



## 2012 Land Use Forecast / FEBRUARY 2012 /

### Introduction

The last regional and small area forecast of population and employment for the region released by PSRC was in 2006. This forecast was generated for use in developing PSRC's VISION 2040 plan and transportation planning process and has been a key set of inputs for various transportation related projects across the region. Over the last six years many things have changed and it is time for a new set of small geography population and employment forecasts for the region.

In addition to the changes experienced in the regional economy, Land use forecasting at the PSRC has also undergone significant change, culminating with the deployment of a new land use forecasting system in the region, the UrbanSim modeling framework. This document does not represent detailed UrbanSim model documentation but rather a summary of the pertinent information required for review of the Draft 2012 Land Use Forecasts released on February 28<sup>th</sup>. More information about the PSRC UrbanSim models can be found on the PSRC web page at <http://www.psrc.org/data/models/urbansim/>.

### Background

Land use forecasting at the PSRC has undergone significant change over the last few years, culminating with the deployment of a new land use forecasting system in the region. Previous land use forecasting was completed using the DRAM/EMPAL software framework, while current and future land use forecasting will be completed using the UrbanSim modeling framework. UrbanSim is an urban simulation system developed over the past several years to better inform deliberation on public policy choices by simulating long-term, significant effects on growth patterns. The principal motivation for the change was that the urban environment is complex enough that it is not feasible to anticipate the effects of alternative courses of action without some form of analysis reflecting the cause and effect interactions that could have both intended and possibly unintended consequences. UrbanSim was designed to reflect the interdependencies in dynamic urban systems, focusing on the real estate market and the transportation system, and on the effects of individual interventions, and combinations of them, on patterns of development, travel demand, and household and firm location.

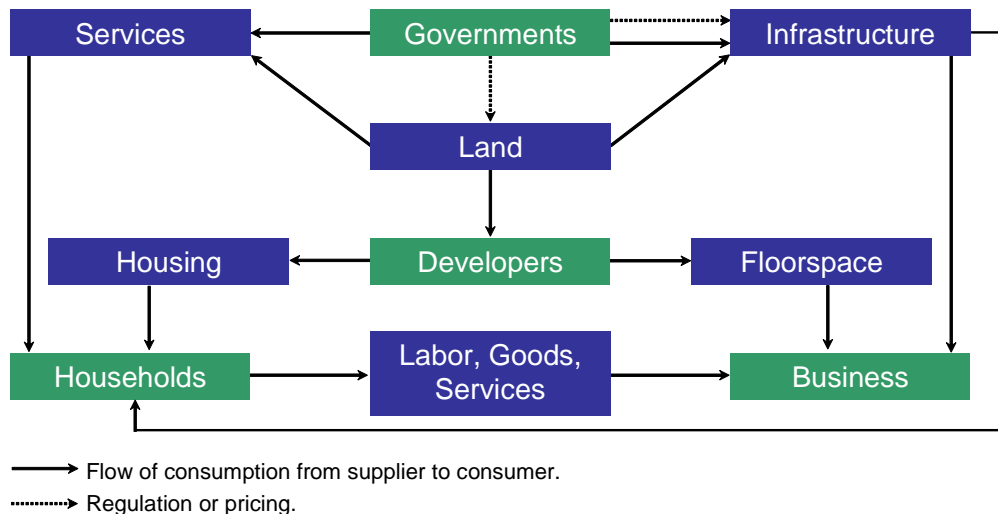
The Regional Council is currently implementing UrbanSim as the framework for land use forecasting. This project began in 2003 with the establishment of an inter-agency agreement with the University of Washington's Center for Urban Simulation and Policy Analysis (CUSPA), under the direction of Dr. Paul Waddell, the designer and lead developer for UrbanSim. The decision to implement UrbanSim is consistent with model improvement objectives outlined in the PSRC study, "Land Use and Travel Demand Forecasting Models," conducted from 2000 to 2003. The UrbanSim model was developed over the last six years for the Puget Sound region by a combination of CUSPA and PSRC staff and continues to undergo refinement and re-estimation as we deploy the system for planning purposes. The agreement between PSRC and CUSPA concluded in 2009 and was replaced by a maintenance agreement with Urban Analytics to provide ongoing support for the UrbanSim software to the agency.

