STEP3

Small Area Demographic Forecasts for Clark County

CALIPER CORPORATION

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1 Introduction and Executive Summary

This report presents the results of a project aimed at producing small area population forecasts for Clark County, Nevada. Clark County is one of the most rapidly growing areas in the United States and has proven to be a highly attractive destination for new residents in addition to being a major tourist destination.

The settled land area in Clark County has grown enormously over the last decade and is expected to continue to grow significantly in the future. Many planning problems and issues can be better addressed if forecasts are available to predict in advance where people will live and work in the County. Long range planning for schools and other publicly provided services will be greatly aided by better and more detailed forecasts.

Forecasting any aspect of the future is fraught with danger and may be an impossible task. In this project, we implement a new method to develop demographic forecasts that allow the exploration of alternative future growth scenarios. This method takes account of organic growth and the evolution of demographics through time. Surprisingly, in many forecasting applications, future year demographics are taken to be identical to base year or current demographics. This is unsatisfactory as we have every reason to believe that future year population characteristics will be rather different from current ones due to the aging and graying of the population. Attendant to these changes will be implications for the provision of additional services.

Increasing tourism and the consequent growth in the gaming industry and other attractions in Clark County and associated growth in employment in hotel accommodations and other services are important drivers of the population forecasting approach. Increases in employment through in-migration are necessary to support the activities that serve greater numbers of tourists. Retirees also move to Clark County because of its favorable winter climate, moderate cost of living, and the growing number of attractions and amenities. Additional service employment is needed to serve both retirees and other in-migrants leading to further population increases.

While the precise determinants of tourism levels and in-migration may not be observable, inferences can be made from empirical data and used in forecasting future growth and development. Incorporating these relationships in the forecasting process results in a model that is tailored specifically for Clark County and its unique characteristics.

A forecasting model whose parameters can be adjusted is much more useful than a forecast made at a single point in time. Tuning the parameters can indicate alternative growth futures that could conceivably occur. Also, adjustment of the parameters can help the model track observed population dynamics more closely and lead to more refined forecasts. This can be especially important because of the impacts of unforeseen exogenous shocks or specific major new developments that do not fit with prior development trends as represented in the model. New values for population and employment can be substituted when planned developments are announced.

Using a structural model whose components correspond directly to real world behavior and the characteristics of households and individuals makes the basis for the forecasting process and the forecasts themselves more understandable. Insights from the forecasting effort may be even more valuable in comprehensive planning than the specific forecast population levels themselves as they allow, for example, appreciation of areas that may expand geographically faster than others.

Some of the relationships that are incorporated in the model are either unmeasured, infrequently measured or poorly measured. They may also be poorly understood from a statistical point of view. For example, household formation through marriage is not directly captured in the annual statistics that are typically available. Also, it is hard to create a precise statistical model to predict who will marry whom in Clark County. Nevertheless, use of approximate rates and simple relationships can help forecast demographics of interest such as the number of children who will need schooling in future years.

Even if we were to become adept in forecasting the future number of residents, planners need to understand where they will live and work to plan for infrastructure. In some communities there may also be a desire to guide the form and location of new development through zoning and other regulatory means. Therefore, it becomes highly important to predict the spatial pattern of future development.

The problem of small area forecasting is generally considered the domain of land-use models. While land use models have been of academic interest for at least 40 years there are, as far as we are aware, no clear documented empirical forecasting successes. A big part of the problem is the inherently unpredictable nature of private sector developer behavior and decision making. Also, markets are highly impacted by price considerations and these, too, may be beyond our capabilities in modeling. In this effort, we try to build a model that does not attempt the impossible, and, therefore, we do not treat developer behavior in great detail.

Developers have found Clark County a favorable location for development, and housing supply constraints do not appear to have limited population growth. Similarly infrastructure has been provided so that water, power, and transportation facilities have been provided over an increasingly wide area as population settlements expanded. We expect this behavior to continue, and thus we do not model the behavior of home builders or infrastructure providers directly. We do examine whether there are constraints upon land availability that might come into play in the future. While it is not a focus of the project, the forecasting tool could be easily expanded to make it possible to examine transportation implications of future growth and development.

The approach to demographic forecasting with STEP3 differs from that used in prior demographic forecasting effort in many ways. Perhaps the most fundamental difference is that it is a disaggregate simulation of individual household change. By this we mean, that we begin with a population of discrete households in a base year such as the year 2000. Because of data limitations and privacy concerns, we don't actually have data on all or most households. Instead we create a synthetic or virtual data file of households such that when we tabulate their characteristics, we get the aggregate values that were measured in the 2000 Census. To do this we make use of actual Census records that are published as the public use microdata sample. A 5% sample is provided for each PUMA district of which there are eleven in Clark County. The sample obscures the location of each household but in the synthetic population, we identify a cell location for each one.

When the sample is built, we do not try to match every single population characteristic for each small area. Rather, we focus on a key subset and then we bring along all the other characteristics associated with the records we draw for that area. By controlling for key demographics, we obtain a more formal and detailed accounting for population characteristics than that provided by aggregate economic growth models and aggregate spatial interaction models.

The synthetic population by itself results in a useful and interesting database which can be used for many applications, but it becomes more useful when we are able to forecast from this base. This is done by evolving the population in a fairly natural way. For example, each person gets one year older each year unless of course they die. This is not the whole story because there are births and marriages and new household formation when children grow up. Migration is the other big factor which in Clark County greatly outstrips emigration. In addition, people retire from the labor force and this has further impacts on the need for additional workers. Models ranging from simple rates to probabilistic explanatory models are used to express these dynamic relationships and generate future forecasts.

An important characteristic of this modeling effort is its use of readily available data. This was one of the more difficult aspects of the project, as there are no ideal data sets for this type of model. These data include the assessor's database and many different types of Census data ranging from time series at the County level to extensive Year 2000 micro and aggregate data. The fact that the data were available does not, however, mean that they are provided in a form that makes them readily useful. On the contrary, a complex and difficult set of data processing tasks was needed to transform the data so that it is usable for input to the model.

Assembling the data involves adding constructs of the accounting framework that is used in the model. Accordingly, we have a file that contains information on each household present and future and the individuals that comprise the household unit. These data are aggregated to 1000 by 1000 meter grid cells that cover the County for which we keep count of employment and residence land use by type. Some cells are unavailable for development if the terrain is unsuitable or if they are already fully occupied by stable land uses.

Various key trends are embodied in the model especially those associated with population growth through in-migration which is principally determined by growth in tourism which stimulates growth in tourism-serving employment. This employment in turn causes further growth in service jobs and the population needed to provide this service employment. Using this simple theory, statistical analysis was used to verify these relationships and estimate the magnitude of the effects.

Historically growth rates that average 5 percent per year have been observed and these form the high end of the projections that we have developed. With these growth rates a population of 3,591,883 people is reached in 2025.

Our predictions are that there will be very high growth in the county and that the settled area will grow significantly. Specifically, high growth will be experienced in the Las Vegas Valley (North, North-West, West, South, South-East), Searchlight, CAL-NEV-ARI, the Primm-Roach-Borax corridor, Sandy Valley, Moapa, Mesquite and Indian Springs.

One should keep in mind that we don't explicitly model redevelopment although this might be important to do in the future. Consequently, the settled area may not be as extensive as the predictions imply. Also one should keep in mind that this is a model and not a guarantee of any specific future situation. More calibration and validation will undoubtedly be warranted if the forecasts are to be used for any particularly important purpose.

The models can be applied in various ways and in different combinations. For example, the population synthesis and progression components can be run by themselves to generate county-wide forecasts. Similarly, the land use spatial distribution models can be run using exogenous or alternative county level forecast numbers. Lastly the whole model sequence can be run including the travel demand model components.

The precursor to STEP3 is STEP2, whose models were innovative in that microsimulation gave more insight and policy sensitivity to travel forecasts. Also, residential and work place choices were incorporated and these have been greatly improved for STEP3. Also, STEP2 did not predict settlement of rural or presently unsettled parts of Clark County.

In the STEP2 modeling effort, we analyzed sustainability from a transportation point of view but with predetermined future demographics. In other words, a separate forecast of future population by traffic analysis zone was an input. This was a significant limitation, and is one important reason why the STEP3 models are much more informative.

Extensive use of GIS technology was made to prepare the datasets used in STEP3. GIS technology is also used to structure the model and present the model outputs in an understandable form.

STEP3 is easy to run because it has a custom interface and the model software is designed to hide the enormous complexity and volume of computations that are attendant to the implementation of this microsimulation approach.

We posit a simple structural model for population growth in Clark County that reflects both economic and demographic principles. We take in-migration to be a key component of future population and can distinguish in-migration of retirees and near-retirees as well in-migration that serves additional population growth through employment in service industries. Specific growth in the gaming and entertainment industry is taken as being exogenous and a vital input to the model. Gaming and entertainment industry expansion creates large numbers of jobs in Clark County through both construction and remodeling and through the need for gaming and entertainment industry workers. There is also a further multiplier effect in that gaming and entertainment industry workers and their households generate additional service employment.

Total employment grew approximately 7.5 percent in 2005 with a similar rate of growth for the accommodation and food service industry, while tourism continued to grow at over 3%. These factors look set to drive the expansion of settlements within Clark County well into the future, reinforcing the need for models that can aid in the decision making process of planners.

2 Model Background and Overview

2.1 Introduction

In this chapter we describe the methodology used in the implementation of a Household Microsimulation model for Clark County, Nevada. The principal objective of this project is to obtain improved demographic information and forecasts to support transportation and emergency planning in Clark County. Clark County is one of the fastest growing regions in the country and requires models that simulate the effects between transportation system changes and landuse, and the consequent feedback effects on infrastructure and urban form.

STEP3 simulates land use and demographic changes over time at variable levels of geography, enabling the creation of the data required for effective planning for future years. The output from STEP3 includes the number, composition, and economic characteristics of households for small areas in Clark County, including rural areas that at present are only sparsely settled. This is simulated at the micro-scale thus permitting assessment of the average income of households by household size, the number of motor vehicles owned and operated, and estimates of workers by location and type of establishment, as well as the age distribution and employment or student status of all household members. This is possible due to the modeling of changes in households through time, accounting for factors such as births, deaths, household formation, marriages, divorces, and in- and out- migration, all based upon rates that are measured by the Census and estimated from various state and local data sources.

Variable zone sizes and utilizing the individual as the unit of analysis provide the spatial detail that is important for characterization of the production, attraction, and distribution of trips. Spatial detail is also desirable for emergency planning and response. This is especially true in terms of being able to model the population for each small area, thus facilitating evacuation planning. In addition, STEP3 can generate a set of forecasts that will enable the calculation of the future population that falls within close proximity to highway and rail routes that are likely to be used for the transportation of high level nuclear waste for example.

There are three key attributes that make the STEP3 model fundamentally different from traditional planning models:

1. The model is applied at the level of the individual rather than based on zonal averages
2. The model includes components for residential choice and employment location to forecast the spatial distribution of households and jobs in the study area at the disaggregate level
3. STEP3 is an integrated landuse-transportation simulation model. The STEP3 demographic forecasting model is delivered as an add-in to Caliper's TransCAD software, which is in use in Clark County for travel demand forecasting

Consequently, STEP3 is a hybrid of demographic, landuse, and transportation models that simulate the evolution of the study region.

This project builds upon available data and prior forecasting work done in Clark County by various entities, and specifically extends and expands the forecasting simulation tools developed by Caliper in the STEP2 model for Clark County. The extensive review of available data and forecasting techniques resulted in the development of an improved simulation method for demographic-landuse-transportation modeling that will be used to make forecasts for Clark County.

The origin of STEP3 is the STEP policy analysis tool created by Greig Harvey in the 1970s and enhanced through the 80s and 90s (Harvey, 1978, and Harvey and Deakin, 1996). Harvey's work on STEP was based on two key philosophies. The first was the importance and value of applying travel demand models at the level of the individual decision-maker, rather than applying the models based on zonal averages. Application at the level of the individual both allows for the use of more behaviorally rich (i.e., realistic) travel demand models, and also allows for impact analysis to be performed for specific socio-economic groups. The second philosophy was to develop the tools in a way such that they would be accessible to planning agencies without overly burdensome commitments of time and money. Therefore, STEP provided default models that could be calibrated to match local conditions, and the models are based on readily available data such as census data (including SF1, SF3, and PUMS), although it also makes use of household transportation surveys.

The philosophies of the original STEP model are also at the heart of this STEP3 project, in which the STEP modeling tool has been further improved after being revived and enhanced for Clark County in STEP2. This has involved the development and application of state-of-the-art microsimulation transportation planning techniques to capture the essence of environmental, land use and transportation interrelationships. The Caliper STEP models go beyond the original STEP in numerous ways, including running within a GIS environment, incorporating realistic transportation networks and traffic assignment, integrating models that have been developed specifically for Clark County, and making use of the 1996 Las Vegas Valley household survey.

Also, STEP3 significantly extends the capabilities of STEP2 by modeling the progression of households and persons through time while simulating land use changes within Clark County. As an integrated land use-transportation model, the outputs of STEP3 for Clark County can be used to assess environmental, social, and economic impacts of various land use and transportation policies and plans. A valuable aspect of the output is the ability to produce impacts by socio-economic group, and therefore address issues of equity, and also to provide a more realistic representation of the interaction between infrastructure and land use. Furthermore, the modeling analysis tool is expandable to include additional detail in terms of daily trip patterns and sensitivity to demographics and transportation policy variables by incorporating more detailed representation of travel and travel behavior.

2.2 Microsimulation, STEP, and the Objectives of STEP3

The principal objective of this project is to develop and apply state-of-the-art microsimulation transportation planning techniques to capture the essence of environmental, land use, and transportation interrelationships to allow small area demographic forecasts. This effort builds upon and enhances the STEP/STEP2 travel demand analysis packages, the former of which was originally developed in the 1970s as a sketch planning tool for the San Francisco area (Harvey, 1978). The key feature of STEP is that it is based on microsimulation, meaning that it uses the individual or household as the basic unit of analysis.

The essence of what makes the STEP models different from a traditional 4-step aggregate transportation modeling implementation is that all of the processing is done at the level of the household and individuals in these households. That is, while an aggregate 4-step implementation is based on aggregate travel between zones, a microsimulation approach instead simulates a population of representative households and persons, and then makes forecasts by aggregating decisions made at the household level. There are numerous advantages to a microsimulation approach, including being able to tabulate impacts for subgroups of the population (for example, low income or elderly) and the as yet unimplemented capability of explicitly modeling realistic travel behavior patterns such as trip chaining. Such advantages are further explored later in the report.

The use of microsimulation policy analysis tools was pioneered by the economist Guy Orcutt in the late 1950s (Orcutt *et al*., 1976). The driving force is that aggregate demand is made up of a large number of decisions made by individuals, and therefore it is necessary to do the behavioral modeling at the level of the individual. That is, one person (or household) is processed at a time, and then these individual decisions are summed up to produce summary statistics on the behavior (including the impacts of policies). It has long been recognized in transportation (since the 70s, at least) that there is great value in modeling transportation at the level of the individual. The basic argument is that people travel, not zones, and by averaging to the level of the zones, much information is lost. A driving force behind these ideas was Daniel McFadden, whose work on theory and methods for modeling choices at the level of the individual was awarded the Nobel Prize in Economics in 2000. He developed the widely used multinomial logit model (among many contributions), and his first application of it was to forecast ridership for BART in the San Francisco Bay Area. It is these logit-type models that form the building blocks of microsimulation of travel demand and household and business location.

While the theoretical advantages of microsimulation are well known, the technique has not been implemented to a wide extent for either urban development or transportation forecasting. There are many reasons for this. One is that a microsimulation approach is significantly more computationally intensive. However, such computational limitations are being alleviated via dramatic increases in processing power and the use of multiprocessing techniques (for which microsimulation is a perfect application) in software such as TransCAD.

A second reason for slow adaptation is that the methodologies are more complex, and therefore require more expertise for development and also tend to be more data intensive. The original STEP model made great strides in making microsimulation a more viable alternative for transportation planning agencies by creating default specifications that could be calibrated for different study areas. STEP2 and STEP3 continue the progress in this direction. A third is that there is, as of yet, very little hard evidence of realized gains from modeling with microsimulation – a fact that will probably change if microsimulation tools are available to planners.

The objective of the STEP3 project is to build upon previous STEP models to realize the development of a fully integrated microsimulation land use-transportation planning tool for

Clark County, Nevada. This project continues Caliper's work in this arena that included the integration of STEP's home-based work models into TransCAD for Baltimore (Slavin and Lam, 2001), as well as the STEP2 model TransCAD add-in developed for the RTC. The Baltimore project tested some key enhancements to STEP, including the use of a GIS platform and real transportation networks. STEP2 further revived the STEP models and the general philosophy behind them, including modeling at the level of the household and developing tools so that they are easily accessible to planning agencies. Additional enhancements to STEP that were implemented during the STEP2 project include:

- The development of flexible and generic microsimulation tools, data processing, and calibration capabilities so that the default specifications can be readily modified and enhanced.
- The use of TransCAD's GIS environment as a platform, so that model outputs can be analyzed visually using all of the capabilities of a powerful GIS. Also, so that powerful database capabilities can be used for storage, manipulation, and editing of data.
- The use of real transportation networks and incorporation of traffic assignment so that changes in level of service resulting from changes in demand can be calculated internally. (In order to be able to be run quickly, the original STEP model did not have an internal transportation network representation or traffic assignment model.)
- The incorporation of tour- and activity-based modeling concepts by explicitly representing trip-chaining in the work tour.
- The capability of aging the population.
- And, specifically for Clark County,
  - The use of demand models developed for Las Vegas
  - Incorporation of travel behavior statistics derived from the 1996 Las Vegas household survey and recently released Census 2000 data.
  - The inclusion of a residential choice component to determine the spatial distribution of households.

STEP3 extends the capabilities of STEP2 significantly by explicitly incorporating land use models, and by simulating land use, demographic and transportation network development spatially and temporally without reliance on exogenous models and data for projected year-on-year aggregate totals. These enhancements include:

- An integrated land use-transportation simulation tool utilizing future land use plans and retail and residential land use modeling.
- The ability to use any zonal layer: This allows the resolution of the analysis to be changed to support higher or lower level simulation.
- The ability to perform full year-on-year demographic, land use and transportation modeling.
- Use of the latest Census data and rates for population synthesis and lifestage progression.
- A time-series visualization tool, that shows thematic changes over time for any zonal variable modeled.

2.3 Advantages of Integrating Land use Models

Regional planning agencies have long been faced with the problem of assessing the correlation between transportation and land use decisions. Road construction is often cited as the primary reason for suburban sprawl, and is thus frequently opposed by the general public and environmental groups who assume that if roads are built development will follow. However, many of the arguments espoused regarding land use and transportation development linkages are anecdotal. Indeed, the influence of transportation network construction on urban growth is widely debated by practitioners and academics alike. Some have argued that transportation supply merely follows developers' decisions and that road building might even limit population growth due to the land area roads consume. By integrating land use and transportation models, alternative possible future effects can be better simulated and changes in the urban form can be modeled so that there is an appreciation of the influence of both road and land use changes.

The primary reasons for a lack of integration of such models correspond to the points already discussed for microsimulation. These are that there is a perception that any inter-relationships are too complex to be implemented in a generic easy-to use tool that is accessible to planning agencies, and secondly that the processing and data requirements for any such models would be excessive. However, recent advances in processing and storage capacity/availability render such considerations obsolete, while the power of the underlying procedures and transportation/GIS components of TransCAD mean that such an integrated model can be effectively implemented.

Consequently, as one of a few integrated land use and transportation models currently in existence, STEP3 is capable of empirically modeling these interactions. STEP3 provides an improved understanding of such relationships by simulating and visualizing scenarios that account for changes in land use and transportation infrastructure and by modeling factors such as local and regional land use and economic development policies, which also play an important role in suburban and rural growth.

3 Methodology and Modeling Approach

3.1 Introduction

In this chapter we provide an overview of STEP3 for Clark County. The goal of the development effort was to develop microsimulation-based small area demographic forecasts for Clark County. This takes the form of a set of integrated demographic, land use and travel demand models that are applied at the individual level. The basic structure of the original STEP model is retained in STEP3, but many of the components have been modified and/or replaced with models developed directly for Las Vegas. Several new features were also incorporated that did not exist in STEP, including the use of a GIS platform, incorporating real transportation networks, a demographic progression process for aging the population, land use modeling, and models for labor force participation and retirees. In addition, many of the STEP models, which were originally estimated using data from San Francisco, were replaced by models developed for Las Vegas from PUMS and the 1996 Las Vegas Household Survey. The sections below discuss the framework of the model, the model development process, and provide an overview of how the model is run in TransCAD.

3.2 Framework

The framework of the STEP3 model is provided in Figure 1. There are four major components to the model:

1. Population Synthesis
   Uses PUMS and aggregate zonal data to generate a representative population of specific (but synthetic) individuals and their personal and household characteristics

2. Progression
   This population is then progressed/projected on an annual basis and it is determined for each individual whether or not the person is a worker or retired

3. Land use Modeling
   Estimates residential and employment growth in terms of residential and job units

4. Household Locational Behavior
   Simulates workplace and residential choice for each individual in the synthetic population

Additional detail on these stages is provided below.

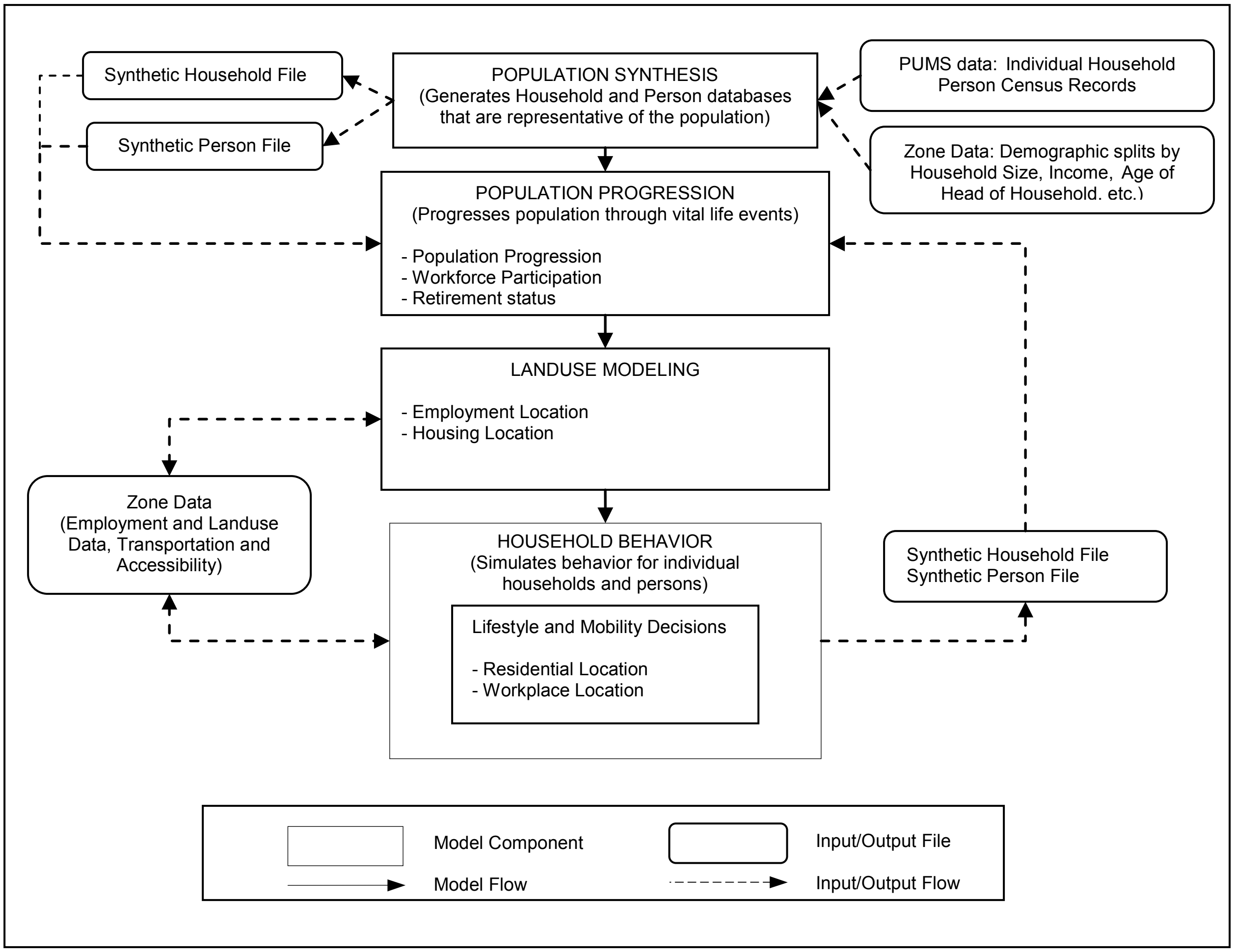


Figure 1: Model Framework for STEP3

3.3 Model Basics

3.3.1 Types and Source of Models

Making up the general framework of the STEP3 model shown in Figure 1 are a large number of behavioral models that are used to simulate each decision in the hierarchy. These models come in one of several forms including choice models (logit and nested logit), the use of cross-classification lookup tables, and probability distribution lookup tables. The STEP3 implementation makes use of models developed for Las Vegas by Parsons-Brinckerhoff for the RTC. In addition, new models were developed for STEP2 and STEP3 using PUMS data, the 1996 RTC household survey, as well as disparate Clark County data sources including employer and visitor databases. The specifics of the models are described below.

3.3.2 Zone System

The model can be based on any zone structure. The default is a grid cell layer with cells that are 1000 by 1000 meters.

3.3.3 Simulating Individual Choices

In most cases, the outputs of a disaggregate demand model are the probabilities with which each available outcome will occur. For example, the probability of being retired and the probability of not being retired. For the microsimulator, these probabilities must be used to generate a particular outcome for any given individual. The basic approach is to draw a realization from the distribution. The method of doing this in practice is fairly straightforward and is best described by example.

Assume the model is a residential choice model and there are 10 alternative residence zones. The choice model would predict, for each person, the probability with which each residence zone will be selected, an example is shown in the middle column of Figure 2. A specific choice outcome is simulated for each person by drawing a realization based on the probability distribution generated by the model. This is done by calculating the cumulative distribution function (column 3 in Figure 2), generating a random number between 0 and 1 (a different number is generated for each person and each choice situation). The bin of the cumulative distribution function into which this random number falls is the simulated chosen alternative (in the example, a random draw of 0.555 leads to a simulated outcome of zone 7). In this way, if an infinite number of realizations where drawn, the probability distribution would be replicated. This procedure is used for almost all of the models described below to translate the probability distribution into realized outcomes.

Outcome	Probability Distribution	Cumulative Probability Distribution
Zone 1	0.0353	0.0353
Zone 2	0.0906	0.1259
Zone 3	0.0209	0.1468
Zone 4	0.1120	0.2588
Zone 5	0.1120	0.3708
Zone 6	0.0842	0.4550
Zone 7	**0.1428**	**0.5978**
Zone 8	0.0795	0.6773
Zone 9	0.1666	0.8439
Zone 10	0.1561	1.0000

If the random draw is 0.555, then the simulated outcome is Zone 7.

Figure 2: Example of Simulating a Choice Outcome for an Individual

Note that the point of this simulation is not to be able to predict accurately nor exactly any particular individual's residential choices. Rather, the objective is to simulate choices that are representative of what people actually do. Furthermore, it is important to incorporate in these models the behavior that is driving these residential patterns, in terms of the impact of individual characteristics (for example age, household structure, race, and income) so that we understand who is impacted. Also, it is important to incorporate transportation level of service and other policy variables and land use characteristics so that the impacts of policy variables can be determined.

3.4 Running the Model in TransCAD

3.4.1 Introduction

The STEP3 model runs as an add-in to TransCAD 5.0, and is run via a custom interface shown in Figure 3. The specific functionality of this interface is described in the STEP3 User's Guide. Each model step can be run by clicking on the model buttons. TransCAD's powerful GIS capability can then be used to modify inputs, visualize the results, and perform additional analysis.

The add-in allows you to store any number of scenarios. Upon installation, all of the necessary input files are provided for several scenarios for Clark County. Scenarios are defined by a scenario name, a set of input files, output files, and model parameters. There are special features in the add-in to assist in setting up and modifying scenarios, which are shown in Figure 4. The Project Scenarios dialog box is invoked by clicking on the Setup button from the main dialog box, and it provides tools for managing the scenarios. Scenarios can be added, deleted, sorted, described, and renamed. The Parameter Manager dialog box is launched by clicking the Contents button in the Project Scenarios dialog box, and this is where detailed information regarding the scenario is entered and modified. From the parameter manager dialog box input and output files can be opened or changed and model parameters can be viewed or changed.

3.4.2 Data Requirements

The specific inputs are described in the Users Guide, and include:

- The Public Use Microsample (PUMS)
- Zonal system, including information on:
  - Number of households broken down by household size, income, age of head of household and group quarters
  - Designation (e.g., CBD or Strip)
  - Terminal transportation information (e.g., parking costs and walk access times)
  - Employment by employment type by place of work
  - Residential units by tenure
  - Developable land area
- Transportation network files for auto and transit for the base and future years
- Behavioral model parameters and specifications

With the current installation, all the necessary files for running the included scenarios are provided.

3.4.3 Outputs

The specific outputs are described in the User's Guide, and include:

- Synthetic Household and Person databases that are representative of the population and include detailed information obtained from the PUMS databases (income, ages, occupations, race, etc.), and which have been aged from the census year to the study year, including a determination of each person's work status (worker, non-worker, or retired)

- Land use development by zone utilizing future land use plans and retail plus residential land use modeling
- Simulated outputs from Mobility and Lifestyle behavioral models on each household's zone of residence and each person's zone of work location
- Aggregate forecasts of the spatial distribution of households by zone and by demographics

Generic procedures were developed for STEP3 to distribute employment and households among zones. The interfaces for these tools are shown in Figure 5.

A new time-series visualization tool was developed for STEP3 to enable a better understanding of changes over time. For each temporal increment, those features time-stamped with that date appear in the map. The interface for this tool and an example application are shown in Figure 6. This illustrates parcel construction in Boulder City, NV, with the time-series paused for the years 1966 and 2000. This time-series tool can also display themes over time such that a zone or zones could be viewed so that the number of people by income group could be monitored temporally.

Finally, the population synthesis tool was also improved for STEP3 with enhancements such as the inclusion of a marginal tolerance. This allows flexibility in the input zonal marginals when they are not the same (e.g. the number of household persons does not correspond to the number of persons as is often the case in PUMS data). This tolerance is used to allow a predetermined difference in these marginals so that the undercount marginals are scaled up to match the maximum marginal.

