Technical Report

1999 Employment Density Study

METRO

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Management Summary

Abstract.

The purpose of this report is to increase our understanding of the land need inside the Metro UGB[1] for industrial, retail, office and other commercial uses. The land demand is determined by an economic forecast of the Metro Region, and the regional land supply is based on Metro's Vacant Land Study and the RLIS[2] database. Demand may then be balanced with supply to determine the need to expand the UGB if necessary. This report describes new data and a refinement in calculating land demand that will enable technical discussion of the Region's future land need in terms of these three factors:

1) the size of available parcels,
2) the location of the demand and supply of land, and
3) the type of land use needed.

This employment density report is the first half of a larger study to be completed for the Urban Growth Report. No "*need numbers*"[3] are reported in this paper; instead we discuss the findings from the employment density study and how the new study results are incorporated into a refined portrayal of the regional land need.

This paper suggests a refinement to the way we measure the need for buildable lands for non-residential purposes. The changes are in response to Metro's Business Advisory Committee and industry representatives who have identified weaknesses in previous land need assessments. These concerns are related to the call for additional land information in terms of size, location, and type of uses which might be needed.

This study addresses these concerns and incorporates them into the employment density study. As this paper will show, the refinements to the land need calculations allow for disaggregation in terms of a supply and demand balance (or imbalance) by location and by land use type. The size issue is not addressed on the demand side, but is a calculation in terms of land supply.

Employment density is an important factor and is one of over a dozen key assumptions contained in the Urban Growth Report. Density parameters are used to determine the amount of land needed for future employment growth in the UGB. Employment densities in the region are analyzed in this report so that we may have current (observed) findings

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[1] UGB stands for Urban Growth Boundary.
[2] RLIS stands for Regional Land Information System. A GIS database maintained by the Data Resource Center. RLIS contains mapping layers for the region's streets and arterials, soils, water, environmental ly sensitive land, topography, transportation network, land use/zoning data, and socioeconomic information.
[3] The so-called "need number" for Employment Units in the 1998 UGR Addendum was estimated to have a deficit in capacity of 2,900 jobs. (See: Urban Growth Report Addendum, Aug. 26, 1998)

to base future projections of the rate and amount of land that may be consumed for employment-related purposes. Based on a projection of employment growth in the Metro region, the number of jobs forecasted is converted to an estimate of land demand by relating job growth and employment density parameters for each industry.

Typically, employment density (or interchangeably referred to as job density) is measured as:

1. Employees per acre (parcel density), or
2. Square-foot per employee (building density[4]).

The Metro area economic forecast provides the employment projections by industry. The Metro regional forecast is based on a state-of-the-art integrated structural econometric/demographic model (MARIO[5]) of the Portland-Vancouver economic region[6].

Job densities measure how efficient (or inefficient) land is being used per unit of employment. Some industries have a very compact form, while others use vast amounts of land per employee. Even within the same industry classification, each type of firm may employ a different ratio of employment to land (or building space) depending upon the particular manufacturing (or service provider) process. Employment densities also vary across geographic areas. Average densities are computed for each geographic subarea.

Geography is important to job density due to zoning requirements. Traditional planning methods tend to segregate uses by industrial, retail, office, and other commercial uses. This tendency is changing under the 2040 Growth Concept as mixed-use employment areas are being promoted as a means to achieve tighter integration between transportation and land use. Still, regulatory factors such as FARs and parking factors impact the efficiency of land consumed for employment-related uses. Lastly, market factors such as agglomeration (e.g., high-tech producers and suppliers) and physical resource needs (e.g., proximity to air, sea or rail terminals) are the main forces behind why some industries and firms locate in one particular geographic area than another in the region.

In the 1999 Employment Density Study, updated job density parameters are estimated by industry and by geographic subareas of the Metro region. These job density parameters are in the form of observed FARs and observed building densities (i.e., square-feet of building space per employee). These density parameters are detailed in this report.

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[4] Combining building density and a floor-to-area ratio (FAR), employment is then converted to acres.
[5] MARIO is short for **M**etro **A**rea **R**egional **I**ntegrated **O**utput model. This model integrates a structural econometric model with input-output parameters to produce a forecast of regional employment forecast.
[6] The economic region encompasses Multnomah, Clackamas, Washington, Yamhill, Columbia and Clark counties.

Employment Density Study - 1999

Introduction.

This report summarizes the early findings of an ongoing research project to measure employment densities in the Metro region. The study provides information of the types and amounts of land needed for employment. These initial findings are being considered in preparing the land need estimate for the 1999 Urban Growth Report (UGR)[7]. In this report, a refined approach for computing employment-related land supply and demand is discussed. Previous UGRs approached the question of non-residential land need denominated in terms of jobs – that is whether the current supply of vacant buildable land is sufficient to accommodate the future. This approach had flaws – currently being debated in the State Legislature in the form of Senate Bill 87.

This paper suggests a refinement to the way we measure the need for buildable lands for non-residential purposes. The changes are in response to Metro's Business Advisory Committee and industry representatives who have identified weaknesses in previous land need assessments. These concerns are related to the call for additional land information in terms of size, location, and type of uses which might be needed.

The refined paradigm divides the jobs land need into four categories of land need instead of just one. In this paradigm, land supply and demand are the focal point of measurement. Former UGRs approached non-residential land need from the viewpoint of jobs capacity. Instead, why should we be using a surrogate (i.e., jobs) when the debate is ultimately over land? There is no justification for converting land supply estimates into jobs capacity when the central debate centers around the land supply by size, type and location.

The approach discussed in this report moves the discussion from job capacity to land and provides a much more transparent means of tracking demand and land supply inventories. In the context of the UGR, we envision direct policy levers in which compliance data and policy makers can influence the regional land supply outlook. On the supply-side, regulatory changes in zoning can be directly linked back to the available supply of land by location and type. On the demand side, density parameters contained in the land demand model can be changed to incorporate the zone changes and reflected in the FARs (floor-to-area ratios) assumed in the calculation of land demand. This paradigm gives policy makers a rational framework based on technical findings to make decisions about the region's land supply outlook for employment-related purposes.

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[7] The 1999 Urban Growth Report is scheduled to be presented to Metro Council by the Summer 1999 in partial fulfillment of State requirements to provide a sufficient residential land supply to accommodate a 20-year demand.

The early findings of the employment density study support our thesis that job density throughout the region is not all created the same and should not be treated or modeled as invariant. This study attempts to identify and quantify the variations in employment across spatial dimensions. Jobs are much more heterogeneous than housing – from the viewpoint of both supply and demand – hence the need to consider land for employment-related purposes in much broader dimensions. The earlier versions of the UGR approached the region's land supply in terms of jobs and in a one-size fits all manner. The alternate approach being considered for the computation of land demand is an improvement because it adds precision by location and type. This refined paradigm also fits in with revisions going on in how the land supply is being analyzed and tabulated. This refined land supply accounting approach creates an ability to "map back" to the land inventory by specific types of land, and to identify precise parcels to accommodate each type of employment. The result of the map back feature is land supply data categorized by location, type, and parcel sizes.