UrbanSim uses a micro-simulation approach to land use forecasting; models predict the individual decisions of households, workers, jobs, developers and land owners. The culmination of their decisions, within the policy boundaries set by the model user (allowable land use development types and densities, transportation systems, etc.), determine the predicted future year use of each parcel in the modeled region. These results can then be summed to arrive at forecasts by zone, city, county, or any other geography specified by the model user. The key design features are summarized below:

- Simulates the location decisions for each household and job in the region – each household and job ultimately is assigned to a specific building, and correspondingly a parcel
- Produces a forecast for each year in the simulation (currently out to 2040)
- Tailored to interact with PSRC’s travel models so the impacts of land use on transportation, and vice-versa, can be modeled
- Predicts land development at a parcel level
- Requires as an input an interpretation of how many housing units or square feet of building space can be built under existing comprehensive plans, including adjustments for environmentally sensitive areas.

### UrbanSim Overview

The PSRC land use model is a parcel-based, market-driven model. The urban simulation process reflects the broad scope of interactions among households, firms, developers and governments within markets for real estate, labor, and goods and services.



In any given simulation year, the PSRC land use model predicts how the individual actors make decisions that culminate in the annual land development and location decisions.

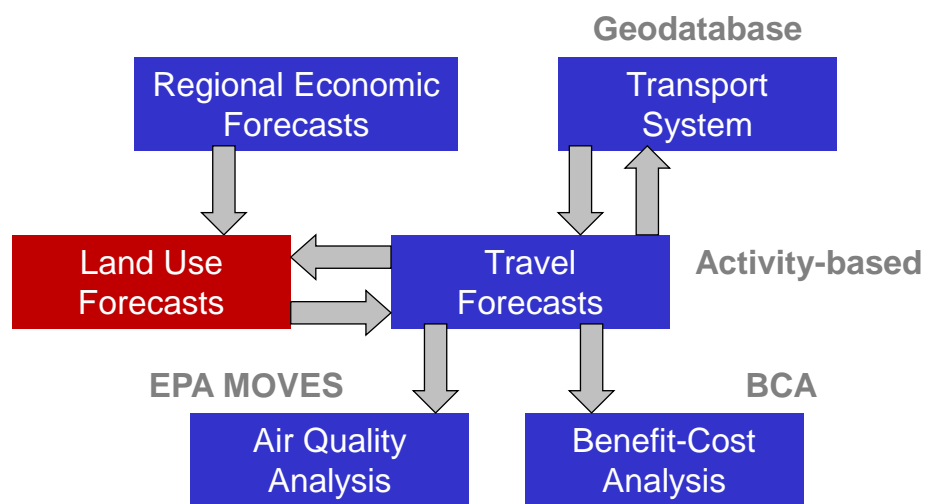
- Developers use land to construct housing and nonresidential floor space that are demanded by households and businesses, which are also interacting in the labor market and the markets for goods and services.
- Governments provide infrastructure and services, regulate and in some cases alter prices for the use of land and infrastructure.
- The key agents that generate or respond to the policies outlined are households, individuals, employers, developers, and governments.
- Households make a cluster of interdependent long-term lifestyle choices, including when to move, neighborhoods to locate within, the type of housing to rent or purchase and the number of vehicles to own. Individuals within households choose their labor force and educational status, their job mobility and job search, their daily activity schedule, their transportation mode and route.
- Employers choose to start and close establishments, and choose site locations, size of employment, and types and quantities of real estate to rent or purchase.
- Developers choose to undertake real-estate development projects, and the scale and locations of those projects.
- Governments set policies and make investments that affect the choices of other agents, and also make development choices regarding public facilities, including type, location, and scale of development.

**What is the PSRC land use model used for?**

In most forecast model suites, the land use model serves three primary purposes:

- Supporting the travel demand models by providing inputs needed to predict travel demand
- Producing forecasts of demographics and land use for planning studies
- Informing decision-makers through policy and scenario analysis – varying inputs to help answer “what if” types of questions.