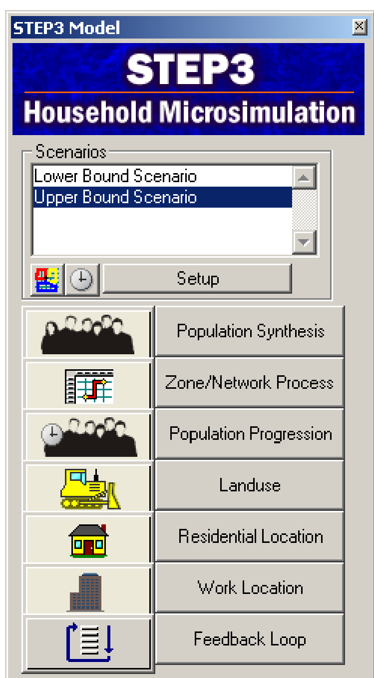
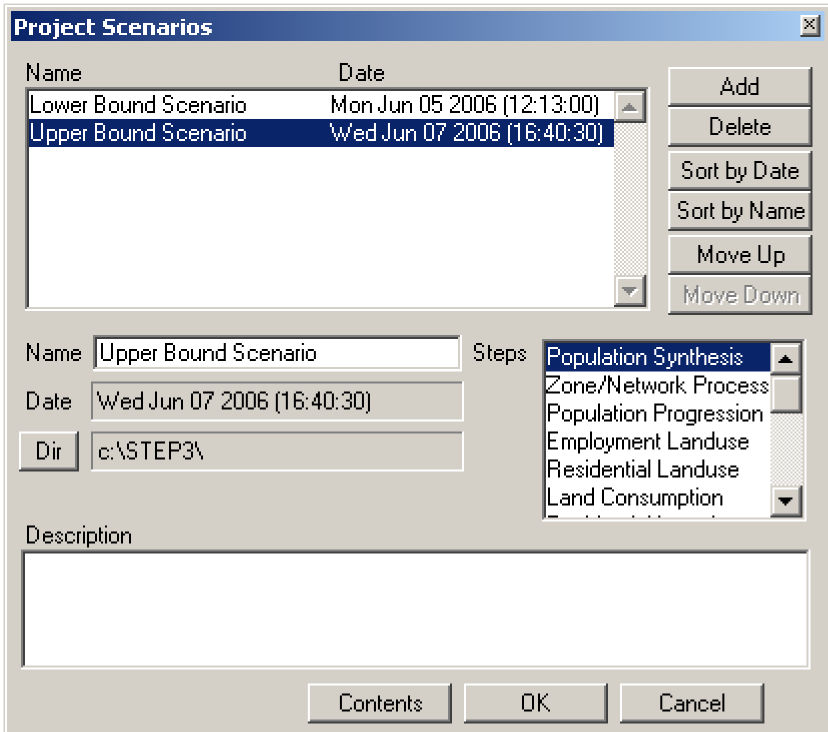


Figure 3: Custom TransCAD Model Toolbox for STEP3



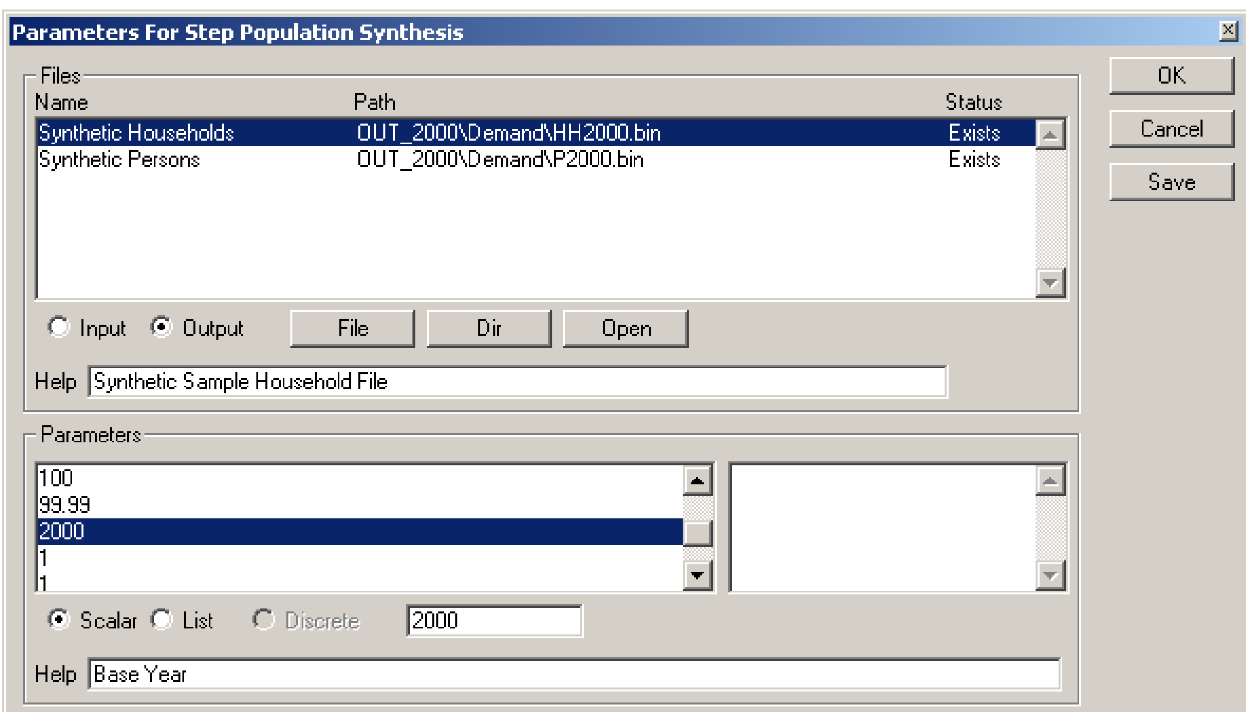


Figure 4: Scenario and File Managers for STEP3 in TransCAD

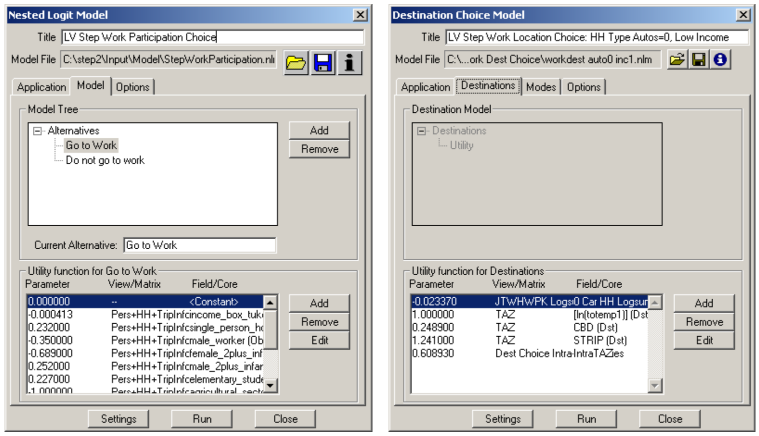


Figure 5: TransCAD Procedures: For Logit-based Microsimulation

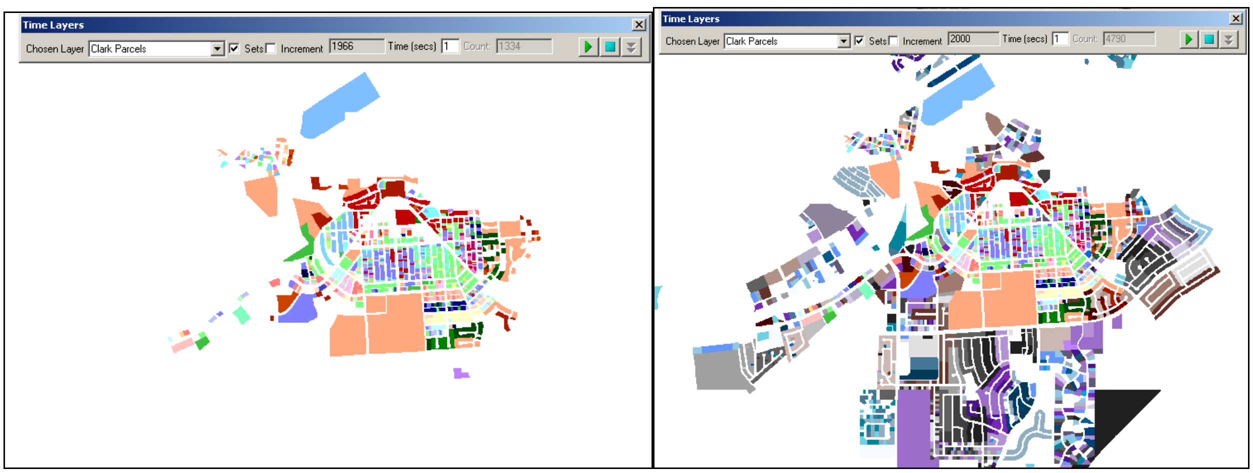


Figure 6: TransCAD Procedures: New Time-Series Visualization Tool for STEP3

3.5 Population Synthesis and Progression

3.5.1 Introduction

Implementing a household microsimulation model requires that the model has a list of individual households and persons on which to apply the model. For each household, all of the explanatory variables that are used in the model (such as income, household size, gender and age of each person in the household) must be known. Since such a list of households is not available, simulation techniques are used to generate a population of households. The objective of the simulation is to generate a fictitious population such that it closely replicates key demographics of the real population. There are two steps to this process: synthesizing the population from Census PUMS to match aggregate zonal statistics, and progressing the PUMS population from the year of data collection to the study year on an annual basis.

In this chapter, we describe the core methods for synthesizing a base year population and predicting its future characteristics on an annual basis.

3.5.2 Population Synthesis

The general concept behind population synthesis is to make use of Census data to generate a synthetic population for the base year that consists of individual household records and person records. Basically a sample of persons is provided by the Public Use Microdata Sample (PUMS) for the Year 2000. Using a population synthesis procedure we utilize the PUMS weight that indicates how many households each household actually represents in the full Census population. This weight is used to expand the households to create a complete synthetic individual population that matches the known aggregate data for the study region.

Two types of census data are used to generate a base population for the year 2000 for this study. First, data from the Census Summary Files (SF1 and SF3) were used to obtain aggregate statistics of the population by Block Group, Block and Cell that are to be matched by the synthetic population. The dimensions used for matching are household size, owner or renter dwelling unit status by age of the head of household, household income, and whether or not the household is in group quarters. The following table details these characteristics:

Table 1 Required Fields at the Zonal Level for Population Synthesis

Census Field
Household Income <$10K
Household Income $10K-14,999
Household Income $15K-24,999
Household Income $25K-34,999
Household Income $35K-49,999
Household Income $50K-74,999
Household Income $75K-99,999
Household Income $100K-149,999
Household Income $150K-199,999
Household Income $200K+
Occupied Housing Unit Rented by Householder 15-24
Occupied Housing Unit Owned by Householder 15-24
Occupied Housing Unit Rented by Householder 25-34
Occupied Housing Unit Owned by Householder 25-34
Occupied Housing Unit Rented by Householder 35-44
Occupied Housing Unit Owned by Householder 35-44
Occupied Housing Unit Rented by Householder 45-54
Occupied Housing Unit Owned by Householder 45-54
Occupied Housing Unit Rented by Householder 55-59
Occupied Housing Unit Owned by Householder 55-59
Occupied Housing Unit Rented by Householder 60-64
Occupied Housing Unit Owned by Householder 60-64
Occupied Housing Unit Rented by Householder 65-74
Occupied Housing Unit Owned by Householder 65-74
Occupied Housing Unit Rented by Householder 75-84
Occupied Housing Unit Owned by Householder 75-84
Occupied Housing Unit Rented by Householder 85+
Occupied Housing Unit Owned by Householder 85+
Occupied Housing Unit: 1-person Household
Occupied Housing Unit: 2-person Household

Occupied Housing Unit: 3-person Household
Occupied Housing Unit: 4-person Household
Occupied Housing Unit: 5-person Household
Occupied Housing Unit: 6-person Household
Occupied Housing Unit: 7+-person Household
Not in group quarters
In group quarters Institutionalized
In group quarters Noninstitutionalized

For example, the number of households by each income group may be tabulated for each zone, as well as the number of households by each household size. The PUMS data (a 5% sample of census household records) are then used to generate specific household records for each zone and they are generated in a way that matches the aggregate data compiled for each zone. In the STEP3 implementation, the characteristics that are matched are household size (4 categories), age of head of household (3 categories), income (4 categories) and group quarters (3 categories):

Table 2 Characteristic Classes

Characteristic	Classes
Household Size	0-2, 2-3, 3-4, 4+
Household Income ($)	0-25000, 25000-50000, 50000-75000
Age	0-25, 25-65, 65+
Group Quarters	Not group quarters, Institutionalized, Noninstitutionalized

A key feature of STEP3 is that it is a stand-alone tool and does not rely on exogenous models to provide yearly data. The base year population is derived from the 2000 Census and the scenario is simulated on an annual basis thus providing the input data for the next year in the estimation cycle. SF1/SF3 were used to provide the number of households for each zone and the proportion of households within each zone that are within each of these categories, a generic example of which is shown in Figure 7. The objective in population synthesis is to generate households that match these statistics.

		Proportion of Zone Households in Various Demographic Groups											
	Number of	Income				Size of Household				Age of Head of Household			
Zone	Households	Low	Moderate	Middle	High	1	2	3	4 plus	< 24	24-43	44-63	> 63
1108	925	29%	25%	24%	22%	17%	34%	18%	30%	2%	43%	36%	19%
357	764	34%	26%	24%	17%	29%	18%	13%	40%	13%	48%	23%	16%
112	662	23%	23%	25%	29%	8%	32%	23%	37%	2%	57%	32%	9%
707	297	24%	23%	25%	28%	26%	39%	18%	17%	3%	22%	52%	23%
1138	276	32%	25%	24%	19%	16%	18%	19%	47%	9%	56%	30%	5%
557	196	25%	24%	25%	27%	22%	44%	15%	18%	3%	29%	35%	33%
920	236	11%	19%	26%	43%	25%	39%	16%	20%	3%	31%	45%	21%
305	159	31%	25%	24%	20%	12%	31%	21%	36%	5%	49%	38%	8%
60	146	24%	23%	25%	28%	11%	34%	22%	34%	1%	55%	38%	6%
990	130	24%	23%	25%	28%	18%	36%	17%	29%	1%	46%	36%	17%
1122	76	27%	24%	24%	24%	15%	38%	18%	29%	1%	40%	47%	11%
…													

Figure 7: Form of Inputs for Population Synthesis

The first step of population synthesis is to take these marginal distributions (for example, Figure 7) and generate the joint distribution, which is the proportion of households in each zone that are within each permutation of the combination of the demographic groups. For example, the proportion of households for each zone that are (low income, and have only 1 household member, and who is under 24) through to the proportion of households in the zone that are (high income, and have 4 or more people in the household, and the head of household is older than 63). This procedure of generating the joint distribution from the marginal distribution is performed by a procedure called Iterative Proportional Fitting, or IPF. This procedure has starting seed values and then iteratively adjusts the values of the joint distribution to match each set of marginals (i.e., first adjust to income, then adjust to age, then adjust to household size, then adjust to income, etc.) The procedure eventually converges on a joint distribution that matches all marginal distributions.

Once this joint distribution is known, the use of the PUMS household records comes in. PUMS provides complete household information for 5% of the population. Data are included at both the household level and person level as shown in Figure 8.

PUMS Household Data

Household ID	Number of Persons	Home PUMA	Income	Autos	...
1001101	3	3200202	19687	2	
1001102	1	3200202	37475	1	
1001103	2	3200202	7050	0	
1001104	3	3200204	125500	3	
.					
.					
.					

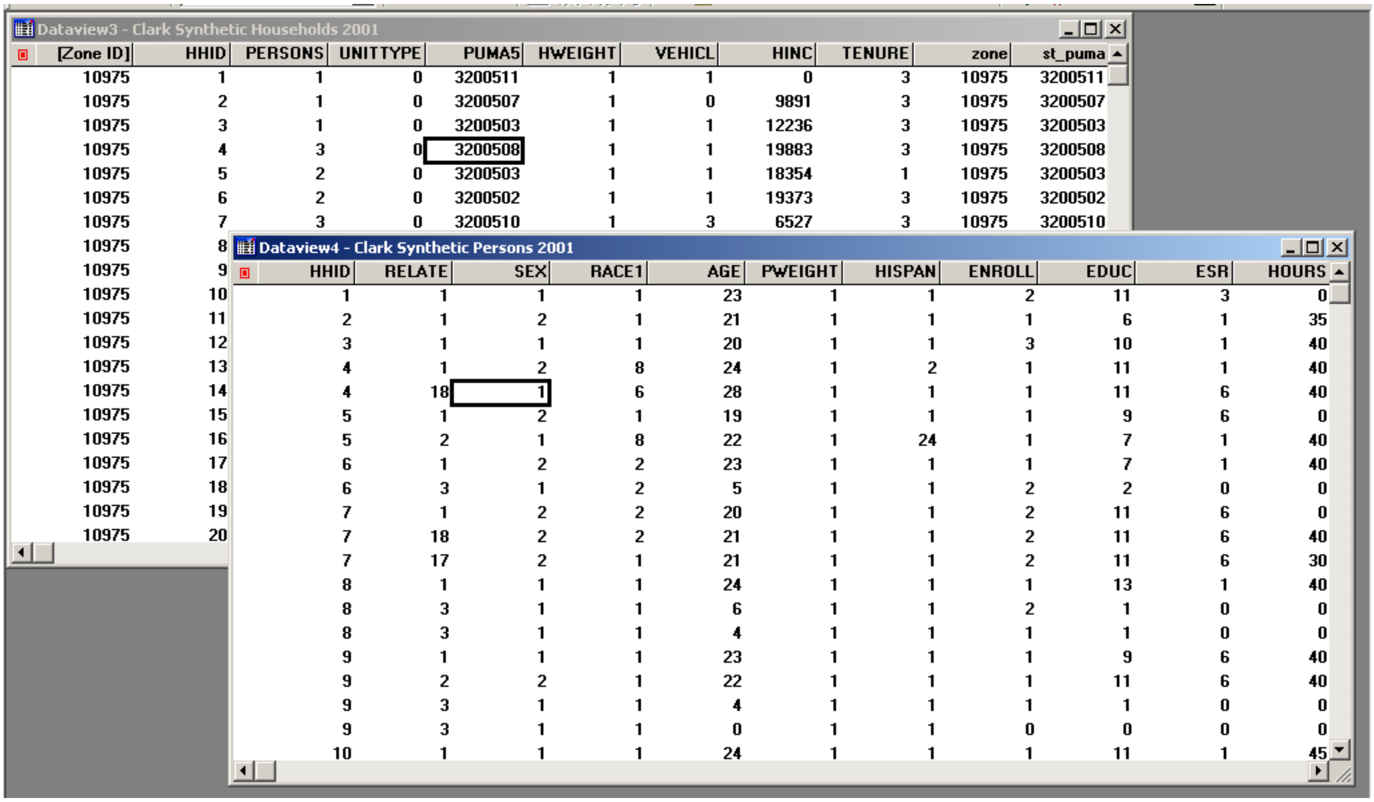
PUMS Person Data

Household ID	Person Number	Relationship (1=householder)	Gender	Age	...
1001101	1	1	0	32	
1001101	2	1	1	30	
1001101	3	2	0	2	
1001102	1	1	1	53	
1001103	1	1	0	20	
1001103	2	9	0	19	
1001104	1	1	0	62	
1001104	2	6	1	13	
1001104	3	7	1	40	
.					
.					
.					

Figure 8: PUMS Household and Person Data Records

The PUMS household records are used to generate actual households for each of the zones. The household records will not only include information on income, household size, and age of household, but also include all of the data that are included in the PUMS record (for example, occupation, gender, auto ownership, etc.) This is important as many of these other factors are used as explanatory variables in the landuse and location models. Households are drawn for each zone according to the joint distribution of demographic factors for that zone, that is, so that the households in each zone match the input aggregate statistics for that zone. The result is a fictitious population of households and persons that are representative of the actual population as shown in Figure 9. The STEP3 models are applied to this complete synthesized population, allowing a very rich and detailed understanding of the future characteristics of Clark County.

Using the Census data, it is quite straightforward to generate a realistic synthetic population for census years. The population is only synthesized for the base year (2000), and STEP3 uses this to estimate the population and landuse changes for 2001. In order to create a synthetic population for the forecast years post-2001, each intervening year is modeled using the output from STEP3 for the previous year.



Dataview3 - Clark Synthetic Households 2001

[Zone ID]	HHID	PERSONS	UNITTYPE	PUMA5	HWEIGHT	VEHICL	HINC	TENURE	zone	st_puma
10975	1	1	0	3200511	1	1	0	3	10975	3200511
10975	2	1	0	3200507	1	0	9891	3	10975	3200507
10975	3	1	0	3200503	1	1	12236	3	10975	3200503
10975	4	3	0	3200508	1	1	19883	3	10975	3200508
10975	5	2	0	3200503	1	1	18354	1	10975	3200503
10975	6	2	0	3200502	1	1	19373	3	10975	3200502
10975	7	3	0	3200510	1	3	6527	3	10975	3200510
10975	8									
10975	9									
10975	10									
10975	11									
10975	12									
10975	13									
10975	14									
10975	15									
10975	16									
10975	17									
10975	18									
10975	19									
10975	20									

Dataview4 - Clark Synthetic Persons 2001

HHID	RELATE	SEX	RACE1	AGE	PWEIGHT	HISPAN	ENROLL	EDUC	ESR	HOURS
1	1	1	1	23	1	1	2	11	3	0
2	1	2	1	21	1	1	1	6	1	35
3	1	1	1	20	1	1	3	10	1	40
4	1	2	8	24	1	2	1	11	1	40
4	18	1	6	28	1	1	1	11	6	40
5	1	2	1	19	1	1	1	9	6	0
5	2	1	8	22	1	24	1	7	1	40
6	1	2	2	23	1	1	1	7	1	40
6	3	1	2	5	1	1	2	2	0	0
7	1	2	2	20	1	1	2	11	6	0
7	18	2	2	21	1	1	2	11	6	40
7	17	2	1	21	1	1	2	11	6	30
8	1	1	1	24	1	1	1	13	1	40
8	3	1	1	6	1	1	2	1	0	0
8	3	1	1	4	1	1	1	1	0	0
9	1	1	1	23	1	1	1	9	6	40
9	2	2	1	22	1	1	1	11	6	40
9	3	1	1	4	1	1	1	1	0	0
9	3	1	1	0	1	1	0	0	0	0
10	1	1	1	24	1	1	1	11	1	45

Figure 9: Household and Person Files Generated by Population Synthesis

3.5.3 <u>Population Progression</u>

3.5.3.1 Introduction

The best source for accurate population demographics is from the Census or from sources such as household surveys. The decennial nature of the Census means that the data quickly become outdated and are of little use when the population of a region is changing rapidly as is the case in Clark County. Conducting local surveys to update such detailed and extensive information is a prohibitively costly exercise if the sample size is to generate small area statistics. So the only solution is to develop models that give fairly good approximations of the true population. Such simulations take as input, for example, the known base year population (from the Census) and use reasonable parameters and models to progress this population and evolve its characteristics through time to the target year.

In STEP3, the Population Progression module creates a demographic projection of individual persons and households for the region by aging the *full* synthetic population, estimating household formation, and accounting for migration into and out of the study region. This projection is a rich micro-scale description of the general populace that can be expected to be living in the study area given the base-year data and variables that depict the expected changes in the residents of Clark County. The progression is run annually in conjunction with the other modules in STEP3.

It should be noted that if a subfamily is present they are treated in the same way as the primary householders described below, and all relationships are updated as appropriate. New subfamilies do not form in STEP3. Also, people in Group Quarters are excluded from population progression for several reasons including the need to ensure that group quarter institutions do not contribute to overall growth and because it is assumed that people in group quarters are representative of the population in those quarters at any given time (e.g. hospital, prison and military turnover.)

For each one year increment the data are brought forward by performing the following procedures.

3.5.3.2 Aging, Mortality and Births

First the population, one individual at a time, is aged by 1 year. A ceiling is placed on the maximum age that can be reached, and this is 115 years old. However, in the simulations already run, the death rate applied (see below) typically ensures that few, if any, individuals actually come close to this extended lifespan, as would be expected. Next, the educational attainment of children between the ages of 6 and 17 is increased by one and children are assumed to enter the public school system upon reaching the age of 6. Thus under 6 year-olds do not attend school (Note: the educational institution type is not currently modeled by the STEP3 model).

We next predict the growth of wealth for our simulated people. Thus, personal income and wages are grown using personal income and wage growth rates from the Bureau of Economic Analysis (BEA). As each individual belongs to a specific household, it is easy to obtain the household income simply by summing the personal incomes of its members.

Having aged the population, we must now predict those that do not survive into the next model year. This is done by randomly eliminating some of our population based on their age, gender and locality. This is achieved by applying age-gender specific mortality rates to each person, where these rates are scaled by a factor based on PUMA of residence, the latter of which are provided by the Census. If a person reaches the age of 115 they are eliminated from the population.

We can now "grow" our population through natality. This is essentially the opposite of the mortality step just described, whereby population *growth* is now introduced using the birth rate by age of parent and a local scaling factor based on the parents' PUMA of residence. Again, the scaling factor is provided by the Census bureau. The gender of each child is determined randomly using the proportion of male babies born, which obviously also accounts for the proportion of female baby births. The racial characteristics of the newborn follow the mother's characteristics.

3.5.3.3 Household Formation and Dissolution

The next several steps relate to marital status and household formation. Firstly, we look at existing households forming new households, which fall under two categories: new households as a result of divorce and new households due to young adults moving out.

Young adults are assumed to leave home at age 22, which was judged to be a reasonable break-point. Each of these young adults forms a new household that is assigned to a zone using the residential choice model described below. The presence of an automobile in the new household is determined using a random probability, which is based on the ratio of automobiles to people in the original household. The initial employment/industry of the new adult is also randomly chosen, this time based on the general distribution of employment types in the region. Next the personal income is randomly computed using a normal distribution and aged to the correct year using the wage growth rate, where the wage is assumed to be a computed fraction of income. The original household income and automobiles are reduced to reflect the departure of this person. This is true except when only a single automobile exists in the "parents' household" such that a single vehicle will always remain and will not be removed.

Each household in our synthetic population has a head-of-household person, with all other people in the household having their relationship defined in terms of their status with regard to this primary householder. Consequently, divorce is determined based on the age and gender of the head-of-the-household, where this person is defined as being in a married couple. This divorce rate can be scaled using a local factor based on PUMA of residence. In the case of Clark County 1.2 is used since non-residents may significantly boost the rate in Las Vegas, despite the fact that you now have to be a Nevada resident for 6 weeks before you can obtain a divorce. For these separated couples the original household income and automobiles are split, with the special case of one-car households, in which case each of the new divorcee homes gets an automobile after the separation. The children are randomly assigned to a parent using a gender defined custody probability, which generally has a significantly higher probability of the children being assigned to the mother rather than the father as is the case in Clark County. Finally, the marital status of divorcees is changed to be single.

Our singles now have the opportunity to get married. When this occurs, two existing households are merged into one new homestead by marrying single men and single women. A single man is identified as now entering into marriage by using a marriage rate by age, combined with a local scaling factor for the PUMA of residence. For Clark County 1.0 is used, since non-residents significantly boost this rate in Las Vegas, and it is very hard to identify those who marry in the county and who are also residents. This is because providing the location of residence on the marriage certificate is voluntary. Next, a set of prospective female brides is determined by taking all single women whose age is within three years of the age of each eligible single man (initially of the same race). For each man to be married, the woman is chosen randomly from among the set of brides. If a wife is not selected then the age restrictions are relaxed, and female candidates 4 and 5 years older/younger than the groom are allowed. If this still does not produce a match, then the rules are relaxed further and a bride with a difference in age of 6 years apart and of any race is allowed. The household is created by merging the two former households, with a combined maximum total of 7 cars.

3.5.3.4 Migration

Regional in- and out- migration is modeled for the study area based on patterns exhibited in data for actual year-on-year household moves. A primary source for the initial calibration of the migration rates used in STEP3 is the year-to-year changes in the addresses shown on the population of returns from the IRS Individual Master File system. This table presents data on migration patterns by county for the entire United States, including inflows and outflows. The data include the number of returns (which can be used to approximate the number of households), the number of personal exemptions (which can be used to approximate the population), total “adjusted gross income” (starting with 1995-1996), “median adjusted gross income” (starting with 1995-1996), total money income (for years 1992-1993 through 1995-1996), and median total money income (for years 1992-1993 through 1995-1996).

Thus, in- and out- migration totals as well as net migration can be analyzed. Figure 10 below shows that there is clearly a trend of net gain in terms of the balance in people moving into and out of the county. This is reinforced by Figure 11 which depicts the numbers of households lost and gained each year for Clark County, as well as showing the net migration (which is positive) and the overall trend for growth of the population (in numbers of households). As the population increases, the number of people lost to out-migration increases for the region as shown in Figure 12. This graph shows a regression plot of projected out-migration and actual out-migration, which exhibits a high level of predictive accuracy and is clearly a negative process. These relationships can be easily modified to reflect expected growth patterns, and vary in the STEP3 scenarios in order to model different levels of expansion and the expectations of planners in the study area.

The ability to observe these annual migrations means that migration rates for both in- and out-migration are used to determine if a person/household enters or leaves the county and existing households are sampled for duplication or deletion. Intra-county migration is modeled using the residential choice model below where the rate of internal movement is obtained from 2000 Census SF3 data. These local moves are distinct from the regional moves that are described here. When a household enters the region, the household in the PUMA that was randomly used to determine the new entrant is duplicated. When a household emigrates from the county, an existing household is removed from all households in a particular PUMA and thus from the population entirely.

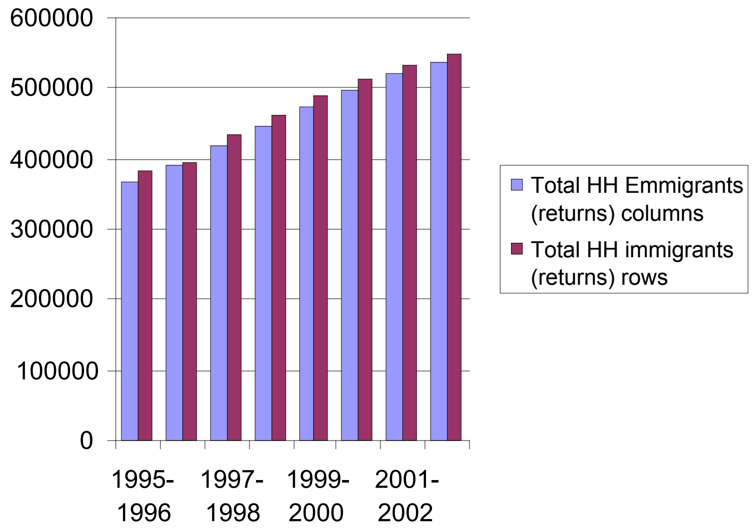


Figure 10: In- and Out- Migration

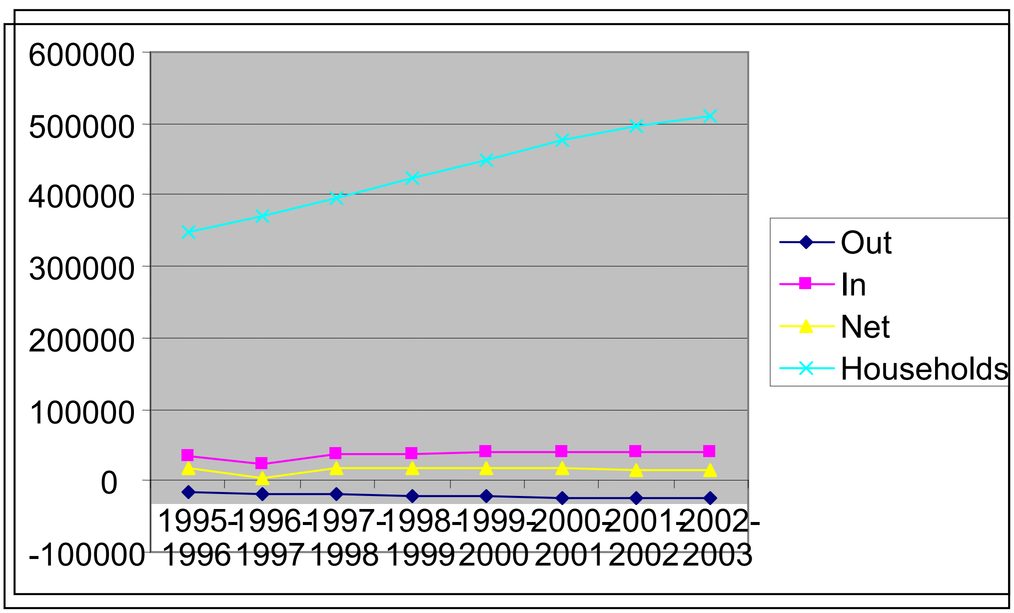


Figure 11: Migration Trend

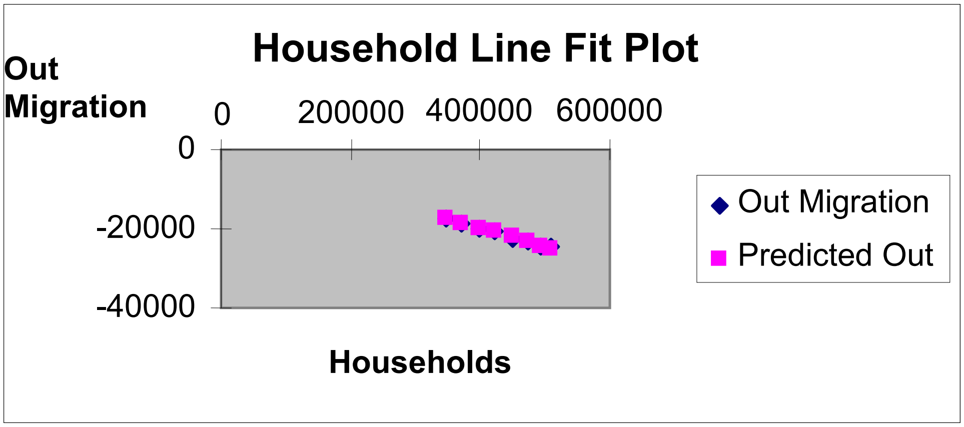


Figure 12: Out-Migration Line Fit Plot

3.5.4 Labor Force Participation and Retirees

A final element in the construction of a synthetic population that is progressed on an annual basis is to use models to predict workforce participation. These were developed using PUMS data and the 1996 Las Vegas Household Survey which provides a detailed description of a sample of the local population. These models predict the probability that an adult is in the workforce, whether the person is unemployed and whether the person is retired. In Clark County where the population is known to have large numbers of retirees, this is a critical facet of synthesizing and understanding the demographics of the region, especially in conjunction with estimating who is actually an active worker.

There are three models, the first of which is the workforce participation model and this is applied to determine whether an individual is a worker or not based on probabilities. Whether or not a person is a worker is influenced by the person's gender and household structure (married or not, children or not and what age) and the person's age and race. This model was estimated using PUMS data primarily because PUMS includes information on race, which is thought to be a significant factor in labor force participation. For people over 65 years of age, an additional model is applied to determine whether they are retired or not. Retirees are an important demographic group and may have significantly different lifestyle characteristics than other population segments. Since PUMS does not provide information on retirement status, the 1996 household survey was used for this model. Retirement status is determined by gender and household structure as well as age. Applying this model to the synthetic population produces a probability that the person is retired or not, and from this probability an actual retiree status (retired or not) is simulated for the person. For those people in the workforce, a model is run to determine if they are unemployed using published Clark County unemployment rates.

The characteristics used in each of the models are shown in the following figure:

Workforce Participation

Gender and Household Structure:

Single Female with Children under 18
Single Female with Children under 6
Single Female without Children under 18
Single Male with Children under 18
Single Male with Children under 6
Single Male without Children under 18
Married Female with Children under 18
Married Female with Children under 6
Married Female without Children under 18
Married Male with Children under 18
Married Male with Children under 6
Married Male without Children under 18

Age

Years 16 to 18
Years 18 to 25
Years 25 to 35
Years 35 to 45
Years 45 to 55
Years 55 to 65
Years 65 to 75
Years beyond 75

Race

Black
Asian
Hispanic
Other
White

Retiree Status

Gender and Household Structure:

Single Female with Children under 18
Single Female without Children under 18
Single Male with Children under 18
Single Male without Children under 18
Married Female with Children under 18
Married Female without Children under 18
Married Male with Children under 18
Married Male without Children under 18

Age

Years 16 to 35
Years 35 to 45
Years 45 to 55
Years 55 to 65
Years 65 to 75
Years beyond 75

(Race not available in HH Survey)

Unemployment

Labour Force Participation:

Not in universe (Under 16 years)
Employed, at work
Employed, with a job but not at work
Unemployed
Armed Forces, at work
Armed Forces, with a job but not at work
Not in labor force

Industry:

Hotel
Office
Industrial
Regional Retail
Community Retail
Neighborhood Retail
Other Non-Retail

Age

Years 16+

Figure 13: Workforce Participation, Retiree Model and Unemployment Variables

3.6 Geographic Databases, Network Development and Network Skimming

Important inputs to the models are the transportation networks and level of service matrices (containing travel times and costs between zones). The STEP3 implementation includes internal representations of transportation networks and calculation of transportation level of service characteristics.

The transportation networks were also enhanced to include all streets in regions at the periphery of current development and in rural areas to better support any future modeled growth in these areas. Most importantly, as STEP3 is a fully integrated package, it was necessary to have networks at intervals of 5 years to reflect planned changes in the transportation infrastructure. Thus, STEP3 ships with complete networks and transit route systems for the base year of 2000, and for the years 2005, 2010, 2015 and 2025. These networks reflect the actual and planned improvements to the transportation system of Clark County, such as new roads, monorail development, and bus route openings and closings. The default scenarios shipped with STEP3 do not currently use the future networks.

Because STEP3 runs in the TransCAD GIS environment, model output can be analyzed visually using all of the capabilities of a powerful GIS. Therefore, geographic files of both the zones and transportation networks are, of course, included.

3.7 Land Use Modeling

3.7.1 Introduction

STEP3 combines analytical tools and micro-simulation models with graphical visualization to allow exploration of the possible future development scenarios in Clark County. The ability to manipulate the growth of the study-area while exploring the outcome of these changes is valuable for urban planning and environmental impact assessment as well as for approximating populations effected by potential hazards such as nuclear waste routing.

In this section we describe the methods used in STEP3 for land-use modeling. STEP3 takes account of undevelopable land such as water-bodies and mountainous terrain as well as "fixed" features such as airports and military installations. In addition, group quarters (prisons, military bases, campuses etc.) are handled explicitly, ensuring growth constraints for this settlement form.

Residential units and job location are simulated using organic growth, seeding and exogenous ground truth data, the combination of which allows for a realistic and rich urban simulation. All of these steps are executed for each year of the model run, taking account of previous growth and extending this expansion into the future.

3.7.2 Exogenous Inputs

STEP3 can run without any post-2000 landuse inputs. However, there is often knowledge of future developments and also the need to assess potential changes and future plans. Such information is incorporated into STEP3 via a landuse layer that allows the user to specify many different characteristics of the proposed developments.

