. The load density maps are designed with several objectives in mind:

1) to create an immediate impression of the areas of high and low load density;

2) to allow, upon closer examination, a nice discrimination

of load densities, almost to the point of tabular format, but in a geographic framework;

3) to employ a standarized symbolization which moderates the inherent visual complexity of 464 projection units of widely ranging size and shape;

4) to enable a correlation of load density with real-world locations in the study area by providing sufficient detail in the base map;

5) to limit the presentation to a page-size format.

The central design problem is the representation of electrical load. The matters of visual balance, typography, the figure-ground relationship, and so on, are not inconsequential, but they are left to the reader's own review and rumination.[23]

Regarding the representation of electrical load, the map reader can observe the following characteristics of the data units: 1) they are square except when divided by the study area boundary, and 2) graduated amounts of blue ink are found in each one, with little arrows in them pointing every which way but up.

The squares are approximations of surveyed sections. The sections are used as data units because:

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23. Two details must be pointed out, however. First, the moiré pattern bordering the city limits is an attempt to raise the visual prominence of said boundaries without resorting to heavy applications of ink. The effect is produced by the orthogonal overprinting of a 120-line transfer screen and the printer's 133-line screens (thus the pattern repeats 13 times per inch). Second, an apparent neocortical lesion has caused the cartographer to conclude that two times 61,500 equals 133,000. The true map scale of all study area maps, as the scale bars correctly indicate, is 1:123,000.

1) they eliminate the cluttered appearance that would result from mapping individual or aggregated projection units;

2) they provide a conventional geographic grid to enable referral to larger-scale maps for more detailed examination of the make-up of each section;

3) they fall within the range of adequate areal resolution for the purposes of this study's analysis stage (see Figure 2).

It is felt that sections having the same load intensity should be portrayed in the same manner. Therefore load density, rather than pure demand, is used in the data compilation. This means that a section with a demand of 1,000 kw from accounts in the study area, but which is only 50 percent inside it, has the same area symbol as a section which is fully within the study area and has a demand of 2,000 kw.

The load class symbolization within each section has color, form, and numerical correlation. The choice of blue as the second color is strongly argued: it is the hydrographic convention; it has high "pleasingness value" (Robinson, 1967); it strikes no conflict with the idea of electrical load density (hydroelectricity?); and, most importantly, it is favored by the head of Pacific's Load Forecasting and Analysis Department, through whom printing costs were covered.

The form of the symbols is chosen to provide clear class differentiation and to convey the sense of a wide range of electrical load intensity. There is approximately a 60-fold increase in area inked between the lowest and highest classes. The near-empty appearance of the sections in the lowest two classes corresponds to the field impression one gains of them: the sections are nearly devoid of consumptive devices.

Quantitatively, the load densities range from zero to over 26,000 kw per square mile. Using the data for the projected 1987 load map, Figure 12 shows the occurrence of given load densities to be strongly skewed toward the low end. The figure's scale is logarithmic to accomodate the spread. To discriminate among the many sections of lower density and to isolate the few of very high density, the classification system uses arithmetically increasing but proportionally decreasing class increments. For the nine load classes, the eight points of division between them are defined as

$$\frac{22,500}{(n+1)!\ (0.5^n)} \quad \text{, for } n = 1 \text{ through } 8,$$

in which n=1 is the division between the highest and second-highest classes, and n=8 is the division between the lowest and second-lowest classes. The nine load classes (in kw per square mile) derived by the above method are, with slight rounding in the lowest three classes: 0-16, 16-72; 72-290; 290-1,000; 1,000-3,000, 3,000-7,500; 7,500-15,000; 15,000-22,500; and over 22,500.

The desire to retain most of the accuracy of compilation leads to the use of an arrow in each data unit: the orientation of the arrows provides a gray-scale of finer resolution within each load class. Figure 13 is an aid to interpolation, but it should not be inferred that 20-percent steps are used on the maps--the arrows