The PSRC land use model’s location in the PSRC modeling structure takes inputs from the PSRC’s long-run regional economic model in the form of annual totals of households, persons, and jobs, which are used by the PSRC land use model to add or subtract appropriate numbers of each as needed. The PSRC land use model and the travel model have an



interactive relationship, as outputs of one model become inputs to the other, enabling the PSRC to directly model and assess the impacts of land use on travel forecasts, and the influence of the transportation system on the land use patterns of the region over time.

The agency has recently utilized the PSRC land use model to support the analysis work for the update of the regional transportation plan, Transportation 2040. Using an internal representation of the region's collective future year land use plans as a starting point, existing comprehensive plan constraints were modified in areas designated in VISION 2040 as areas likely to see more intensive growth. These changes allowed the region to accommodate the full amount of growth predicted for the central Puget Sound by 2040, while allowing for enough development capacity in the models where land use patterns could be influenced by the various transportation plans being evaluated. The PSRC is currently using the PSRC land use model to produce an updated sub-regional forecast of population, households and employment (the *PSRC 2012 Land Use Forecast*) to be finalized at the end of May 2012.

### ***What are the advantages and limitations of the PSRC land use model?***

The model is unique in that it departs from prior operational land use models based on cross-sectional, equilibrium, and aggregate approaches to adopt an approach that models individual households, jobs, buildings and parcels, and their changes from one year to the next as a consequence of economic changes, policy interventions, and market interactions.

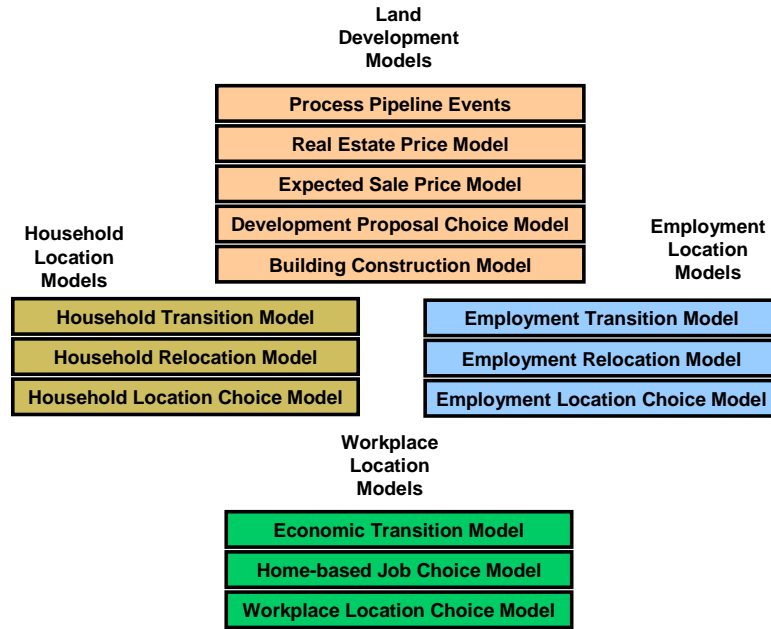
The design of the PSRC land use model adopted several elements to address these implementation goals, and these have remained foundational in the development of the system over time. These design elements include:

- The representation of individual agents: persons and jobs.
- The representation of the supply and characteristics of land and of real estate development, at a fine spatial scale.
- The adoption of a dynamic perspective of time.
- The use of real estate markets as a central organizing focus, with consumer choices and supplier choices explicitly represented.
- The use of standard discrete choice models to represent the choices made by households and firms and developers (principally location choices).
- Integration of the urban simulation system with existing transportation model systems.
- The adoption of an open source licensing for the software.

The key limitations of such models are that they are more complex than more aggregate models: they require large quantities of quality data, increased model runtimes, and advanced statistical methods and software programming knowledge to estimate and implement.

*How does the PSRC land use model operate?*

The PSRC land use model is implemented currently as one model suite within a larger framework referred to as OPUS (Open Platform for Urban Simulation). OPUS is designed around a modular, open-source software system, allowing new models to be added. The PSRC land use model itself is also designed as a series of models, currently organized under four main types of models.