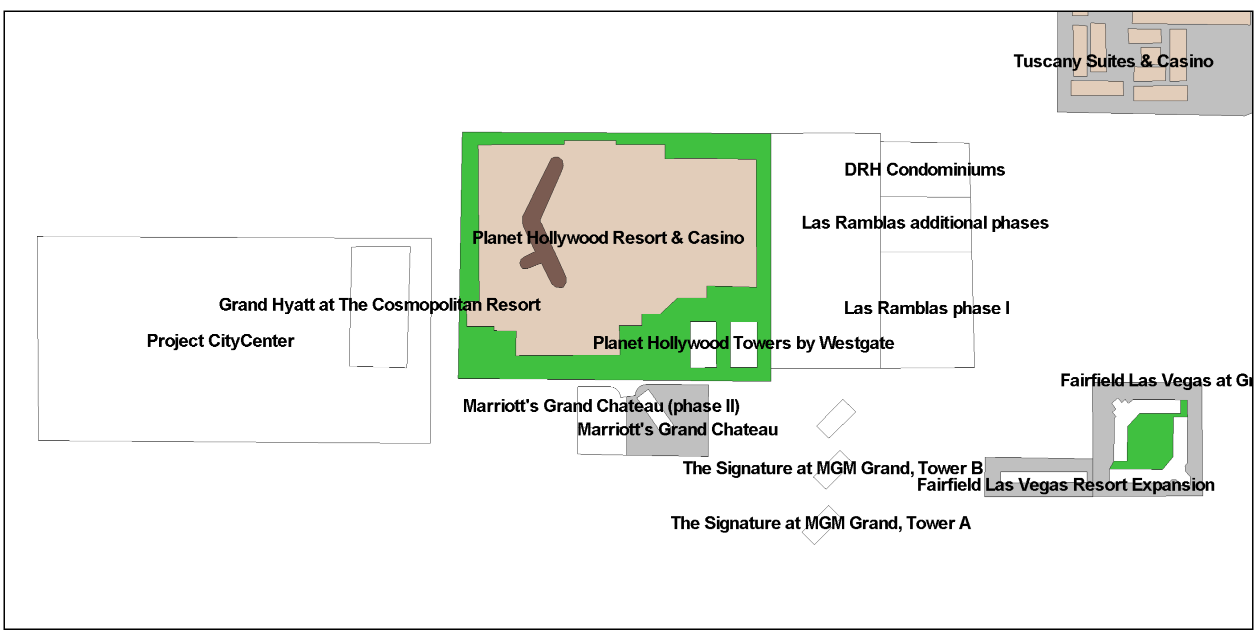


Figure 14: Post-2000 Developments Layer

This layer has already been extensively modified by Caliper staff that researched and identified many future developments. It can, no doubt, be improved by those with detailed local knowledge and should be updated periodically to reflect current conditions.

Using an interactive toolbox (see the User's Guide) the user can add additional polygons representing residential and employment buildings. These can overlap, which allows multiple buildings at a particular location to be added reflecting alternative and changing construction.

For residential construction, the expected number of owner occupied and renter occupied units are each input along with the year the polygon is to be entered into the model. The year built is also required for the non-residential polygons in addition to the number of jobs in each of the seven employment sectors (Hotel, Office, Industrial, Regional Retail, Community Retail, Neighborhood Retail, and Other Non-Retail). It should also be noted that the user can actually add employment for the residential units and employment for the dwellings, and the amount of undevelopable land in both cases.

Additional descriptive information such as the name and type of the unit is optional. Finally, existing or previously added features can also be edited if their expected footprint changes for example.

3.7.3 Undevelopable Land

Undevelopable land is that which is off-limits to settlement growth. Such areas include military installations, airports, water bodies, environmentally sensitive or protected lands, parks and areas of steep gradient. These values are pre-determined for the base-year but the amount of undevelopable land in any given cell can be edited for 2000 by the user. The gradient considered undevelopable is a scenario option and defaults to 0.2 as this is considered to be an overly steep average value for a 1km cell.

3.7.4 Residential Cell Growth

The expansion of residential areas is simulated as the growth of existing settled areas. The scenario defaults are that a cell is considered for growth only if it has two neighboring cells with a population of at least 919 people each. These options can be modified by the user to produce schemas that relax these constraints thus increasing dispersion or to restrict the expansion of the city which increases density.

For a cell to be considered as a "birth" cell it must also be developable while not being flagged as group quarters. If all these criteria are met, then empty dwelling units are added to the cell up to a user specified limit, distributed 60-40 owner-renter as enumerated in the 2000 Census. These empty residences are then available to the residential choice models which permit households to move to these cells. When cells that are already developed become full, then the number of homes available also increases up to the specified ceiling.

In the Figure below for example there are very constrained opportunities for growth. To the north and north-west there are undevelopable and group quarters cells, to the west there are cells with a high percentage of undevelopable land (indicated by the cell labels) and to the east there is land with steep gradient. The population is clustered in the south west and it is the neighbors of these cells that would be considered for new growth.

Figure 15: Cell Characteristics Influencing Urban Growth

3.7.5 Employment Seeds

In addition to growth based on exogenous inputs, the non-retail employment types grow proportionately based on existing distributions.

The three retail employment types also utilize the external employment inputs, but in addition use seeds to grow in new regions. Hot-spot mapping is used to identify areas where there is high population but little retail. Deficit "peaks" are identified by analyzing the gradient of the retail by population density surface and these cells are then assigned the number of retail jobs required by retail workers based on the height of their "peak" in relation to overall density. This means that the number of jobs required to meet retail employment needs are distributed to those cells that have a deficit of such jobs in relation to their population and are assigned the number of jobs based on the strength of this deficit.

3.8 Locational Choices

3.8.1 Introduction

The demand models describe household and job location decisions. An overview is provided here of the modeling of this household behavior. For example, all of the following are simulated within STEP3 for each person:

- The zone in which the person's home is located
- For workers, the zone in which the person's work is located

To simplify the complex, multidimensional interdependencies of decision making the problem is represented as a sequence of choices in a choice hierarchy (see Ben-Akiva and Lerman, 1985, for more discussion). The STEP3 framework is an example of such a choice hierarchy, in which residence and workplace decisions are made sequentially.

The residential choice model is not run for the year 2000, since the residence zones are synthesized using population synthesis and they match the Census 2000 estimates. The work choice model is however run for the base year for all workers in each of the seven industry types.

For the future years, the residence location is determined only for the movers. All non-movers do not change their residence location from that of the previous year. Similarly, the work location is only run for workers who are either movers or who have just entered the labor force. The work zone of persons who have exited the labor force is set to null.

The hierarchy of residence and work location choice for future years is as follows:

1. First, the work location is determined for head of households who are employed in the hotel sector
2. Then, the residence location is determined for the households to which the above head of householders belong. This choice depends on the work zone of the head of household workers
3. The residential location is then determined for all the remaining households
4. Finally, the work location is then determined for all the remaining workers and the work location depends on the residence zone of the worker

The logic behind the order of residence and work choice location reflects the choice pattern in Clark County. Since the region mainly attracts people and new employment due to its hotel and casino industry, it is conceivable that these new migrants know their work location and then decide the residence location based on the work location. These types of conditionality and feedback are introduced throughout the STEP3 model. Increasing these types of linkages will lead to more behaviorally realistic models, but will also increase the complexity of model estimation and application.

3.8.2 Work Location for Head of Household Hotel Workers

A simple model is used to determine the work zone of the head of householders who are in the hotel sector. The basis of this model is that hotel workers are inclined to obtain jobs in the CBD and the Las Vegas Strip. The utility for each destination is as follows:

$$U_i = \beta_1 (CBD_i) + \beta_2 (STRIP_i) + \beta_3 (\ln(AvailableHotelJobs_i))$$

The utility is a function of only the destination attributes and is independent of the characteristics of the worker making the choice. The parameters β_1, β_2 and β_3 are 0.985, 0.2927 and 1 respectively. Thus a zone in the CBD or the STRIP region is likely to attract more hotel workers. The log of the number of available hotel jobs (often called the size variable) is necessary in the work choice model to account for the varying number of jobs across zones. The higher the number of job units in any zone, the higher the probability that a worker will choose to work in that zone. In order to ensure that the job capacity in each zone is not exceeded, the number of available hotel jobs is used as the size variable, and each time a worker selects to work in a zone, the number of available jobs is reduced by 1. When all the available jobs are taken in a particular zone, this zone is dropped from the choice set.

Since we are allocating jobs only for the movers, the vector of available jobs is computed before the work allocation process. This is done by subtracting the jobs taken by the non-movers from the previous year from the total employment of the current year. This is done for each of the seven industry types.

After the procedure is complete, the available jobs vector is recomputed.

3.8.3 Residence Location for Head of Household Hotel Workers

This model simulates the residence location for those households where the head of householder is a hotel worker. Thus, the work zone of the individual is known prior to making the residence zone decision.

The residential choice model included in STEP3 is similar to the specification in the original STEP model, but has several modifications. The utility derived from living in each zone is as follows:

$$\begin{aligned}
U_i^s = \beta_1 \; & \textit{(Travel time from zone i to work zone)} \\
& + \beta_2 \textit{(Average home ownership cost in relation to household income}_i^s \textit{ - home owners only)} \\
& + \beta_3 \textit{(Average rental cost in relation to household income}_i^s \textit{ - renters only)} \\
& + \beta_4 \textit{(Re sidential density in housing units per acre}_i \textit{)} \\
& + \beta_5 \textit{(Ln(Jobs per employed resident}_i \textit{))} \\
& + \beta_6 \textit{(Manufacturing jobs per acre}_i \textit{)} \\
& + \beta_6 \textit{(Violent crimes per capita}_i \textit{)} \\
& + \textit{ln(Number of housing units (owner occupied or rental, depending on household)}_i \textit{)}
\end{aligned}$$

The utility is a function of the travel time to the work zone, prices (in relation to household income), local environment and job availability, and safety. The residential choice model is conditional on job location. The utility specification is a function of socio-economic characteristics (denoted by the *s* superscript) including income and owner or renter status of the household. As in the work choice model, the log of the number of housing units (often called the size variable) is necessary in a residential choice model to account for the varying number of units across zones. The higher the number of units in any zone, the higher the probability that a household will live in that zone. In order to assure that the number of households in a zone is in line with the number of dwelling units in a zone, the number of available housing units is used as the size variable, and this number is decreased each time a household is selected to live in the zone (and therefore use up an available dwelling unit.) The explanatory variables for the model were collected using Census 2000 data. Crime data were not available, so do not influence the model at this time. The jobs per employed resident was also removed from the model, because it was overly impacting the residential choice decision. The choice to move is based on the rate of internal movement in Clark County (different house in the same county) as described in the 2000 Census SF3 data. This proportion is entered as an input parameter, which can be adjusted by the user.

For households that are selected for the move, the utilities for each zone are specified using the equation above, and the probability of a particular household residing in a particular zone is equal to the logit probability:

$$P_n(i) = \frac{exp\left(U_i^s\right)}{\sum_{all\ TAZ\ t} exp(U_t^s)} \qquad \text{where person } n \text{ is in segment } s$$

From the resulting probability vector, a specific residential zone is simulated for each household.

3.8.4 Residential Location for the Remaining Households

The residential location model is similar to the one above, except that it is no longer contingent on work location of the head of householder. The first term in the above equation, which is the distance to the work zone of the head of householder is replaced by an average time measure. This variable is computed by a weighted average of the peak travel time, with the weights being the total employment in each work zone. Thus the variable for each home zone *i* is computed as:

$$AvgTime_i = \sum_d (Emp_d * TT_{id}) / \sum_d (Emp_d)$$

In the above equation, Emp_d is the total employment in work zone *d* and TT_{id} is the travel time from home zone *i* to work zone *d*

The rest of the application of the residence choice model is identical to the method described above.

3.8.5 Work Location for the Remaining Workers

A work destination choice model is used to determine the work zone for each worker in the synthetic population. The Parsons Brinckerhoff Las Vegas destination choice models for the home-based work trip purpose were used in STEP2 and also STEP3. While the model is the same, the application is very different. In an aggregate model, the destination choice model is applied on a zone-to-zone basis. In the microsimulation framework, the model is applied at the level of the individual worker, and a specific work zone for each worker is determined. The assumption is that each worker will choose the work zone that maximizes his or her utility. The utility (according to the PB model) of making a home-based work trip from origin zone *o* to destination zone *d* is defined as:

$$\begin{aligned} U_{od} = {} & \beta_1 \, (transportation\ level\ of\ service_{od}) \\ & + \beta_2 \, (CBD\ dummy_d) \\ & + \beta_3 \, (STRIP\ dummy_d) \\ & + \beta_4 \, (INTRATAZ\ dummy_{od}) \\ & + \ln(Available\ sector\ jobs_s) \end{aligned}$$

The probability of person *n* working in zone *d* is then:

$$P_n(d) = \frac{\exp\left(U_{\text{home zone of } n,d}\right)}{\sum_{all\ TAZ\ t} \exp(U_{\text{home zone of } n,t})}$$

4 Socio-economic trends in Clark County

4.1 Introduction

Key to forecasting the future characteristics of development in any location is an assessment of the trends at work historically and those that might be continued or emerge in the future. As we have noted, Clark County has been one of the fastest growing areas in the United States and this growth trend appears to be continuing. Despite rising housing prices, there has been continued strong growth in population.

Much of the population growth has come from net migration rather than from organic growth of the resident population. Reasons cited in surveys for moving to Las Vegas are primarily job-oriented with roughly half associated with a job transfer and one-sixth associated with the search for a better job. Approximately ten percent of in-migrants indicate that they are seeking a better life-style. There are no income taxes in Las Vegas or in Nevada, nor are there taxes upon inheritance or gifts making it a more attractive destination for many. As many as 4.5% of new residents circa 2005 were retirees.

In this chapter we examine population, employment, and related demographics in order to assess trends and to form the basis for calibrating the demographic forecasting models and scenarios implemented in STEP3.

4.2 Time-Series of Socio-Economic Data

In this section we look at five key variables to describe the population of Clark County over time during the fifteen year period from 1990-2005. These variables are listed below.

1. Population
2. Employment
3. Visitors
4. In-migration
5. Out-migration

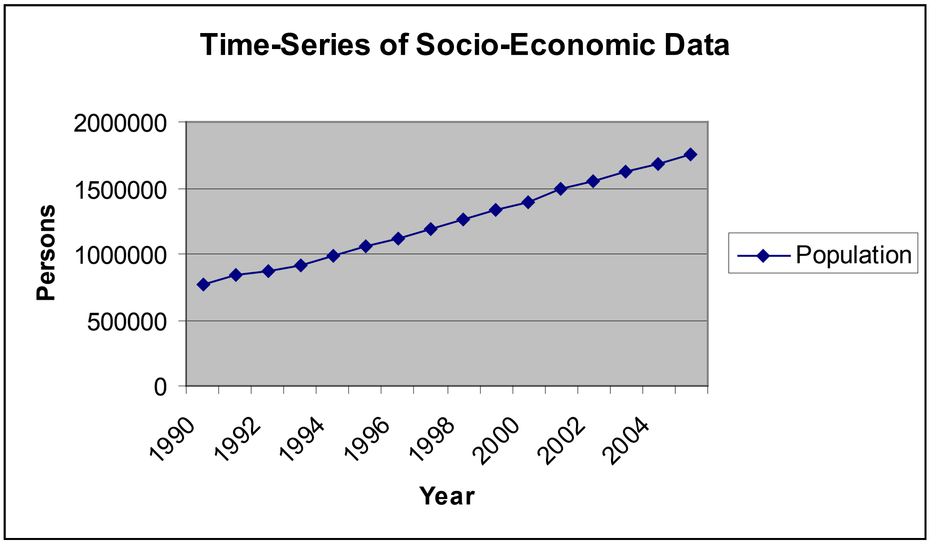
A reasonable assumption is that these factors would vary in conjunction with one another, and thus would fluctuate through similar cycles and respond to systematic shocks in a reasonably uniform manner. This is expected due to the strong influences that these characteristics exert upon each other.

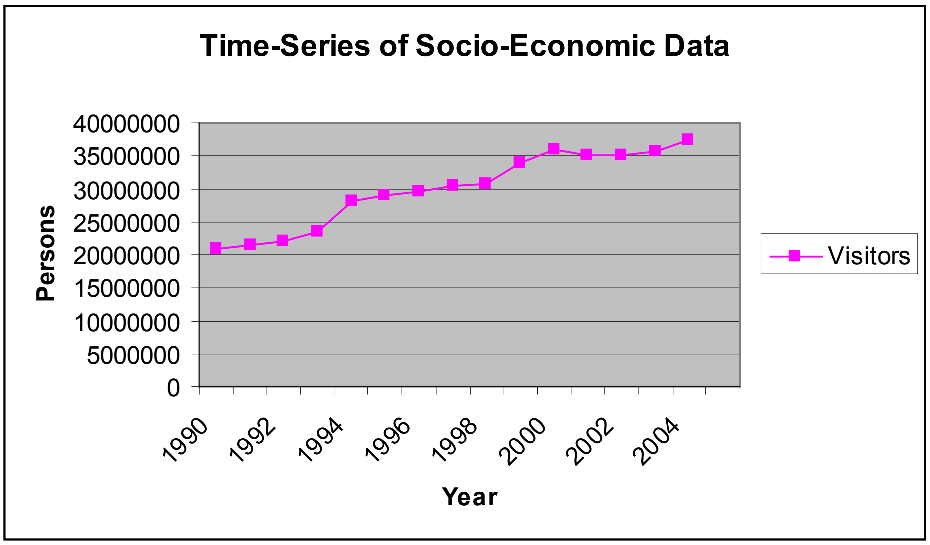
To observe any such trends we listed the available data by year in the table below. We can see that all the numbers increase as we get closer to the end of the millennium, but that in 2001 the level of visitors drops as does immigration. This coincides with the slow-down in the economy as well as with the repercussions from the terrorist attacks during that year. The numbers of employed people continue to grow throughout the analysis period as does the population, while visitors increase again after this apparently temporary drop, with in-migration fluctuating around the 2001 levels, in conjunction with what could be a current plateau in out-migration as of 2002.

Table 3 Numbers of People by Socio-Economic Variable

Year	Population	Employment	Visitors	In-migration (Comp Plan)	Out-migration (Comp Plan)
1990	770280	387881	20954420		
1991	835080	409425	21315116	77640	42948
1992	873730	426768	21886865	73758	36864
1993	916837	454787	23522593	82056	32232
1994	990564	497081	28214362	94476	42318
1995	1055435	527087	29002122	106050	48006
1996	1119052	562981	29636361	118044	62346
1997	1193388	602494	30464635	123354	69798
1998	1261150	637980	30605128	127020	61800
1999	1327145	675963	33809134	128730	59442
2000	1394440	694465	35849691	135042	69186
2001	**1485855**	**718295**	**35017317**	**138192**	**75318**
2002	**1549657**	**733562**	**35071504**	**138900**	**79626**
2003	1620748	759808	35540126	147624	77436
2004	1686827	791774	37388781	77640	42948
2005	1751608	830865			

Diagrammatically it is easy to see that the population of Clark County supports a population of visitors many times its own size annually. In addition it appears that the population is growing at a faster rate than the number of employed people highlighting a growing segment of the population who are non-workers (children, students, unemployed, retired). Finally, migration is contributing to the demographic expansion of the County.





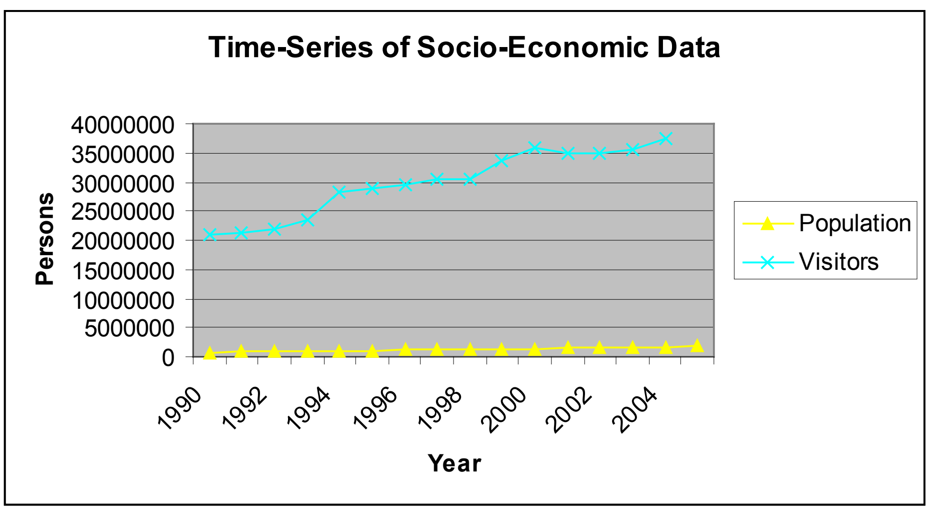


Figure 16: Time Series of Socio-Economic Data (Population & Visitors)

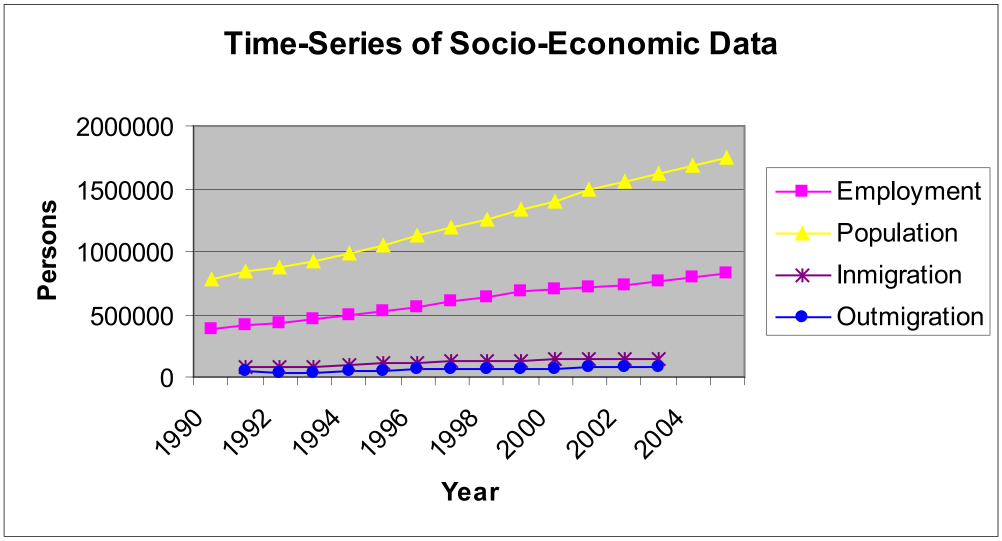


Figure 17: Time Series of Socio-Economic Data (Employment, Population, Migration)

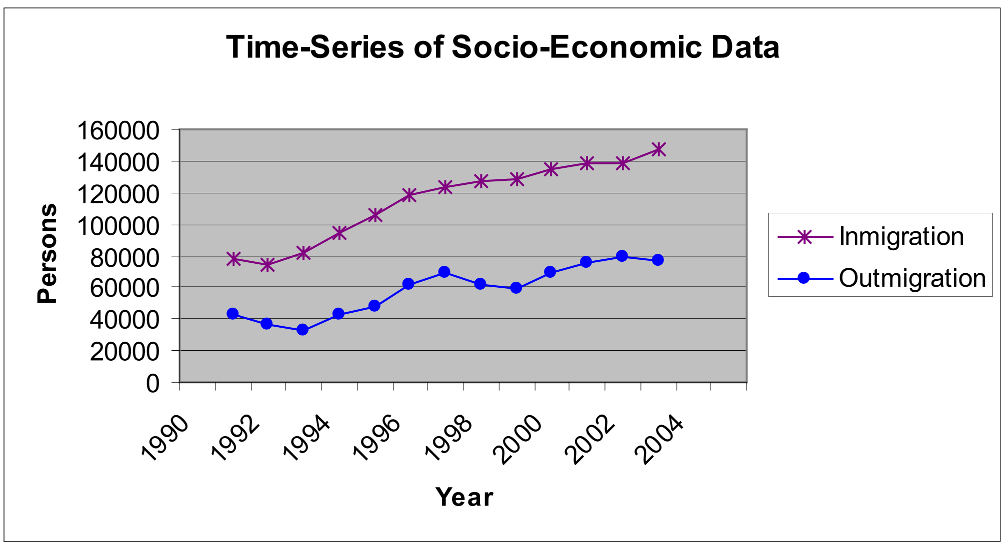


Figure 18: Time Series of Socio-Economic Data (Migration)

Comprehensive Planning has produced their own estimates of migration totals, using driving license registrations in combination with other data sources. An average monthly number is provided for both in- and out- migration for July-June, and we use these data to construct an approximation of the annual calendar year movements. The results provide numbers that are higher than those produced using IRS data, the latter of which may suffer from undercounts due to incomplete coverage as not all returns are included (just those through late September) and there are segments of the population that are not well represented by tax returns. The difference in levels of immigration and emigration are generally comparable between the two series. However the trends vary. For example, 2003 sees a growth in immigration and a decrease in out-migration for the Comprehensive Planning data, while the IRS data exhibit a pattern of slightly declining numbers.

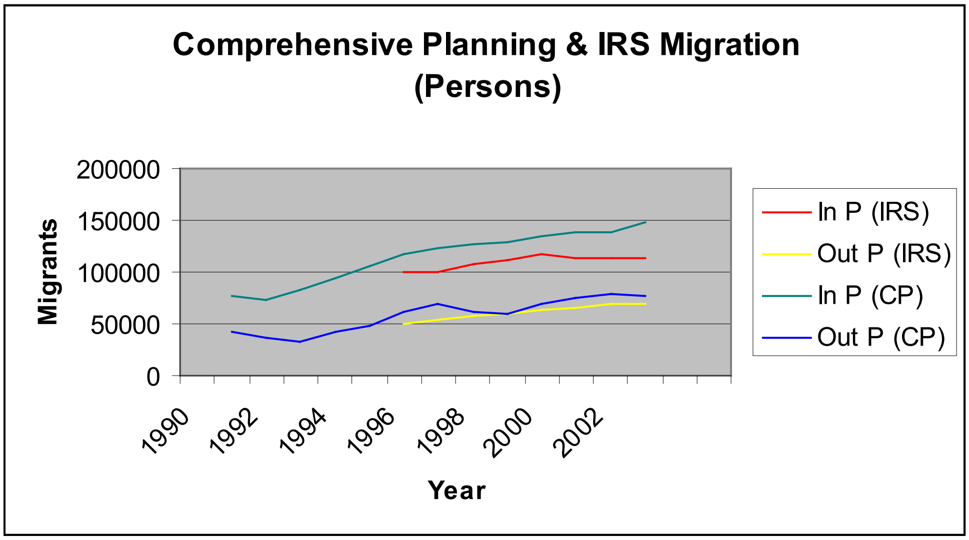


Figure 19: Comprehensive Planning and IRS Migration

Source: Clark County Comprehensive Planning, State of Nevada Department of Motor Vehicles, and State of Nevada Bureau of Health Planning & Statistics.

In addition to looking at absolute numbers, we can also look at the percentage change year-on-year in our demographic variables. We can now see that in addition to a drop in immigrants and tourists, there was also a slow-down in the pace of population and employment growth, with the drop in visitors appearing to precipitate this (see also the Figure below). Also, the slow-down in the growth of population does not bounce back to its original levels while employment does, which indicates a slight growth in the proportion of workers in the populace. The annual change in the growth rate of out-migration appears to be the inverse of the variations in population and employment, such that it decreases as the latter increases and vice versa. In fact, the rate of change is almost always lower than that for employment or population when they experience growth and higher than their rates when they experience decline.

Table 4 Annual Change in Numbers of People by Socio-Economic Variable (%)

Year	Population	Employment	Visitors	In-migration (Comp Plan)	Out-migration (Comp Plan)
1990	0.00	0.00	0.00		
1991	7.76	5.26	1.69	0.00	0.00
1992	4.42	4.06	2.61	-5.26	-16.50
1993	4.70	6.16	6.95	10.11	-14.37
1994	7.44	8.51	16.63	13.15	23.83
1995	6.15	5.69	2.72	10.91	11.85

1996	5.68	6.38	2.14	10.16	23.00
1997	6.23	6.56	2.72	4.30	10.68
1998	5.37	5.56	0.46	2.89	-12.94
1999	4.97	5.62	9.48	1.33	-3.97
2000	4.83	2.66	5.69	4.67	14.08
2001	6.15	3.32	-2.38	2.28	8.14
2002	4.12	2.08	0.15	0.51	5.41
2003	4.39	3.45	1.32	5.91	-2.83
2004	3.92	4.04	4.94		
2005	3.70	4.70			

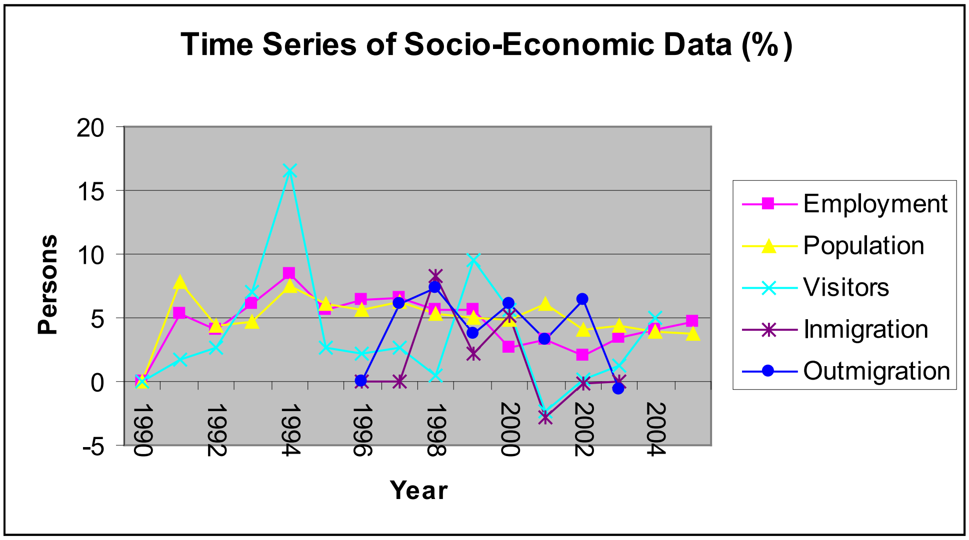


Figure 20: IRS Migration

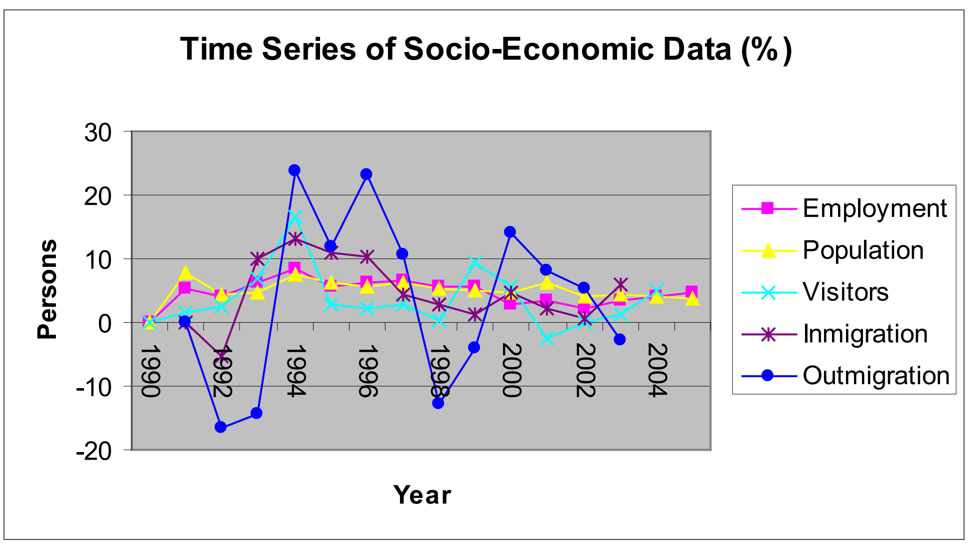


Figure 21: Comprehensive Planning Migration

4.3 Visitors

A brief mention can be made here about the relationships between visitors to Clack County and passengers to the study area, based on Las Vegas air carrier arrivals. As would be expected there is a high correlation between the two variables, with both experiencing similar variations. The estimates of visitors are much higher than the number of passengers recorded. We generally see a positive annual increase in these numbers, except for 1998 when there appears to have been a mild slow-down in tourism and also in 2001-02.

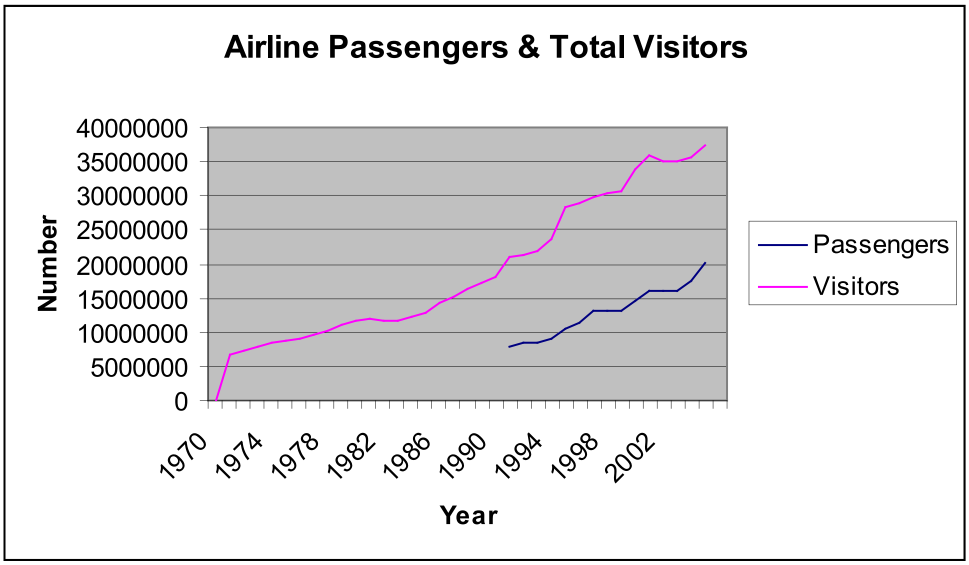


Figure 22: Airline Passengers and Total Visitors

4.4 Previous Population Projections & Estimates

Five sets of projections and estimates previously generated for Clark County are presented and compared below; they range from those produced commercially, locally, academically and federally. The Caliper Tract Estimates were produced for 2000 Census Tracts; the IRS estimates are based on the year-to-year changes in the addresses shown on tax returns; the Nevada State Demographer's Office produces Annual Population Estimates for Counties; Regional Economic Models, Inc. (REMI) uses a general equilibrium demographic and economic model to make forecasts and published results in a hard-copy report; and each year, the Regional Transportation Commission (RTC), the Southern Nevada Water Authority (SNWA), Clark County Comprehensive Planning (CCCP), and the Center for Business and Economic Research (CBER) at the University of Nevada, Las Vegas, work together to provide a long-term forecast of economic and demographic variables influencing Clark County.