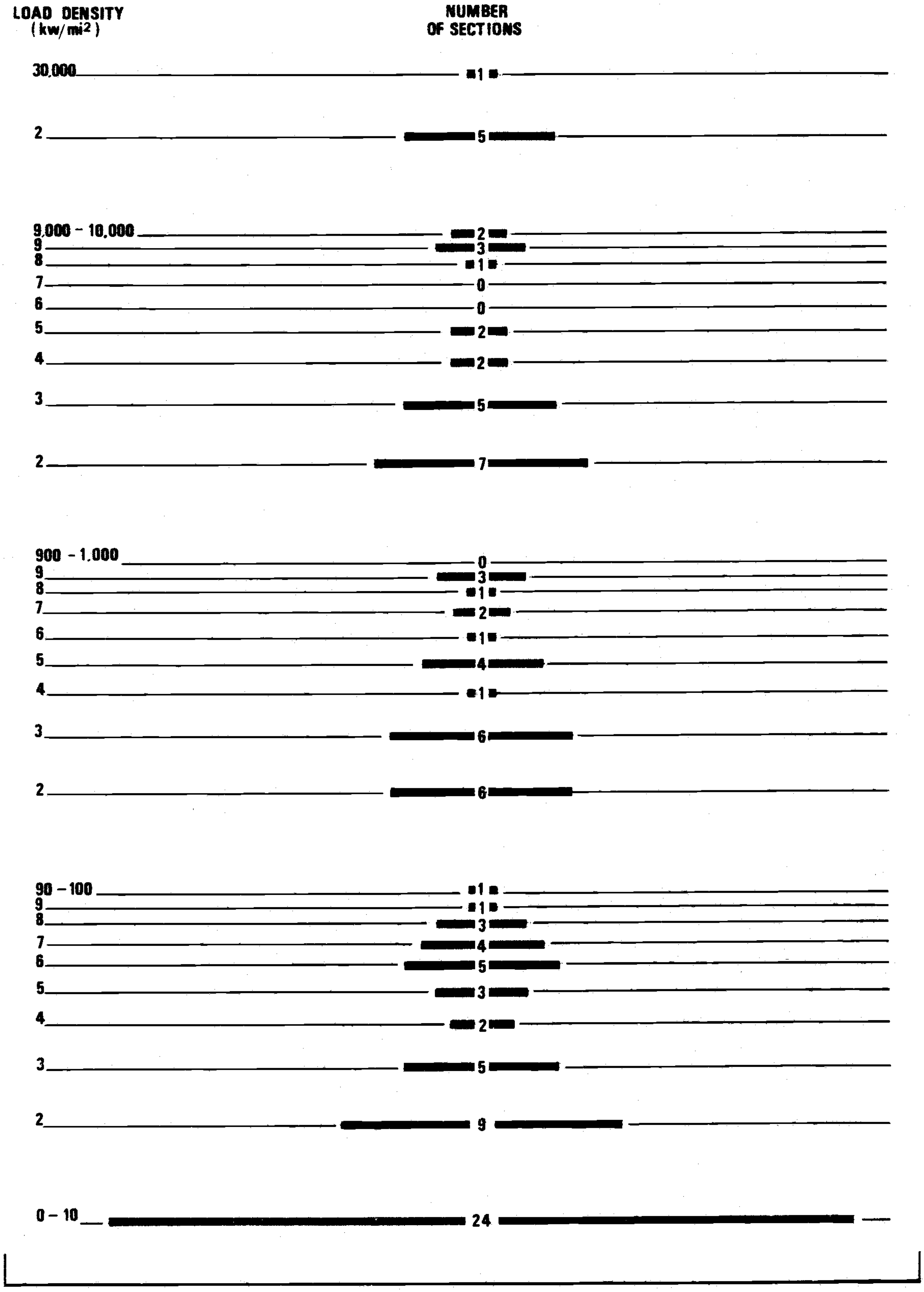


Figure 12. Distribution of sections by load density: projected 1987 data.

are oriented with much more precision than that. The absence in the figure of the highest load class is due to its being open-ended.

Map production. Linework for the maps is at about twice the final scale except for the "gray scale" arrows, which were added at scale for each map after the production of color proofs. Transfer screens are used on the ten-percent blue hydrography and the ten-percent black city limit borders; otherwise, all area tints are from peel coats. Counting the peel coats, negatives, and positive masks, the three load density maps are made from 14 separations, six of which are common to all three. Figure 14 and Table 16 summarize the production processes.

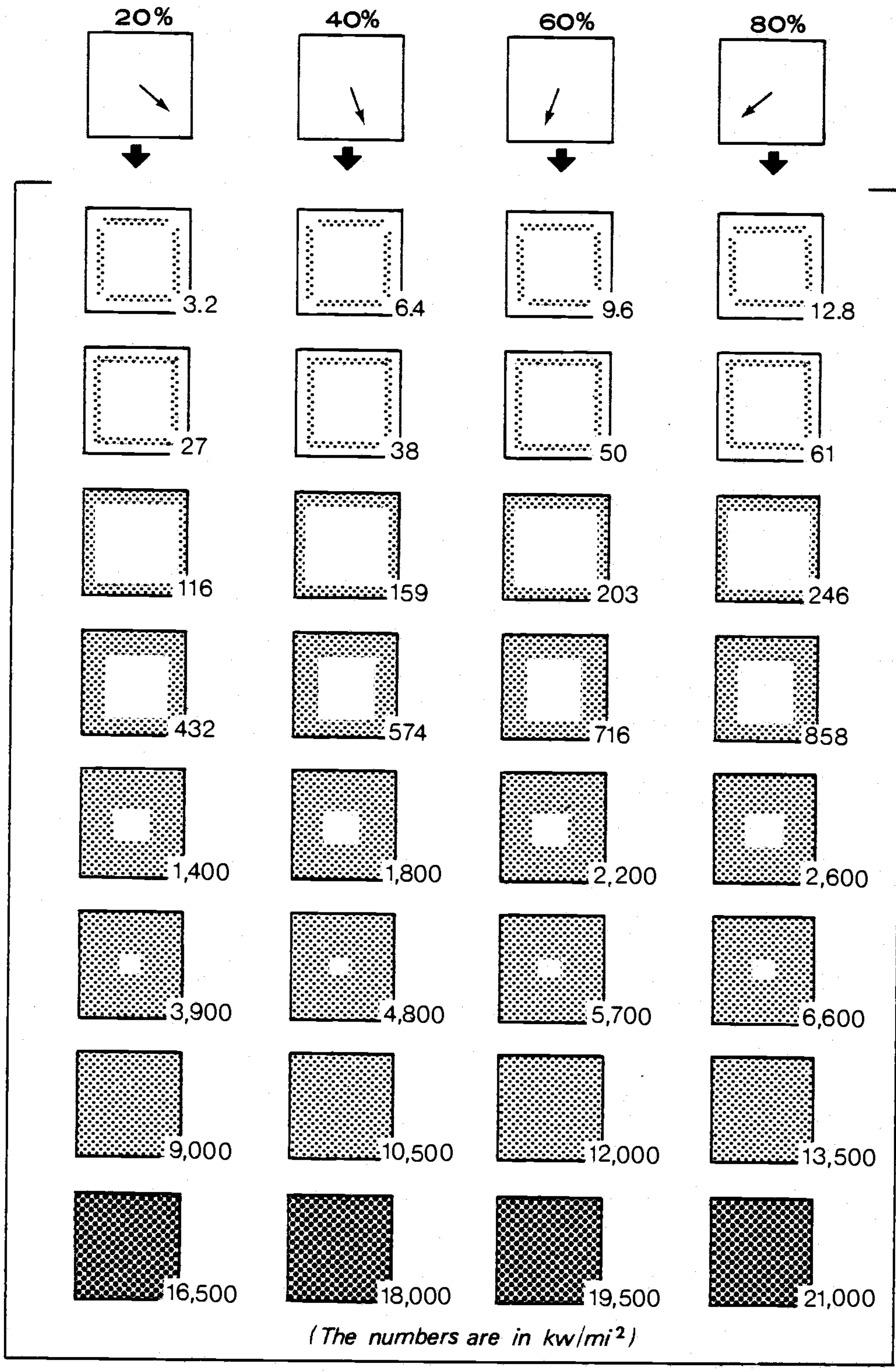


Figure 13. Interpolative guide for Figures 15, 16, and 17.