This refined method re-directs emphasis from the supply-side on to the demand-side of the ledger. Density factors are applied to the employment forecast and converted to a projection of demand denominated in units of land (e.g., net acres). The land demand forecast is now arrayed by location and land use type. The advantage of this approach in terms of inventorying the land supply is that the supply can now be directly tabulated by parcel by location, design type, land use type, and parcel sizes that can be analyzed individually or as a whole. Determination of what types of land are needed can now be explicitly balanced between a range of supply and demand features.

The main findings in the text of this report are at the regional level. Subregional calculations are included in the appendix. The main purposes of this research are to:

- Coordinate an analysis of the region's non-residential land demand with the corresponding vacant land/buildable lands analysis with far greater precision and detail by location, parcel size and land use type,
- Improve the comprehensiveness of the employment density factors (i.e., FARs and square-feet per employee) in the Metro region,
- Incorporate job density refinements into modeling and estimating future non-residential land demand,
- Provide a point of departure to study spatial allocation models for future job growth, and
- Provide policy makers with better land use information for determining Metro urban growth boundary amendments.

This report introduces a refined method of calculating non-residential land demand by location and type of use. The approach provides a wider range of detail not available under previous Urban Growth Reports. Land demand projections are now divided into demand for land by industrial, office, retail and other commercial categories. The employment density study provides enhanced job density parameters that allow us to refine the current methodology to greater detail.

In the forthcoming 1999 Urban Growth Report, we shall reflect the improvement in methodology and estimates of land demand and also in the reporting out the land supply data from RLIS using the same categories as shown by demand. In this way, Metro Council and stakeholders can more precisely analyze surpluses and deficits of various land needs by type, size and geography.

Employment density parameters are important factors used to determine the need for future employment-related land. This paper describes how Metro carried out the study and how the information can be used to inform land use needs for commerce and other employment-related purposes. The major findings of the study are reported in section 3 and additional tables, charts and maps are included in the appendix. Provided in this report are updated FARs and building density estimates arrayed by geography, 2040 design type and industry classifications.

Section 1.

Background – 1990 Metro Employment Density Study.

In 1990, Metro's Data Resource Center (DRC) completed a telephone survey of a dozen (12) sites and facilities with a variety of industry mixes. Over 200 firms were included in this telephone survey. The survey method employed a case study approach. Sample areas were chosen from various areas around the Metro region to reflect urban and suburban uses. Density measurements from sources outside the Metro region were also available and used in comparison with the Metro survey results.

Data from the telephone survey became part of the 1990 Metro Employment Density Study. (A copy of the 1990 employment density study is included in the Appendix.) The firms contained in the sample were grouped by Standard Industrial Classification (SIC) codes. Two different employment density factors were calculated from the survey results:

1) average square-feet per employee (building density), and
2) average employees per acre (parcel density).

These results were analyzed and density factors and guidelines were recommended. Ultimately, an average employees per acre statistic was recommended for each SIC.

The 1990 job density factors later became the basis for determining future land demand needs for the Region 2040 Growth Concept. In subsequent analysis, in particular the Urban Growth Report[8], the density measures were modified in order to calculate the job capacity of the land stock by 2040 Regional Plan Category.

[8] Urban Growth Report – Final Draft, December 18, 1997 and Urban Growth Report Addendum, August 26, 1998.

1999 Employment Density Study.

Nearly a decade later, the employment density factors are being revisited for the Metro region. Job densities are a key element for determining land need and land capacity. Legislative actions at the state and local level are drawing increased scrutiny of the technical assumptions employed in projecting future land need. Interests groups and stakeholders are demanding more detailed findings to backup policy decisions[9]. The new findings from this study will provide technical foundations for policy makers and help satisfy legal requirements.

Policy officials need to know how much land will be consumed in the future based on a forecast of economic growth. Land demand type should be categorized by industry needs such as: 1) industrial, 2) office (including flex-office space), 3) warehouse and distribution, 4) schools, 5) churches and public facilities, 6) retail, 7) mixed-uses, 8) medical facilities, 9) and other employment-related uses. Land demand projections are also needed by parcel size[10] and by geographic location. Previous Metro studies have left out important aspects that determine land demand characteristics such as type, size, and location. This study addresses the type and location of land demand. On the supply-side, the paradigm being considered allows the inventory of vacant land in the UGB to be tabulated by type, parcel sizes and location and then compared with the land demand projected by type and location to determine whether surpluses or deficits exist in any one category of land.

While the exact relationship between land supply and economic development may not have been fully quantified, a correlation does exist. This study attempts to quantify this relationship by measuring job densities of various sample locations selected in the Metro region. Without a sufficient amount of buildable land for housing and non-residential purposes, regional economic growth could stagnate. Too much land could also be bad for the economy, contributing to inefficient densities or inefficient spatial patterns. The policy consensus (2040 Growth Concept) is to incrementally add urban reserves to the UGB at a rate sufficient to maintain economic growth, without limiting the supply of buildable land to a point below which the land market is unable to reach an equilibrium. This study overall attempts to answer where, how much and what type of land is needed. This study increases our understanding of the relationship between employment and commercial and industrial[11] land needs for the Metro region.

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[9] Senate Bill 87 which is coming before the Oregon Legislature could bring the issue of future non-residential land consumption and capacity to an equal footing with housing matters in the UGB debate.

[10] Land demand by size is not forecasted by the land demand model. We have not yet incorporated a practical means yet to convert the employment forecast into a projection of parcel demand by size. However, using GIS and the RLIS database, we can tabulate the size of individual vacant parcel (as well as location and type of use – based on zoning data).

[11] Metro, in partnership with Commercial Real Estate Economic Coalition (CREEC), Port of Portland, et. al., have formed a joint study group with a consultant (OTAK) to determine in detail the industrial land

The 1999 Employment Density Study is to be a major factual component of Metro's regional land need projections. It will help quantify the amount of land needed to maintain an efficient land market inside the Metro UGB. A key objective from this study is to accurately estimate the land demand for commercial, retail, office, industrial and other job needs[12]. In the past, Metro has been unable to precisely quantify the amount of land demand for employment purposes by categories that stakeholders could agree on. Nor has Metro been able to satisfy the question of the amount and quality of the stock (or supply) of commercial and industrial land inside the Metro UGB. Differences in definitions and parameter estimates have been confusing. This study attempts to bridge these differences.

This study updates current estimates of average square feet per employee and floor to area ratios for the region. The next step, to be completed in Fall 1999, will be to enhance the methodology further by attempting to develop a state-of-the-art non-residential real estate location model[13]. Meanwhile, the job density findings from this research affords us the opportunity to improve our present understanding of the disaggregate spatial dynamics of job creation and land consumption at the sub-regional level[14]. For now, the job density data should be incorporated into the new land demand paradigm and used in preparing the Urban Growth Report.

Section 2.

Methodology, Data, and Study Area Selection.

Methods.

The 1999 Employment Density Study employs a case study approach for sampling industrial, commercial, office and retail places in the region. Employment areas were

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demand and supply balance of the Metro region using current RLIS data (from the 1997 vacant land analysis).

[12] Mixed-use is not per se a type of land that industries initially demand. Rather, mixed use is a supply-side response to commercial land demand. Regulators, in their role as suppliers of land, provide the option for firms to choose from an array of land types which would include mixed use. Firms do not actively say beforehand that they are in the market necessarily to locate on mixed use land, instead mixed use is something that is presented to the market as one product out of many that they can choose from to satisfy their needs.