Table 5 Projections & Estimates

Year	Caliper Tract Estimates	Comp. Plan etc.	State Demographer	IRS	REMI
1986			587760		
1987			616650		
1988			661690		
1989			708750		
1990	756173		770280		
1991	816080		835080		
1992	857353		873730		
1993	902337		916837		
1994	972624		990564		
1995	1035852		1055435		
1996	1099883		1119052	1180278	
1997	1177233		1193388	1213133	
1998	1251262		1261150	1333498	
1999	1321253		1327145	1419652	
2000	1393249		1394440	1506658	
2001	1456962		1485855	1583107	1467645
2002	1517487		1549657	1648267	1539871
2003	1578746	1641529	1620748	1708487	1609979
2004	1654125	1747025	1686827		1677269
2005		1833500	1751608		1744041
2006		1923420	1815303		1809513
2007		2012215	1877843		1873676
2008		2103275	1939097		1936408
2009		2192447	1999250		1997675
2010		2281340	2058063		2057552
2011		2367952	2115551		2115563
2012		2452825	2171538		2171706
2013		2534696	2225668		2225742
2014		2612657	2277967		2277627
2015		2687055	2328564		2327470
2016		2757719	2378317		2375100
2017		2824689	2427325		2420904
2018		2887097	2475641		2464659
2019		2945254	2523185		2506510
2020		2999953	2569960		2546671
2021		3051144	2616166		2585018
2022		3099231	2661626		2622512
2023		3144571	2706694		2659213
2024		3187352	2751082		2695274
2025		3228140			2731036
2026		3266627			2766267
2027		3303652			2801782
2028		3339758			2837385
2029		3375368			2873385
2030		3410332			2909848
2031		3444402			2946447
2032		3479012			2983698

2033		3513467			3021497
2034		3547328			3059705
2035		3580908			3098327

The IRS numbers are consistently the highest and overlap with only one year of the Comprehensive Planning estimates. From this point forward, these latter numbers are then the highest among all those produced. The figures published by the State Demographer are generally in line with the data released by REMI in their published report, and also with the Tract estimates developed by Caliper. The Caliper numbers were not intended to be used for long range forecasting. They are biased downward due to Census undercounts and their chief property is consistency with published Census data. For this reason, we do not recommend using them except for generating small area estimates. In this case they should be factored up to match known counts. There are many other differences that can be observed. For example, as time increases the gap between the Comprehensive Planning and the original REMI predictions increases.

These results exemplify how, with different data and methodologies, significantly varying results can be obtained when attempting to extrapolate patterns into the future. The overall trends are consistent however with an initially steeper curve that eventually levels out towards the end of the predicted time-frame. Thus, there is generally an expectation of a period of increasing growth in Clark County. In the Figure that follows, the forecasts are shown diagrammatically.

Note that for STEP3, each scenario can produce a new series, with the default scenarios being based upon the trends discussed here and additional modeled relationships. The results of the STEP3 model runs are described later in this report.

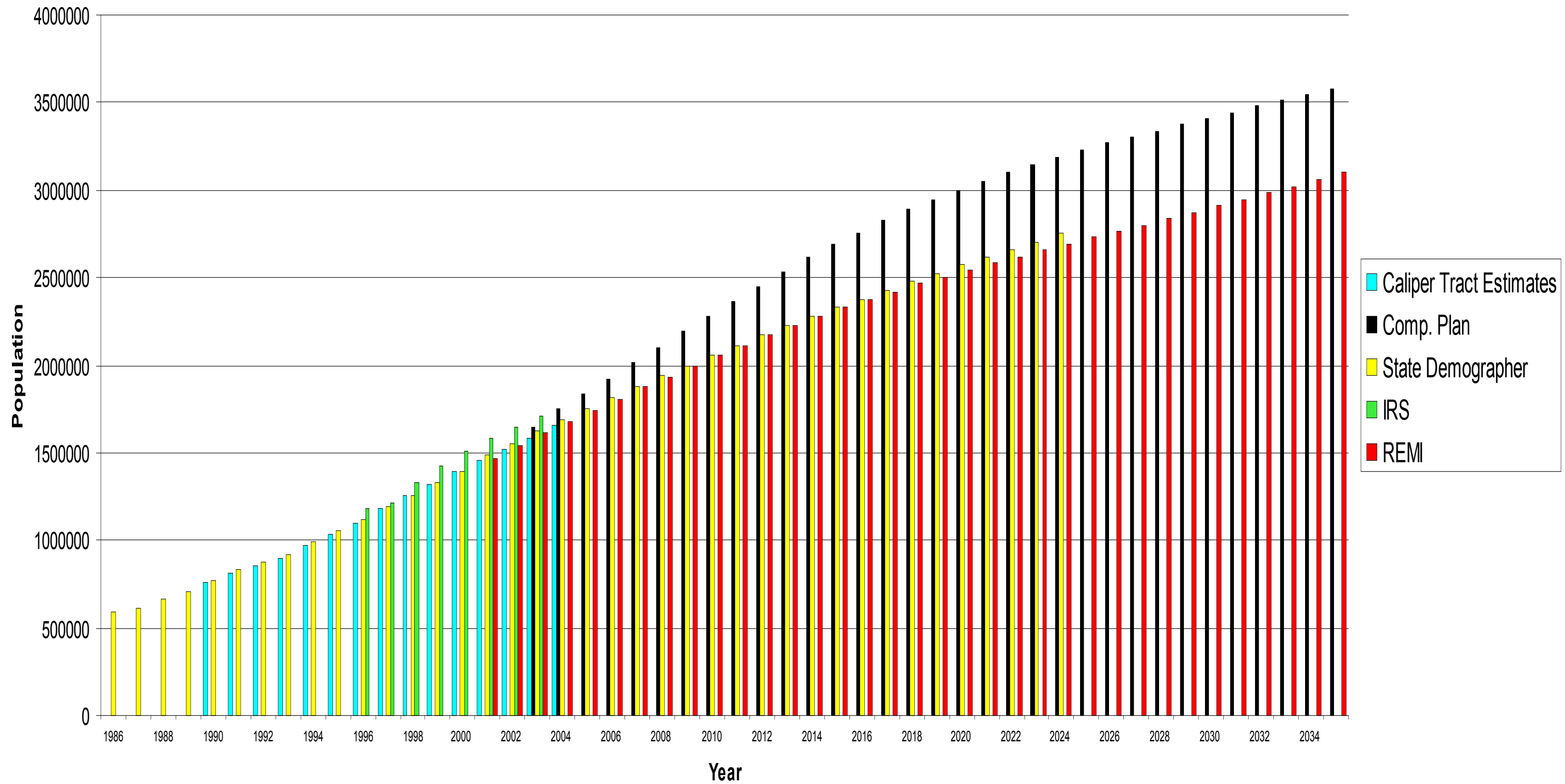


Figure 23: Population Projections and Estimates

5 Spatial Distribution of Population and Employment

5.1 Introduction

To model the spatial growth of development in Clark County it is vital to begin with the observation of historical trends. By understanding the expansion patterns already in existence in the study area, the modeler is in a much better position from which to develop procedures that can forecast future patterns.

In this Chapter we describe and analyze the base year development pattern, the situation historically and also the recent changes in the distribution of land use for the years between the base case and the present. This allows a discussion of the trends in the spatial pattern of development in Clark County.

Clark County, Nevada, is the primary locus of development in the state of Nevada and encompasses areas with both high and virtually non-existent levels of human activity. The built environment is centered on the urban core of Las Vegas, with a few satellite conurbations some distance from the city. The natural environment of the area has been greatly modified by man including structures such as the Hoover Dam and Lake Mead, while the County also has extremes of height and slope as well as of diurnal temperature due to being a predominantly desert environment.

These geographical factors have had a strong influence on the existing distribution of population and employment, as discussed below. These trends can reasonably be expected to continue to exert controls on the spatial distribution of human settlement and activity into the future.

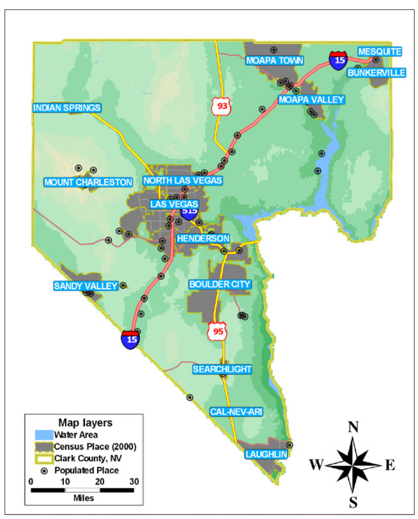


Figure 24: Clark County

5.2 <u>Development of the Spatial Database for Analysis</u>

To ensure a uniform unit of analysis across the County, a single layer of grid cells was created. Each of these gridded units represents locations as a cell of 1000 by 1000 meters, each containing an area of about 250 acres. While the cell size can be modified, these dimensions were chosen as they were felt to be appropriate given the size of the County. This areal grid allows explicit cross-referencing of other spatial features such as planning and political boundaries encompassing cities, traffic zones, urban growth boundaries; and environmental features such as wetlands, slopes, and other environmental landuse types.

To demonstrate the high level resolution such cells provide we have extracted one grid cell in a Las Vegas neighborhood with parcel boundaries over an aerial image. For the entire County, external data are collapsed into the cells to generate composite representations of the mix and density of landuse types at each location.

These development types are those commonly used by planning agencies in Clark County (including Comprehensive Planning) and they represent at a local neighborhood scale the land use mix and density of development. The land use types are as follows:

- Hotel
- Office
- Industrial
- Regional Retail
- Community Retail
- Other Retail
- Other Non-Retail
- Residential Renter Occupied
- Residential Owner Occupied

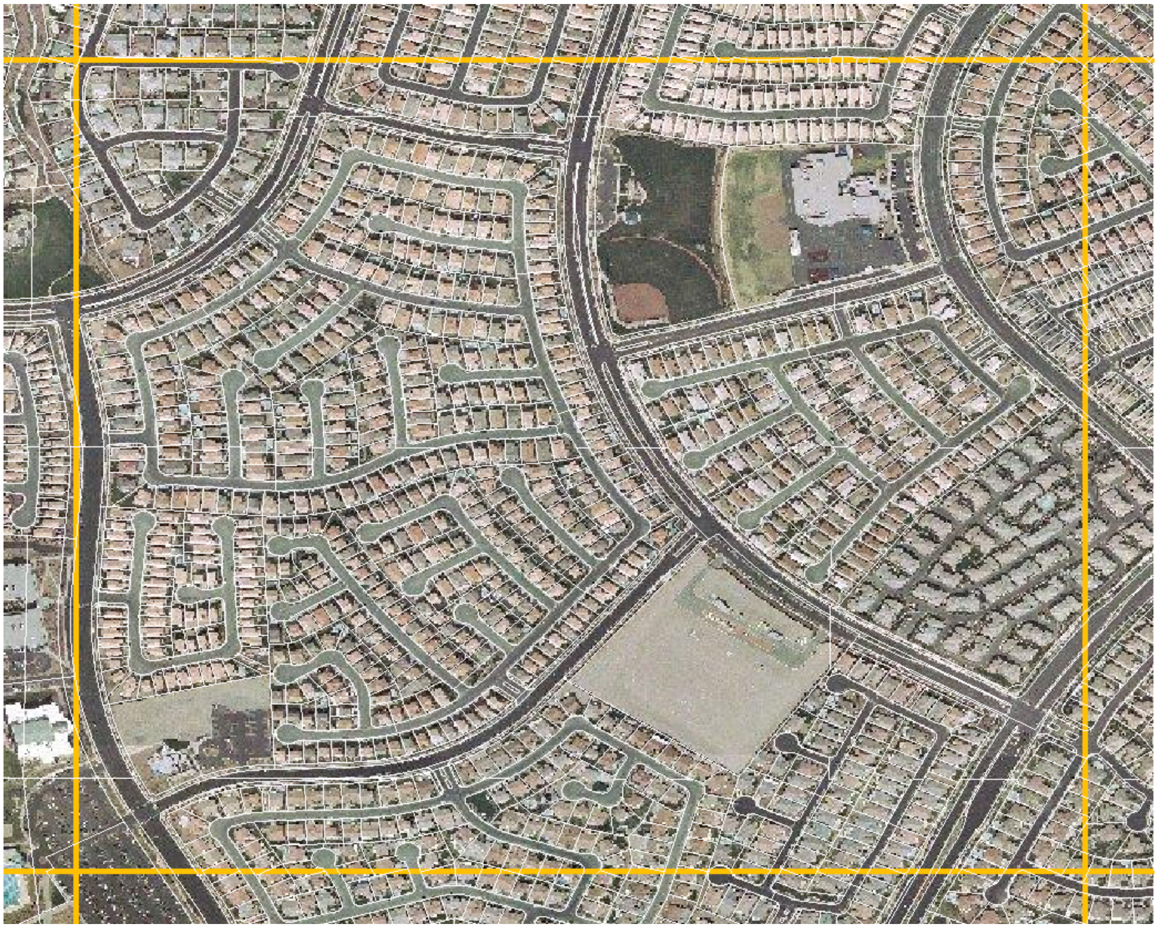


Figure 25: Grid Cell

Having constructed the grid cell layer, it was then necessary to establish the core database for the model. The input data used to construct this included business establishment files, census data, GIS overlays representing environmental, political and planning boundaries, and a location grid. The software tool used almost exclusively in the construction of this database was TransCAD, which read these input files, diagnosed problems in them such as missing or miscoded data, and applied decision rules to synthesize missing or erroneous data and construct the model database. An overview of the actual process for integrating these disparate data sources for STEP3 is depicted below:

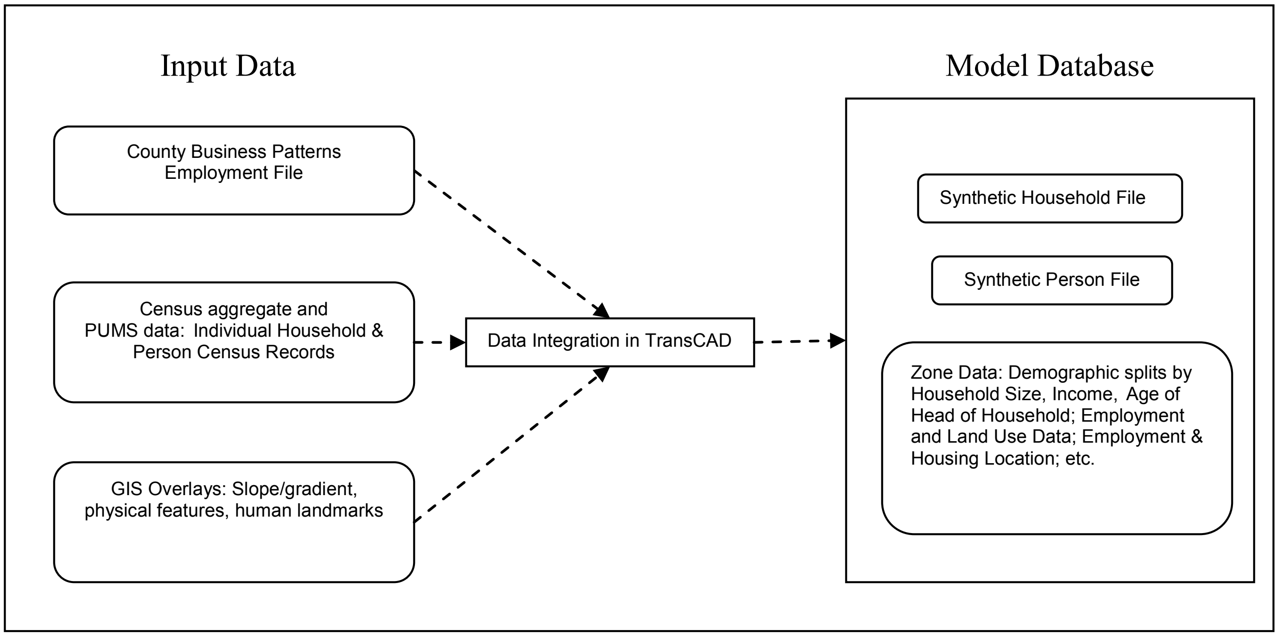


Figure 26: Model Structure

The database represents each household in the study area as an individual object, with the primary characteristics relevant to modeling location and travel behavior encompassing for example household income, size, age of head, presence of children, and number of workers.

To create the household list it was necessary to synthesize Census household-level data from the Public Use Microdata Sample tabulations by Census Block, and to assign these households probabilistically to cells, using a procedure called iterative Proportional Fitting. This method synthesizes individuals from a regional level sample of households down to the local (Block) level using the aggregate (marginal) totals available for the geographic Summary Level.

To explore growth patterns, parcels were obtained from GILIS (Geographically Integrated Land Use System). This is a planning land use database that is based on the Clark County Assessor's parcel information and which is reviewed and cleaned by the planning staff of the various cities and counties for planning purposes. These data came in many disparate formats with the majority belonging to an ArcGIS Library structure which Caliper did not have direct access to. This Library described 3135 tiles that encompass Clark County via 5 layers:

- PARCEL: Parcels
- CONDO: Condominium parcels
- LOTLINE: Parcel lot lines
- ROADEASE: Road easements
- ASSREASE: Assessor easements

It was necessary to import the ArcGIS files into TransCAD, which involved extensive data cleaning and processing and resulted in a single integrated parcel database. This parcel database is a useful product for analysis of various types.

For households, employment is represented in the data as individual records, with each employed person being explicitly associated with their employment sector. These data were obtained from County Business Patterns (CBP), which provides annual estimates for the number and employment size classes of establishments by detailed industry. These employment types are by industrial classification (SIC: 1994-1997; NAICS: 1998-2002) and needed extensive processing in order to match them to the employment/landuse types generally used in Clark (see above) in the following landuse codings:

- Southern Nevada Regional Planning Coalition (SNRPC) Landuse Codes
- Regional Transportation Commission of Southern Nevada (RTC) Landuse Codes
- Parcel based Population Estimation and Projection Program (PPEPP) Graphic Integrated Land Information System (GILIS) Land Use Codes
- Clark County Comprehensive Planning Land Use Codes

In addition, extensive record cleaning and geocoding were employed to locate the businesses as accurately as possible, which can be visualized in the following Figure. The Strip is clearly identifiable as having high concentrations of the highest numbers of employees.

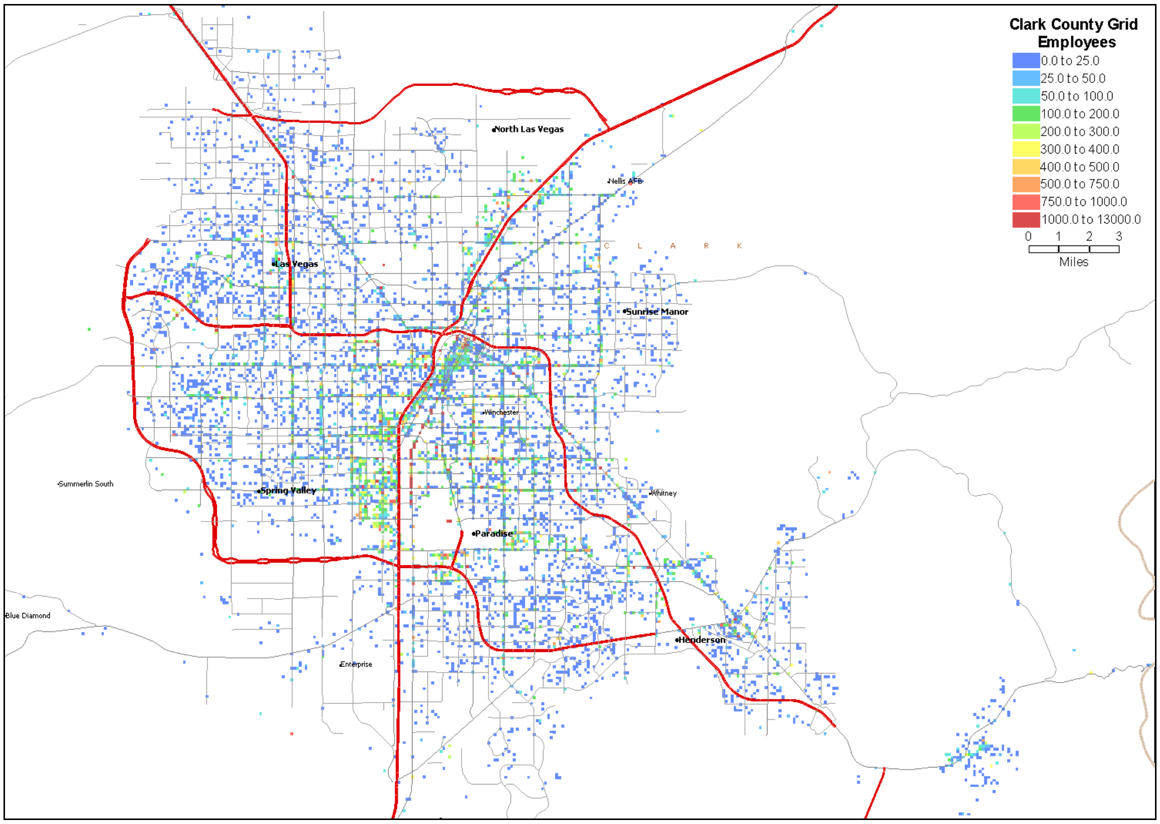


Figure 27: Geocoded Businesses

5.3 <u>Base Case and Historical Patterns</u>

5.3.1 <u>Census Data</u>

The base year for the study is 2000. This period was chosen as it is the most recent Census year from which several demographic variables required by the model can be obtained. These data are required at both the aggregate zonal level and also at the regional individual person and household level.

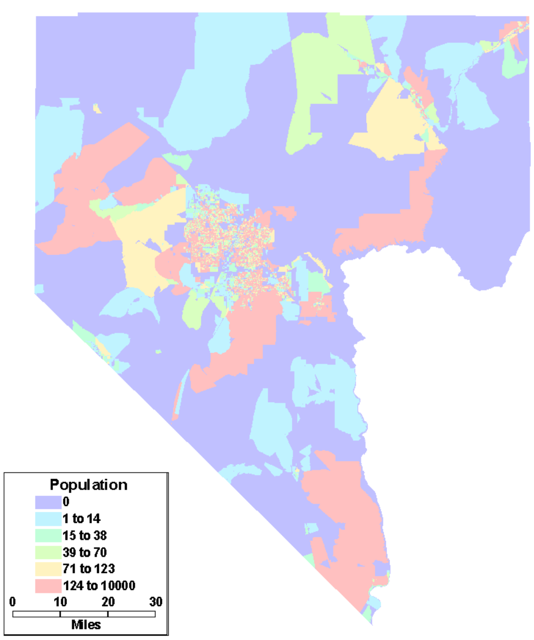
The variables modeled include various characteristics of which the primary ones are summarized here:

Table 6 Census Characteristics

Aggregate Zonal	Disaggregate Household	Disaggregate Person
Population	Number of people in household	Relationship to householder
Dwelling Units	Place of residence	Gender
Occupied Housing Units by Tenure	Number of automobiles	Race
Median Rent	Household income	Age
Median Owner Costs	Rent or own	Ethnicity
Aggregate Household Income	Group Quarters	Type of Education

1999		
Occupied Housing Units by Tenure by Car Ownership		Years of schooling
Household Income		Employment status
Occupied Housing Units by Tenure by Householder Age		Hours worked last week
Occupied Housing Units by Household Size		Place of work
Group Quarters		Industry
		Total person's income
		Wages or salary
		Nonfarm self-employment
		Subfamily Relationship
		Marital Status

These variables allow a picture of the population to be developed and relationships between location and people to be established. Before this is possible, however, the characteristics need to be in a format that can be easily manipulated within the models. The variables discussed are available at several different summary levels and are sourced from several Census profiles. The highest resolution summary level provided is that of the Census Block. Blocks are the smallest entity for which the Census Bureau collects and tabulates census information (SF1 profile only). For those data at the SF3 level and consequently only available at the Block Group level (in order to ensure anonymity of the Census returns) a disaggregation method was used to assign these data to the smaller, higher resolution Blocks. The Census data were then assigned from the Blocks to the 1000m grid cells using the polygon overlay techniques in TransCAD. By comparing the population totals at the Block and grid cell levels it is clear that due to the high resolution of the grid cells the assignment of population distribution is very accurate.



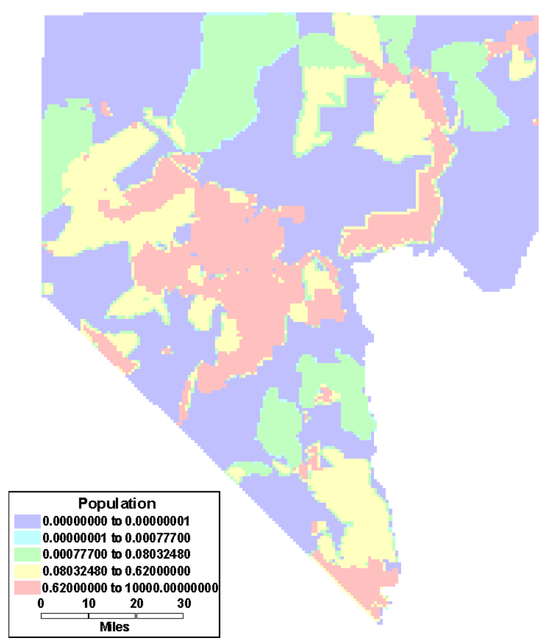


Figure 28: Total Population Distribution at the Block and Cell Level (respectively)

The disaggregate characteristics of persons and households are synthesized such that a full individual scale population is created at the grid cell level.

5.3.2 Landuse Data

In order to identify the areas of growth, those regions that contained features such as airports, dams, military installations, parks and water bodies were flagged. These landuse types cannot be developed upon anymore than they already are and represent fixed development types. A county level view of the major landmarks clearly shows where the biggest of these features are (with parks, water bodies and military installations predominating):

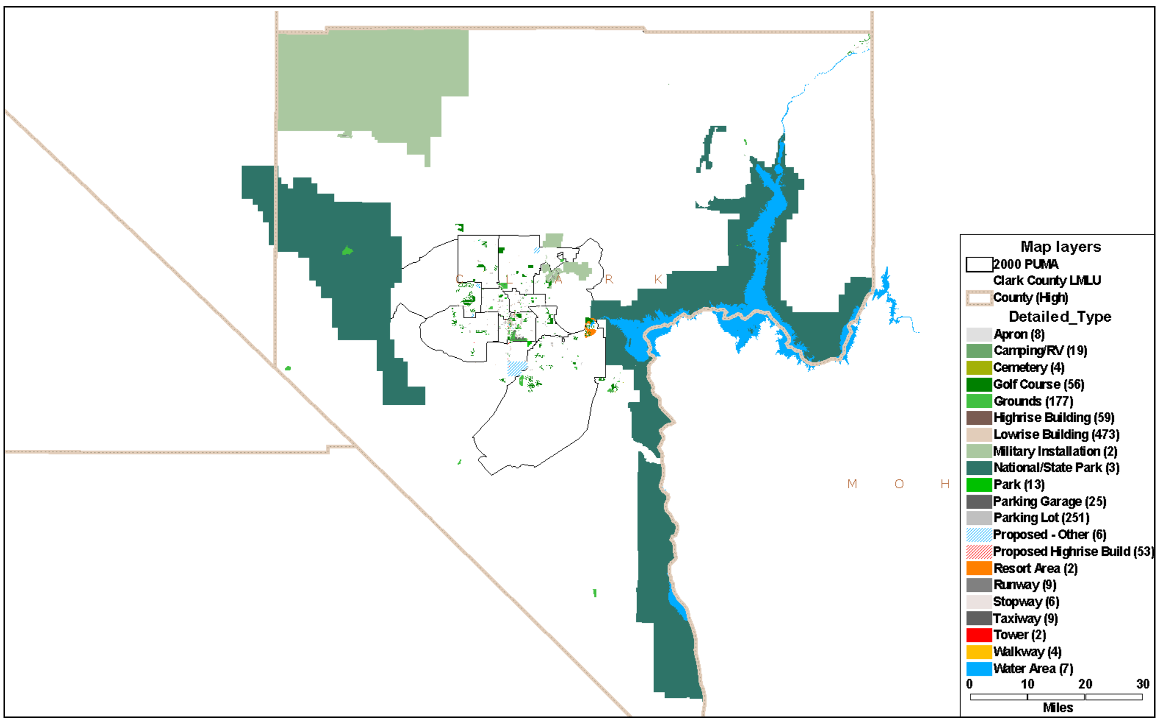


Figure 29: Clark County Landmarks

The construction of this landmark layer was extremely time consuming and involved the use of aerial photos, paper maps, Internet resources, and digital GIS datasets resulting in a database that provides high levels of detail for the base year. This can be seen for the central urban area of Las Vegas, the view of which also shows for example the area of the existing airport that cannot be further developed:

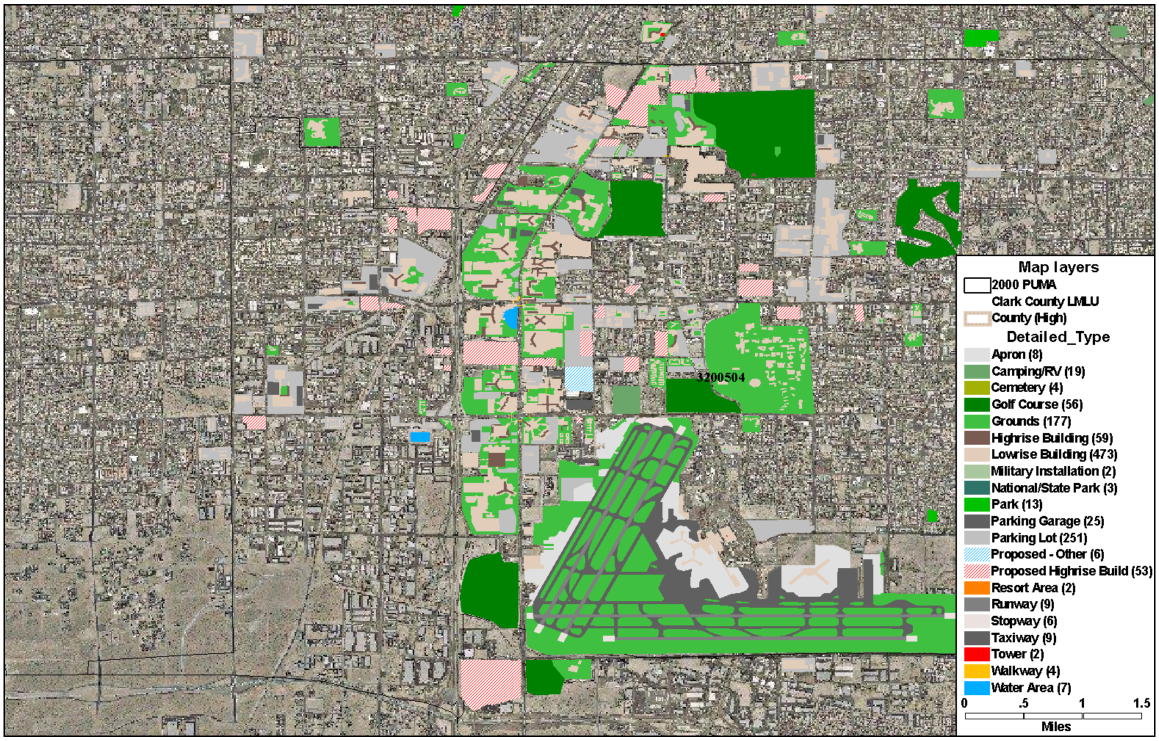


Figure 30: Las Vegas Valley

While identifying both the existing human land uses and obvious natural features that likely prevent additional construction, it is also necessary to examine the gradient of the study area. This is particularly important given the incidence of rugged terrain in the region and the effects this has already had on urban form. Typically for individual construction a slope of 2:1 (two units in the horizontal for every one unit in the vertical) is considered problematic. We calculate the gradient at intervals of 75 meters and take the average gradient for each 1000 meter zone cell. If the average gradient is greater than 5:1 we consider this to be undevelopable as there must be a considerable number of steep slopes within such a cell to produce this high average gradient.

When these areas are combined with our initial undevelopable land, we can clearly identify the places where it is assumed that less extensive construction can occur. For the base year, a view of this undevelopable land overlaid with the street network highlights how such factors interact to control urban expansion. The urban areas are visibly hemmed in (indicated by the streets), while the major transportation corridors traverse paths of least resistance, both of which are to be expected in a reasonably planned region. While such characteristics are not unusual, such comparisons serve to qualify the designation of these areas as units of restricted expansion in our models.