Printing Plate Production

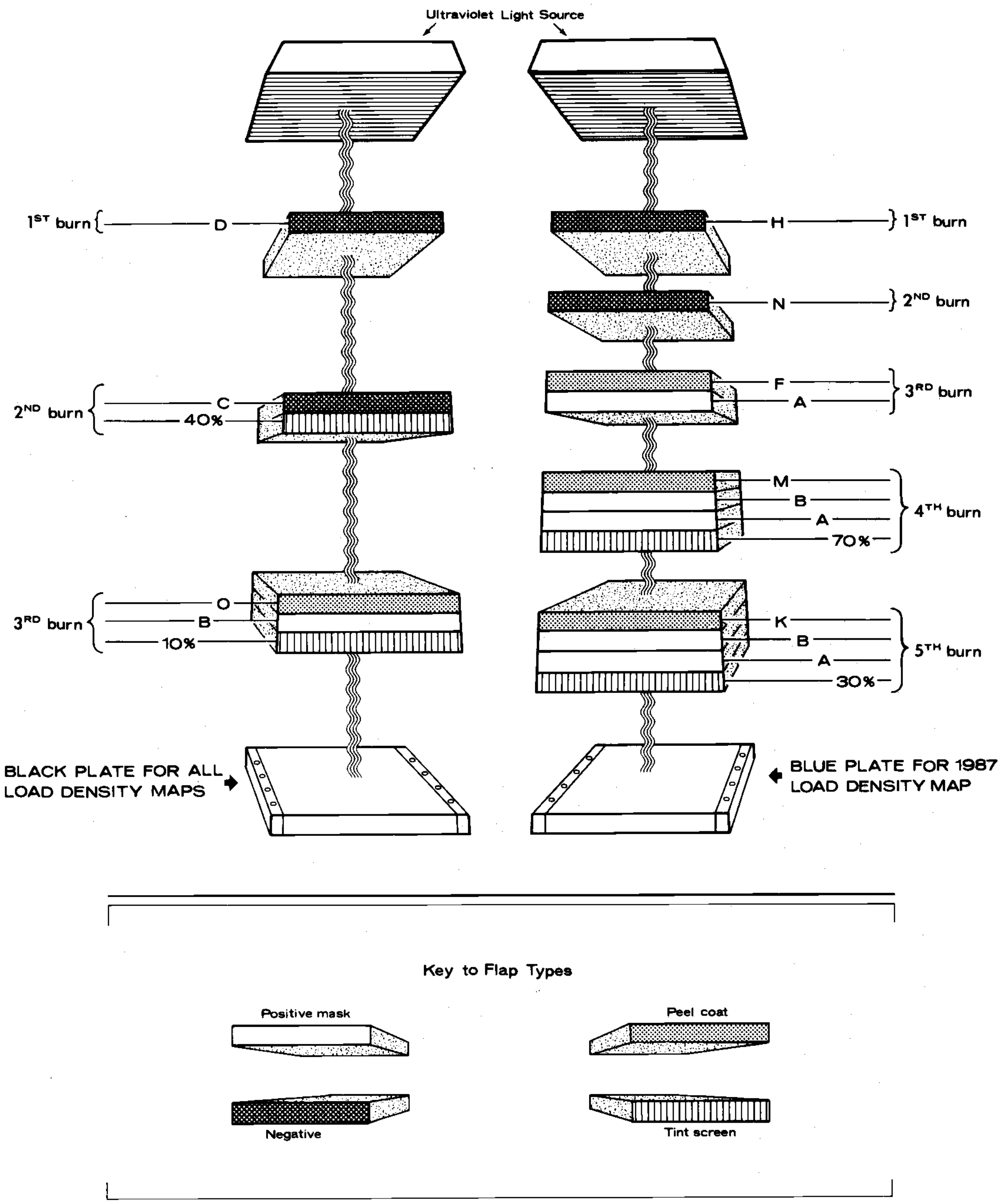


Figure 14

Table 16. Key to separations in Figure 14.

Designation	Flap Type	Description
Flap A	Positive	Mask for Corvallis and Philomath city streets
Flap B	Positive	Mask for tinted hydrography
Flap C	Negative	40% black: neat line, highways and roads, section lines outside study area, "Linn Co." and "Benton Co."
Flap D	Negative	100% black: black lettering and linework (legend boxes, runways, city limits, section lines in study area, OSU and "Detail" outlines, non-fluvial county bounds, scale bars, RR tracks)
Flap N	Negative	100% blue: arrows
Flap H	Negative	100% blue: study area boundary, hydrographic symbols & lettering, legend block
Flap K	Peel coat	30% blue: area symbols for densities from 0-15,000 kw/mi^2
Flap M	Peel coat	70% blue: title block with lettering mask, area symbols for densities from 15,000-22,500 kw/mi^2
Flap F	Peel coat	100% blue: area symbols for densities over 22,500 kw/mi^2
Flap O	Peel coat	10% black: land outside the study area