[13] Metro presently has an operational regional macroeconomic model (MARIO), residential real-estate location model (RELM), and various transportation models. The missing piece to this series of analytical models is a non-residential (or employment) location model. Without the benefit of an operational employment location model, our current modeling approach is based on a combination of small area regression models and expert opinion (in the past we have called this the Growth Allocation Workshop).

[14] Reference to ZELDA (Zonal Employment Land Density Analysis model) in this report.

selected on the basis of geographic location and by 2040 Growth Concept design. Two sample areas were chosen for each of six employment-related design types. In total, twelve sample areas were selected for their geographic breadth and pattern of existing development[15].

Table 1 lists the sample areas chosen for the study from the 2040 Growth Concept Map. These sites were selected because they represent the mix of employment and type of employment densities that exist today that could develop for the rest of the region under the 2040 Growth Concept. While the 2040 Growth Concept does not assume much change in residential areas, it does assume a reasonable amount of change in employment areas. In particular, it assumes that employment will be concentrated in the six types of employment-related design types and that the land within these areas will be used more efficiently.

For example, Hawthorne, Hollywood, and Washington Square areas were selected in the study as examples of how main streets, town centers and regional centers could be developed in other areas targeted for higher density development in the 2040 Growth Concept Map. These sample areas already demonstrate some success at achieving 2040 expectations.

Table 1.
1999 Employment Density
Site Locations

2040 Design Type	**Sample Location**	**2040 Design Type**	**Sample Location**
Regional Center:	Oregon City Washington Square	Corridor:	Barbur Blvd. Kruse Way
Town Center:	Hollywood Raleigh Hills	Main Street:	Division Hawthorne
Employment Area:	Hillsboro Tigard Triangle	Industrial Area:	Clackamas County Rivergate

[15] The size of the current study is significantly greater than the 1990 study, but we caution that the size of the sample may not be statistical representative of the region's total employment profile. For example, small businesses, high-rise office employment and large box retailers are under sampled. We will correct the central-city bias by collecting additional data. In this study, a total of 5,000 employers (representing about 10% of employers doing business in the Tri-counties) were represented in the sample which included over 50,000 jobs (or about 6% of the Tri-county jobs)[15]. Before we present the results of ZELDA, we will have populated the model with precise density estimates for the Central City.

Source: Metro Data Resource Center

Data.

The main data elements in this study are employment data from the State[16], assessor tax files from the counties (Multnomah, Clackamas, and Washington), and the Metro Regional Land Information System (RLIS) Geographic Information System (GIS) database. Assessor files and RLIS are relational files linked by a common tax lot identification field. The State employer file is a foreign file that does not have any common field to tie in with the assessor data or RLIS.

In order to remedy this relational problem between the State employment file and other data, the DRC went through a process of geocoding the State employment file. Each record in the file was assigned a parcel identification tied to the tax lot identification number from the assessor. Employer addresses were first corrected and standardized using commercial mailing software (AccuMail). The standardized addresses were then run through the RLIS master address file and E-TIGER[17] file to locate on a map where each employer is located. This location can then be tied to an individual tax lot or parcel identifier. Approximately 70 percent of the addresses geocoded without any trouble using this method. Another 20 percent required additional address clean-up and manual geocoding of the address point. In total, about 90 percent of the ES-202 file precisely geocoded.

A 90 percent success rate is exceptionally good. Reasons why the other ten percent did not geocode are numerous, include the following:

- The employer address is invalid or undeliverable to the address given,
- The address is a post office box number that can not be assigned a location,
- The address is out of State or out of the Portland PMSA, which again is not useable for our purposes,
- Or the address is missing or insufficient to locate using our GIS.

The geocoded employer file provided the information we need to estimate how many jobs are located in any particular parcel or building[18].

In order to determine the building sizes or the amount of floor space in each parcel, we turned to the counties' assessor files to fill-in part of the missing information. While not

[16] Employment securities data (ES-202) are used because this employment data includes employer and employer address data which does not exist for any series of employment data.
[17] E-TIGER is a topologically integrated linearly related referencing system to identify street networks and address within address ranges contained in the street network.
[18] In the density analysis of square-feet per employee, when we were unable to divide employment of individual firms to exact building or floor space, that particular data point was excluded from the computations.

a complete data set, the assessor's records provided some information about floor space and number of floors for some commercial buildings. Where data fields were still missing, on-site field surveys, personal interviews with property owners and commercial real estate broker(s) provided additional information that helped fill-in the gaps. When none of the these sources yielded any information, planametric maps[19] of the city's built environment were used to complete the data. Finally, we performed field checks to verify the size and dimensions of our sample records.

Field checks led to some corrections and augmentation of the buildings data set. Even with all the effort invested in collecting building size information, we recognized that the data on floor space and building size were still incomplete and not entirely what we expected. Many buildings are shared between multiple tenants with much different space requirements for their line of business. It was difficult and at times impossible to differentiate individual businesses with their own floor space. In this instance, we left the data aggregated, which is not a problem in calculating FARs but is a problem for calculating observed square footage per employee by SIC categories.

The last data element collected for this study was based on parcel area. Parcel area proved to be the easiest and most reliable element of the job density analysis. From the RLIS database, we were able to compute the actual square footage or number of acres in each developed parcel in our sample.

Two density parameters are created in this study: 1) floor-to-area ratios, and 2) building densities. Floor-to-area ratios relate the amount of area contained in a building to the area of the entire parcel that the building sits on. An FAR (gross floor area is used by this study) reflects how much existing land in addition to the footprint of the building is required based on zoning regulations. Depending upon zoning regulations, there may be significant amount of land needed for building setbacks, parking ratios and environmental constraints. The FAR measures how efficiently any particular parcel or land area is being used for actually housing the employment in the building or area. The FAR equation is given in table 2. The second density parameter is building density. It merely measures the average office-space, for example, that each worker is given to perform his/her duties. The building density is given by equation 2.2.

Table 2.

Equation 2.1 Floor to Area Ratio
FAR = (Square footage of Building) / (Parcel Area)
Equation 2.2 Square-foot per employee

[19] Planametric data does not exist for the entire region. Only Oregon City, Portland and Hillsboro had any of this kind of data available. Planametric data is a GIS map layer that describes the contours and footprints of an area's built environment. It may include streets, sidewalks, vegetation (trees and shrubs), utility devices (street lights and lamps), building footprint, and so on.

Building Density = (Square footage of Building) / (No. of Employees)

Source: Metro Data Resource Center

The FARs and building densities calculated in the employment study are based on existing building space or observed densities not what zoning might allow. Later, we will discuss how regulatory changes today might influence tomorrows FARs or building densities, but the reader should not confuse the density parameters that this study has tabulated for the region. The density data are based on what has been built and observable by this study.

Study Area.

Boundaries were drawn for each of the 12 study areas based on firms currently doing business in those areas. In some cases, delineation of what parts were included in the study area analysis was simple because there was a clear demarcation between residential and non-residential land. In other cases, the architectual style of buildings and zoning were determining factors. And in a few cases, the study area was justified based on subjective criteria, such as common street-name definitions of where main streets and corridors began and ended.