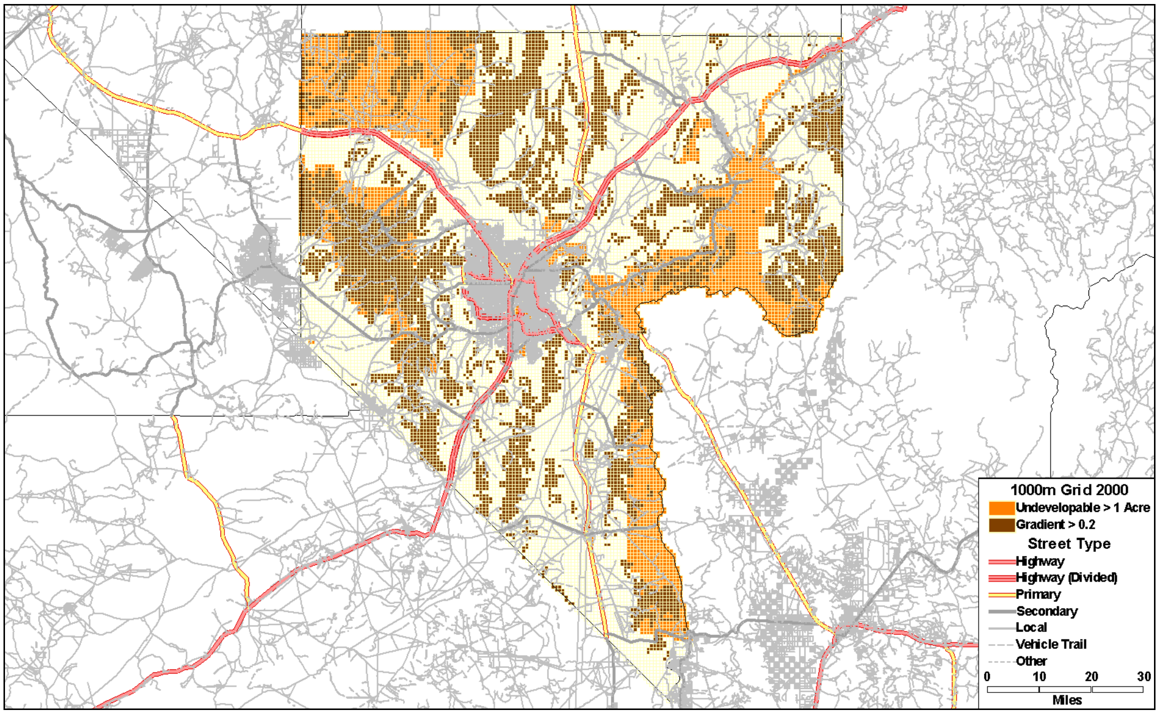


Figure 31: Undevelopable Land and the Street Network for Clark County

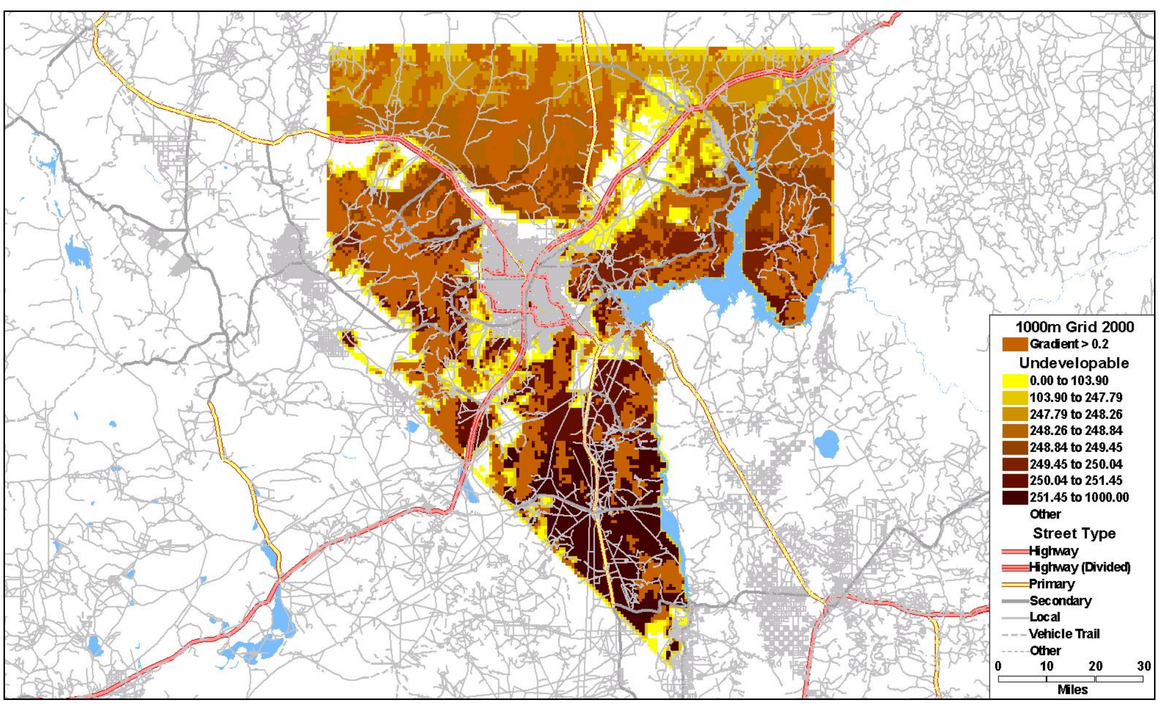


Figure 32: Undevelopable & Environmentally Constrained Land in Clark County

At a local level such behavior is again displayed, especially when contours are examined at the scale of the parcel. The time based element of this second map shows how more recent construction has occurred at the base of steeper slopes at the edge of existing settlements.

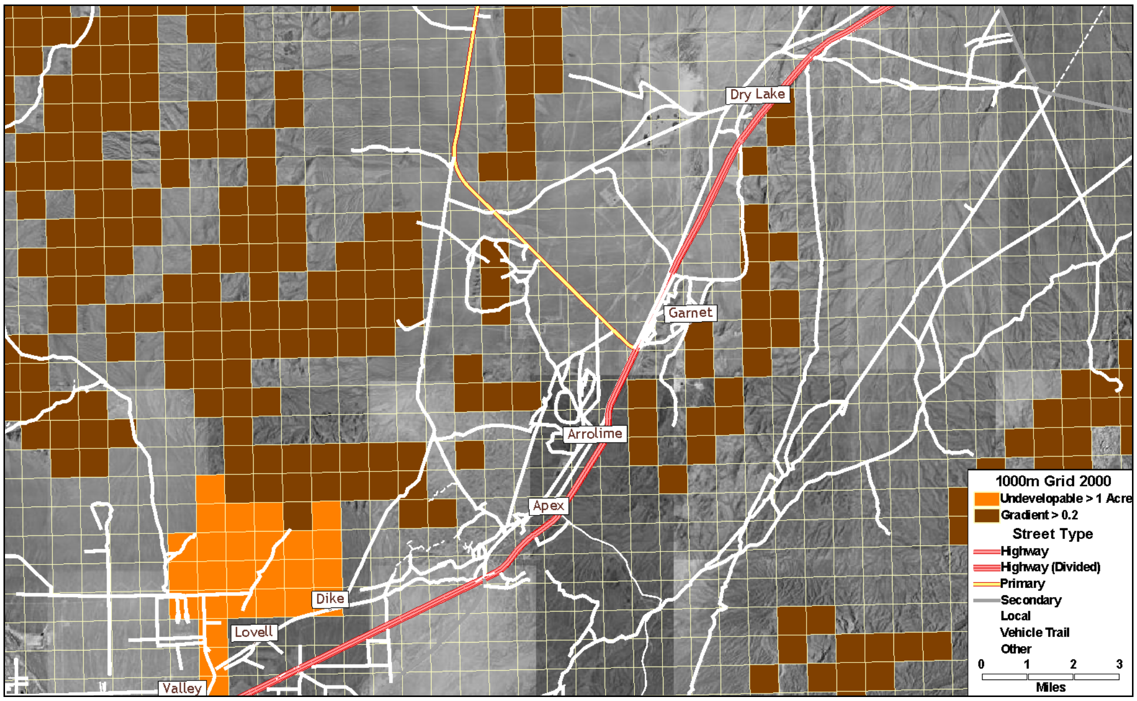


Figure 33: Undevelopable Land and the Street Network for Apex and Environs

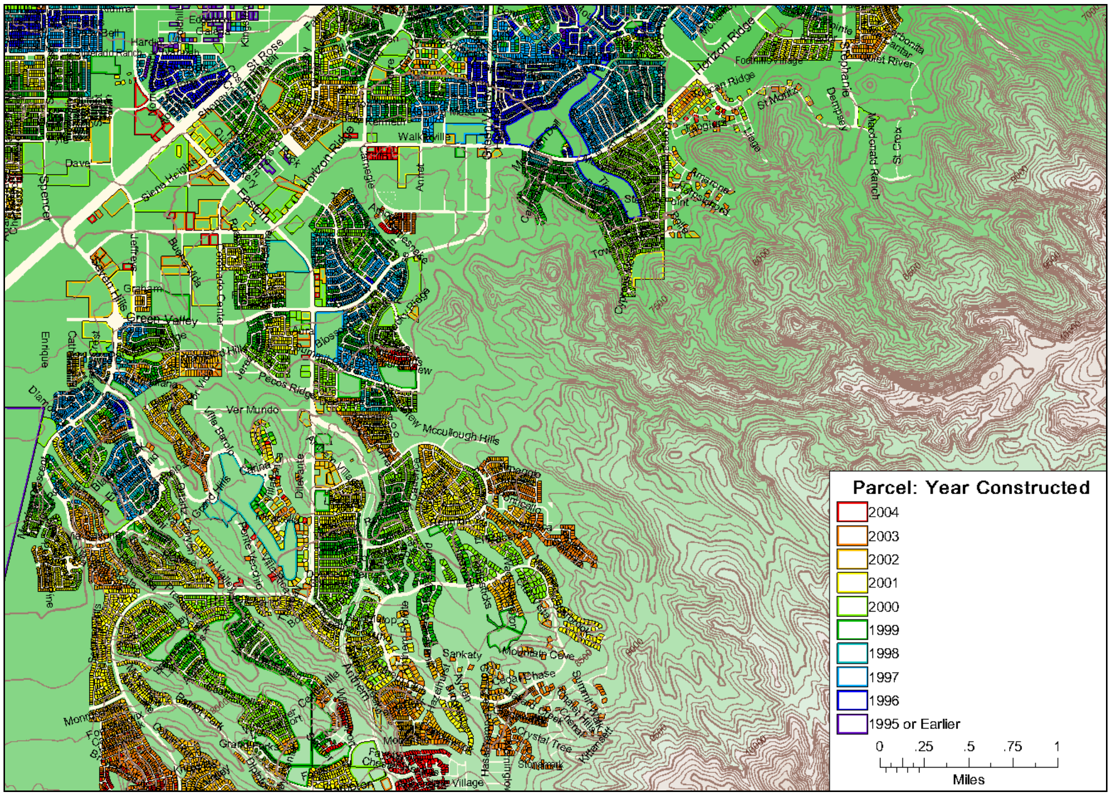


Figure 34: Parcel Year of Construction and Elevation Contours: Red is newer construction, blue is older: Shows new construction advancing on hills

The ability to view development in a GIS as a uniform grid of cells is highly advantageous in that trends over time can easily be discerned. By overlaying several different themes of data a high-level overview is obtained that will form the foundation for our model conception. For example, in the next four maps we explore the relationship between undevelopable land and the developed land for the years 1990, 1995, 2000 and 2004. The purple themed shading of the 1000m grid cells indicates the number of acres developed in each cell. Clearly, there is both an expansion of the developed region as well as densification of the existing developed extent.

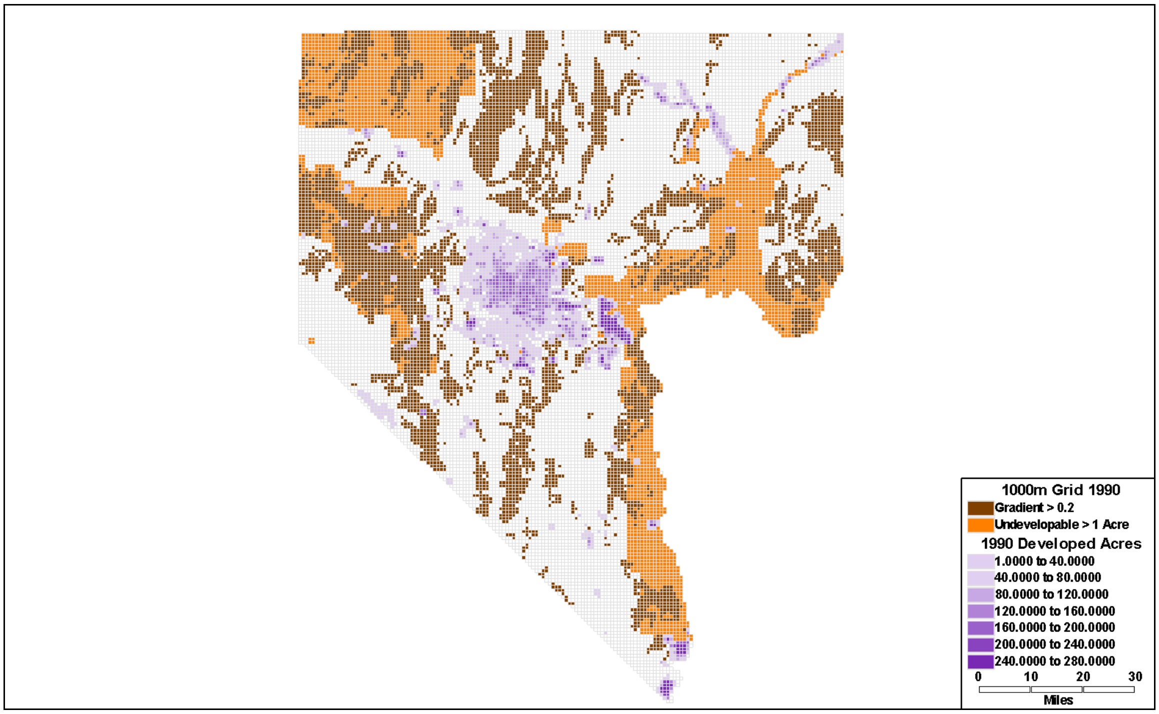


Figure 35: Grid Cells Showing Undevelopable and Developable Land (1990)

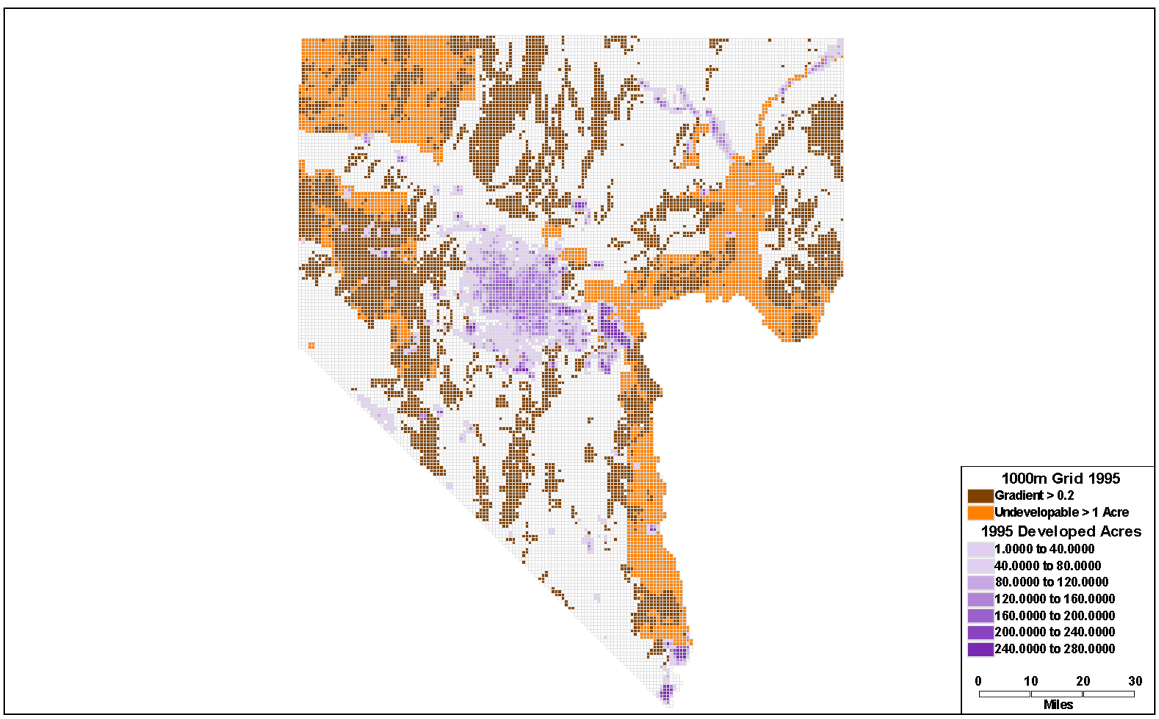


Figure 36: Grid Cells Showing Undevelopable and Developable Land (1995)

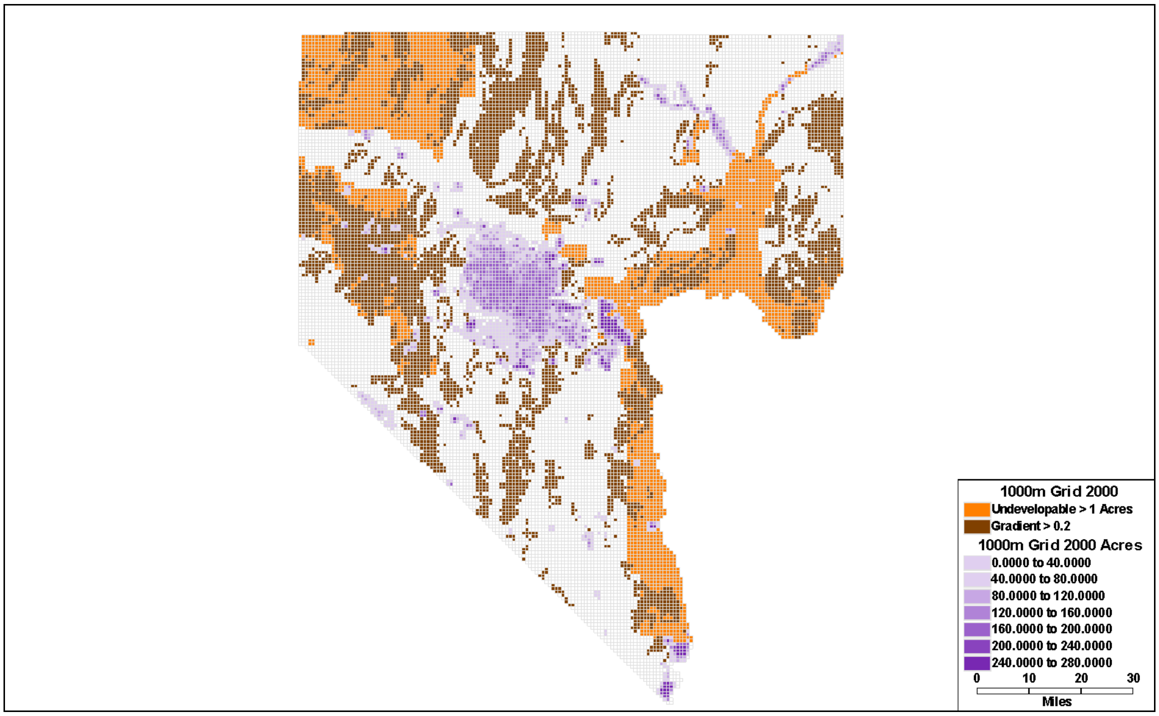


Figure 37: Grid Cells Showing Undevelopable and Developable Land (2000)

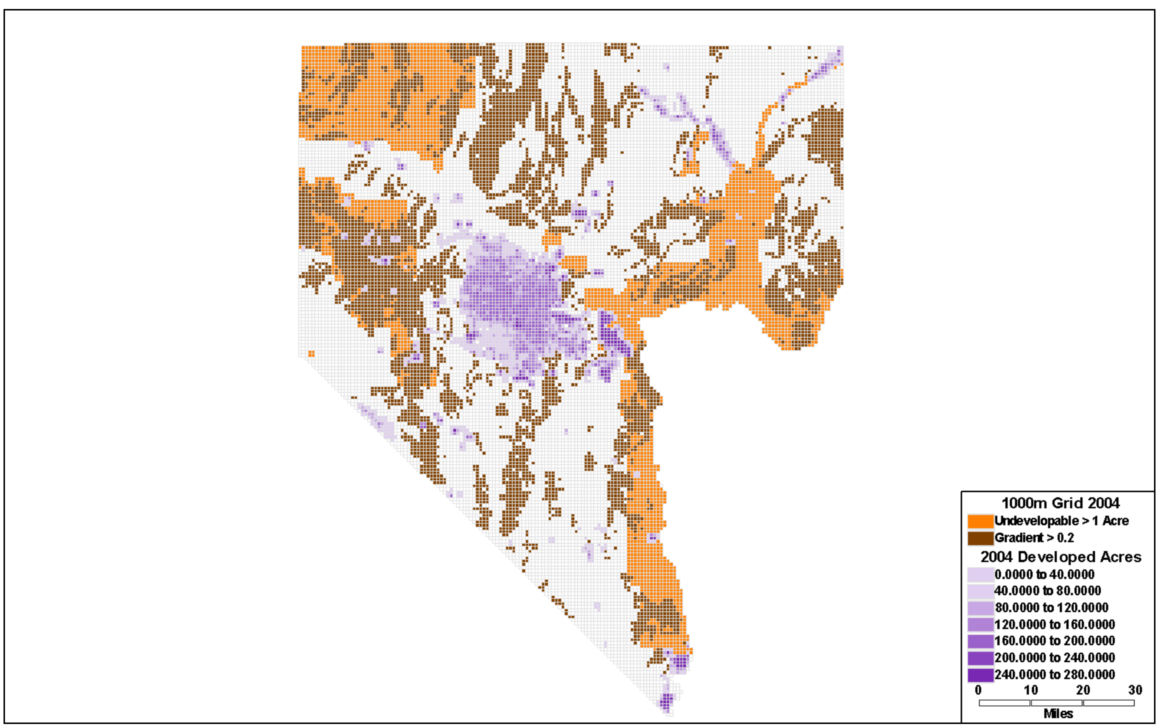


Figure 38: Grid Cells Showing Undevelopable and Developable Land (2004)

Such overview maps provide a good understanding of the regional situation. At the meso-scale we can observe the situation in greater detail by segmenting the developed areas into their landuse types and by determining a range of colors to appreciate varying amounts of undevelopable land. It can be seen from the following four maps that growth trends clearly indicate an expansion, most noticeably in the occurrence and share of residential landuse at the periphery of the already developed urban expanse:

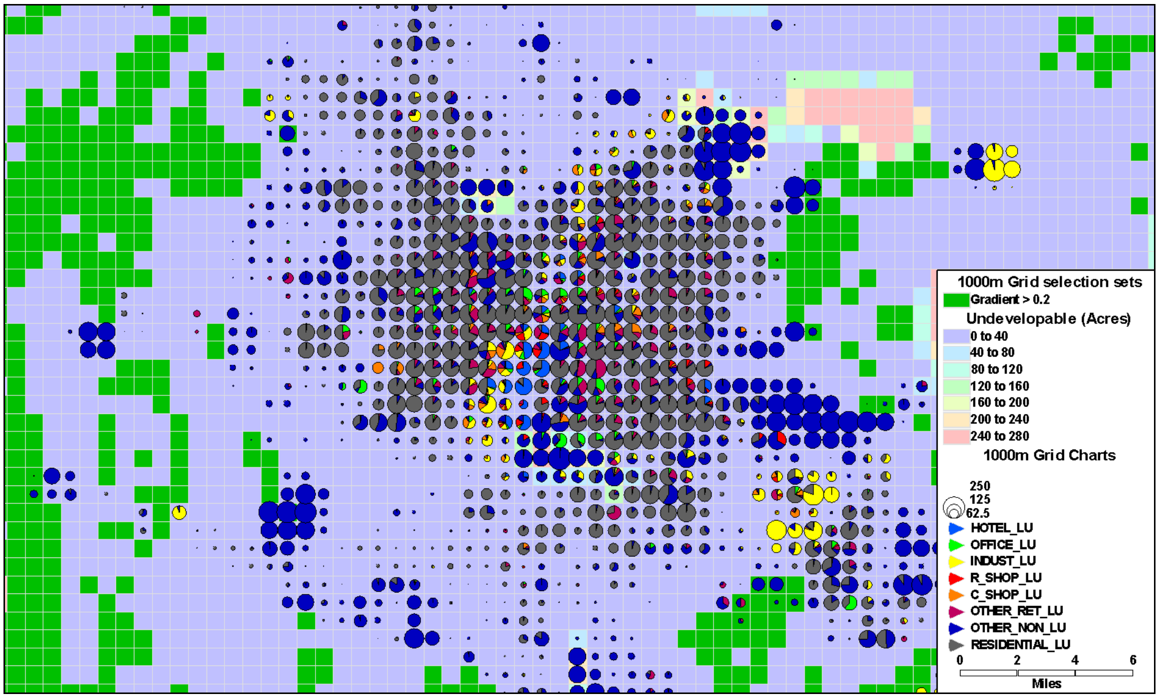


Figure 39: 1990 Las Vegas Landuse Types, Gradients & Undevelopable Land

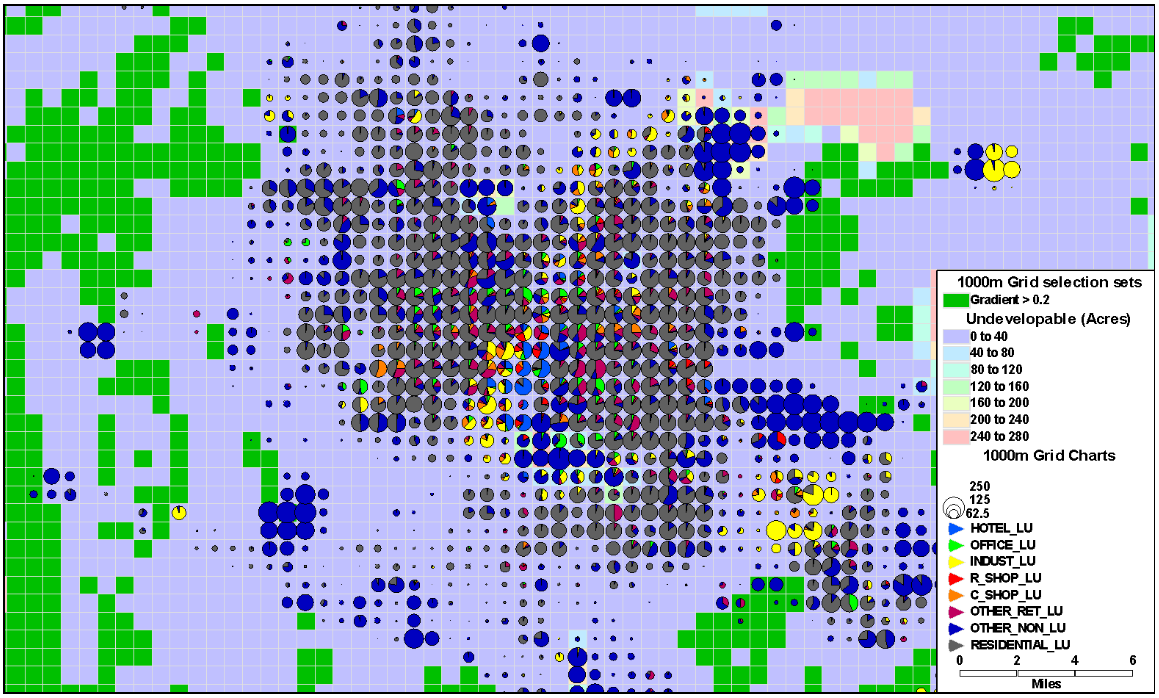


Figure 40: 1995 Las Vegas Landuse Types, Gradients & Undevelopable Land

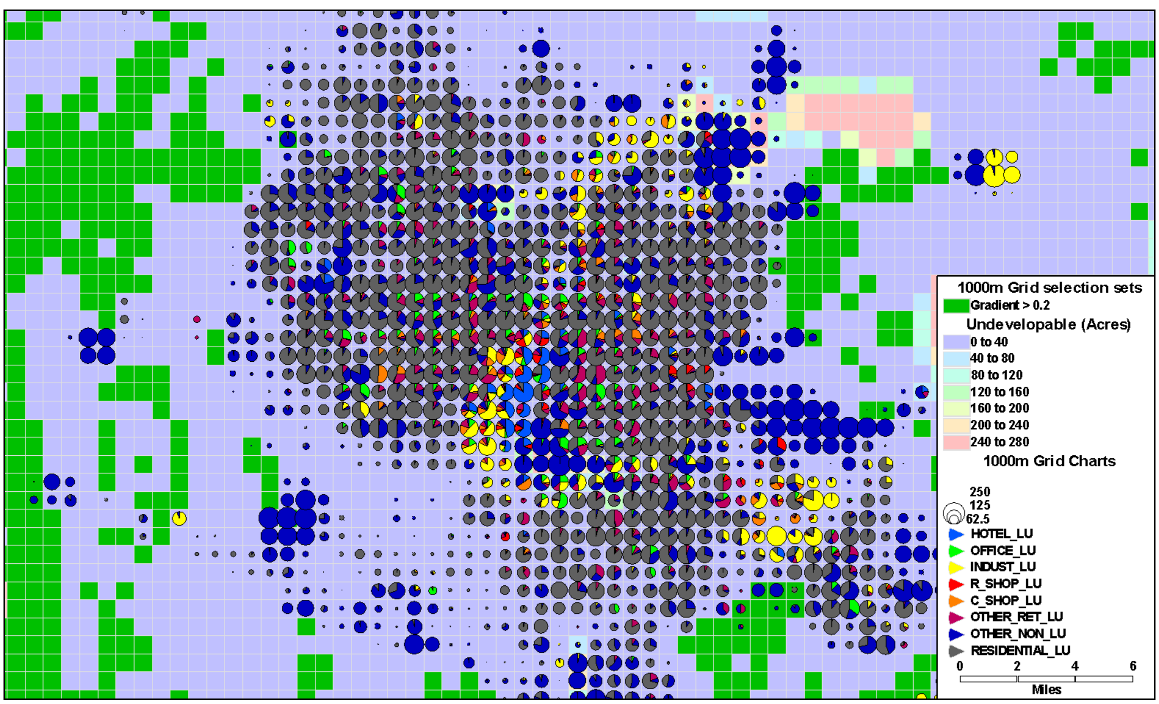


Figure 41: 2000 Las Vegas Landuse Types, Gradients & Undevelopable Land

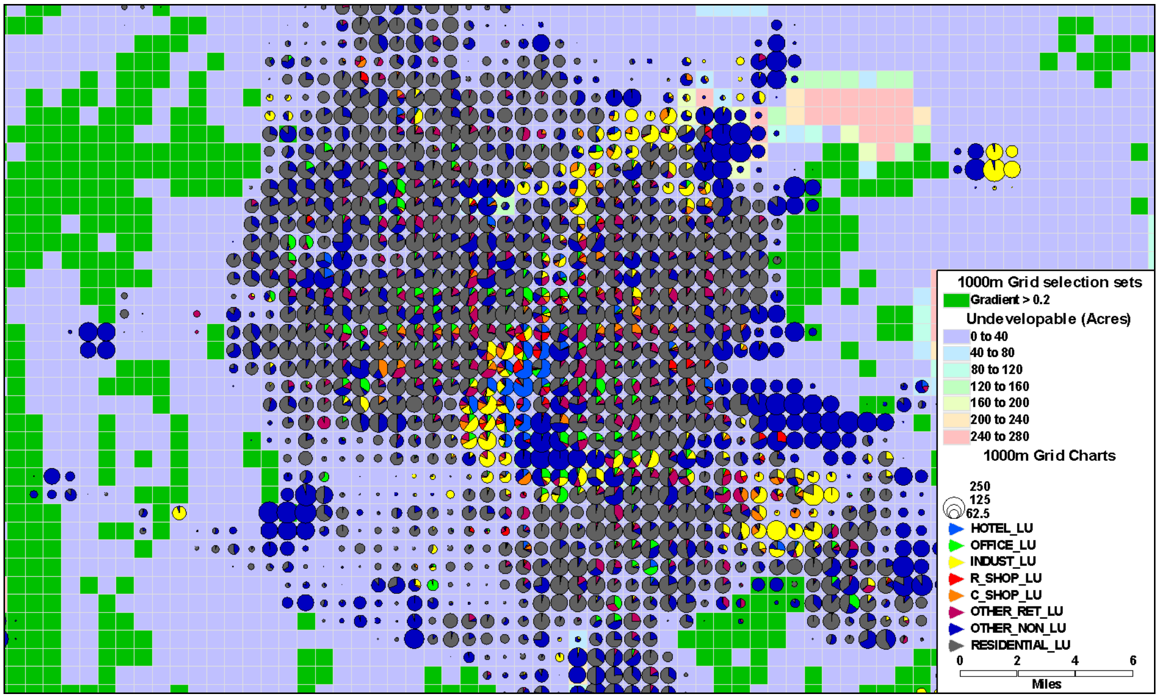


Figure 42: 2004 Las Vegas Landuse Types, Gradients & Undevelopable Land

In these maps the landuse pie-charts allow easy identification of the Strip (central light blue hotel segments) as well as McCarran International Airport (dark blue block of other non-retail segments to the south of the conurbation) and Nellis Air Force Base (dark blue block of other non-retail segments to the north of the conurbation in conjunction with land designated as undevelopable due to its status as a military base). In addition it is also apparent that the cells identified as having higher gradient surfaces act as barriers to sprawl, which although expected, highlights how this element is likely to be effectively handled in the STEP3 models.

A macro-scale map in conjunction with a meso-scale representation of employment also confirms expectations and indicates the accuracy of the spatial processing. These figures depict the density of employment as well as the numbers and shares of employment by type. Las Vegas is obviously the local employment engine, and within the city the Strip and airport are without doubt the primary employers.

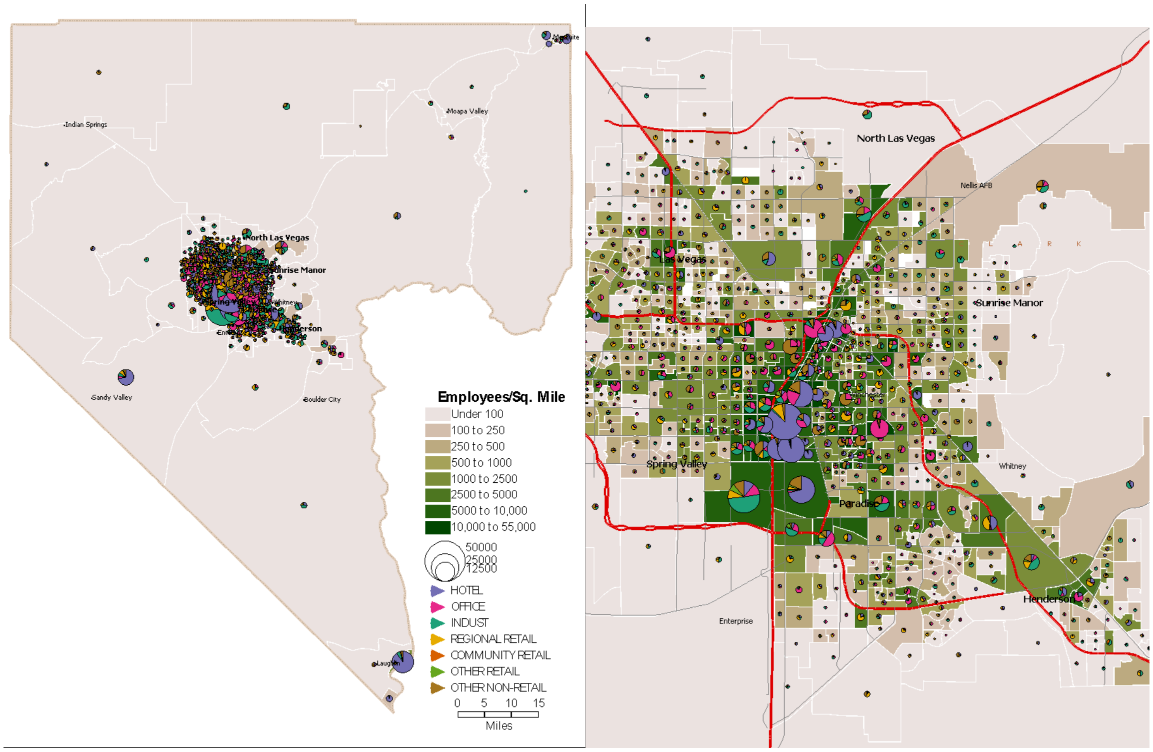


Figure 43: Employment

While such concentrations are to be expected, the spatial distribution of landuse types exhibit some subtle differences in our base case, as indicated by the landuse densities of hotel, retail, industrial and residential development.