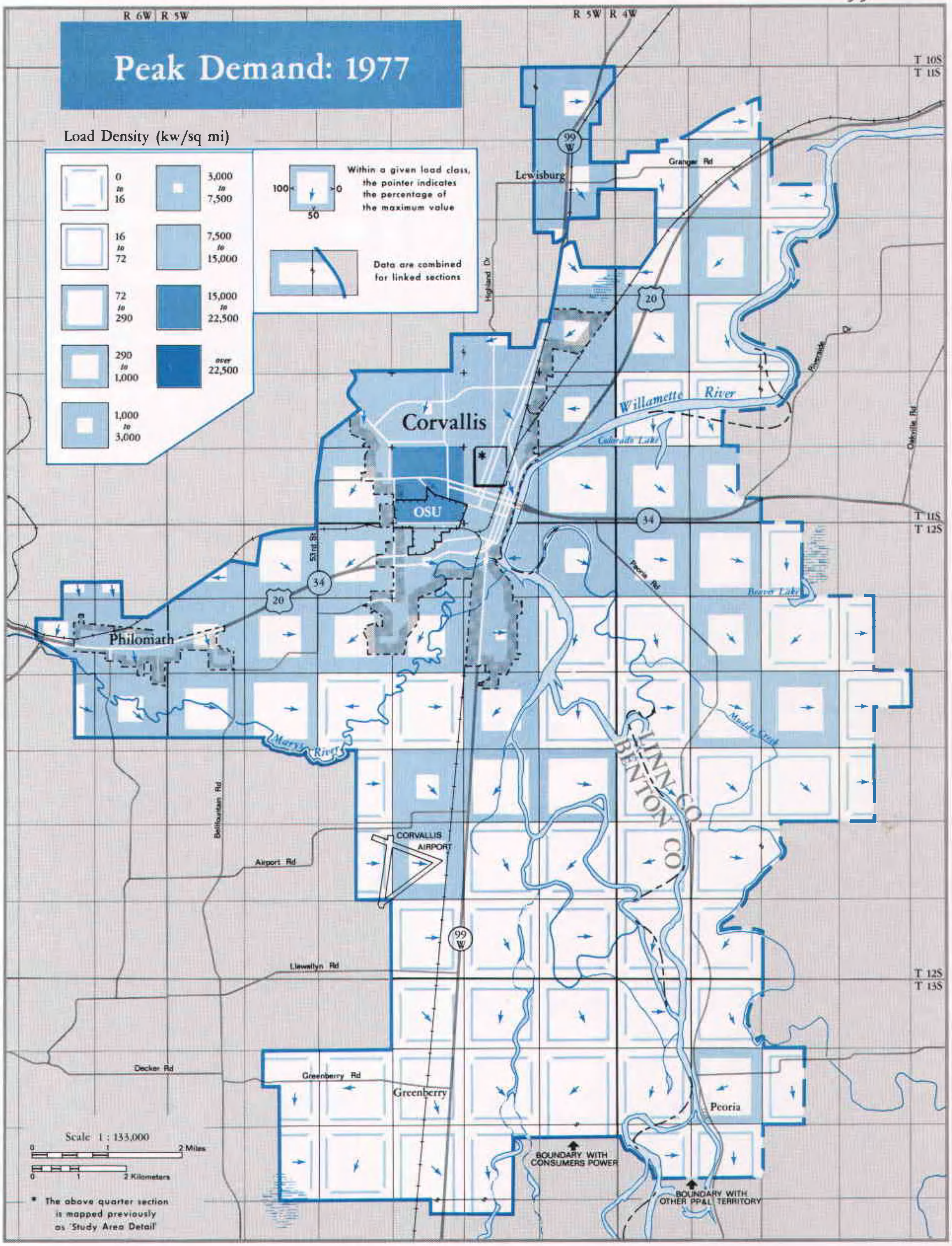
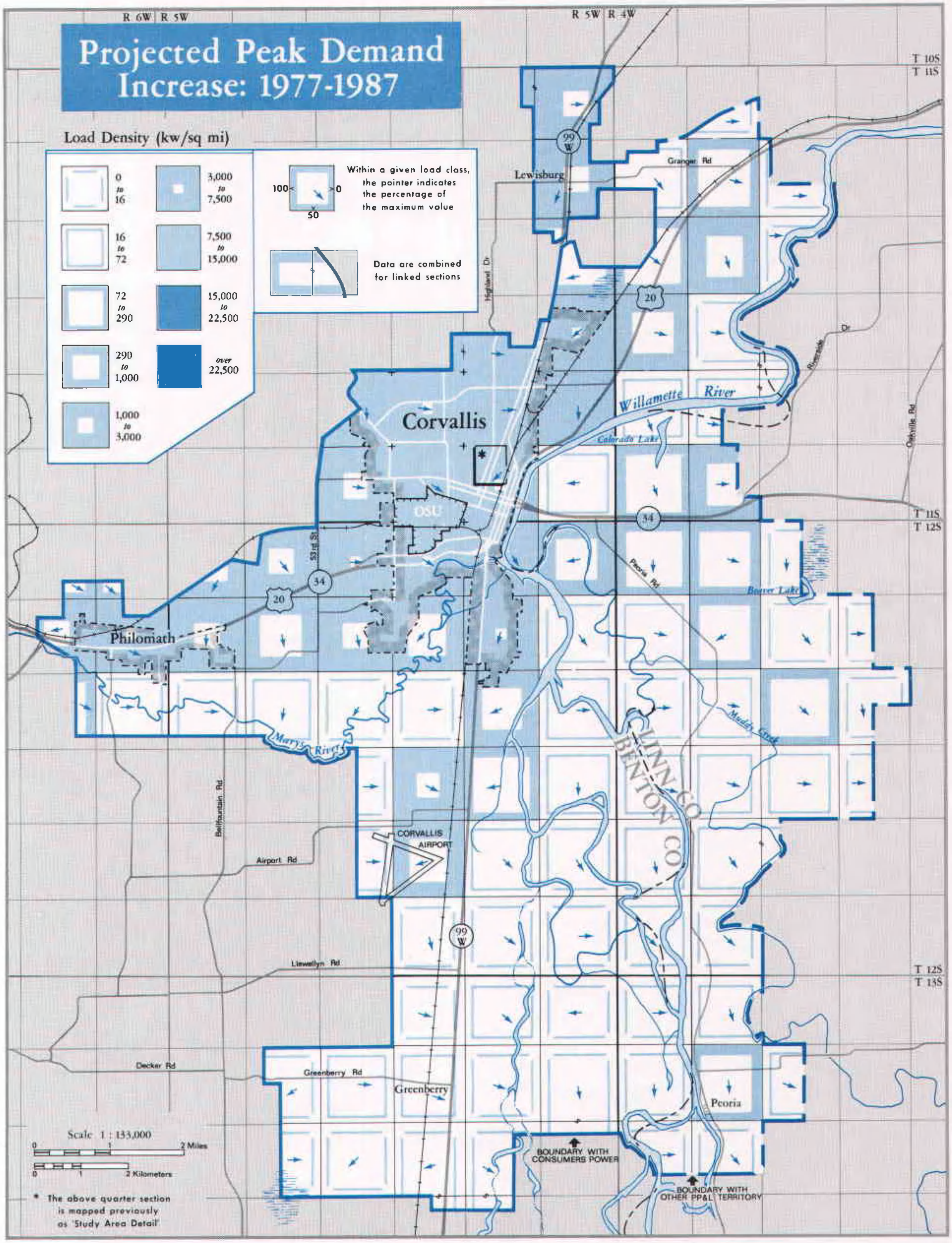