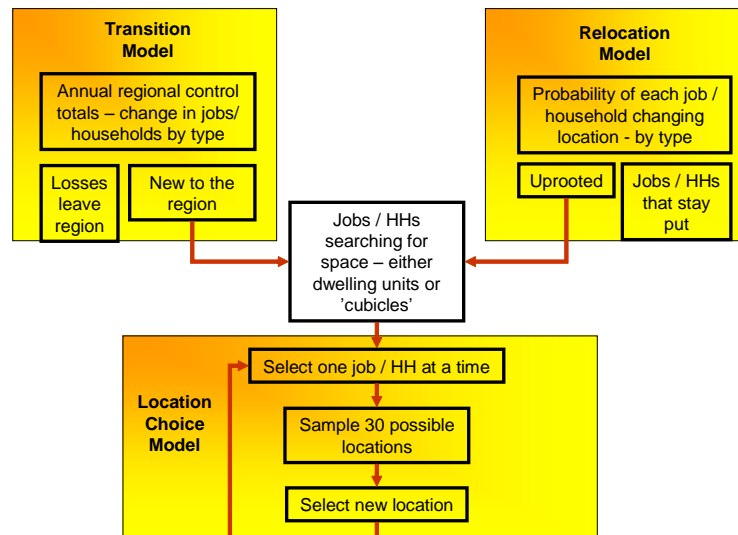
For every simulation year, the PSRC land use model runs the models in a sequential process. The sequence begins with models that simulate the land development markets. As a first step, the

<b>Process Pipeline Events</b>	<i>Developments assumed to be completed independent of model forecasting process</i>
<b>Real Estate Price Model</b>	<i>Predicts price of land if vacant, price of land + buildings if parcel is developed</i>
<b>Expected Sale Price Model</b>	<i>Generates possible development proposals for each eligible parcel, and the predicted return on investment</i>
<b>Development Proposal Choice Model</b>	<i>Selects proposals based on return on investment, current vacancy rates</i>
<b>Building Construction Model</b>	<i>Adds new buildings / demolishes redeveloped ones</i>
<b>Household Transition Model</b>	<i>Adds or subtracts households to the region to match the annual control totals from the user – subtractions are randomly selected, additions are not yet placed in a parcel or building. Employment same as Household with controls at the sector level</i>
<b>Employment Transition Model</b>	
<b>Household Relocation Model</b>	<i>Selects households that will move based on user’s probability inputs</i>
<b>Household Location Choice Model</b>	<i>Chooses vacant dwelling units for households added through Transition model and households moving via the Relocation model</i>
<b>Employment Relocation Model</b>	<i>Same function as Household Relocation model</i>
<b>Employment Location Choice Model</b>	<i>Same function as Household Location Choice model, but jobs choose building spaces (ie cubicles)</i>
<b>Economic Transition Model</b>	<i>Predicts whether a worker will leave a job, and adds new workers to the pool searching for a job.</i>
<b>Home-based Job Choice Model</b>	<i>Classifies workers into a work at home workers or one that commutes for their job</i>
<b>Workplace Location Choice Model</b>	<i>Matches workers who commute with a job</i>

Process Pipeline Events model allows the user to “override” the market prediction process for land development, programming in major planned developments or projects considered otherwise to be “in the pipeline”. After updating the valuation of the current stock of buildings and parcels in the Real Estate Price Model, the PSRC land use model then assesses which parcels are available for development, including parcels that are vacant, underutilized, and potentially re-developable. The Expected Sales Price Model creates a comprehensive list of potential development proposals for each parcel, along with the expected return on investment for each proposal. The Development Proposal Choice Model then randomly selects proposals for completion by the Building Construction Model, using the return on investment as weighting for the proposal selection process, and subject to the demand for each development type as represented by the current vacancy rates by building type.