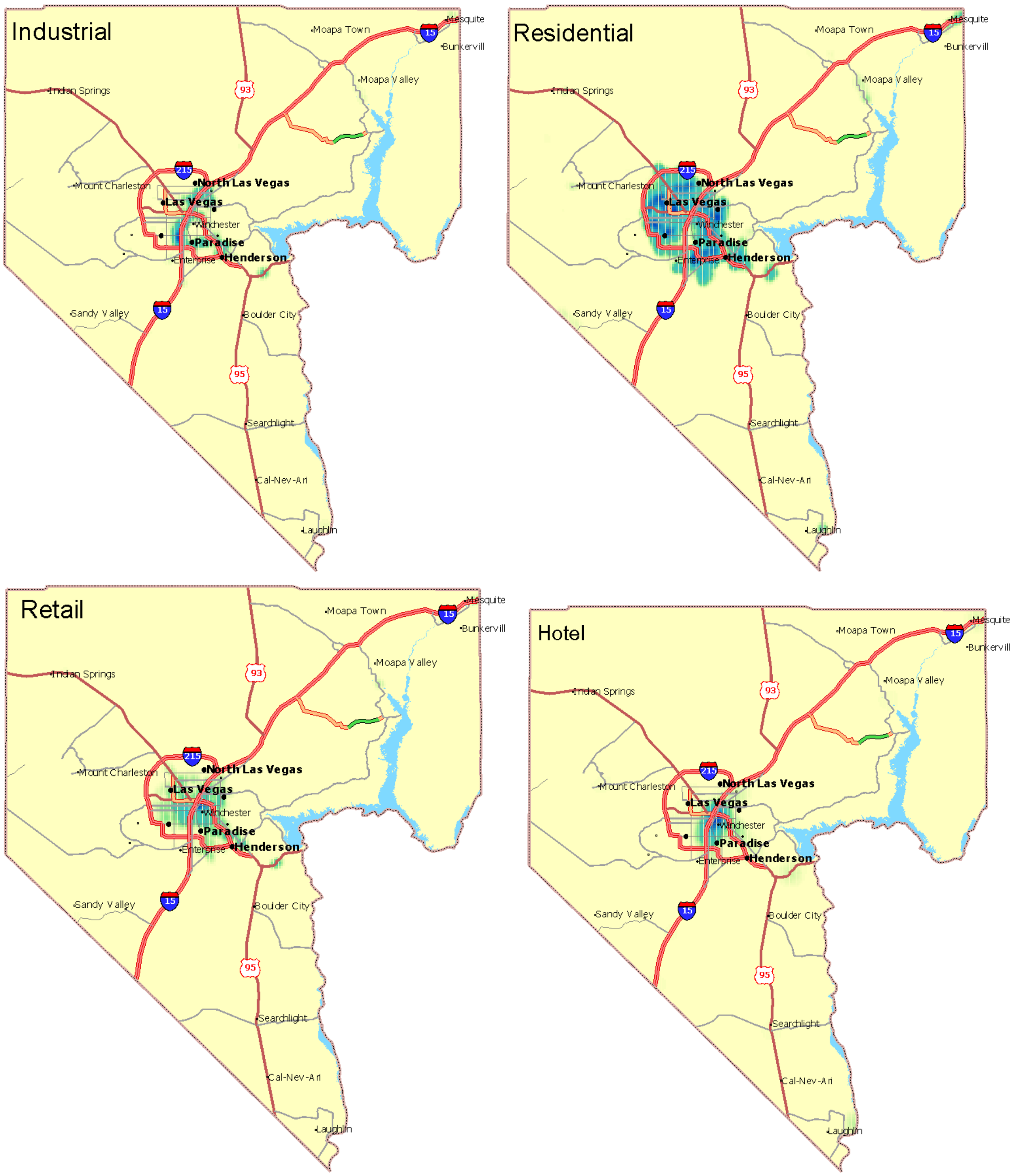


Figure 44: Hotel, Retail, Industrial and Residential Land Use Density

It is clear that the highest densities of retail and hotel space are in the downtown area. Retail concentrations are then distributed out from this core, while hotel densities are highest along the Strip. Activities classed as industrial occur heavily to the west of the Strip and the Las Vegas Freeway, and then linearly north up Interstate 15 as well as through Paradise, Whitney and Henderson. As would be expected the residential densities occur away from the CBD in more suburban areas and they parallel the extent of the street network.

5.3.3 Transportation Data

An exploration of the base year transportation infrastructure was also conducted to explore levels of accessibility to be included in STEP3 as well as to establish transportation networks for future years.

Using the data that were available we were able to establish the transportation infrastructure for 2000 as well as some of the likely future changes. In terms of the street network, more recent updates to the Census TIGER files were available and these allowed the demarcation of growth up to the current period. As can be seen, new streets have primarily been built all along the south, west and north/north-west of the central urban area during the period from 2000 to 2005.

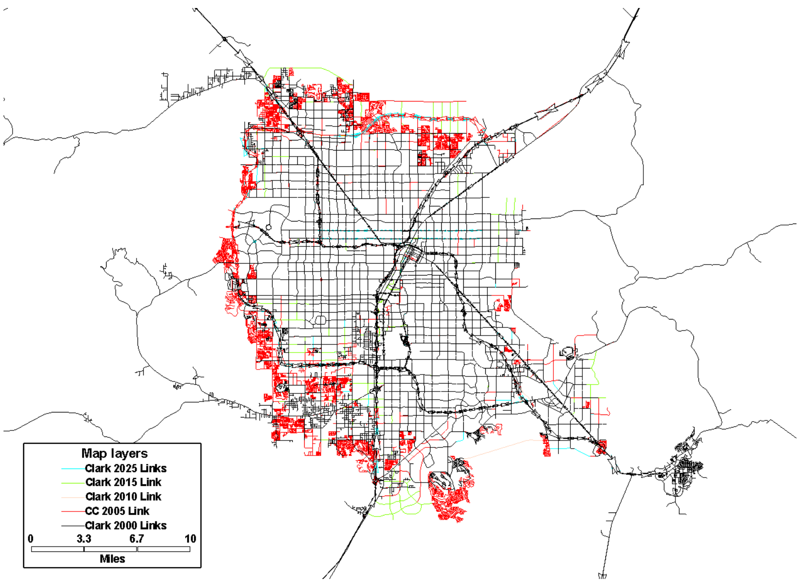


Figure 45: Road Network (2000-2005)

In addition, the existing and planned transit routes were collated and overlaid, highlighting the extensions, new implementations and closures envisioned for such routes. For example, the Strip Express service started in October 1996, was temporarily discontinued between January 2003 and June 2003 and permanently cancelled in October 2005.

Accessibility was also determined in terms of quarter and half mile bands around transit stops (peach and pink bands respectively). From available information it is clear that current and planned transit does not extend beyond the central conurbation of the County, but that within Las Vegas transit is widely spatial distributed.

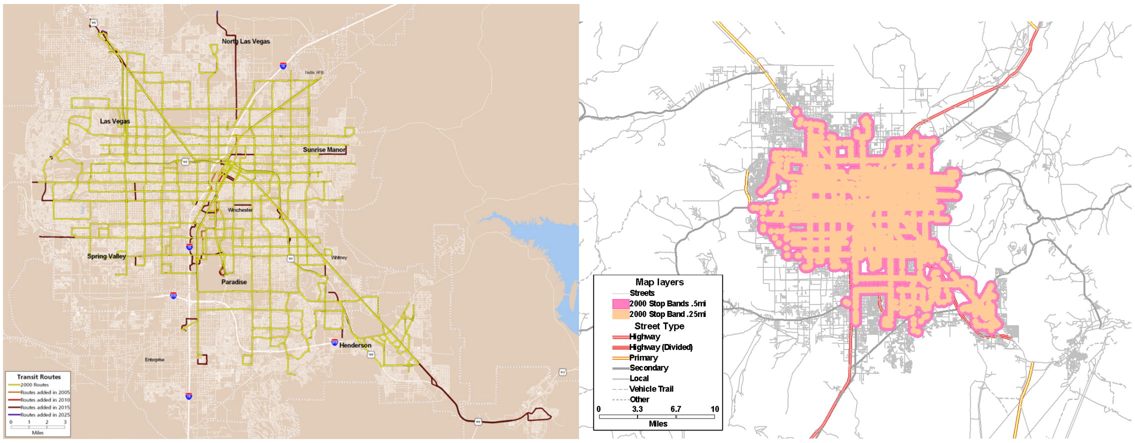


Figure 46: The Transit Network and Accessibility to Transit

The collation of extensive datasets for the base year allow a more robust model to be developed, while the design of STEP3 has also evolved to reflect the ground truths of the study area and the trends discerned within the historical information for the region.

5.4 Trends

5.4.1 Introduction

In this section we go beyond our evaluation of the base year by exploring the trends that led to the current situation and their implications for future growth and model expectations.

5.4.2 Population

With a growth rate of about 4.1 percent, Nevada has consistently ranked first among the fastest expanding states for at least the last 18 consecutive years. Clark County is the primary source of this population increase and has some of the fastest-growing large cities in the country including North Las Vegas and Henderson.

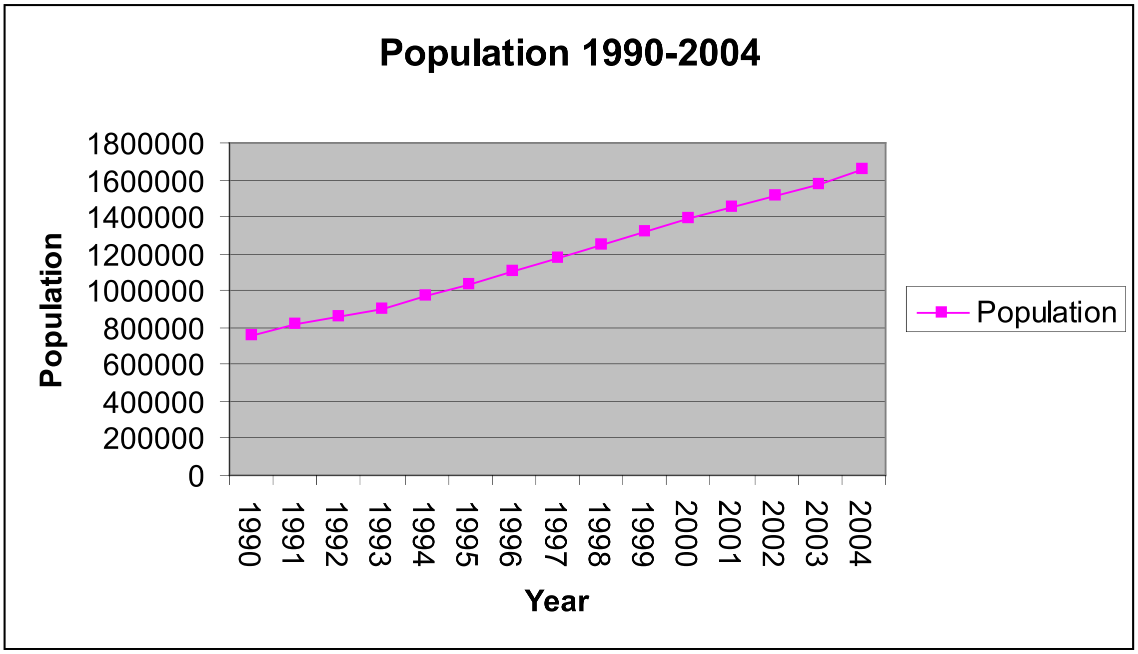
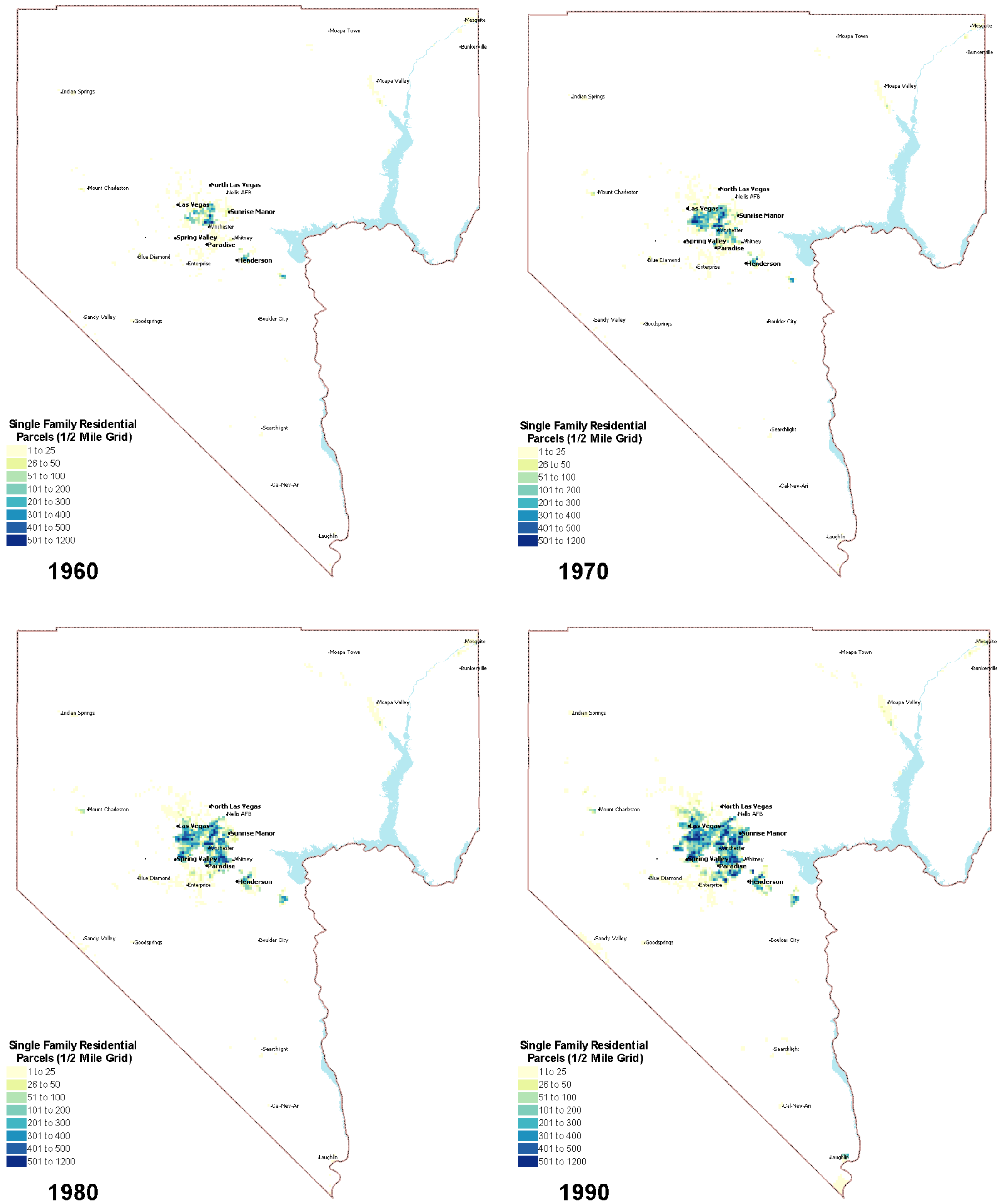


Figure 47: Population of Clark County (1990-2004)

To examine this increase we use historical parcel data to gauge the growth of single family residences in the study area for the period from 1960 to 2004. The primary areas of note are the Las Vegas metropolitan area, Mount Charleston, Sandy Valley, Moapa Valley, Laughlin and Mesquite. However, despite smaller town growth the areal expansion of the central conurbation is at a much higher rate than that occurring anywhere else in the County, while the absolute numbers of new residential parcels in the Las Vegas area also far outweigh that of any of the other settlements in the County.


Mesquite
Moapa Town
Bunkerville
Moapa Valley
Indian Springs
Mount Charleston
North Las Vegas
Nellis AFB
Las Vegas
Sunrise Manor
Spring Valley
Whitney
Paradise
Blue Diamond
Enterprise
Henderson
Sandy Valley
Goodsprings
Boulder City
Searchlight
Cal-Nev-Ari
Laughlin
Single Family Residential Parcels (1/2 Mile Grid)
1 to 25
26 to 50
51 to 100
101 to 200
201 to 300
301 to 400
401 to 500
501 to 1200
1960
1970
1980
1990

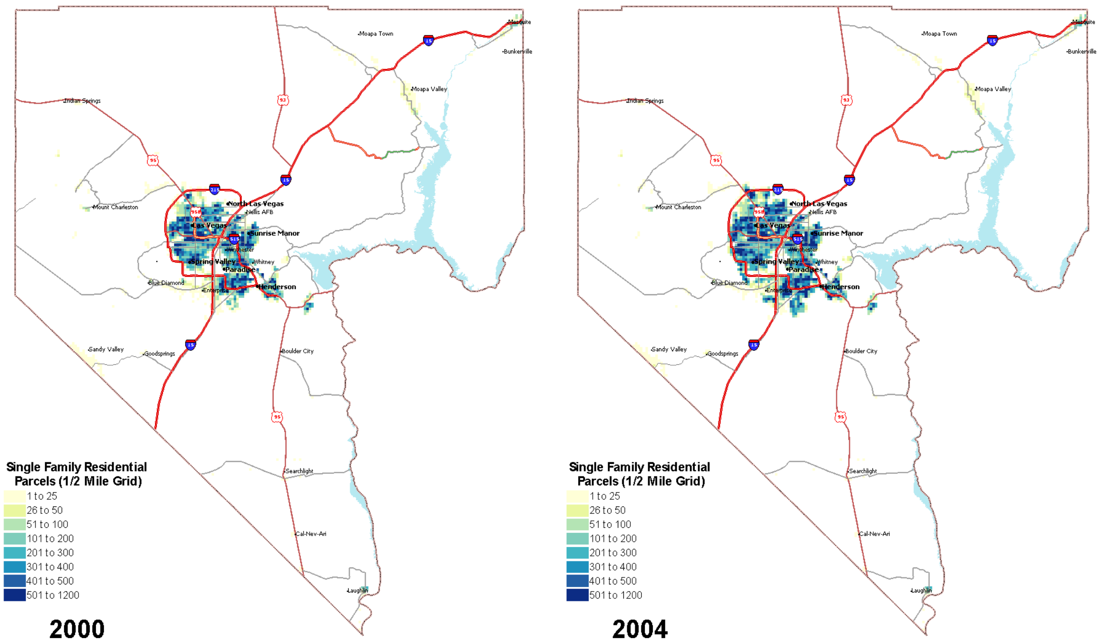


Figure 48: Single Family Residential Parcels (1960-2004; 0.5 mile grid)

This growth has been primarily to the south, west and north/north-west of the city, avoiding the environmental barriers to the east (see undevelopable acres maps above) while following the major arterials.

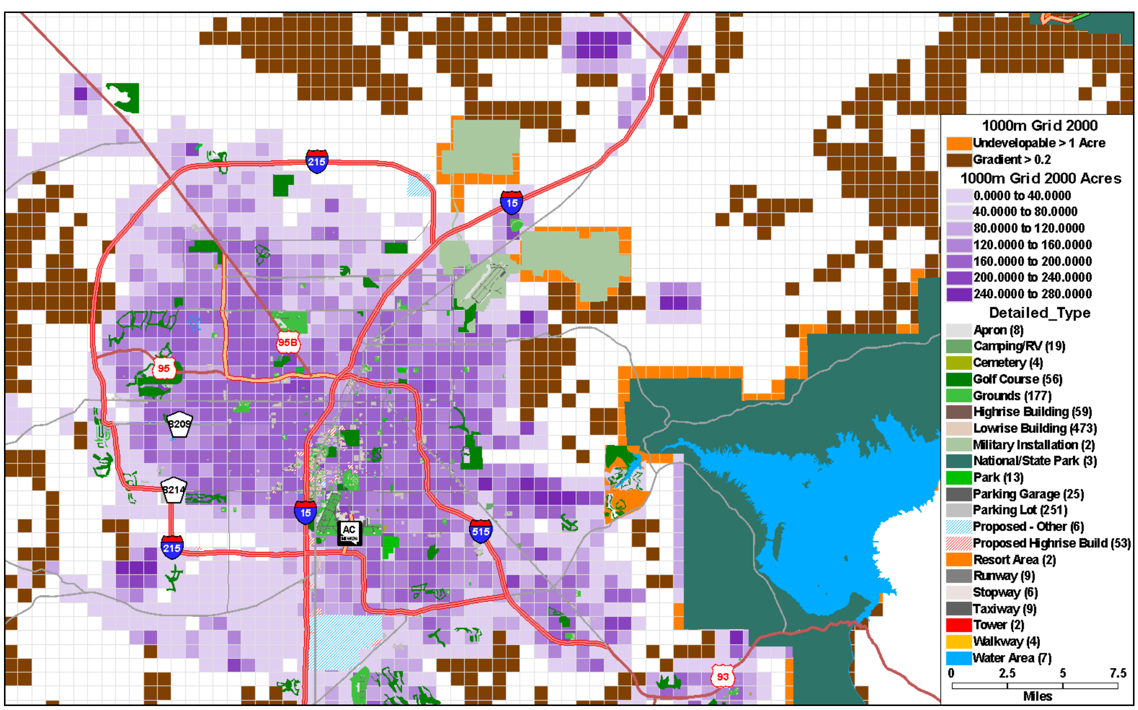


Figure 49: Central Clark County (2000)

When observing the population using Tract-based time-series data (produced using demographic estimation methodologies) an interesting trend is the local decrease in population in several of the County's peripheral towns. In addition, we again detect the population increases at the edge of the city in the same locations as previously noted.

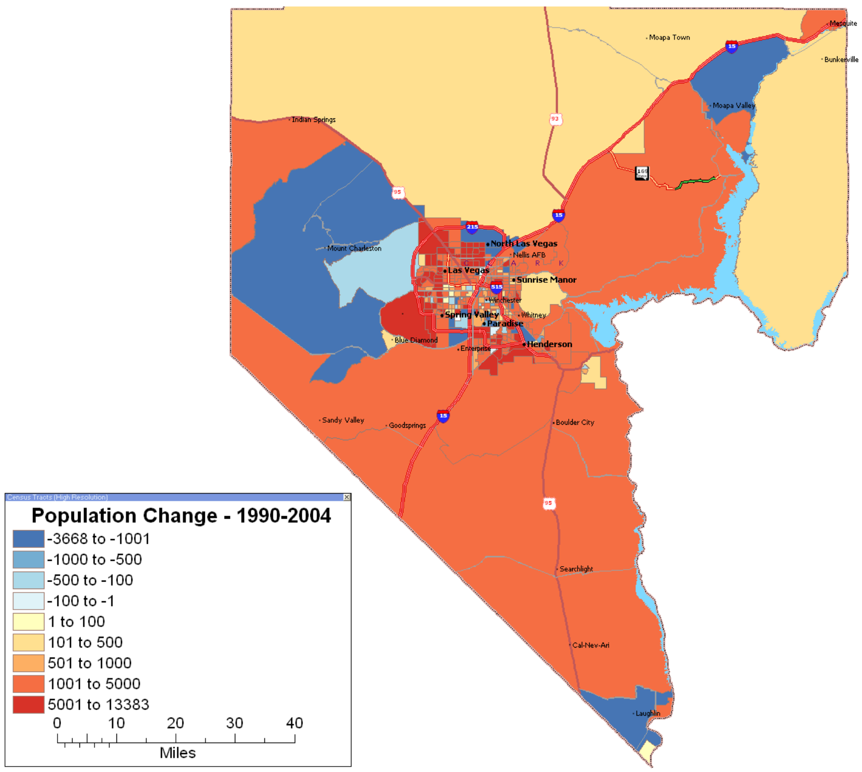


Figure 50: Population Change by Tract: 1990 to 2004

By observing the population density changes over time it is apparent that there actually is an agglomeration of population in the east but this is relatively fixed in space.

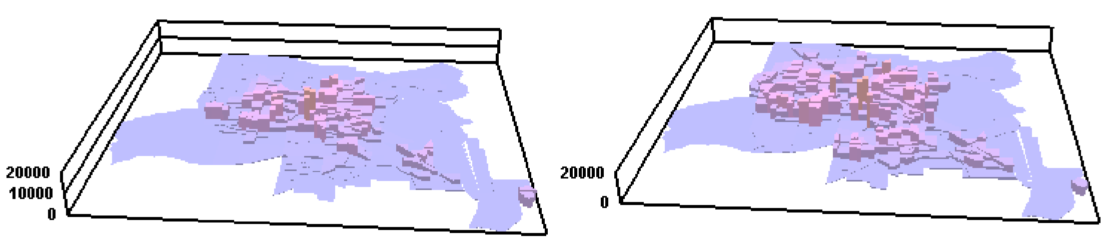


Figure 51: 1990 and 2000 Population Densities by Tract

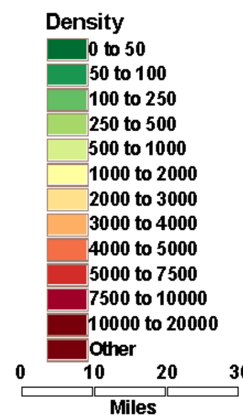


Figure 52: Population Density by Tract Time Series: 1990 to 2004

5.4.3 Landuse and Parcels

We will now explore parcel development over time to determine if the patterns noted so far are further validated. By observing the numbers of parcels constructed we move away from a simple population based perception of the region's growth and incorporate all functional landuse types. This also provides us a clear and simple way to produce County wide maps depicting where growth has been taking place. As can be seen from the Figure below, Las Vegas has remained the focus of expansion but there has been notable development in some of the satellite towns such as Sandy Valley and Moapa Valley.

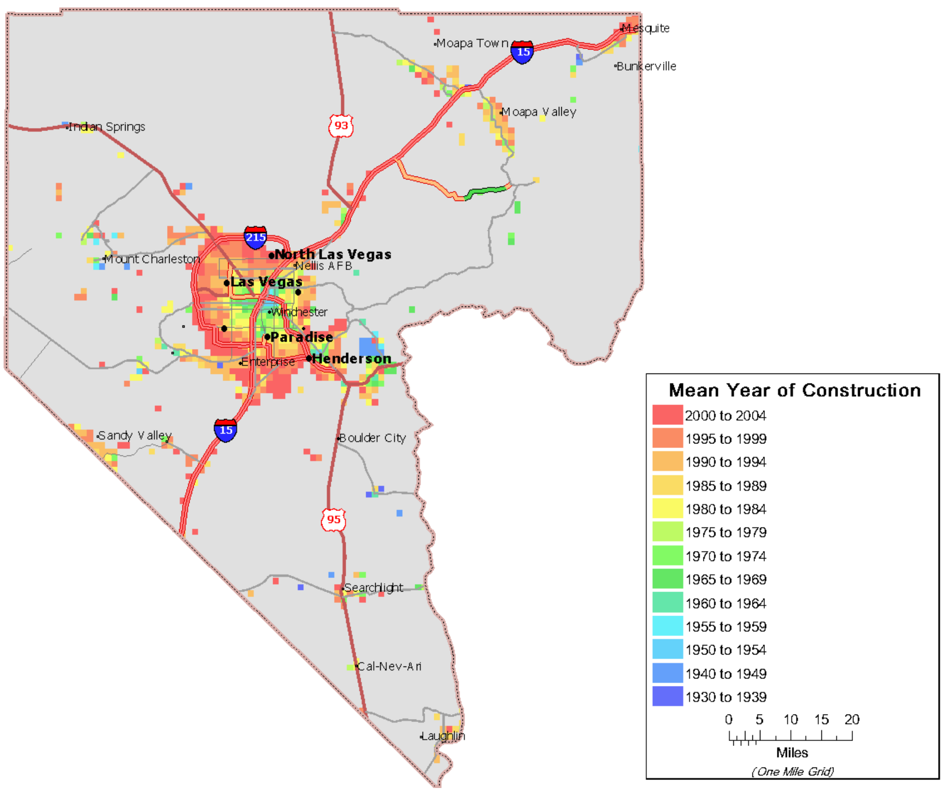


Figure 53: Average Construction Year: 1 mile grid with aggregated average parcel construction date

By observing the parcels themselves rather than averages by grid cell we can better comprehend the actual physical expansion of the urban area. The growth to the south-east should be noted along Interstate 515 in addition to the directions of growth already discussed.

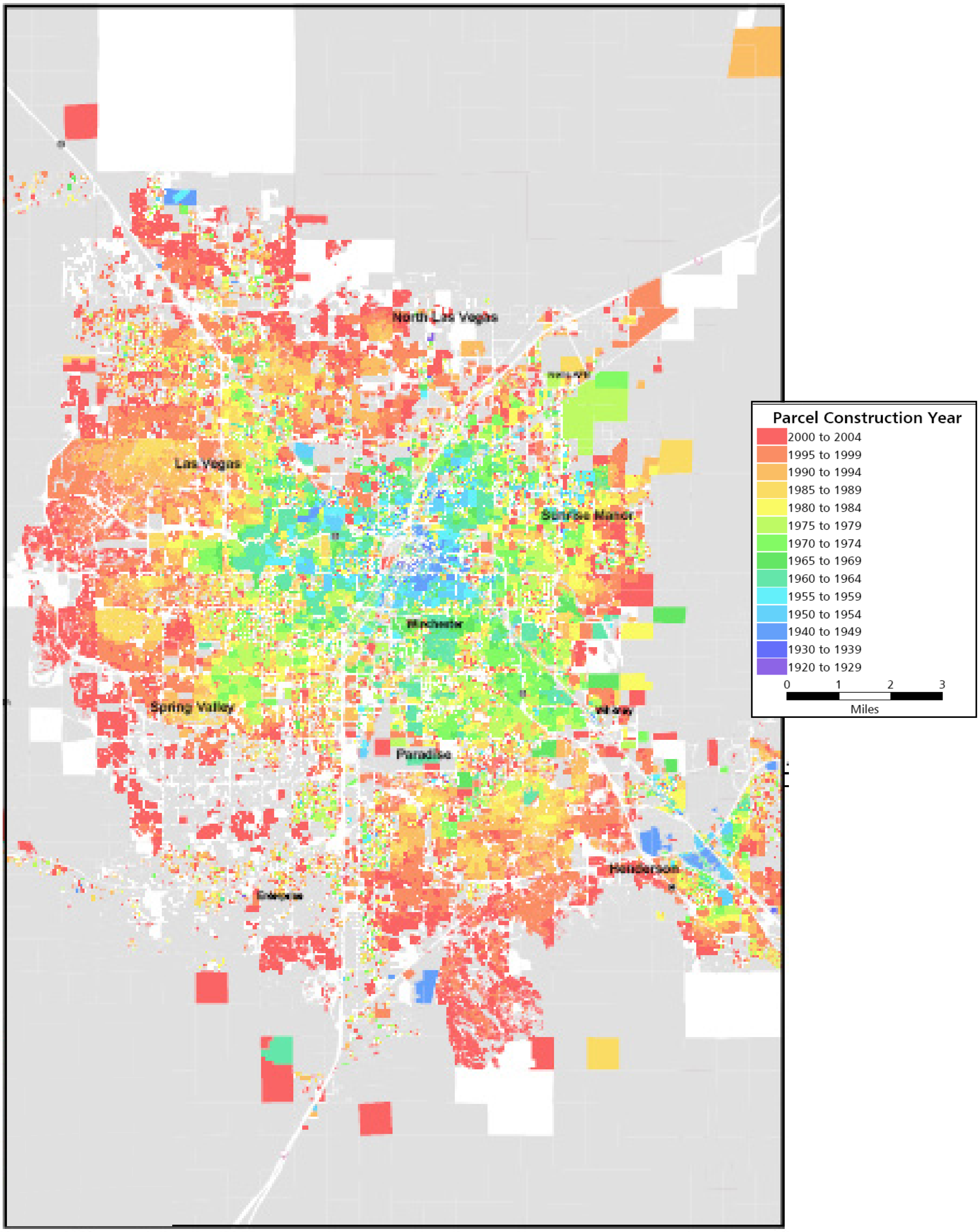


Figure 54: Parcel Year of Construction: Red is newer construction, blue is older

In terms of hotel parcel construction, there is a drift away from the traditional downtown, an increasing size of parcels, and the construction of hotels/casinos away from both the Strip and the old CBD. The latter point highlights the increasing spatial diversification of the gaming industry, with new trends such as locating away from the Strip and the mega-hotel experience. Such hotels typically target mixed markets that include both locals and tourists by providing attractions such as more intimate settings, providing locals with repeat custom "perks" and also through more specifically higher-end gaming experiences for example.

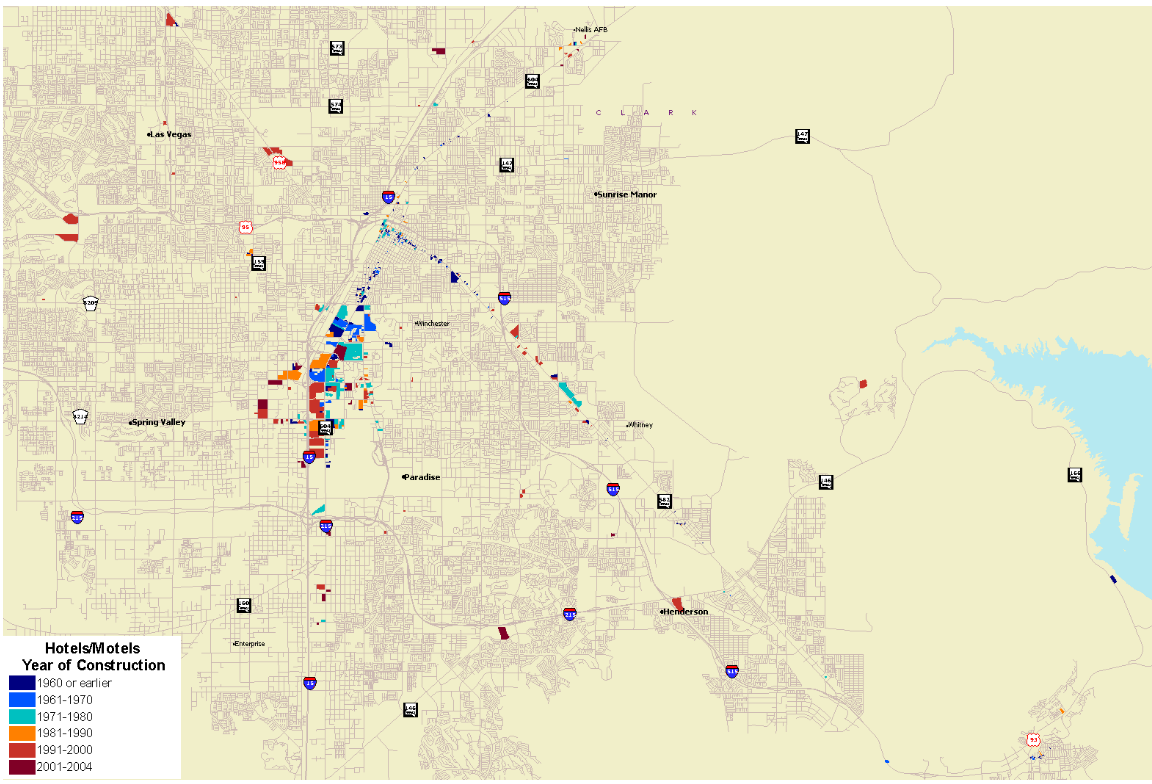


Figure 55: Hotel Parcel Construction

A graph based analysis of development over time in Clark County was then performed in order to obtain a deeper appreciation for the processes operating in the region.

Firstly, the construction year of parcels was used to visualize the year-on-year aggregate increase in absolute numbers of parcels by landuse type. As can be seen from these Figures, there was an overall steep increase in the 1940s as the region initially developed, with another sharp increase in the 1990s that tapers off around 2001, and then begins to climb again.