A database for each study area was created. Each database contained an attribute for the business name, street address, tax lot, parcel area, building footprint, building square feet, business square feet, estimated number of employees, estimated employees per acre, estimated square feet per employee, and a 2-digit SIC code.

First, using the 2-digit SIC codes, each business was assigned to an industry grouping consistent with the industry groupings employed in the regional forecast. Projected employment growth for each of the industry groupings can be used to estimate a land need (demand) by correlating those industry groupings with observed employment densities. The industry groupings are listed in table 3.

Next, staff began to investigate methods for describing employment density. Staff focused on square feet per employee (building density) estimates instead of employee per acre (parcel density) estimates. Parcel density estimates aggregate the number of employees to the parcel without reference to how efficiently that parcel is utilized because there is no reference to building size. As a result, estimates that use parcel densities are established without regard to possible zoning changes that could allow a parcel to be used more (or less) efficiently at a later point in time. As a trade-off, while building density estimates allow greater flexibility, they must be paired with a second variable that captures how efficiently the parcel is used. This second variable, floor-to-area ratio (FAR) is addressed later in this section.

In calculating square feet per employee estimates for these businesses, staff addressed constraints in the data set, mentioned earlier. Individual businesses in shared office buildings, while listed separately, do not have a parcel area and frequently lack data on their floor area. For this portion of the data, it is virtually impossible to correlate specific industry type groupings with square feet per employee densities, employee per acre densities or floor-to-area ratios.

Side-stepping this issue, staff re-selected only businesses that did not share space with other tenants in the same parcel. Building densities were then computed for each re-selected record and tabulated by SIC. The building density is measured by square feet per employee and weighted by employment to give a weighted-mean for each SIC. Despite, re-selection, the sample sizes for each subset were still sufficient for this analysis.

Table 3.
List of Industry Groups

Industry Grouping (SIC code)	Description of Industry Types
1-19	Agriculture, Forest, Mining
20	Food & Kindred
21	Tobacco
22,23	Textile & Apparel
24	Lumber & Wood
25,32, 39	Furniture, Clay, Stone, Glass
26	Paper & Allied
27	Printing, Publishing & Allied
28-31	Chemicals, Petrol, Rubber, Leather
33,34	Primary & Fabricated Metals
35	Machinery
36,38	Electrical Machinery, Equipment
37	Transportation Equipment
40-42, 44, 45,47	TCPU – Transportation and Warehousing
43, 46, 48,49	TCPU – Communications and Public Utilities
50,51	Wholesale Trade
52-59	Retail Trade
60-68	Finance, Insurance & Real Estate
70-79	Non-Health Services (part A)
80	Health Services
81-89	Non-Health Services (part B)
90-99	Government

Source: Standard Industrial Classification Manual, 1987, Executive Office of the President, Office of Management and Budget

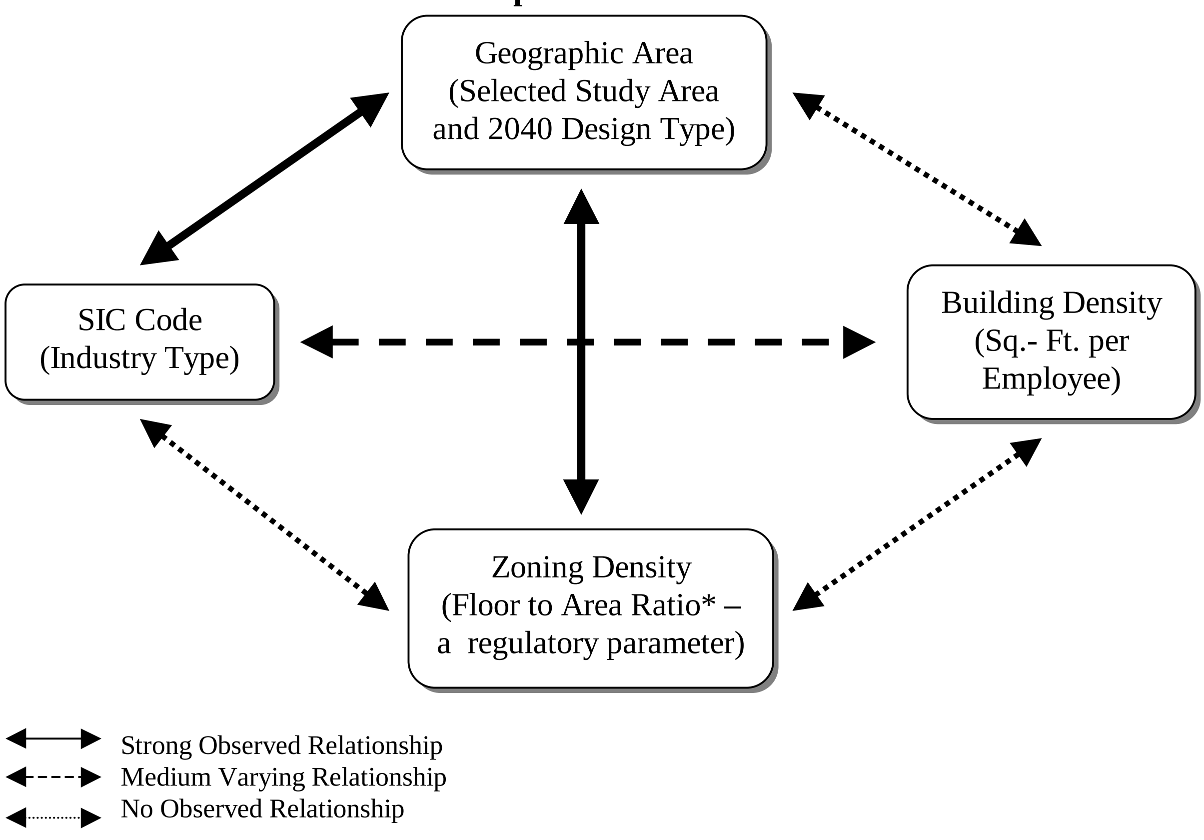
Section 3.

Study Findings.

Data Relationships.

The study indicated that the employment density parameters contain variations by regional subareas, by design type, and by industry. We determined that FARs vary significantly between industry and locations. The same was true for building densities. The FAR parameters that we re-calculated for each subarea are adjusted to be statistically representative of the land supply within each subarea. Each FAR in each subarea has a sample-calculated FAR which is re-weighted to reflect the amount of land by type tabulated using the RLIS database. This re-weighting gives a statistically valid representation of the FAR densities. Similarly, we adjust the building density parameters.

Figure 1.
Zonal Employment Land Demand Analysis (ZELDA)
Conceptual Framework



* The FARs in this study are calculated based on observed findings. FARs reflect the zoning characteristics allowed by communities and hence is a regulatory parameter. FARs change over time so what is observed in actuality may differ from current zoning assumptions.