The location models for households and jobs are handled in a similar fashion. First, a Transition Model adds and subtracts households (and persons) and jobs by type as called for by the regional forecasts. New households and jobs are not yet assigned a building; instead, they are temporarily assigned to a pool of actors “looking for a space”. The Relocation Models add to that pool, randomly selecting

households and jobs that choose to move during a simulation year, based on parameters that vary by the attributes of the households or job (for example, the probability of relocation for households headed up by someone over age 40 can be set much lower than households with heads under age 40). Finally, the Location Choice Model (LCM) cycles through each un-located household or job



in a random order, sampling from possible locations (either vacant dwelling units, or space (“cubicles”) in buildings, and evaluating the utility – or overall attractiveness -- of each location relative to the characteristics of the household or job, before choosing a new location based on the predicted utility.

The last sequence of the PSRC land use model matches workers to specific jobs. Procedurally, it mirrors the structure of the Household and Employment Location Choice Model blocks. An Economic Transition Model evaluates whether workers need to find a new workplace location, based on the relocation decisions of either the worker or job earlier in the simulation. The Economic Transition Model also identifies new persons who are workers, and new jobs, that can enter the labor market simulated by previous models. The Home-Based Job Model runs next, separating workers into those who elect to usually work at home versus those who usually work outside the home, involving some commute from home to a workplace. Those who usually work at home are given the same workplace location as their assigned housing unit building (house,

apartment, condo, etc.). The Workplace Location Choice Model then matches the remaining workers with a job, again based on the utility or attractiveness of each job randomly sampled from the pool of open jobs.

### *What data inputs are needed in the PSRC land use model?*

The basic structure of the PSRC land use model resides in the parcels and buildings tables, developed from county assessor files:

- The parcel tables provide spatial structure, as well as a reference to development constraints.
- The building tables provide location space for households or workers, non residential square feet and residential units, as well as building type and year built.

The households, persons, and jobs tables provide the individual agents whose location behavior is modeled. Households and persons are essentially nested units, and both tables are created by synthesizing a set of disaggregate records from aggregate summary data. The 2000 PUMS microdata file provided a set of disaggregate households specific to our region, which were then selectively duplicated to closely approximate regional demographic distributions by household type, age of household head, number of children, income level, race, and number of workers.

Unlike households and persons, the bulk of regional employment data was available by sector at a disaggregate level already, via Quarterly Census of Employment and Wages (QCEW) workplace records, and with precise geographic information.

The PSRC land use model uses spatially relevant development constraints and non residential utilization rates to condition future development. The development constraints table was developed as a distillation of the comprehensive plans and zoning requirements for all jurisdictions within the region, including allowed building types as well as minimum and maximum density (in housing units or floor area ratio). In addition to zoning and comprehensive plan layers, these constraints also reflect legal restrictions on development within certain types of geographic features, such as steep slopes, floodplains or stream buffers, as set forward in local critical areas ordinances. The resulting, cumulative set of constraints is applied directly at the parcel level.

All buildings that get built within the PSRC land use model are instances of an existing development template, analogous to the way a programming object is an instance of a class. The set of development templates for the PSRC land use model implementation was developed from empirical cluster analysis of permitted projects within the region. Additional templates were created or modified to more adequately cover the full range of allowed development. For specific, known development projects (i.e., Major Planned Developments), templates were instantiated and given the characteristics of the planned project to deterministically create them within the PSRC land use model in a given simulation year. Finally, the extent of development activity that occurs in each simulation year is constrained by a set of annual, regional target vacancy rates, specific to building type.

The land use model (UrbanSim) and the travel model (EMME) have been coupled/integrated such that modeling of land use and transportation policy assumptions interact with each other. The land use policy assumptions are introduced through the characterization of future year land use

designations or zoning regulations. While the transportation policies are implemented through modifications of the region's transportation network and demand model assumptions.