Clark County experienced a hotel construction boom in the late 1990s which has caused some models to overestimate employment growth. In addition, the effects of the speculative stock market bubble of the late 1990s and increased competition in the gaming industry should be considered, as should the increase in services for such a rapidly growing area. These factors all go some way to explaining the steeper curves for almost all landuse types up to the period of slower growth after 2000 as the economy slowed and tourism dipped.

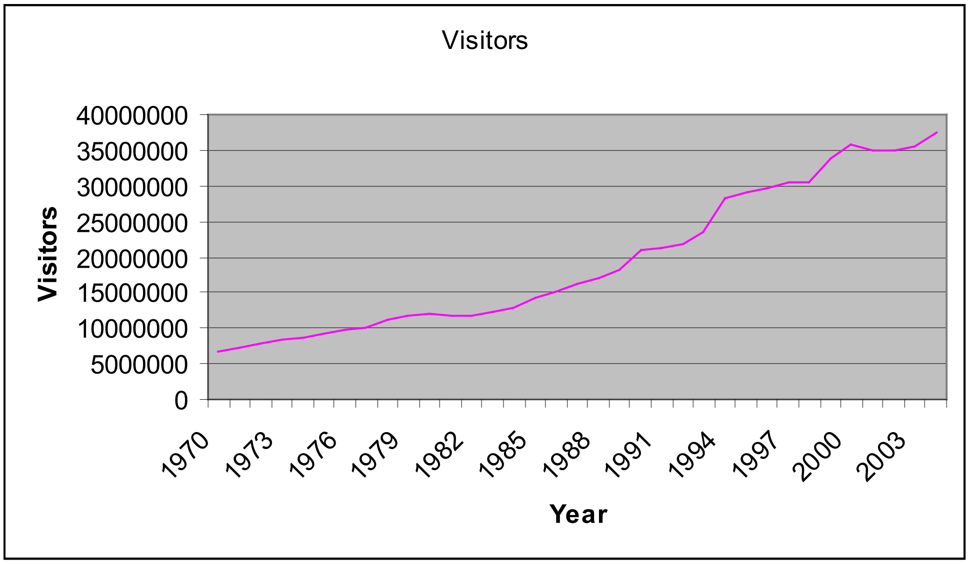


Figure 56: Visitors

A particularly noticeable increase in the number of parcels developed is exhibited by the graph for regional retail. Retail development is generally reliant on population growth, so given the demographic increases that Las Vegas has experienced, an expansion of retail development is expected. Indeed, when Clark County reached one million residents in 1994, a new assortment of retailers, such as Lowes Companies, Inc., and Walgreen Co., joined the ever growing wealth of retail and factory outlet centers, including nine malls, more than 90 major supermarkets and more than 100 major shopping centers now in existence.

Areas reporting the most new retail activity are those in which residential growth has increased most sharply (such as suburban Green Valley and Summerlin), and along the path of the new Las Vegas Beltway. In 2000, nearly 4.4 million square feet of new retail space was planned, while existing malls such as the Fashion Show and the Forum Shops at Caesars Palace are in the process of doubling their capacity. In addition, Clark County retail sales topped $21.1. billion in 2000, a figure more than double the report for 1993. More than 26.3 million square feet of rentable shopping center space is available in Southern Nevada, with a vacancy rate of only 3.1 percent. Consequently, Las Vegas is now home to most of the nation’s largest and best-known department stores and specialty shops.

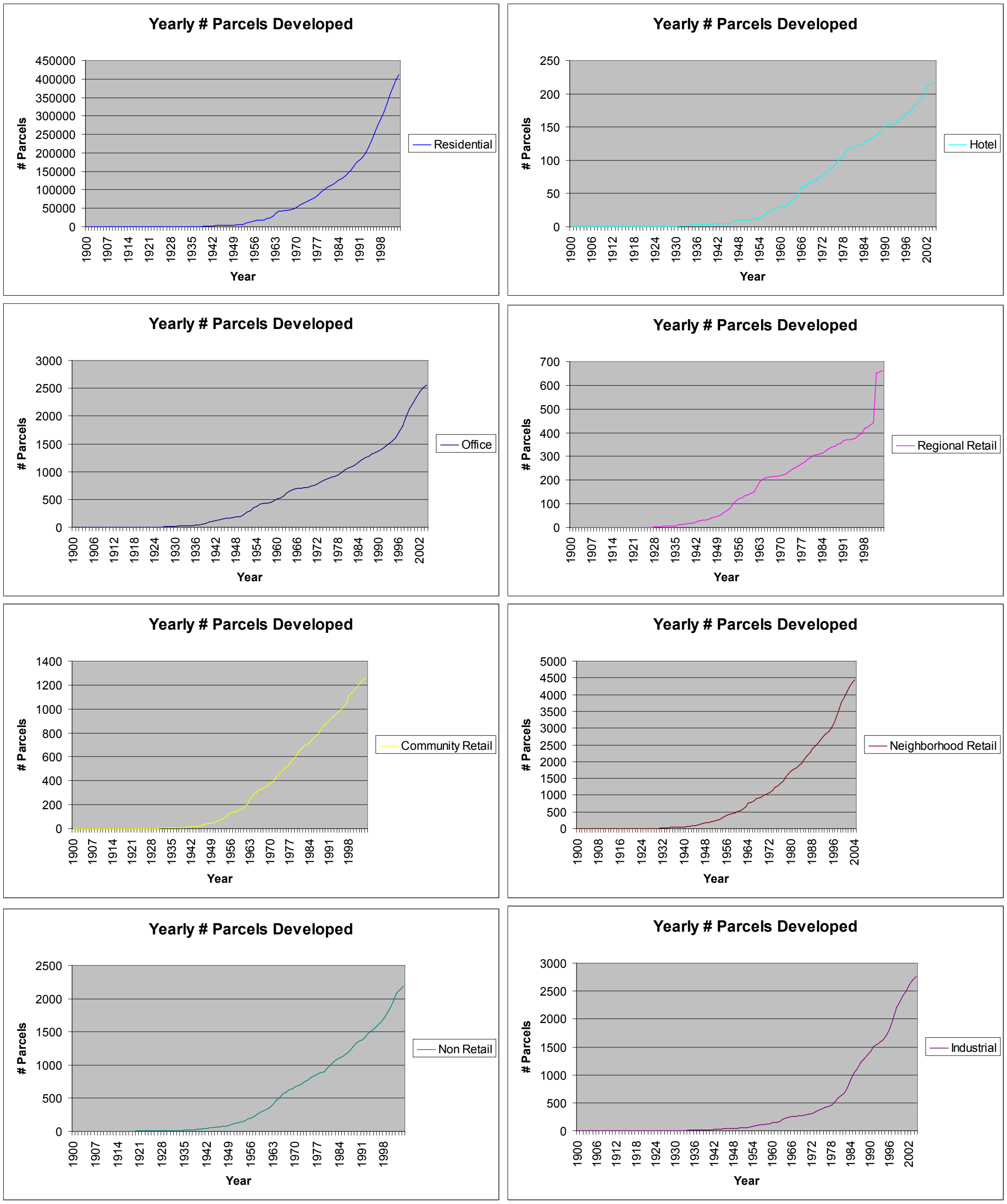


Figure 57: Yearly Number of Parcels Developed

Next, the area of the parcels was analyzed to visualize the year-on-year aggregate increase in the square mileage occupied by the parcels by landuse type. As can be seen from these Figures, overall there are periods where there is large-scale development in each of the landuse types. The landuse type with one of the smoothest curves is residential, showing a continuous expansion in land occupied by housing.

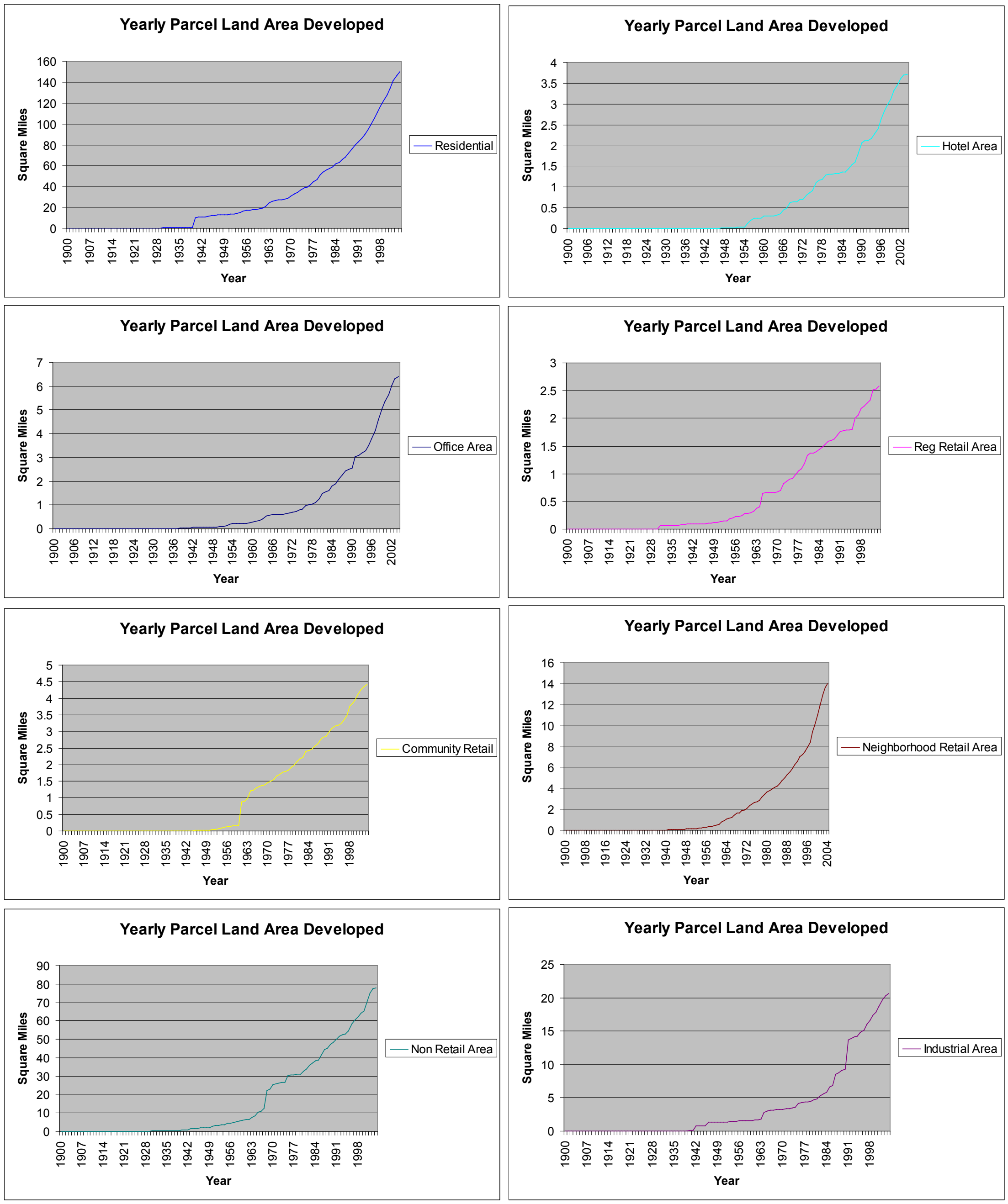


Figure 58: Yearly Parcel Land Area Developed

5.4.4 Conclusion

The data for Clark County exhibit strong positive correlations between visitors and growth. Such inter-relationships extend to other characteristics of the region's development such as migration whereby interactions between commercial development and tourism strongly influence population growth and residential expansion thus spurring further need for infrastructure and services. The demands for amenities, jobs, attractions and land have continued unabated in Clark County and are likely to continue to do so while current conditions persist.

6 Forecast Results

6.1 Introduction

We established four STEP3 scenarios for growth in Clark County. These ranged from high population growth with extensive urban dispersion to lower population growth with constrained dispersion. Our general model is that there is organic growth and change from those already resident, adjusted for births and deaths to which we add net migration. We posit that net migration is driven by growth in tourism which must be served by additional employment in tourist serving industries including gaming, hotels, restaurants, and entertainment. Employees in these industries and their families also require additional services which stimulates additional retail and service employment.

As can bee seen in the Figure below, the upper bound forecasts (Caliper UBF) exceed the expected population forecast by Comprehensive Planning, while the lower bound trends (Caliper LBF) are more inline with projections by REMI and the State Demographer. Dispersion reflects the density of development and so the Caliper forecasts for total population are identical depending only on the bound used.

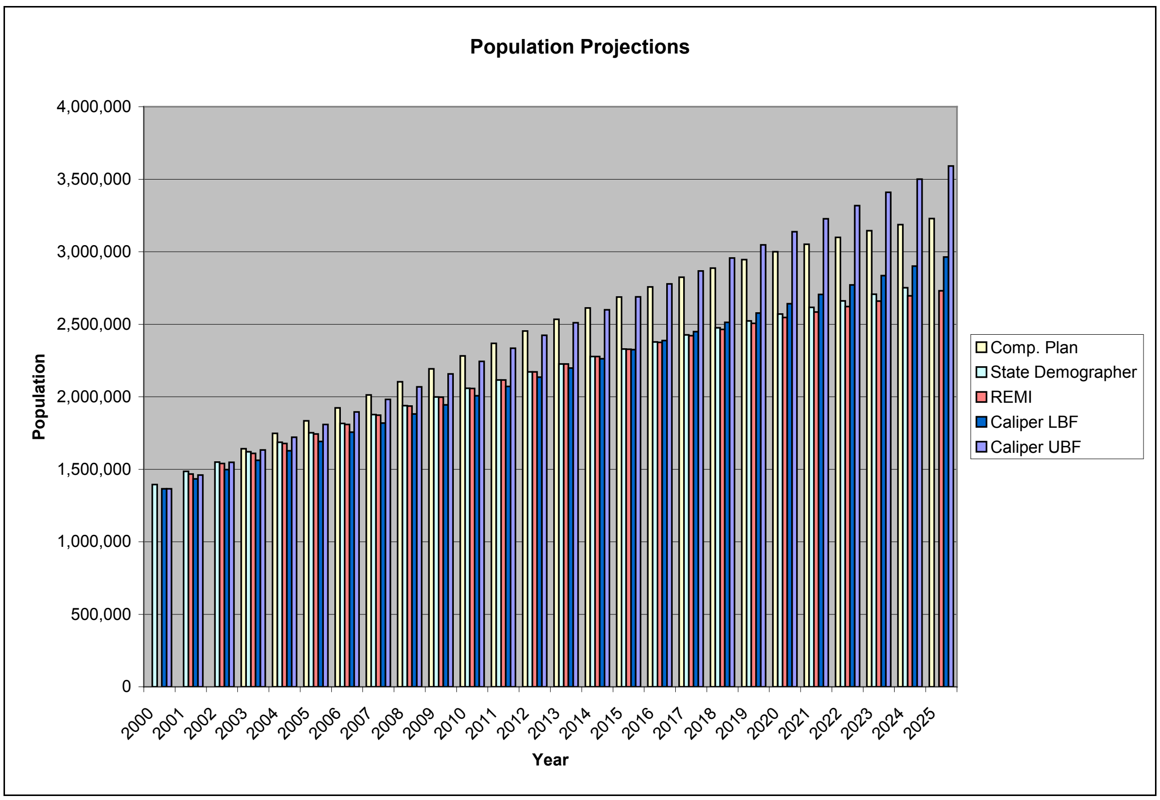


Figure 59: Population Projections

Growth of the settled areas is always constrained by the amount of developable land available, and these restrictions are being observed in the models as can be clearly seen in the Figures below, where the chloropleth shading indicates population and the brown cells are undevelopable:

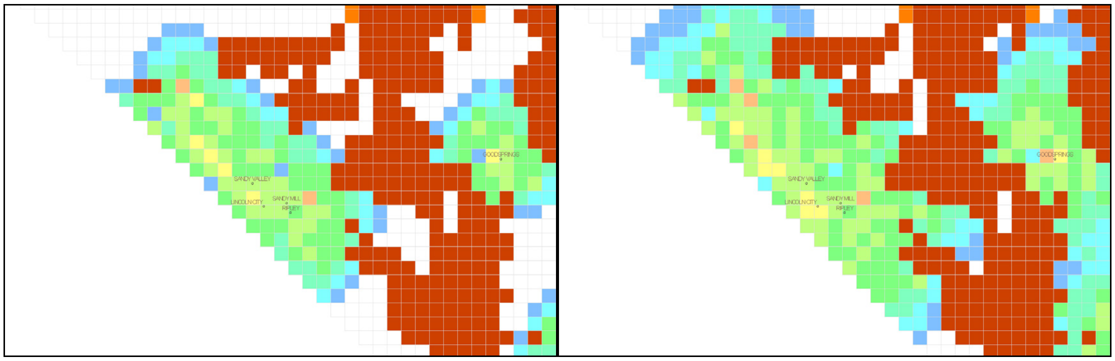


Figure 60: Growth of Sandy Valley Cells 2005-2010 (lower bound dispersion)

6.2 Upper Bound Forecasts

6.2.1 Overview

The Table below shows the results of the upper bound forecast for several of the core variables for each of the years modeled. There are increases across the board in the total population and the number of households. The numbers of people moving internally plus those immigrating to the County also see a steady rise (Movers). The worker, retired and non-worker segments all grow over time, while unemployment is stabilized at about 4%.

As is illustrated in the Figure below, hotel workers are the largest employment group and continue to outpace the other segments. Combined retail is a large employer, with varying totals within the three sub-groups. Office, non-retail and industrial are the single largest sectors after hotels.

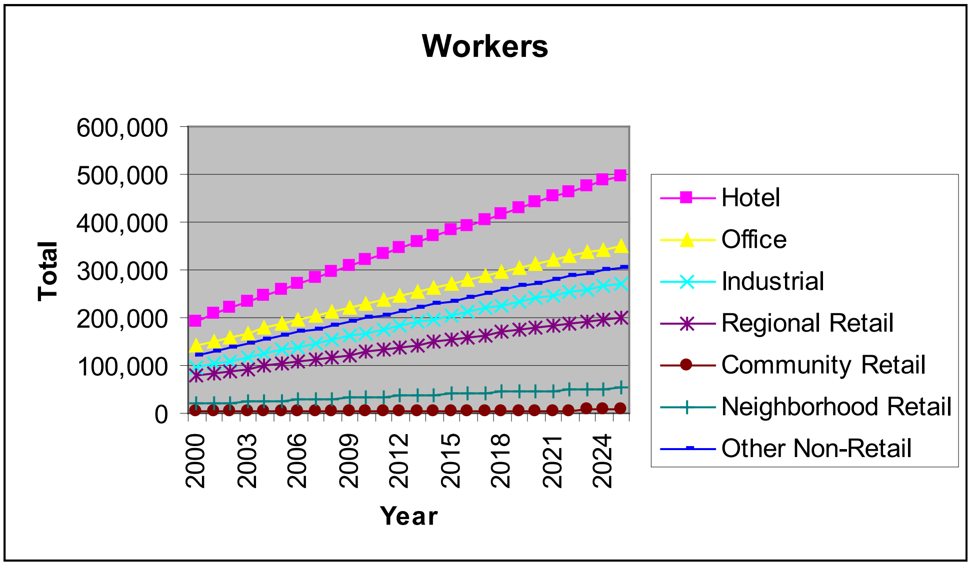


Figure 61: Upper Bound Workers

These trends indicate that the model is operating as expected, reflecting the observed patterns in Clark County that were used to calibrate and design STEP3. Specifically, this upper-bound forecast corresponds to the population totals envisioned by Comprehensive Planning.

Table 7 Upper Bound Forecast

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HOUSEHOLDS	528,202	605,941	637,877	671,303	706,319	744,787	784,769	825,999	868,255	910,892
Movers	0	136,131	102,314	107,654	113,634	121,190	127,440	133,814	140,015	145,798
POPULATION	1,365,774	1,460,197	1,547,850	1,633,505	1,721,502	1,808,262	1,894,846	1,981,181	2,067,757	2,157,049
Retired People	142,186	161,131	174,654	189,223	204,149	217,829	233,637	249,325	266,765	285,703
Workers Total	651,031	696,275	736,429	781,474	828,871	874,315	917,215	958,448	998,922	1,040,203
Hotel	193,694	207,052	218,955	232,337	246,026	259,203	271,727	284,063	295,836	307,969
Office	141,956	150,867	159,191	168,476	178,428	188,097	197,016	205,637	213,632	222,091
Industrial	94,636	102,224	108,781	116,467	124,502	132,066	139,493	146,489	153,654	160,877
Regional Retail	77,808	83,222	87,873	92,954	98,396	103,852	108,673	113,413	118,006	122,729
Community Retail	2,101	2,281	2,448	2,660	2,855	3,061	3,256	3,440	3,655	3,848
Neighborhood Retail	19,536	21,087	22,365	23,913	25,398	26,761	28,125	29,356	30,595	31,836
Other Non-Retail	121,300	129,542	136,816	144,667	153,266	161,275	168,925	176,050	183,544	190,853
Non-Workers Total	714,743	763,922	811,421	852,031	892,631	933,947	977,631	1,022,733	1,068,835	1,116,846
Age < 16	323,386	346,698	368,430	389,418	410,882	430,486	447,720	462,603	478,592	494,857
Unemployed but in Labor Force	40,090	42,659	47,409	45,144	40,529	38,809	38,642	40,245	41,874	43,459
Not in Labor Force	351,267	374,565	395,582	417,469	441,220	464,652	491,269	519,885	548,369	578,530
Unemployment Rate	5.86	5.82	6.10	5.50	4.69	4.28	4.06	4.05	4.04	4.03

(Table continued)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HOUSEHOLDS	952,492	995,834	1,041,140	1,088,116	1,133,464	1,179,855	1,225,991	1,271,016	1,316,779	1,361,382
Movers	150,672	157,845	164,935	173,017	177,006	184,228	189,769	194,870	201,661	206,140
POPULATION	2,244,470	2,334,303	2,423,380	2,510,169	2,600,024	2,688,581	2,778,206	2,867,177	2,957,171	3,047,222
Retired People	303,918	322,170	344,015	363,976	384,060	404,224	424,190	443,561	464,161	486,401
Workers Total	1,082,312	1,125,340	1,166,501	1,207,776	1,249,909	1,291,832	1,334,503	1,377,049	1,419,203	1,459,372
Hotel	320,101	332,600	344,638	356,801	368,938	381,271	393,650	405,834	418,146	430,162
Office	230,401	239,120	247,510	255,797	264,044	272,313	280,653	289,068	297,445	305,318
Industrial	168,235	175,758	183,237	190,397	197,571	205,074	212,461	219,718	226,767	233,731
Regional Retail	127,971	133,083	137,945	143,024	148,347	153,518	159,184	164,350	169,694	174,557
Community Retail	4,041	4,213	4,356	4,575	4,732	4,877	5,094	5,294	5,529	5,693
Neighborhood Retail	33,200	34,560	35,780	37,104	38,525	39,887	41,264	42,664	43,981	45,134
Other Non-Retail	198,363	206,006	213,035	220,078	227,752	234,892	242,197	250,121	257,641	264,777
Non-Workers Total	1,162,158	1,208,963	1,256,879	1,302,393	1,350,115	1,396,749	1,443,703	1,490,128	1,537,968	1,587,850
Age < 16	510,111	526,741	542,646	558,262	572,585	586,319	603,690	620,122	638,059	656,480
Unemployed but in Labor Force	45,126	46,828	48,501	50,126	51,799	53,446	55,100	56,803	58,448	60,053
Not in Labor Force	606,921	635,394	665,732	694,005	725,731	756,984	784,913	813,203	841,461	871,317
Unemployment Rate	4.02	4.01	4.01	4.00	3.99	3.98	3.98	3.97	3.96	3.96

(Table continued)

Year	2020	2021	2022	2023	2024	2025
HOUSEHOLDS	1,407,833	1,455,553	1,500,555	1,548,357	1,594,226	1,642,182
Movers	213,849	220,925	224,624	232,895	237,797	245,270
POPULATION	3,138,465	3,227,366	3,318,129	3,409,574	3,500,652	3,591,883
Retired People	510,581	532,277	556,671	579,947	603,839	629,887
Workers Total	1,497,704	1,537,123	1,574,412	1,612,110	1,648,435	1,682,799
Hotel	441,525	453,226	463,981	475,009	486,039	495,712
Office	312,733	320,518	328,189	336,101	343,249	350,399
Industrial	240,204	246,714	253,132	259,137	265,151	271,221
Regional Retail	179,363	183,998	188,317	192,743	196,892	200,999
Community Retail	5,829	5,990	6,140	6,319	6,467	6,577
Neighborhood Retail	46,335	47,633	48,787	49,952	51,236	52,371
Other Non-Retail	271,715	279,044	285,866	292,849	299,401	305,520
Non-Workers Total	1,640,761	1,690,243	1,743,717	1,797,464	1,852,217	1,909,084
Age < 16	675,666	694,370	715,322	737,266	759,914	782,677
Unemployed but in Labor Force	61,546	63,089	64,567	66,128	67,578	68,896
Not in Labor Force	903,549	932,784	963,828	994,070	1,024,725	1,057,511
Unemployment Rate	3.95	3.95	3.95	3.95	3.94	3.94

6.2.2 Constrained Dispersion

The Figure below showing the upper bound population at five year increments for this scenario model run shows spatial growth at the peripheries of several settlements. This is around the following (see Figure below): Primm-Roach corridor, Boulder City (south), and around Las Vegas (north, south-east, south-west, west), and Laughlin.

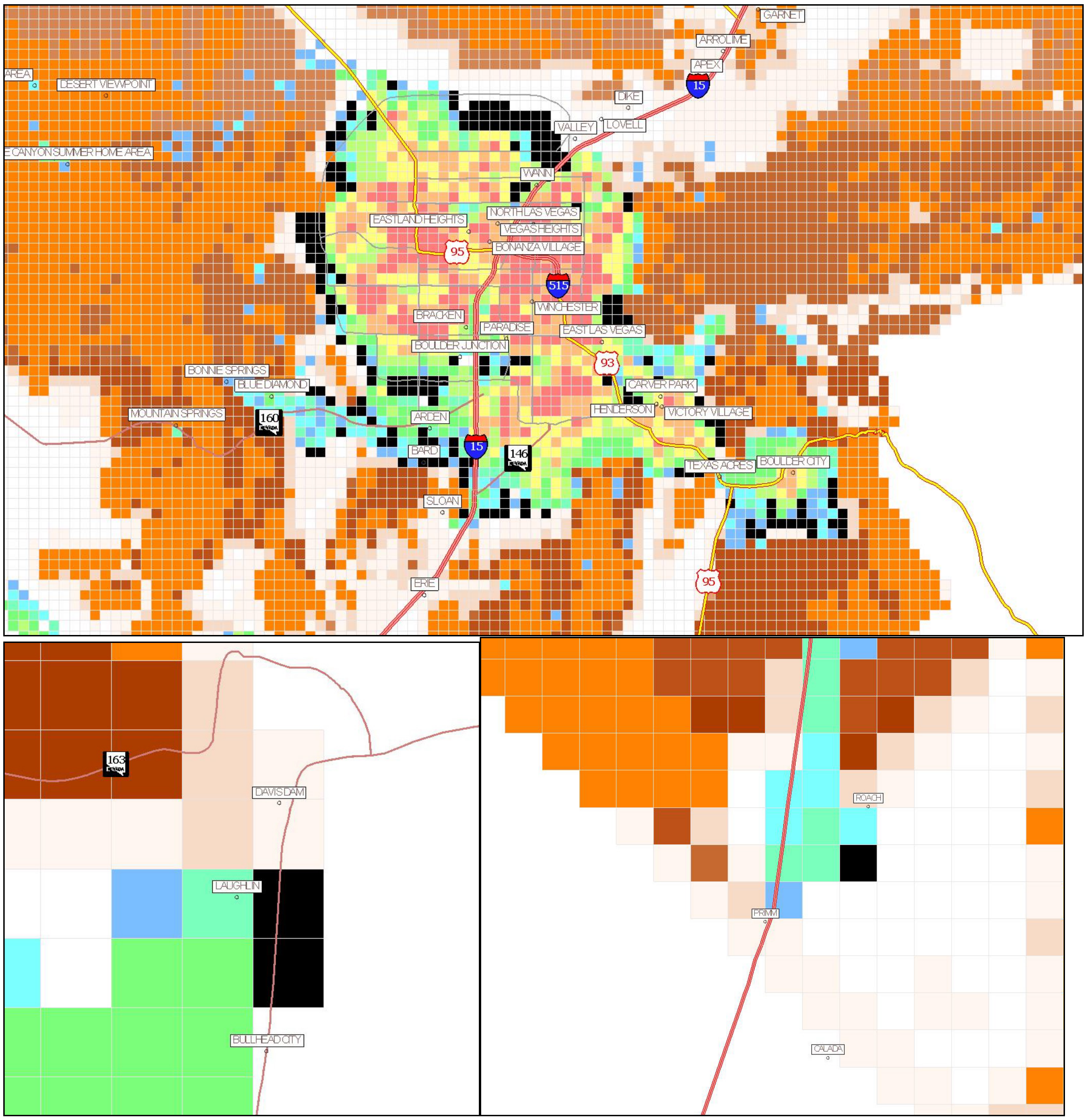


Figure 62: New Populated Cells 2000-2025 (upper bound; black are post-2000)

Figure 63: Upper Bound Population (2000, 2005, 2010, 2015, 2020, 2025)

6.2.3 Dispersion

The Figure below showing the upper bound population at five year increments for this scenario model run shows extensive spatial growth. The constraints on dispersion have been relaxed and this has resulted in the merging of many settlements and the development of much of the developable area of Clark County. However, the majority of this growth is very low density with most people choosing to live near the jobs in the urban areas (see the 3D Figure below).

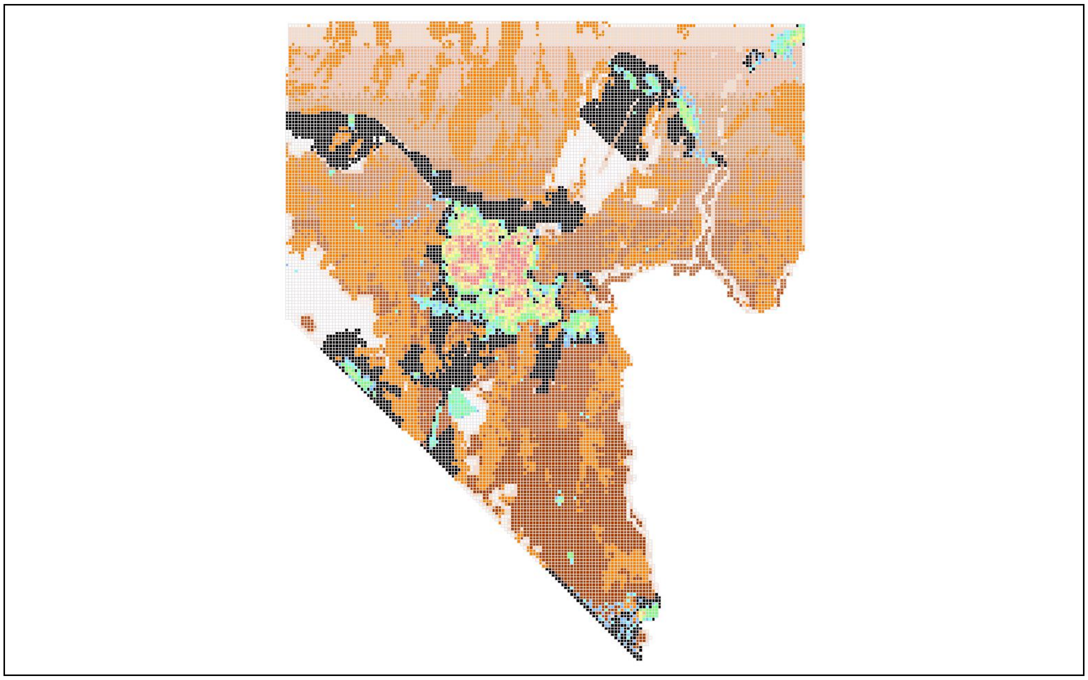


Figure 64: New Populated Cells 2000-2025 (upper bound dispersion; black are post-2000)

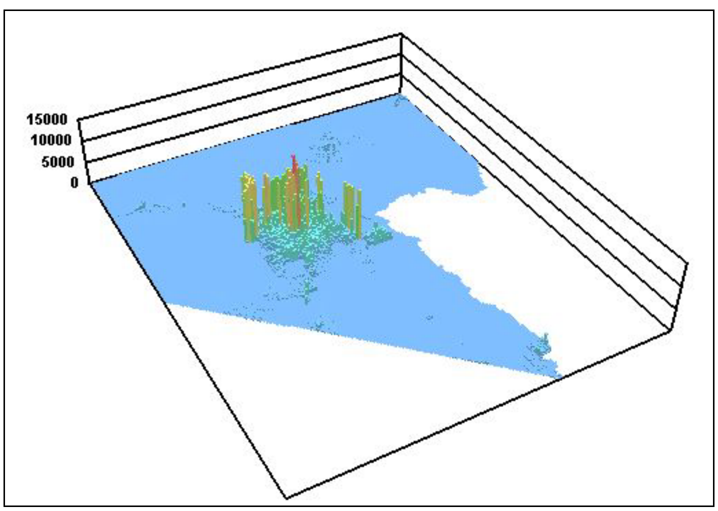


Figure 65: 3D Populated Cells 2025 (upper bound dispersion)

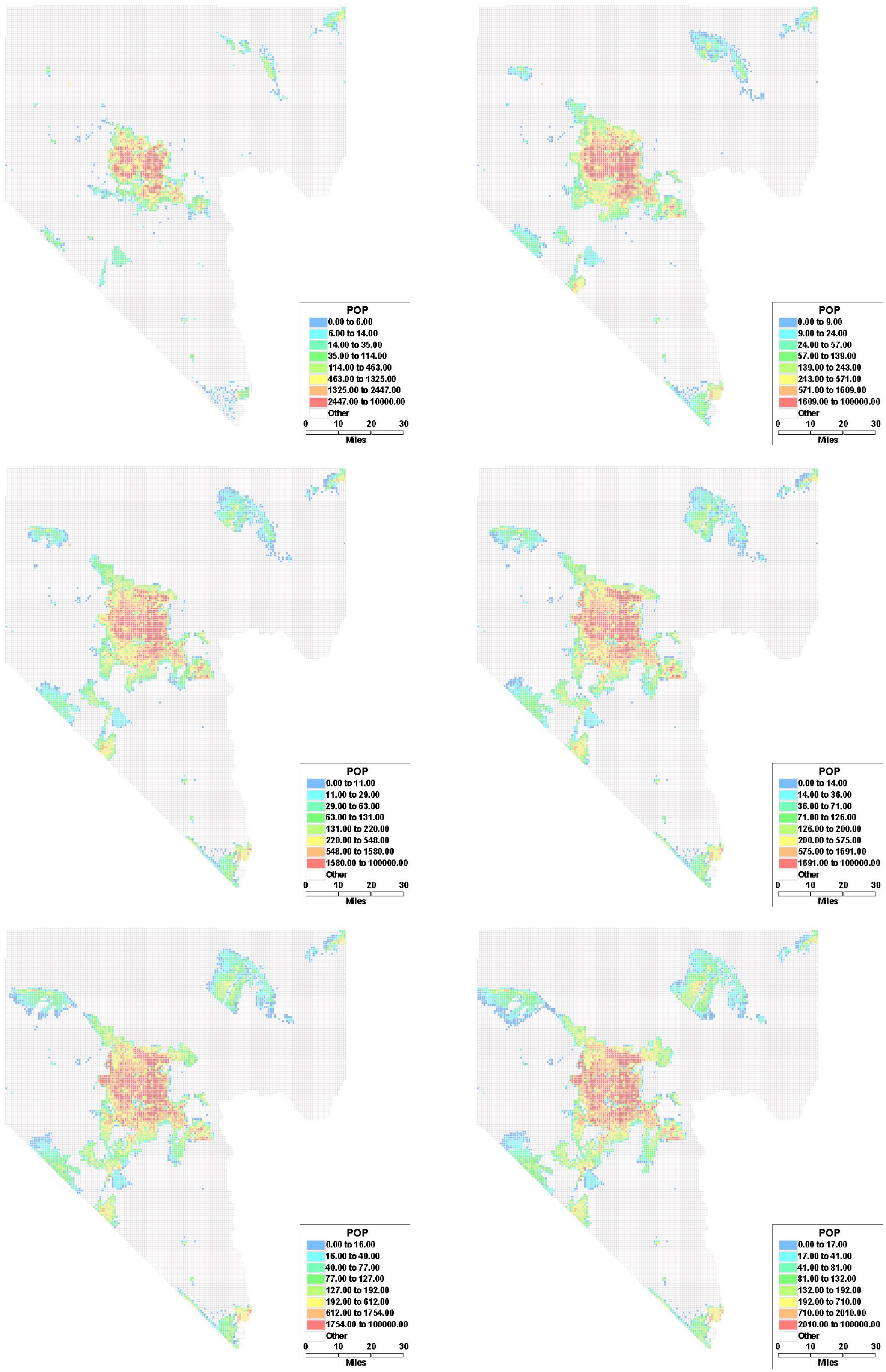


Figure 66: Upper Bound Population Dispersion (2000, 2005, 2010, 2015, 2020, 2025)

6.3 Lower Bound Forecasts

6.3.1 Overview

The Table below shows the results of the lower bound forecast for several of the core variables for each of the years modeled. There are increases across the board in the total population and the number of households. The number of people moving internally plus those immigrating to the County also sees a steady rise (Movers). The worker, retired and non-worker segments all grow over time, while unemployment is stabilized at about 4%.