Peak Demand: 1977
Load Density (kw/sq mi)
0 to 16
16 to 72
72 to 290
290 to 1,000
1,000 to 3,000
3,000 to 7,500
7,500 to 15,000
15,000 to 22,500
over 22,500
Within a given load class, the pointer indicates the percentage of the maximum value
100
0
50
Data are combined for linked sections
R 6W
R 5W
R 5W
R 4W
T 10S
T 11S
T 11S
T 12S
T 12S
T 13S
Lewisburg
Granger Rd
Highland Dr
Corvallis
OSU
Willamette River
Colorado Lake
Philomath
Marys River
53rd St
Peoria Rd
Beaver Lake
Muddy Creek
LINN CO
BENTON CO
Bellfountain Rd
Airport Rd
CORVALLIS AIRPORT
Llewellyn Rd
Decker Rd
Greenberry Rd
Greenberry
Peoria
Riverside Dr
Oakville Rd
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY
Scale 1 : 133,000
2 Miles
2 Kilometers
* The above quarter section is mapped previously as 'Study Area Detail'

Figure 15



Projected Peak Demand Increase: 1977-1987
Load Density (kw/sq mi)
0 to 16
16 to 72
72 to 290
290 to 1,000
1,000 to 3,000
3,000 to 7,500
7,500 to 15,000
15,000 to 22,500
over 22,500
Within a given load class, the pointer indicates the percentage of the maximum value
100
0
50
Data are combined for linked sections
R 6W R 5W
R 5W R 4W
T 10S
T 11S
T 12S
T 13S
Lewisburg
Corvallis
OSU
Philomath
Greenberry
Peoria
Willamette River
Colorado Lake
Beaver Lake
Marys River
Muddy Creek
LINN CO
BENTON CO
CORVALLIS AIRPORT
Airport Rd
Llewellyn Rd
Decker Rd
Greenberry Rd
Granger Rd
Highland Dr
53rd St
Bellfountain Rd
Peoria Rd
Riverside Dr
Oakville Rd
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY
Scale 1 : 133,000
2 Miles
2 Kilometers
* The above quarter section is mapped previously as 'Study Area Detail'

Figure 16

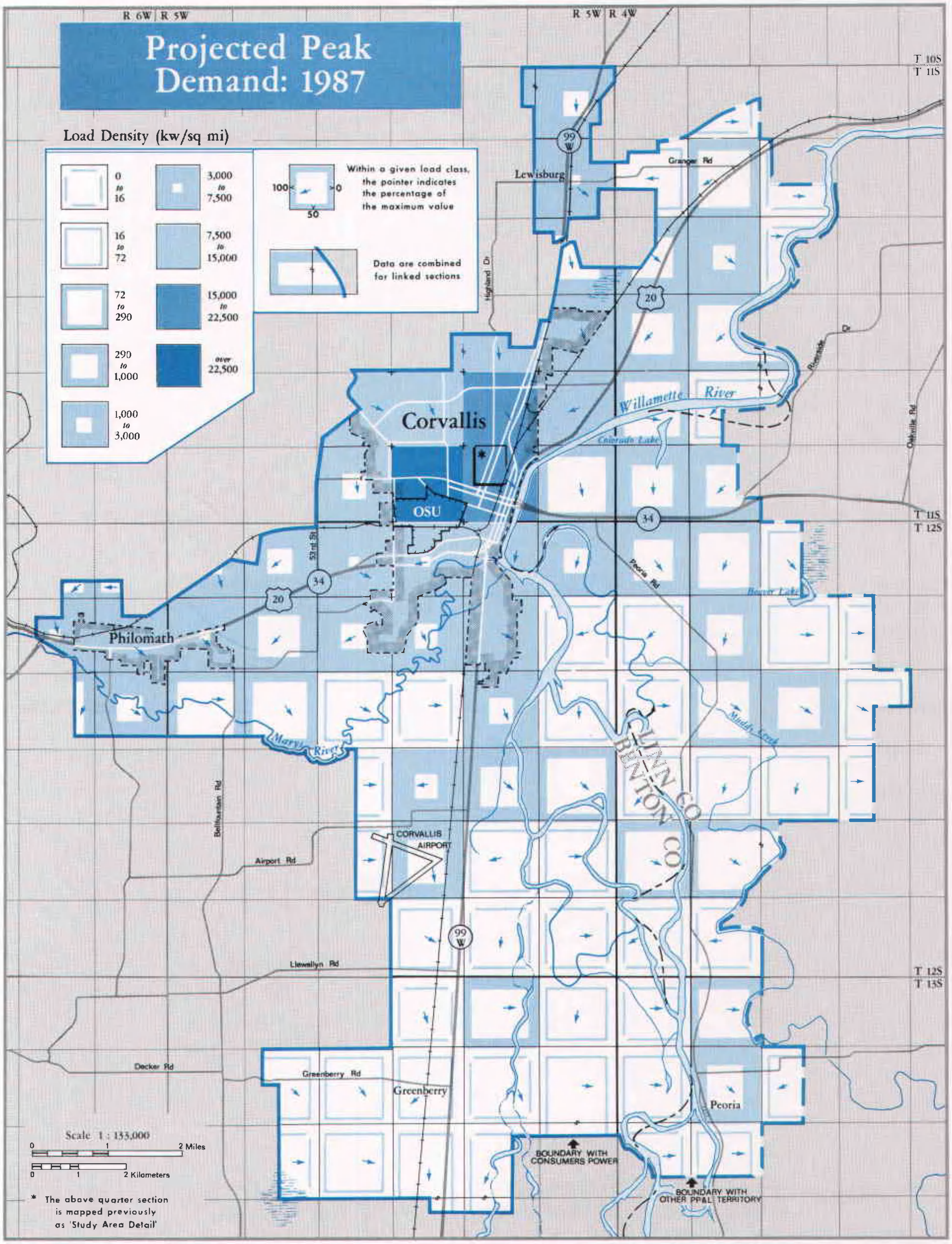

Projected Peak Demand: 1987
Load Density (kw/sq mi)
0 to 16
16 to 72
72 to 290
290 to 1,000
1,000 to 3,000
3,000 to 7,500
7,500 to 15,000
15,000 to 22,500
over 22,500
Within a given load class, the pointer indicates the percentage of the maximum value
Data are combined for linked sections
Corvallis
OSU
Philomath
Lewisburg
Greenberry
Peoria
Willamette River
Marys River
LINN CO
BENTON CO
CORVALLIS AIRPORT
Airport Rd
Llewellyn Rd
Decker Rd
Greenberry Rd
Granger Rd
Highland Dr
Bellfountain Rd
53rd St
Peoria Rd
BOUNDARY WITH CONSUMERS POWER
BOUNDARY WITH OTHER PP&L TERRITORY
Scale 1 : 133,000
2 Miles
2 Kilometers
* The above quarter section is mapped previously as 'Study Area Detail'
R 6W R 5W
R 5W R 4W
T 10S T 11S
T 11S T 12S
T 12S T 13S