Below is a listing of some of the key data elements of the PSRC land use model as implemented at PSRC:

### **1. Base year regional inventory**

- Area\_types – Lookup table that generalizes the 6 regional geographies. Used in variables constraining mover distance
- Building\_types – Lookup table containing the 22 building types reduced from county assessor building type designations.
- Buildings – covered.
- Cities – Lookup table of the region's cities
- Development\_templates – The templates table contains the different types of buildings that can be developed in project proposals. Templates are permitted to be built by the size and density allowed on a given parcel.
- Development\_template\_components – Components specify more information about the template that are important for its construction including construction cost, and for mixed use templates, the portion of the development to go to each use.
- Gridcells – Foundational table for the original PSRC land use model application, now used for travel distance measures that it contains.
- FAZs – Lookup table of PSRC's Forecast Analysis Zones (FAZs)
- Households – covered
- Households\_for\_estimation – A subset of households used for estimating the household location choice model.
- Jobs – covered.
- Land\_use\_types – Lookup table containing the 30 land use types reduced from county parcel land use designations.
- Large\_areas – Lookup table of 19 groupings of zones
- Parcels – covered.
- Persons – covered
- Persons\_for\_estimation – A subset of persons used for estimating the workplace location choice model.
- Zones – Lookup table of PSRC's 938 Traffic Analysis Zones (TAZs)

### **2. Policy Assumptions - Land development regulations**

- Development\_constraints – Developed from city/county comprehensive plans, this table provides the generalized allowed densities and building types allowed on each parcel.
- Critical Areas -- Listed are eight environmental features that are used in the PSRC land use model's representation of critical areas, along with their sources:
  - Floodplain – FEMA
  - Forest – Washington State Department of Transportation
  - Major public lands – Puget Sound Regional Council
  - National wetlands inventory – US Fish and Wildlife Services
  - Parks and open space – Puget Sound Regional Council
  - Steep slope – Puget Sound Regional Council
  - Streams – Washington State Department of Ecology
  - Water bodies – Puget Sound Regional Council



- Major Planned Developments – Contained in the project proposals table. MPDs are definite, regionally significant developments manually input by the model user to ensure their development

### 3. Model parameters

- Annual\_household\_control\_totals – Controlled number of households in a given year
- Annual\_relocation\_rates\_for\_households – Relocation rates are developed for household age of head and income groupings, and dictate the probability of a household relocating in any year
- Employment\_location\_choice\_model\_coefficients and specification – Collection of variable definitions and estimation results of the employment location choice model.
- Household\_characteristics\_for\_ht – This table summarizes the variables and ranges that the model targets when adding/subtracting households in the household transition model
- Household\_location\_choice\_model\_coefficients and specification – Collection of variable definitions and estimation results of the household location choice model.
- Real\_estate\_price\_model\_coefficients and specification – Collection of variable definitions and estimation results of the real estate price model.
- Target\_vacancies – The developer model constructs buildings depending on how different the current (end of previous year) vacancy is from the annual target vacancy rate. If the current vacancy rate is higher than the target, no buildings of that type will be built.
- Workplace\_location\_choice\_model\_coefficients and specification – Collection of variable definitions and estimation results of the workplace location choice model.

### Recent Efforts to Ready UrbanSim for Land Use Forecasting

Over the past year PSRC has worked closely with our Land Use Technical Advisory Committee (LUTAC) to ready UrbanSim for use in the creation of the 2012 Land Use Forecast. This effort was undertaken to ensure that the model generates reasonable results and has resulted in numerous improvements to the model system. These efforts to refine the UrbanSim models can be grouped into the following major categories:

1. Regional Economic Forecast
2. Parcel inputs and assumptions
3. Developer inputs and assumptions
4. Other Key Assumptions
5. Model re-estimation
6. Refinement Model Functionality and Confidence Intervals

#### *Regional Economic Forecast*

A key input to the UrbanSim model is a set of regional control totals for population and employment. These inputs define the allowable population and employment forecast that UrbanSim allocates to parcels throughout the region. The last time PSRC released a Regional Economic Forecast was 2006, at the height of the housing boom and two years before the start of the Great Recession. The first step required to move forward with the production of the 2012 Land Use Forecasts was a revised Regional Economic Forecast.

PSRC staff has worked closely with our economic modeling consultants and LUTAC to prepare a draft central Puget Sound economic forecast through 2040 that provides key inputs to the UrbanSim land use model. The regional model developed by our consultants makes use of an open source model of the U.S. economy, extended out to 2040, as an exogenous input to forecasting the region's economy. This model was originally created for the region in 2006 and has been updated for use in the 2012 Land Use Forecasts and reflects the latest thinking on the regional and national economies. Below are a few key highlights from the results of the latest regional economic forecast.