Based on our data, we believe the most sensible approach is to treat each subregion separately and use specific density factors:

1. By subarea (20 districts),
2. By industry (SICs), and
3. By regional zoning[20].

Figure 1, above, is an illustration of the multi-correlation or relationships that exists in the job density data between industry jobs by SIC, square-feet per employee (building density), and FAR. Strong statistical links exist between *geographic area* and *industry type* (SIC code), and *geographic area* and *zoning density* (or FARs). A weaker correlation, but still statistically valid, exists between *industry type* and *building density*. The strong and medium correlations are incorporated into the *Zonal Employment Land Demand Analysis* model (ZELDA).

Geographic location matters because, in part, past regulatory zoning has tended to segregate business types into a narrow range of locations. More importantly, market forces of agglomeration tend to further focus these concentrations. Physical requirements such as proximity to water, rail, arterials and markets combine to determine locations of various other business types. The fact that concentrations exist by industry type are confirmed in the density analyses performed in this study.

Table 4, below, lists the observed density parameter for each industry. The employment densities range from between 300 (Machinery manufacturing – including computers and office equipment) to 4,180 (warehousing) square feet-per employee. These observed building densities are based on the entire sample data set. The appendix shows the disaggregation of these "regional" parameters into county subarea density parameters. (A map is given in the appendix describing the boundaries of each county subarea.)

In fact, employment is quite diverse in the region[21]. Not only is there diversity in employment, the industries that support that employment are equally diverse. As a consequence, the supply of land for future economic growth should also treat the need for land in a diverse manner; that is, future economic growth will depend in part on a range of land types in the land supply inventory to accommodate the demand associated with varying economic trends projected for each industry.

Based on the relationships between density and geography, we can also define new FAR parameters based on geography. FAR parameters are computed by county subarea (see: County Subarea map) and shown in the appendix. The 20 district subarea is a traditional division of the region based on land use and transportation considerations. By

[20] Metro does not enforce regional zoning. Instead, regional zoning is a composite of local zoning that has been normalized and standardized to create a regional aggregation of local zoning types (e.g. industrial, retail, office, and so forth).

[21] See: Profiles of the Portland-Vancouver Economy, Metro, Data Resource Center, May 1994
also see: 1998 Regional Economic Profile, Portland PMSA, State of Oregon, Employment Department, December 1997.

disaggregating the region into 20 subareas, we are able to employ more area specific ratios in which a single regional FAR might not be as accurate or informative.

Observed floor-to-area ratios convert estimates of building square footage into estimates of acreage utilization. The FAR statistic combines various land use factors which are important to the supply calculation. In the ratio, factors such as parking, landscape setbacks, and various other zoning regulations are embodied in the FAR.

Table 4.
Observed Building Densities
(Square Feet per Employee on a Regional Sample Basis)

Industry Grouping (SIC)	**Description**	**Weighted Square Feet per Employee***
1-19	Ag., Fish & Forest Services; Constr.; Mining	590
20	Food & Kindred Products	630
21	Tobacco (industry does not exist in Oregon)	0
22,23	Textile & Apparel	930
24	Lumber & Wood	640
25,32,39	Furniture; Clay, Stone & Glass; Misc.	760
26	Paper & Allied	1,600
27	Printing, Publishing & Allied	450
28-31	Chemicals, Petroleum, Rubber, Leather	720
33,34	Primary & Fabricated Metals	420
35	Machinery Equipment	300
36,38	Electrical Machinery, Equipment	400
37	Transportation Equipment	700
40-42, 44, 45,47	TCPU – Transportation and Warehousing	3,290
43, 46, 48,49	TCPU – Communications and Public Utilities	460
50,51	Wholesale Trade	1,390
52-59	Retail Trade	470
60-68	Finance, Insurance & Real Estate	370
70-79	Non-Health Services	770
80	Health Services	350
81-89	Educational, Social, Membership Services	740
90-99	Government	530

* Averages weighted by the size of firms in the Study Areas.

Source: Data Resource Center and Growth Management Services

Table Notes:
Both types of density parameters shown in tables 4, 5 and in the appendix are calculated from the observed data of the firms and parcels contained in the selected study areas. Care was taken to choose study areas

that were thought to already show signs of development that are consistent with the goals and objectives of the 2040 Growth Concept. Hence, the density figures that we display in this report show observed densities that incorporate in some part the “aspirational” densities one would expect of 2040 – although probably not fully up to the expected densities that zoning might allow. 2040-type densities for each subarea should eventually be reflected in FARs. Other areas across the Region may not yet be as far along with 2040-type development, so their FARs would presumably be lower. For the land demand forecast, we use the observed densities which in theory include partway the aspirational densities of the 2040 Growth Concept Plan.

Table 5.
Observed Floor to Area Ratios

2040 Design Type	**Floor to Area Ratio (FAR)***
Barbur Blvd. (Corridor)	0.35
Division (Main Street)	0.26
Hawthorne (Main Street)	0.63
Hillsboro (Employment Area)	0.20
Hollywood (Town Center)	0.62
Clackamas County (Industrial Area)	0.24
Kruse Way (Corridor)	0.46
Oregon City (Regional Center)	0.44
Raleigh Hills (Town Center)	0.29
Rivergate (Industrial Area)	0.21
Tigard (Employment Area)	0.33
Washington Square (Regional Center)	0.36

* Study Area Averages

Source: Data Resource Center and Growth Management Services

The Land Demand Forecast.

Equation 3.1, below, illustrates how the employment forecast is converted into a demand forecast for land need. Figure 2 illustrates the conceptual framework of land demand forecast model and process.

Equation 3.1 (generalized)

$$\text{Land Demand} = (\text{Employment Growth}) * (\text{SF/Employee}) * (1/\text{FAR})$$

The amount of land needed (or demanded) for future employment-related growth is determined based on several inputs:

1. Forecast of regional economic (employment) growth,

2. Allocation of the regional growth into subareas,
3. Employment Density information
   a) Building Densities
   b) FARs
4. Vacancy Rates
5. Percent of workers in each industry by land use type

Combining these inputs provides a projection of land demand or need by different land types: 1) industrial, 2) retail, 3) office, and 4) other commercial uses. Depending upon the degree of refinement, for example, total industrial land demand could be further subdivided into high-tech flex, warehouse and distribution, and general industrial use types. Mixed use is not a type of land demand that firms or industries demand in particular. Rather, mixed use is a product that local jurisdictions can incorporate into their zoning plans as a means of supplying industrial, office, retail, or residential land for development purposes. Mixed use enters into the calculations as a subset of the vacant land stock as a supply to a combination of industrial, office, retail and housing demand.

The final land category, other commercial, encapsulates a variety of land uses ranging from places of worship (e.g., churches, temples, etc.), membership/social organizations (e.g., Elks lodges, Rotary Clubs, Kiwanis, and so forth), medical (e.g., hospitals, clinics, and others), schools, and government facilities (e.g., local, state, and federal).

The results, derived using ZELDA, are projections of land need by industrial, retail, office and other commercial demand. Multiple models and processes are employed before ZELDA can provide estimates of land demand. First, a regional employment forecast is required to provide the overall economic drivers that describe the future growth path of the economy. The regional forecast is determined from a regional macroeconomic model (MARIO). The regional forecast is then disaggregated to subareas by industry. The allocation is determined by a modified Delphi approach – in other words the allocation is based on information from RELM, a series of stochastic subarea regression models, and expert judgement from a panel of local land use and transportation planners.