Figure 17

IV. CONCLUSION

Summary

Electrical load forecasting is a planning tool used at several geographic and temporal scales. The Corvallis area forecast is an example of a smaller-scale project with an intermediate forecast period. The project seeks to anticipate the magnitude and distribution of the study area load so that additional distribution facilities may be introduced in an efficient and timely manner.

Two elements of the forecast are emphasized in this paper: 1) the methods used to project the nature and intensity of land use ten years in the future, and 2) the cartographic tools used to produce and portray the projection.

The land use methodology is based in part on a finely resolved data resource obtained from map work, field work, and computer processing of all 18,000 customers in the study area. The information derived gives the number and type of customers, electrical usage figures, and historical growth for all projection units, which are based on zoning designations. Including the 81 large customers which are analyzed separately from the above zoning units, the total future load is the sum of 464 individual projections.

Because of the level of detail of this particular study, the more commonly used projective techniques are largely supplanted by the informed judgment of the field staff and others with special knowledge of the area. An external population projection is used for corroboration at the end of the study, rather than for guidance during it, and although not all the elements of the load forecast can be introduced in the comparison, the two works are in general agreement.

The cartographic resources are useful not only in building a data base, but also in the analytical phase of making the projections. The graphical element is more important here, however, in making a comprehensible and enlightening presentation of the projection results. Population growth as well as electrical demand growth are portrayed.

Conclusion

Ideally, load forecasting ought to resemble an ecological study: a system's development is understood through analysis of all its components and their interactions. A wide range of problems prevent load forecasting from applying this principle in much detail. Presently, the most widely used projective technique, extrapolation, uses an utterly opposite approach. Some newer methods, however, develop functional system models akin to those in biological (and other) system studies--econometric-based forecasts being the most prominent of this type. Their limitations are not only of predictive power but also of scale. It is the matter of scale in particular which makes most modeling schemes inappropriate in the Corvallis study.

Although the most objective study is not always the most credible, this study is most open to question for its bulk of subjectivity. It is unnecessary and undesirable to eliminate all of it, but there is a problem during the study of knowing whether its net influence is reasonable. A possible solution may lie in external referencing. In larger-scale forecasts one may integrate disinterested-party forecasts (which seem reasonable) to diminish the self-serving overtones some critics may ascribe to completely in-house projects. For a small study area such as this one, which entails limited accountability, the general guidance of an external projection may serve to reduce the possibility of a load growth rate popping up at the end which is totally unacceptable even to the utility. If this brings to mind: Why do the study if you already know the answer?, it should be noted that the acceptable range may be broad, the other projection is not likely to address electrical load explicitly, and, in any event, the spatial distribution of the projected load is new and useful information.

A problem with all forecasts is knowing when to dig up more details and when to quit. Much could be learned by interviewing every landowner in the territory, but the looming uncertainty of the future can swallow whole a ream of tidbits. On the matter of forming a future image of the study area, it is doubtful whether the reasoning or decisions of the field staff could intelligently differ if this was a nine-year instead of a ten-year projection. Thus it is useful to assess the general capabilities of the study and avoid both pointless labor and glossing over. Examples of both flaws can be noted in the Corvallis forecast.

Besides acknowledging the imperfections in their work, load forecasters should also appreciate that techniques are non-universal. There is, of course, a common body of knowledge, and a particular approach may be suitable in more than one place. But time is better spent in customizing a methodology for a given study area than in developing the forecasting technique or in stuffing a canned forecast into a place it does not fit. It is realistic and probably productive to adopt an attitude like that of some psychologists, who conclude that human behavior is a collection of special cases. Corvallis is certainly a special case, and it was treated as such. Nobody can be sure, however, of the best way to project its electrical future.

The techniques used in the Corvallis study may not be universal, but neither should they be regarded as specific to electrical load concerns. Many other planning projects emphasize the number, location, and activities of people. Remove the usage indicators and this might have been a transportation or water system study. The hopes and dissappointments of forecasting in general are addressed by Heiss, et al. (1973, p. 185), who ". . . downgrade the value of forecasts but uphold the value of forecasting." That is, don't put too much stock in them, but keep them coming.

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APPENDIX A

PROJECTION WORKSHEETS

SINGLE-FAMILY RESIDENTIAL ZONE WORKSHEET

1. Zone description ____________

2. Zone location ____________

3. Map references ________________________
____

4. News articles ____________

5. Zone area ____________ ac.

6. Minimum lot size (MLS) ____________ ac.

7. Street adjustment factor (SAF) ____________

8. Large load adjustment (LLA) ____________

9. Present number of units (PNU)--item d below:
   a) present no. of schedule 04's ______
   b) present no. of schedule 025's ______
   c) residential equivalency value (REV) ______
      (1) calculation of coefficient:

$$\frac{\text{avg. peak use/025}}{\text{avg. peak use/04}} =$$

      (2) REV = (8b)(8c1) =
   d) PNU = (8a) + REV ≐ ____________

10. Total possible no. of units (TPNU)--item j below:

a) total no. of vacant lots less than 2 times MLS ________

b) no. of unbuildable vacant lots ________

Documentation: ____________________________

____

____

____

____

c) net buildable vacant lots (NVL)

(10a) - (10b) = NVL ________

d) total acreage of lots larger than 2 times MLS ________ac.

e) acreage of undevelopable large lots ________ac.

Documentation: ____________________________

____

____

f) acreage of developable large lots (LL) ________ac.