Our preliminary regional economic forecast for wage and salary employment in 2040 is lower than the 2006 forecast by 3%.

- 2006 PSRC Forecast – 2040 Wage and Salary Employment = 2.80 million
- 2012 PSRC Forecast - 2040 Wage and Salary Employment = 2.71 million

Population in the two forecasts is similar.

- 2006 PSRC Forecast – 2040 Total Population = 4.99 million
- 2012 PSRC Forecast - 2040 Total Population = 4.97 million

However households, due to a change in predicted average household size, drops by approximately 8%.

- 2006 PSRC Forecast – 2040 Total Households = 2.19 million
- 2012 PSRC Forecast - 2040 Total Households = 2.02 million

For more detail about the Regional Economic Forecast, please go to <http://www.psrc.org/data/forecasts/econdem/>

### ***Parcel Inputs***

This area of model refinement has focused on cleaning up key parcel-level input files. UrbanSim requires as input a set of tables that together comprise a base year representation of land, buildings, and actors (persons, households and jobs). PSRC staff have worked to identify and correct for data input issues in the current year 2000 Base Year Database and to provide a reasonable set of base conditions for forecasting out to 2040.

The Future Development Constraints and corresponding Future Year Land Use database reflect allowable future development as allowed via currently adopted Comprehensive Plans. The current representation provides a reasonable interpretation of current development constraints; however a major component of the 2012 Land Use Forecast review process will focus on the accuracy of these keys inputs. Developer Inputs and Assumptions

The UrbanSim developer model is structured to predict the probability within a single simulation year of a parcel experiencing a development event, and if it does experience such an event, identifying the type of event that is most likely. This model is a central element of the urban simulation approach and involves a number of steps, relationships with other UrbanSim sub-models and inputs. PSRC focused on several key inputs to the developer models to ensure reasonable results. These include:

1. Review of the development templates to ensure adequate development opportunities for all parcels
2. Testing of parcel redevelopment thresholds for “underutilized” parcels
3. Meta-level review of project development cost assumptions for determining the “profitability” of a development event

4. Testing of vacancy rate thresholds that govern when development proposals of a certain type will be selected
5. Review of the developer model proposal selection procedures

PSRC staff recognizes that this is an area of some complexity within the model system where it is difficult to always disentangle the influence of related inputs and assumptions. We have worked hard to ensure that the models are operating reasonably and provide a suitable platform for the forecast, but we also know that PSRC staff will continue spending some future effort in a more systematic review of the developer model structure and assumptions.

### ***Other Key Assumptions***

In addition to the parcel and developer inputs, a wide range of other inputs received attention in the preparation of the 2012 Land Use Forecast. These include:

- Real estate in UrbanSim uses true spatial terms (parcel size, building floor area); as such some measure of space utilization is necessary to determine employment capacity within any given building. Rather than rely on area-wide averages for a job to square foot value, PSRC has implemented an approach to modeling employment space utilization that preserves space utilization as exists in the base year for existing structures.
- The UrbanSim model system is designed to reflect the influences that land accessibility has upon real estate prices, household and job location decisions, and the identification of usual places of work for employees. In practice, measures of accessibility are provided by the regional travel models; accessibility measures are in part a function of the future transportation network (transportation projects and programs) that are included as assumptions in the travel modeling. For the 2012 Land Use Forecast, the 2040 Baseline Scenario from Transportation 2040 was assumed.
- Households in the region have historically experienced growth in real income (income adjusted for inflation) over time. The most recent regional forecasts predict continued growth in real income through 2040 and the UrbanSim model assumes an annual growth in personal income of 1.0% per year.

### ***Model Re-Estimation***

Prior to using UrbanSim in the production of the 2012 Land Use forecast, PSRC staff re-estimated all key models using the latest estimation data sets and model formulations. This step was necessary since a number of data refinements had been implemented and since more appropriate accessibility data from travel models became available. The re-estimation process had three steps.

1. Re-estimate all models with existing model specifications but with refreshed estimation data.
2. Test of alternative model specifications with any currently available variables of interest.
3. Model calibration based on an assessment of potential model bias.