ZELDA uses the job density parameters from this study to populate the density assumptions that convert the regional employment forecast/allocation into an estimate of future building space need. Projected building space need is then translated into the amount of land needed by each industry sector. This industry land need is then converted into the projection of land demand by land use type.

There are three main policy levers contained in the ZELDA model:
1. Floor-to-area ratios,
2. Building Densities, and
3. Percent workers in each industry (SIC) by land use types.

The first, FARs, present the most straight forward policy link. For the most part, FARs are a regulatory statement about a communities desire for density. FARs tend to define the architectual style of an area, or the amount of open space between buildings and the local environment, height restrictions, structured parking, or how much shrubbery or plantings implied with an FAR, or for that matter just about any other physical feature regarding density.

However, the observed FARs computed from the job density study may not necessarily reflect the current regulatory FARs. Many of the structures in existence today represent a legacy of building activity dating back to the early 1900's. As a result the densities that have been measure by this study are a mixture of many years and so will not necessarily be reflected in today's zoning plans. FARs are a key policy lever in the ZELDA model, and as they impact the efficiency of future land need, FARs represent a topic where policy makers might find further discussions of keen interest to them.

Building densities tend to fluctuate widely due to economic conditions. Normally, during a business cycle, we see building densities increase as firms make more efficient utilization of existing capacity. But as production increases, the marginal rate of productivity declines with each additional unit added, so businesses at this point may expand or move to larger facilities. The effect of this in the latter half of a business cycle is that average building densities tend to decrease. From a policy perspective, building densities could be adjusted for the futures forecast based on aspirational targets. However, because of the variations due to market factors, this line of policy reasoning could be spurious. Building densities can be a policy lever in the ZELDA model.

The percent of workers in industries by land use type is historically determined by detailed analysis and assumptions at the four-digit SIC level of employment data. Some assumptions must be made about what proportion of any industry's workforce, for example, goes into industrial workspace versus office space. The long range trend is for fewer manufacturing workers. This may imply that the proportion of remaining manufacturers requires more (or less) land per worker due to increases in productivity. Robotics and computers may replace the need for humans, but the building densities might decline per employee because fewer workers are needed to produce the same or more output. To some extent, this particular factor may be of interest to policy makers. A debate over productivity implications could be very interesting as it applies to the long term land needs.

ZELDA, MARIO, and the allocation model (see figure 2), represent tools that policy makers can depend on to provide information to help them determine if amendments to the UGB are necessary. Policy makers can direct the model(s) to test for the sensitivity of various policy(s) or test different scenario assumption(s). MARIO to a limited extent can test policies or different scenarios. The allocation model currently in use can not because it is yet to be formulated as a mathematical model that has policy capability. ZELDA, on the other hand, is designed to allow for this policy purpose.

The data currently being fed into ZELDA is based on the observed density findings from the employment density study. Presently, observed FARs and building densities are input into ZELDA. Also, historical vacancy rates and percent workforce by land use type are being used in ZELDA. However, policy officials might want to choose aspirational targets or current regulatory zoning parameters in place of observed parameters. By altering the density assumptions contained in ZELDA, policy makers can test alternative assumptions.

Ultimately, credible land demand projections are based on to the best of our ability sound economic reasoning and scientifically collected data which can support the assumptions that are made throughout the land calculation process.

Land Supply (Capacity).

The land supply is a mathematical statement of how much land still exists within the current UGB for land development purposes. It is a detailed tabulation of the inventory of land in supply today. The Data Resource Center is developing a new methodology to describe the buildable lands inventory in conjunction with this report. (In a forthcoming report we will describe the Vacant Lands Study.) Under this approach, we can achieve an almost parcel by parcel identification of land available for various land needs by type[22].

The Vacant Land Study and the map-back feature incorporated into the Buildable Lands Analysis determines the supply side. The stock of buildable land is arrayed by land use type. The density factors that are explained in this report and the refined method for determining future land demand combined with buildable lands will determine the non-residential land need estimate for the UGR.

Land Supply and Demand Balance.

The land analysis paradigm, which we have described including ZELDA, updated density parameters and the land supply map-back feature, allows policy makers and stakeholders new dimensions for analyzing and discussing the future balance of land supply and demand by subarea and by land use type. For example (not based on any factual findings yet), as figure 4 suggests, land demand by land use type may have a surplus demand for industrial space, but surpluses exist for say retail uses. One policy direction could be to re-zone land, or another might be to add more land to the UGB for specific uses. Locationally, the supply of land and corresponding demand may also be analyzed through this paradigm. Questions about where the UGB should or should not be expanded could be addressed through the analytical paradigm just described.

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[22] In part, this describes the aforementioned “map-back” capability. The concept is that each category (i.e. industrial, retail, office land types or 2040 design type) of land in the RLIS vacant land inventory can be traced back to specific parcels for verification and so on. Because the land supply is capable of mapping back to exact parcels, we can tabulate the land supply any way desired, such as by size and location.