(10d) - (10e) = LL

g) no. of schedule 04's occupying developable large lots (SLL) ________

h) net possible no. of units from developable large lots (NDU):

$$NDU = \frac{(LL)(SAF)}{MLS} - SLL$$ ________

i) projected no. of residential equivalent units (PRE) ________

j) <u>TPNU</u> = PNU + NVL + NDU + PRE ____________

Additional documentation and comments: ________

____

____

____

____

11. Future no. of units (FNU), 10-year estimate ____________

a) historical gains (5 yr.):

1) schedule 04 ________

2) schedule 025 ________

b) estimate of residential units only ________

Documentation and assumptions for FNU estimate: ______________________

____

____

____

____

____

12. Calculation of saturation factors:

a) present saturation (PS)

$$PS = \frac{PNU}{TPNU}$$ ____________%

b) future saturation (FS)

$$FS = \frac{FNU}{TPNU}$$ ____________%

MULTIPLE-FAMILY RESIDENTIAL ZONE WORKSHEET

1. Zone description ____________

2. Zone location ____________

3. Map references ____________________
____

4. News articles ____________

5. Zone area __________ ac.

6. Empirical lot size (ELS) __________ ac.

7. Street adjustment factor (SAF) ____________

8. Large load adjustment (LLA) ____________

9. Present number of units (PNU)--item d below:
   a) present no. of schedule 04's ________
   b) present no. of schedule 025's ________
   c) residential equivalency value (REV) ________
      (1) calculation of coefficient:

      $$\frac{\text{avg. peak use/025}}{\text{avg. peak use/04}} =$$

      (2) REV = (8b)(8cl) =
   d) PNU = (8a) + REV = ____________

10. Total possible no. of units (TPNU)--item h below:

a) total no. of vacant lots less than 10,000 sq. ft. _______

b) no. of unbuildable vacant lots _______

Documentation: __________________________

____

____

____

____

c) net buildable vacant lots (NVL)

(10a) - (10b) = NVL _______

d) total acreage of developable vacant lots greater than 10,000 sq. ft. (VAM) _______ ac.

e) total acreage from demolition (DA)--item 3 below:

(1) acreage occupied by single-family units (SFAM) _______ ac.

(2) demolition rate for single-family units (DR) _______

(3) DA = (SFAM)(DR) _______ ac.

f) net possible units from vacant and demolished acreage (NPU)

$$NPU = \frac{(VA + DA)(SAF)}{ELS} - \text{no. of units demolished}$$ _______

g) projected no. of residential equivalent units (PRE) _______

h) <u>TPNU</u> = PNU + NVL + NDU + PRE __________

Additional documentation and comments: ________

____

____

____

____

11. Future no. of units (FNU), 10-year estimate ____________

   a) historical gains (5 yr.):

      1) schedule 04 ________

      2) schedule 025 ________

   b) estimate of residential units only ________

   Documentation and assumptions for FNU estimate: ________________

   ____

   ____

   ____

   ____

   ____

12. Calculation of saturation factors:

   a) present saturation (PS)

   $$PS = \frac{PNU}{TPNU}$$ ____________ %

   b) future saturation (FS)

   $$FS = \frac{FNU}{TPNU}$$ ____________ %

COMMERCIAL ZONE WORKSHEET

1. Zone description ____________
2. Zone location ____________
3. Map references ________________________
   ____
4. News articles ____________
5. Zone area __________ac.
6. Empirical lot size (ELS)--(comm'l/resid.) ______ac./ ac.
7. Street adjustment factor (SAF) ____________
8. Large load adjustment (LLA) ____________
9. Present no. of units (PNU)--item d below:
   a) present no. of schedule 025's ______
   b) present no. of schedule 04's ______
   c) commercial equivalency value (CEV) ______
      (1) calculation of coefficient:

      $$\frac{\text{avg. peak use/04}}{\text{avg. peak use/025}} =$$

      (2) CEV = (8b)(8cl) =
   d) PNU = (8a) + REV = ____________

10. Total possible number of units (TPNU)--item h below:

a) total no. of vacant lots less than 2 times ELS ________

b) no. of unbuildable vacant lots ________

Documentation: ________________________________

____

____

____

____

c) net buildable vacant lots (NVL)

(10a) - (10b) = NVL ________

d) total acreage of lots larger than 2 times ELS ________ ac.

(1) acreage of developable multi-family residential large lots ________ ac.

(2) acreage of undevelopable large lots ________ ac.

(3) acreage from demolished residential units (DA) ________ ac.

(4) acreage of developable commercial large lots (LL)

LL = (d) - (d1 + d2) + DA ________ ac.

e) no. of schedule 025's occupying large lots (SLL) ________

f) net possible units from developable property (NDU)

$$NDU = \frac{(LL)(SAF)}{ELS} - SLL$$ ________

g) projected no. of commercial equivalent units (PCE) ________

h) TPNU = PNU + NVL + NDU + PCE ____________

Additional documentation and comments: ________

____

____

____

____

11. Future no. of units (FNU), 10-year estimate--item d below:

a) added commercial units =

$$\frac{\text{(added comm'l acreage)} + (x)(DA)(SAF)}{\text{ELS comm'l}}$$ ____

b) added residential units =

$$\frac{\text{(added res. acreage)(SAF)}}{\text{ELS res.}}$$ -

$$\frac{0.5(x)(DA)(SAF)}{2(\text{ELS res.})}$$ ________

c) added commercial equivalent units =

(11b)(8c1) ________

d) FNU = (11a) + (11c) ____________

e) historical gains (5 yr.):

(1) schedule 025 ________

(2) schedule 04 ________

f) estimate of residential units only ________

Documentation and assumptions for FNU estimate: ________________

____

____

____

____

____

12. Calculation of saturation factors:

a) present saturation (PS)

$$PS = \frac{PNU}{TPNU}$$ ______________%

b) future saturation (FS)

$$FS = \frac{FNU}{TPNU}$$ ______________%

INDUSTRIAL ZONE WORKSHEET

1. Zone description ____________

2. Zone location ____________

3. Map references ________________________
____

4. News articles ____________

5. Zone area ____________ ac.

6. Street adjustment factor (SAF) ____________

7. Large load adjustment (LLA) ____________

8. Present saturation (PS), including large loads, item c below:
   a) residential (04) area ________
   b) commercial and industrial (025) area ________
   c) $PS = \frac{(8a) + (8b)}{\text{zone area}}$ ____________ %

9. Present units and consumption, excluding large load
   a) schedule 04 ________ @ ______ kwh/unit
   b) schedule 025 ________ @ ______ kwn/unit

10. Present load density (PD), item c below:

    a) schedule 04 demand =

    $$\frac{\text{(no. units)(consumption/unit)(0.30)}}{720(0.21)}$$ _______

    b) schedule 025 demand =

    $$\frac{\text{(no. units)(consumption/unit)(0.30)}}{720(0.21)}$$ _______

    c) PD = $\frac{(10a + 10b)}{(8a + 8b)}$ _______ kw/ac.