Model Re-Estimation resulted in the removal of a few dummy variables in some of the model components as well as stronger correlation of the model with the estimation data set.

## *Refinement Model Functionality and Confidence Intervals*

Despite all the best efforts in the design and operation of models, it is recognized that situations can occur where specific model output cannot be adequately explained or justified as a reasonable forecast. In situations like these, it may be necessary to adjust results based on sound professional judgment. The Refinement Model is designed to manually adjust model output in one of several ways, and can be directed at any geography formally defined in the model, from individual parcels up to an entire county. Our knowledge of future events is uncertain and as such so are forecasts about the future. Forecasting models also include bias which influences our certainty about model predictions. As a result forecast products are best interpreted through some explicit treatment of forecasting uncertainty. A Bayesian method has been developed within UrbanSim as a means of directly characterizing forecast uncertainty given the stochastic nature of the model outputs and estimates of model error. In this framework the model outputs given the model inputs, become a probability distribution. The 2012 Land Use Forecasts include both expected values and confidence intervals around those expected values for key model outputs (population and employment) for each FAZ. These confidence intervals should be used to guide judgments about post modeling refinement of model outputs at the same spatial scale. The confidence intervals can also help jurisdictions to make judgments about how to use and customize the 2012 Land Use Forecasts for their own use in various planning processes.

### **Forecast Review Process**

On February 28, 2012, PSRC released a Draft 2012 Land Use Forecast that makes use of demographic and employment controls from the new regional economic model and allocations of these via the refined UrbanSim model. The land use forecasts are now undergoing an extensive review from local planners and technical staff in preparation for a final 2012 Land Use Forecast by the end of May 2012. We are on course with the following review and publication schedule for the PSRC 2012 Land Use Forecast and related products.

- February 28 - Draft 2012 Land Use Forecast Review Materials Released
- March 1 - Reviewer Workshop
- March 30 – Forecast Review Period Closes
- May 30 – Final 2012 Land Use Forecast Products Published

To aid the review process and streamline the turnaround of comments, an online web-map tool was developed to assist jurisdictions in examining and, where necessary, submitting corrections to the FLU layer. The viewer displays allowed maximum densities via a color gradient and allows users to make corrections to the land use inputs directly and submit them to PSRC for inclusion into future runs of the UrbanSim model. The Map Viewer also serves as a great resource to document the key model assumptions used in the creation of the forecast. Details about the web mapping tool and the review process can be found at <http://www.psrc.org/data/forecasts/2012-forecast-products/>

In May of 2012, the Land Use Forecast will be published in tandem with a companion product called the Local Targets Representation dataset. The Local Targets Representation dataset, in contrast to the Land Use Forecast, provides a long-range, small area representation of future population, households, and employment that is consistent with local growth targets developed to align with the VISION 2040 regional growth strategy. The draft methodology for developing the Local Targets Representation dataset has also been released for public review and comment.

## **Additional Information**

The current home page for the UrbanSim model is <http://www.urbansim.org/>. A Users Guide for the current stable release can be found at <http://www.urbansim.org/downloads/manual/latest-stable-release/opus-userguide.pdf>. Documentation for the parcel based version of the UrbanSim model can be found at <http://www.urbansim.org/Documentation/Parcel/WebHome>.

Many research papers are also available at <http://www.urbansim.org/Research/ResearchPapers/>. Some feature descriptions of the PSRC application of UrbanSim, although many of those are now somewhat outdated since they refer to the original grid cell based implementation of the model (conversion to the parcel-based version occurred in 2007). Four papers appear at the top of the page are recommended to the reader for basic information on UrbanSim and land use modeling.

PSRC staff have made several presentations to the agency's Regional Technical Forum, the two most recent can be found at [http://psrc.org/assets/1803/rtf\\_061709\\_urbansim.pdf](http://psrc.org/assets/1803/rtf_061709_urbansim.pdf) and [http://psrc.org/assets/1751/RTF\\_UrbanSim\\_Basics\\_July08\\_Prefinal.pdf](http://psrc.org/assets/1751/RTF_UrbanSim_Basics_July08_Prefinal.pdf).