Figure 2.
Zonal Employment Land Demand Analysis (ZELDA) Model

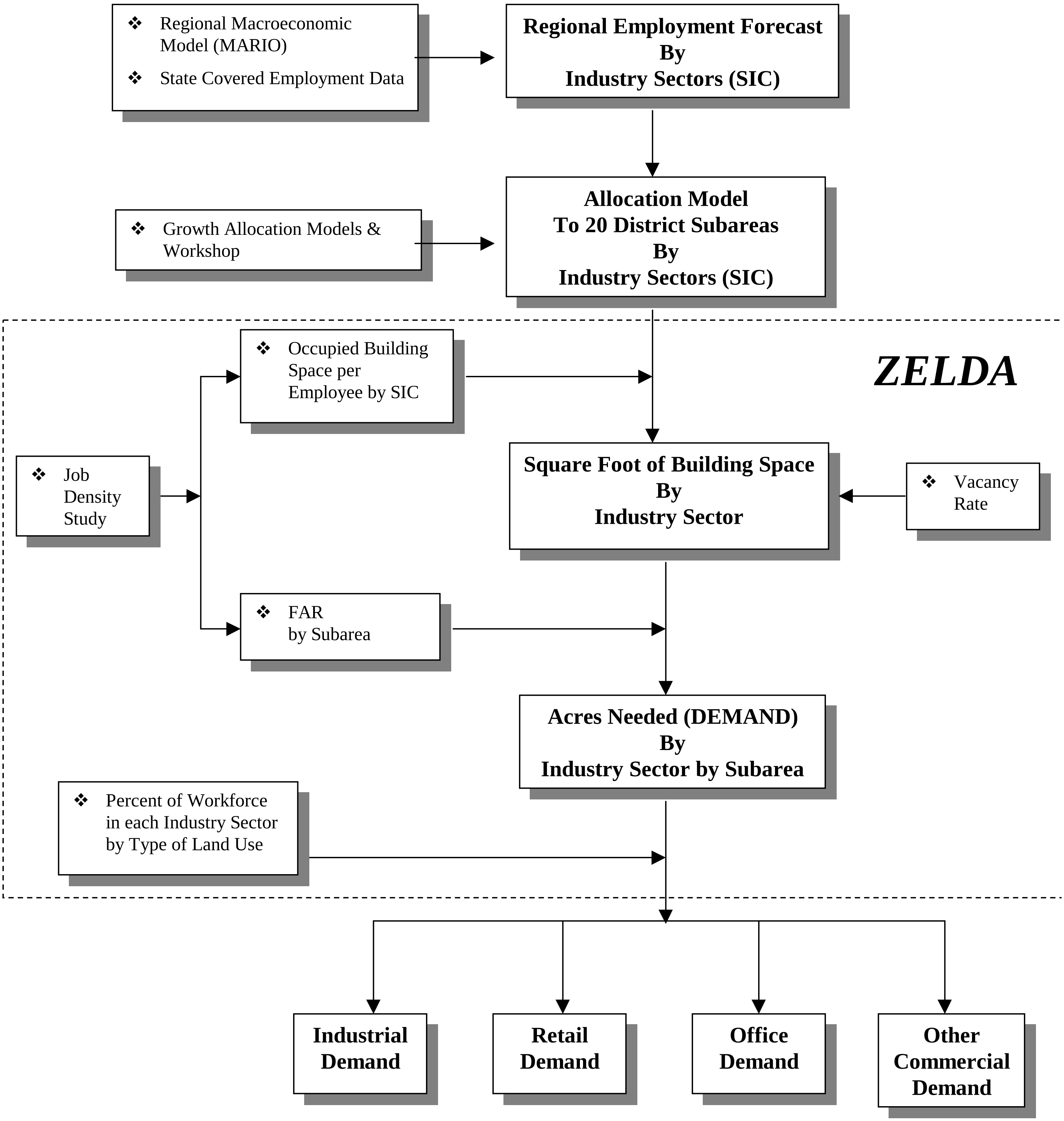


Figure 3
Regional Land Supply Model

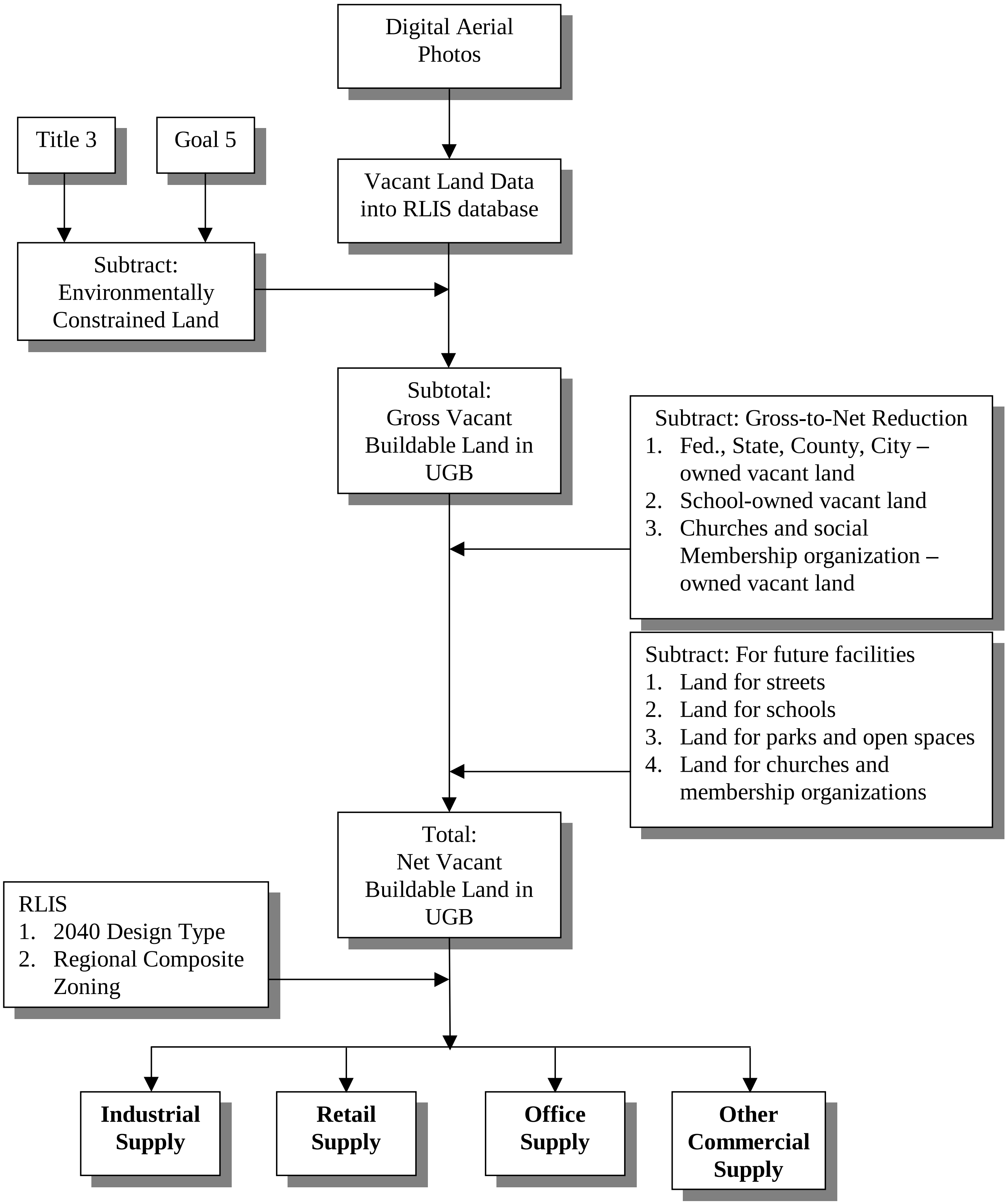
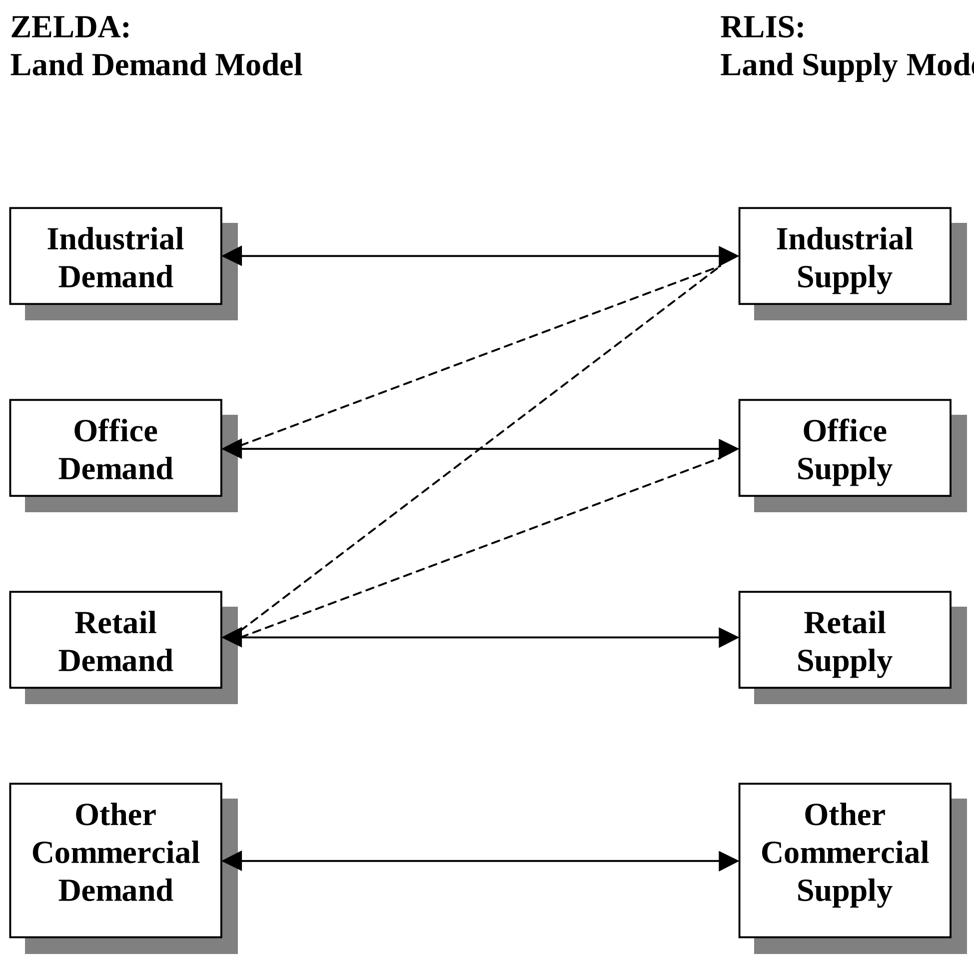