11. Available industrial acres (AI), item e below:

    a) vacant land _______ ac.

    b) undevelopable vacant land _______ ac.

    c) land from residential demolition _______ ac.

    d) land from commercial demolition _______ ac.

    e) AI = (12a - 12b) + (12c + 12d) _______ ac.

12. Future saturation (FS), item d below:

    a) demolished acreage to industrial use (11 c + 11d) _______

    b) adjusted present saturation (APS) =

    $$\frac{(8a + 8b) - (11c + 11d)}{\text{zone area}}$$ _______

    c) total added industrial use area _______

    d) FS = APS + $\frac{12c}{\text{zone area}}$ _______ %

    Documentation (include historical growth): ___

    ____

    ____

    ____

    ____

    ____

PUBLIC ZONE WORKSHEET

1. Zone description ____________

2. Zone location ____________

3. Map references ________________________

____

4. Zone area ____________ ac.

5. Present number of units (PNU), item d below:
   - a) present no. of schedule 04's ________
   - b) present no. of schedule 025's ________
   - c) commercial equivalency value (CEV) ________
     - (1) calculation of coefficient:

       $$\frac{\text{avg. peak use/04}}{\text{avg. peak use/025}} =$$

     - (2) CEV = (5a)(5c1)
   - d) PNU = (5b) + CEV ____________

6. Present load density (PD), item d below:
   - a) avg. consumption/04 ________ kwh
   - b) avg. consumption/025 ________ kwh
   - c) present demand =

     $$\frac{[(5a)(6a) + (5b)(6b)][0.30]}{720\ (0.21)}$$ ________ kw

   - d) PD = $\frac{(12c)}{\text{zone area}}$ ________ kw/ac.

7. Units to be developed within 10 years (DU) ________

8. Total possible no. of units (TPNU):

   TPNU = PNU + 2(DU) ____________

9. Future no. of units (FNU):

   FNU = PNU + DU ____________

10. Historical gains (5 yr.)

    a) schedule 04 ________

    b) schedule 025 ________

11. Estimate of residential units only ________

12. Calculation of saturation factors:

    a) present saturation (PS)

    $$PS = \frac{PNU}{TPNU}$$ ____________ %

    b) future saturation (FS)

    $$FS = \frac{FNU}{TPNU}$$ ____________ %

    Documentation: ________________________________

    ____

    ____

    ____

    ____

COMPREHENSIVE ZONE WORKSHEET

1. Zone description ____________

2. Zone location ____________

3. Map references ________________________

____

4. Zone area ____________ ac.

5. Ultimate density (UD) ____ units/ac.

6. Average lot size (1/UD) ____________ ac.

7. Street adjustment factor (SAF) ____________

8. Large load adjustment ____________

9. Present no. of units (PNU), item d below:
   a) present no. schedule 04's ______
   b) present no. schedule 025's ______
   c) residential equivalency value (REV) ______
      (1) Calculation of coefficient:

      $$\frac{\text{avg. peak use/025}}{\text{avg. peak use/04}} =$$

      (2) REV = (b)(9c1)
   d) PNU = (9a) + REV ____________

11. Ultimate no. of residential equivalent units (REU) :

$$REU = \frac{\text{(comm'l area)(13,200)}}{\text{(avg. consumption/04)}}$$ ________

12. Ultimate no. of units (UNU):

UNU = (zone area - comm'l area)(UD) + REU ________

13. Growth factor (GF) ________

14. Future no. of units (FNU):

FNU = PNU + (GF) (UNU - PNU) ________

Documentation: ________

15. Calculation of saturation factors:

a) present saturation (PS)

$$PS = \frac{PNU}{UNU}$$ ________ %

b) future saturation (FS)

$$FS = \frac{FNU}{UNU}$$ ________ %

APPENDIX B

NOTES ON THE WORKSHEETS

The following notes augment but do not duplicate the information in Chapter III. In practice, field maps at scales of 1" to 400' or 1" to 800' are attached to each worksheet.

Zone description: identifies the zoning classification, the zoning authority, and the specific occurrence of a given zoning type. For example, R1-21-C identifies the 21st R1 zone in Corvallis.

Zone location: the geocode, as described in Chapter III.

Map references: all pertinent maps which cover the particular zone--address maps, zoning maps, and assessor's maps are most common.

News articles: A news file was developed during the study. Over 200 articles were found useful to the projection process, and they were cross-referenced to affected zones so that the staff member making a given projection would be aware of the most recent information concerning that zone.

Estimate of residential units only: This entry is made to facilitate the comparison of the load projection with the CPRC population projection (Chapter III). The need for the entry is to prevent residential equivalent units from being construed as residential units, as could happen if one multiplied the saturation value by the zone capacity (which includes schedule 025 consumption).

<u>Commercial zone worksheet, item 11</u>:

a) In the formula, "x" represents the proportion of eventual residential demolition (DA--from item 10d3) which is expected to occur within ten years.

b) "X" has the same meaning. The denominators (ELS res and 2 x ELS res) differ because it is expected that new residential construction in the CB zones of Corvallis will be of multi-family nature. Thus the number of added residential units is the difference between new construction at higher density and demolished units at lower density.

<u>Industrial zone worksheet, item 10, and public zone worksheet, item 6</u>:

Because consumption is measured in kwh and load density is in terms of kw per unit area, these formulas are provided to make the conversion. The "720" is the number of hours in a month, and "0.30" and "0.21" are the coincidence factor and the load factor, respectively.