Figure 4
Supply and Demand Balance



Note to figure 4:

Land demand by various user segments may be compared or balanced against current land supply that has been tabulated using the Regional Land Information System (RLIS) database. Surplus demand in any particular segment could suggest an increase to the amount of land inside the UGB or regulatory redistribution of existing land from one land type to another segment with deficit amount of land.

The solid line suggests a balancing between land demand and supply by land use type. The dotted lines suggest that land demand can be accommodated by a mixture of mixed-use types. The lines are not meant to be exhaustive; there may be others that one can envision.

Appendix

i. County Subarea Map

ii. 1990 Employment Density Study Paper

iii. Density Study Sample Areas Map

iv. Study Area Maps (individual site maps)
   1. Barbur Blvd.
   2. Division & 122nd Ave.
   3. Hawthorne
   4. Hillsboro
   5. Hollywood
   6. Clackamas County Uninc. Industrial Area
   7. Oregon City
   8. Raleigh Hills
   9. Tigard Triangle and Kruseway
   10. Washington Square
   11. Rivergate

v. 1999 Employment Density Subarea Tables
   1. Floor-to-area Ratios
   2. Building Densities

Floor-to-Area Ratios

Study Area Averages

Study Area	2040 Design Type	Number of Firms	Minimum FAR	Maximum FAR	Average FAR
Oregon City	Regional Center	134	0.07	1.40	0.44
Washington Square	Regional Center	70	0.03	2.38	0.36
Hollywood	Town Center	140	0.02	2.90	0.62
Raleigh Hills	Town Center	34	0.08	0.98	0.29
Division & 122nd	Main Street	104	0.02	3.14	0.26
Hawthorne	Main Street	66	0.13	1.92	0.63
Barbur Boulevard	Corridor	90	0.03	1.85	0.35
Kruse Way	Corridor	10	0.13	0.70	0.46
Hillsboro	Employment Area	58	0.02	0.51	0.20
Tigard	Employment Area	68	0.10	0.66	0.33
Clackamas County	Industrial Area	84	0.02	0.59	0.24
Rivergate	Industrial Area	56	0.01	1.04	0.22

Subarea Weighted-Averages[23]

Floor-to-Area Ratios By 20 District Subareas	
1	4.00
2	0.60
3	0.80
4	0.39
5	0.30
6	0.40
7	0.29
8	0.38
9	0.28
10	0.25
11	0.40
12	0.38
13	0.53
14	0.46
15	0.36
16	0.29
17	0.30
18	0.26
19	0.27

[23] Twenty district FARs are constructed for each subarea based on area weightings of vacant buildable land. The employment zones in each subarea is first described by a combination of 2040 design types. This combination is weighted by the vacant land and summed together for each subarea.

20	0.30

Building Densities
By Regional Subareas

Building Density of each Industry by Subarea

		Metro 20 County Subarea Planning Districts																			
SIC	**Study Avg.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1-19	590	780	503	347	638	845	391	337	1,033	457	1,067	1,396	777	920	637	485	1,054	590	590	309	590
20	627	627	562	717	160	1,691	627	627	627	627	627	627	627	627	627	627	627	627	627	627	627
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22,23	930	316	318	1,331	930	930	930	247	930	930	930	930	930	930	930	930	930	930	930	930	930
24	637	277	727	785	637	372	409	500	637	637	637	637	637	637	637	637	315	637	637	637	637
25,32,39	755	2,139	880	511	508	329	755	118	755	755	755	755	755	755	755	755	755	755	755	755	755
26	1,598	1,598	800	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598	1,598
27	445	854	496	326	304	995	1,631	445	445	445	445	445	2,157	889	1,917	1,847	1,827	445	445	445	445
28-31	724	724	654	1,015	468	560	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724
33,34	419	419	397	260	1,062	308	1,912	236	935	419	419	89	419	419	419	75	419	419	419	419	419
35	304	1,494	260	393	172	471	115	104	304	304	304	304	304	62	469	304	60	304	304	304	304
36,38	398	398	506	297	281	398	178	398	398	398	398	398	398	398	398	609	398	398	398	398	398
37	700	700	680	259	1,401	813	366	700	700	700	700	700	700	700	700	700	700	700	700	700	700
40(A)	3,291	3,522	3,294	2,892	3,425	2,832	1,089	1,508	4,314	2,801	3,291	3,291	2,803	3,291	2,712	3,144	6,262	3,291	3,291	3,291	3,291
40(B)	464	453	407	426	808	989	186	464	464	464	464	464	464	464	464	464	464	464	464	464	464
50,51	1,393	1,258	1,313	1,236	1,462	1,199	878	1,305	2,207	3,492	1,339	1,498	490	1,461	2,287	3,595	5,065	1,393	1,393	1,393	1,393
52-59	466	412	452	382	439	433	416	438	692	261	173	587	1,109	981	556	888	1,225	466	466	466	466
60-68	366	245	332	415	368	408	295	401	687	1,488	1,362	607	627	425	454	589	366	366	823	366	366
70-79	766	721	696	747	778	754	573	687	576	961	1,260	766	2,015	1,505	684	254	2,174	766	132	766	766
80	353	525	323	392	296	316	302	353	2,597	990	353	291	353	353	587	2,139	353	353	353	353	353
81-89	744	657	795	563	840	446	606	1,764	1,456	836	1,208	641	476	1,382	1,295	2,803	966	744	866	744	744
90-99	536	435	539	922	3,667	865	536	232	982	536	536	536	197	536	1,073	536	536	536	536	536	536

40(A) includes 40-42, 44, 45, 47
40(B) includes 43, 46, 48, 49
Study Avg. from observed building densities (see p. 14)

(Subareas with insufficient data assume the study average.)