As is illustrated in the Figure below, hotel workers are the largest employment group and continue to outpace the other segments. Combined retail is a large employer, with varying totals within the three sub-groups. Office, non-retail and industrial are the single largest sectors after hotels.

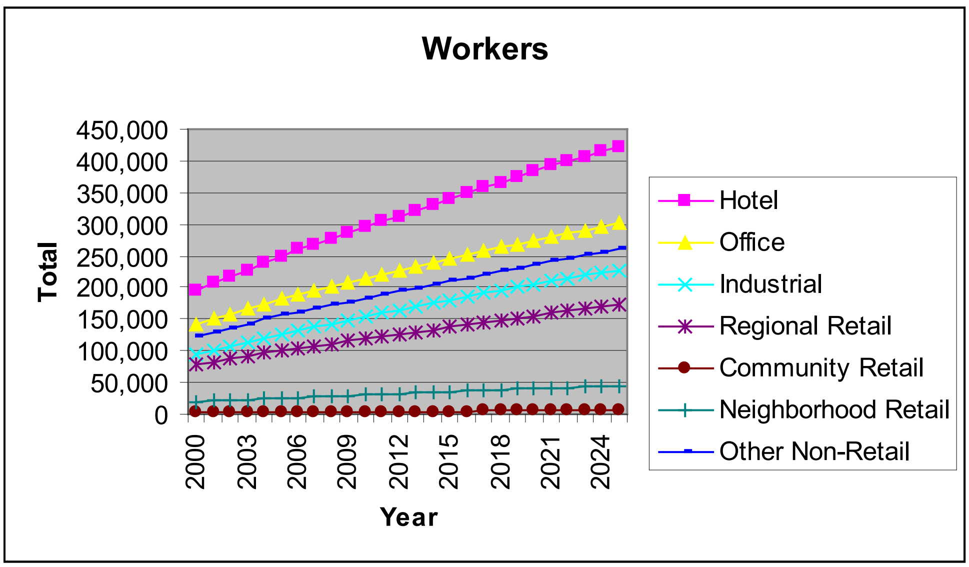


Figure 67: Lower Bound Workers

These trends indicate that the model is operating as expected, reflecting the observed patterns in Clark County that were used to calibrate and design STEP3. Specifically, this upper-bound forecast corresponds to the population totals envisioned by several forecasts including those of REMI and the State Demographer.

Table 8 Lower Bound Forecast

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HOUSEHOLDS	528,202	595,262	618,178	642,203	668,172	696,980	727,071	757,963	789,124	820,200
Movers	0	120,322	85,707	89,486	93,824	99,851	104,443	108,633	112,832	116,423
POPULATION	1,365,774	1,434,025	1,498,480	1,562,260	1,626,942	1,691,851	1,756,536	1,818,892	1,881,757	1,944,176
Retired People	142,186	158,221	169,366	181,217	193,121	203,599	216,076	228,566	241,999	257,446
Workers Total	651,031	694,596	729,229	767,363	806,597	842,937	876,646	907,629	937,993	967,636
Hotel	193,694	206,650	216,662	227,975	239,217	249,754	259,827	268,794	277,395	285,951
Office	141,956	150,673	157,919	165,815	174,000	181,749	188,827	195,243	201,378	207,835
Industrial	94,636	101,697	107,281	113,657	120,482	126,534	132,280	137,549	142,898	148,145
Regional Retail	77,808	82,973	87,315	91,738	96,161	100,346	104,081	107,893	111,587	114,954
Community Retail	2,101	2,287	2,435	2,623	2,785	2,935	3,110	3,255	3,412	3,573
Neighborhood Retail	19,536	20,995	22,104	23,251	24,463	25,600	26,732	27,682	28,645	29,584
Other Non-Retail	121,300	129,321	135,513	142,304	149,489	156,019	161,789	167,213	172,678	177,594
Non-Workers Total	714,743	739,429	769,251	794,897	820,345	848,914	879,890	911,263	943,764	976,540
Age < 16	323,386	340,549	356,450	372,500	388,489	403,473	416,633	426,045	437,291	447,385
Unemployed but in Labor Force	40,090	42,546	46,961	44,433	39,507	37,562	37,036	38,197	39,412	40,542
Not in Labor Force	351,267	356,334	365,840	377,964	392,349	407,879	426,221	447,021	467,061	488,613
Unemployment Rate	5.86	5.82	6.10	5.51	4.70	4.29	4.08	4.06	4.05	4.04

(Table continued)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HOUSEHOLDS	851,437	883,617	917,546	953,026	986,536	1,021,163	1,055,175	1,087,501	1,122,230	1,154,441
Movers	120,171	124,712	130,301	136,258	138,175	143,459	146,943	149,896	155,380	157,166
POPULATION	2,007,269	2,071,485	2,135,458	2,198,098	2,262,465	2,325,224	2,387,727	2,449,473	2,513,333	2,577,031
Retired People	272,223	286,287	304,031	320,206	335,723	351,231	366,293	379,868	394,728	411,406
Workers Total	998,107	1,029,585	1,058,571	1,089,010	1,120,282	1,150,461	1,181,710	1,212,653	1,243,647	1,272,935
Hotel	294,658	303,735	312,452	321,507	330,563	339,382	348,379	357,547	366,544	375,253
Office	213,955	220,304	226,256	232,257	238,302	244,270	250,571	256,877	263,091	268,886
Industrial	153,525	159,006	164,211	169,559	175,219	180,434	185,887	190,935	196,251	201,009
Regional Retail	118,601	122,302	125,605	129,311	133,160	136,896	140,887	144,611	148,406	152,045
Community Retail	3,664	3,797	3,920	4,067	4,232	4,395	4,587	4,758	4,912	5,037
Neighborhood Retail	30,570	31,495	32,484	33,570	34,483	35,485	36,501	37,581	38,528	39,455
Other Non-Retail	183,134	188,946	193,643	198,739	204,323	209,599	214,898	220,344	225,915	231,250
Non-Workers Total	1,009,162	1,041,900	1,076,887	1,109,088	1,142,183	1,174,763	1,206,017	1,236,820	1,269,686	1,304,096
Age < 16	457,238	467,907	477,738	488,323	497,535	506,189	516,357	527,338	539,035	551,308
Unemployed but in Labor Force	41,773	42,955	44,095	45,286	46,541	47,761	49,048	50,258	51,480	52,687
Not in Labor Force	510,151	531,038	555,054	575,479	598,107	620,813	640,612	659,224	679,171	700,101
Unemployment Rate	4.04	4.02	4.02	4.01	4.00	4.00	4.00	3.99	3.99	3.99

(Table continued)

Year	2020	2021	2022	2023	2024	2025
HOUSEHOLDS	1,188,907	1,223,325	1,256,747	1,291,262	1,325,973	1,359,513
Movers	163,067	167,660	170,536	175,367	179,473	182,573
POPULATION	2,641,407	2,705,242	2,770,598	2,835,048	2,900,445	2,963,101
Retired People	429,716	445,359	463,580	480,962	498,989	518,418
Workers Total	1,300,775	1,329,567	1,356,039	1,382,425	1,408,324	1,431,397
Hotel	383,767	392,193	400,082	407,359	414,766	421,312
Office	274,157	279,886	285,102	290,782	295,758	300,537
Industrial	205,409	210,300	214,463	219,010	223,067	226,682
Regional Retail	155,594	159,233	162,446	165,808	169,309	172,115
Community Retail	5,176	5,315	5,450	5,587	5,767	5,815
Neighborhood Retail	40,318	41,048	42,039	43,006	43,922	44,706
Other Non-Retail	236,354	241,592	246,457	250,873	255,735	260,230
Non-Workers Total	1,340,632	1,375,675	1,414,559	1,452,623	1,492,121	1,531,704
Age < 16	565,119	579,132	594,500	610,889	627,597	643,775
Unemployed but in Labor Force	53,772	54,917	55,947	57,020	58,015	58,972
Not in Labor Force	721,741	741,626	764,112	784,714	806,509	828,957
Unemployment Rate	3.98	3.98	3.97	3.97	3.96	3.96

6.3.2 Constrained Dispersion

The Figure below showing the lower bound population at five year increments for this scenario model run shows spatial growth at the peripheries of several settlements. This is around the following (see Figure below): Boulder City (south), and around Las Vegas (north, south-east, south-west, west), and Laughlin.

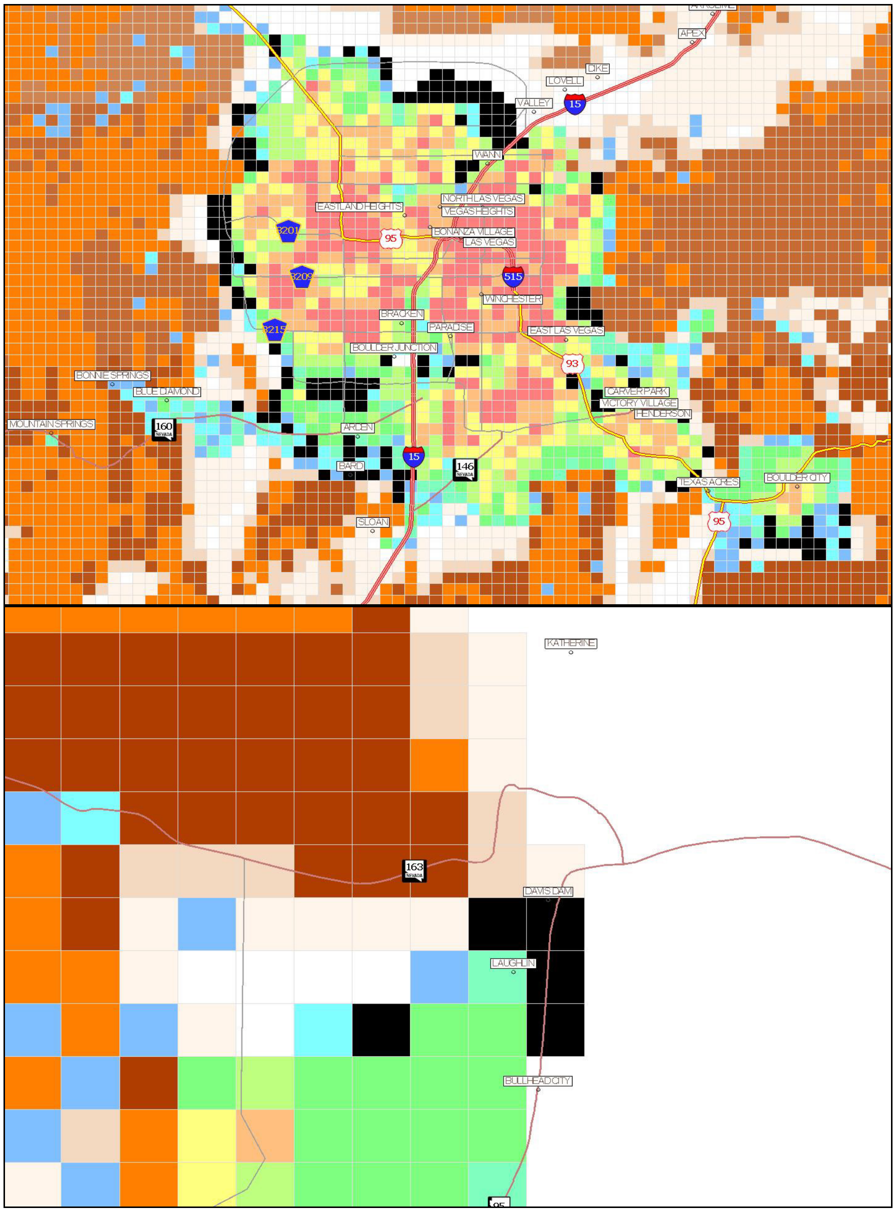


Figure 68: New Populated Cells 2000-2025 (lower bound; black are post-2000)

Figure 69: Lower Bound Population (2000, 2005, 2010, 2015, 2020, 2025)

6.3.3 Dispersion

The Figure below showing the lower bound population at five year increments for this scenario model run shows extensive spatial growth. The constraints on dispersion have been relaxed and this has resulted in the merging of many settlements and the development of much of the developable area of Clark County. However, the majority of this growth is very low density with most people choosing to live near the jobs in the urban areas (see the 3D Figure below).

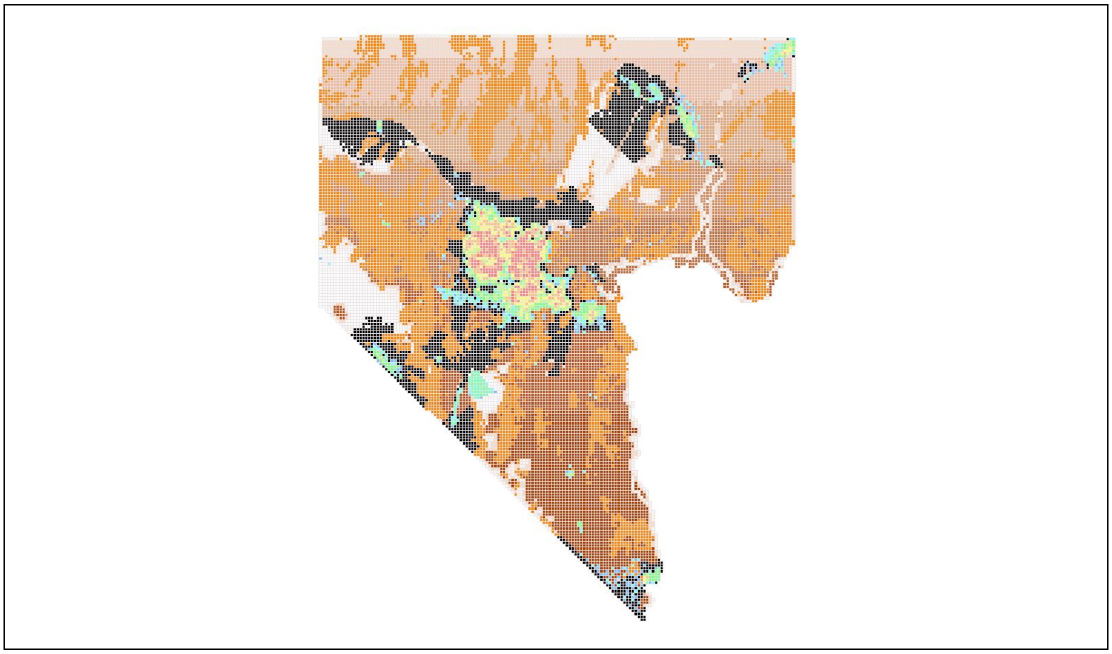


Figure 70: New Populated Cells 2000-2025 (lower bound dispersion; black are post-2000)

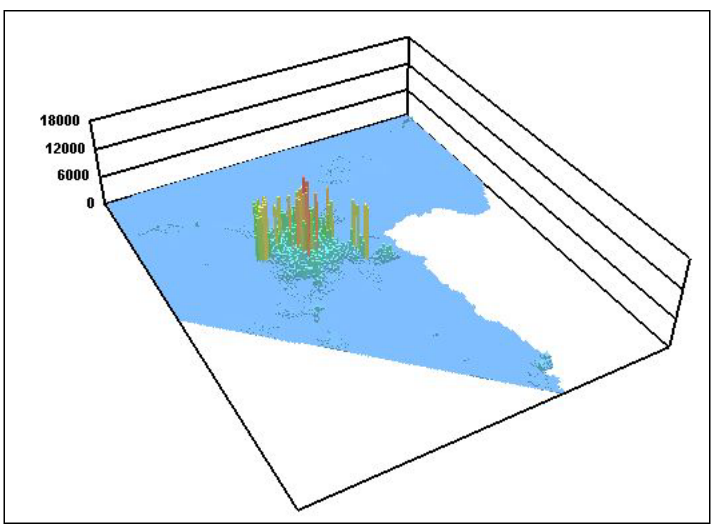


Figure 71: 3D Populated Cells 2025 (lower bound dispersion)

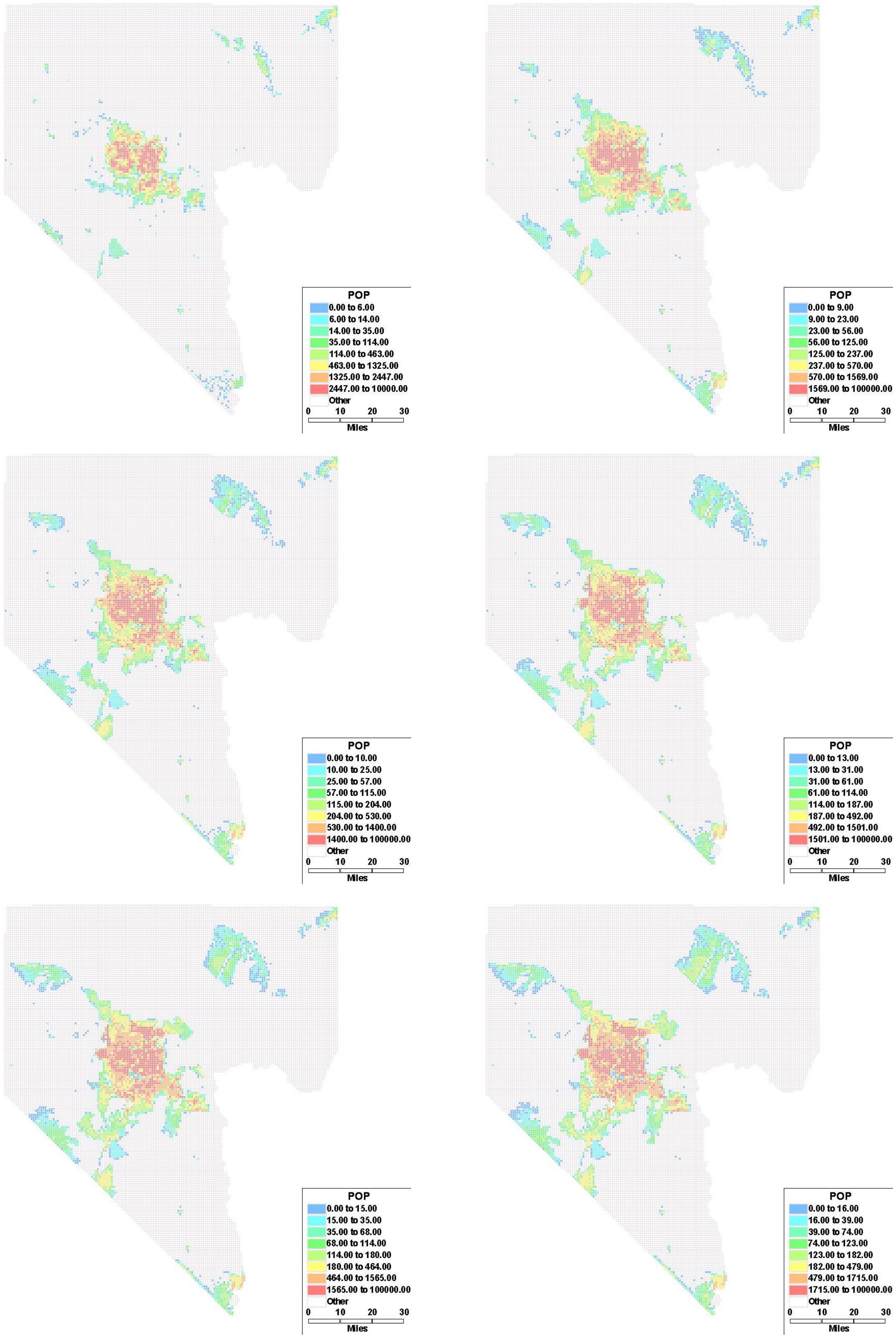


Figure 72: Lower Bound Population Dispersion (2000, 2005, 2010, 2015, 2020, 2025)

7 Implications for HAZMAT Exposure

7.1 Introduction

The US Department of Energy is planning to establish in Nye County, Nevada the Yucca Mountain Geologic Repository for spent nuclear fuel (SNF) and high-level radioactive waste (HLW). The proximity to Clark County of both the facility and the transportation routes has potential impacts on the health, safety, and economy of the local population, not least because of the huge growth of settlements in the area. In this chapter we explore the proposed facility and route sites as well as the projected population that could reasonably be expected to be exposed to this hazard.

7.2 Discussion

The US Department of Energy is attempting to open a high-level nuclear waste facility at Yucca Mountain in Nye County, Nevada. DOE is currently proposing to move the spent nuclear fuel and other high-level nuclear waste to Yucca Mountain using mostly rail transportation (DOE, 2002). The waste from six commercial reactors would be shipped via legal- weight trucks, since they do not have the necessary loading facilities available. A 300+ mile rail connection to Yucca Mountain is planned along the Caliente Corridor (DOE, 2004). In order to estimate the potential population exposure along the shipping routes, the rail and highway routes described in the above scenario were mapped and which currently appear to be the most likely (see Figures below). However, there still remains a great deal of uncertainty given the opposition to both the facility and the transportation of waste.

The Caliente Corridor connects the Union Pacific mainline near Caliente to Yucca Mountain using a circuitous route that goes around Nellis Air Force Range. DOE estimates that 9,052 shipments would come from the east and completely avoid Clark County. Approximately 594 shipments would come from the south and transit Clark County, including downtown Las Vegas and the Government Center on their way to Caliente. The State of Nevada has questioned whether only 7% of the shipments would enter from the south, since the actual routing is left to the discretion of the railroads and they may choose an alternate route based on weather or traffic conditions (State of Nevada, 2004).

All of the waste transported by truck (approximately 1,100 truck shipments) would come from east of Nevada, so it would enter Clark County on Interstate 15 near Mesquite and continue until it reaches the Las Vegas Beltway. After 13-miles it would leave the northern portion of the beltway on US95 and continue until it leaves the county. This Northern Beltway portion would pass through both the City of Las Vegas and the City of North Las Vegas. During the expected 24-year transportation period, estimates are that between 2,600 and 44,250 shipments of SNL and HLW would use the Northern Beltway to access the Repository, depending on which truck and intermodal transportation alternatives are chosen (Louis Berger, 2000).

For both of the routes above, an 800 meter (½ mile) buffer was created and the enclosed population was estimated by overlaying with Census Blocks. This sized buffer was used by DOE for their exposure analysis (DOE, 2002). Using the 2000 Census populations, 16,895 people would be exposed along the highway corridor and 37,729 people would be exposed along the Union Pacific corridor.

An examination was not performed for the possibility that an alternate method would be used to transport the waste through Nevada for up to six years, until the rail connection has been constructed. DOE has stated that the waste facility may be completed prior to the rail connection and truck transportation from an (as yet unidentified) intermodal facility could be used. The State of Nevada has questioned why the transportation cannot wait until the rail line has been completed (State of Nevada, 2004). Given the lack of information and the great uncertainty, this possibility was not analyzed.

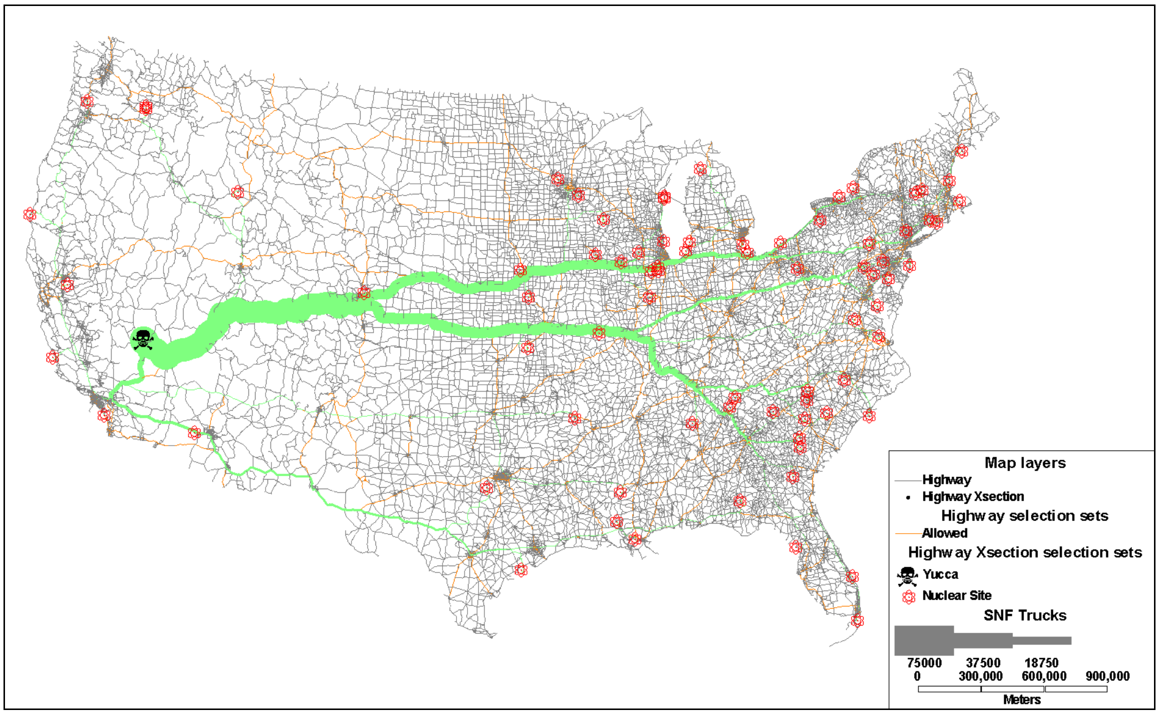


Figure 73: Yucca Mountain Repository and Nuclear Waste Highway Routes

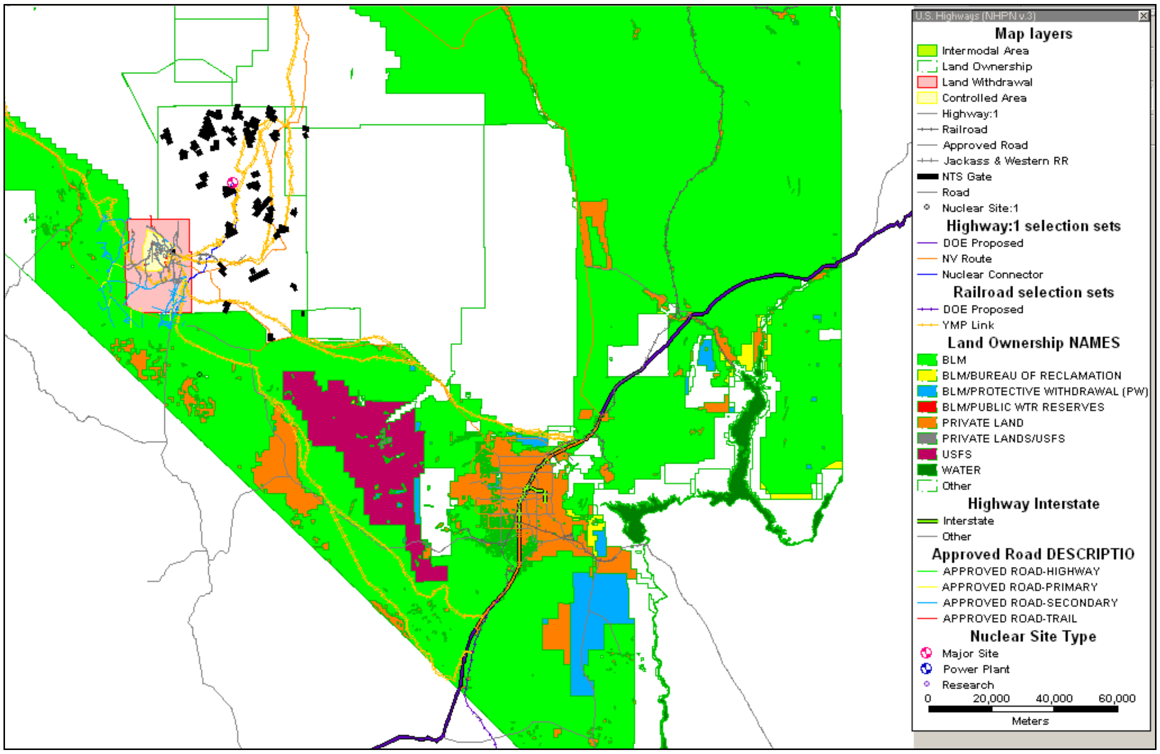


Figure 74: Routes, Nuclear Sites and Land Ownership

7.3 Projected Population Exposure

For the proposed rail and highway routes the 800 meter (½ mile) buffer used above was overlaid with the STEP3 grid cells to determine the enclosed population in Clark County for the projected years 2001-2025 (see map Figure below).

The results of the overlay procedures are provided in the Tables and Figures below. The numbers of people in Clark County exposed along the highway corridor are typically lower than for the Union Pacific corridor as the rail follows the line of settlements that likely developed along this transportation route and also passes through the center of Las Vegas. However, the population along the Northern Beltway is not insignificant with the lowest projection for 2025 being 72,997 and the highest being 204,926. The totals along the railway are 198,141 and 263,467 respectively.

The base year cell population exposed is almost identical to the numbers obtained via the Block overlay that the DOE used (see above). The numbers exposed in the dispersion scenarios are greater than the standard scenarios and generally remain so throughout. This is likely due to the fact that the only land available to development is along the rail and road transportation routes, and within the existing urban areas.

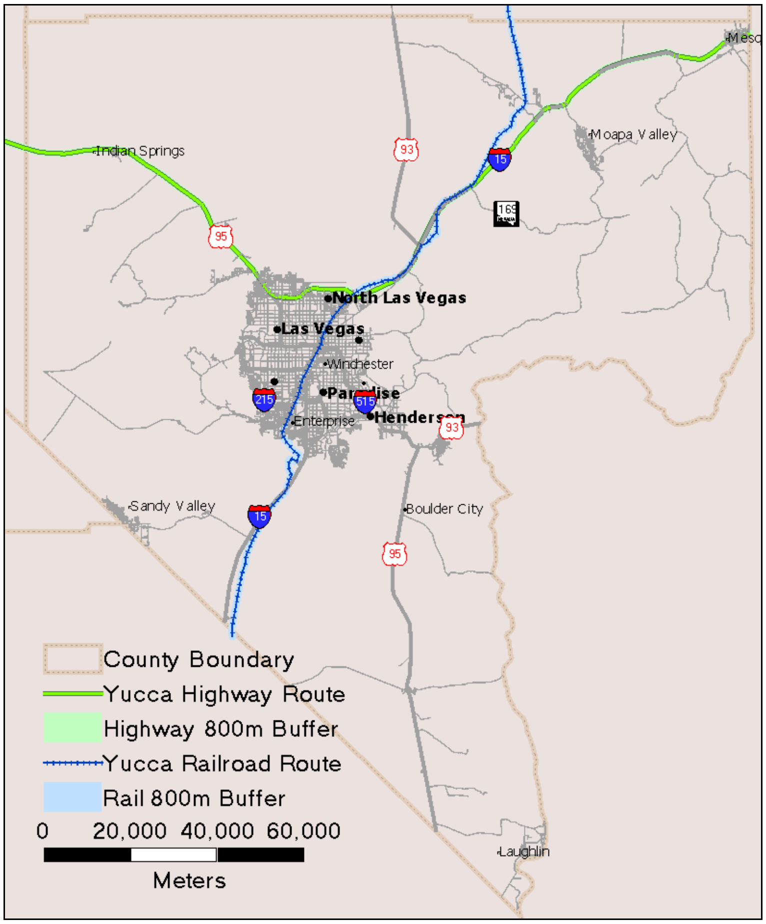


Figure 75: Proposed Nuclear Waste Routes

Table 9 Exposed Population Along Highway Corridor (Clark County)

Year	LBF Hywy	LBF Disperse Hywy	UBF Hywy	UBF Disperse Hywy
2000	16655	16655	16655	16655
2001	16605	17719	16516	17903
2002	16830	20533	16922	20789
2003	17026	23230	16966	24390
2004	16994	27155	16933	29131
2005	17062	31115	17409	34315
2006	17368	34358	19147	39528
2007	17375	39057	20128	48366
2008	17671	42447	22621	60714
2009	17817	45560	25630	66919
2010	18205	54310	30027	81886
2011	19883	60734	33507	93592
2012	24715	67531	39864	104696

2013	25300	76829	43289	119241
2014	27199	81307	52916	129091
2015	28187	84541	59262	139179
2016	29309	88922	61712	150024
2017	32838	92343	64869	153809
2018	36764	95591	68952	157015
2019	41403	104766	76665	159757
2020	45838	111955	81067	163993
2021	52039	118241	82308	171861
2022	58516	122610	88393	180234
2023	63681	129089	93255	187251
2024	69310	134284	97646	193875
2025	72997	138029	104845	204926

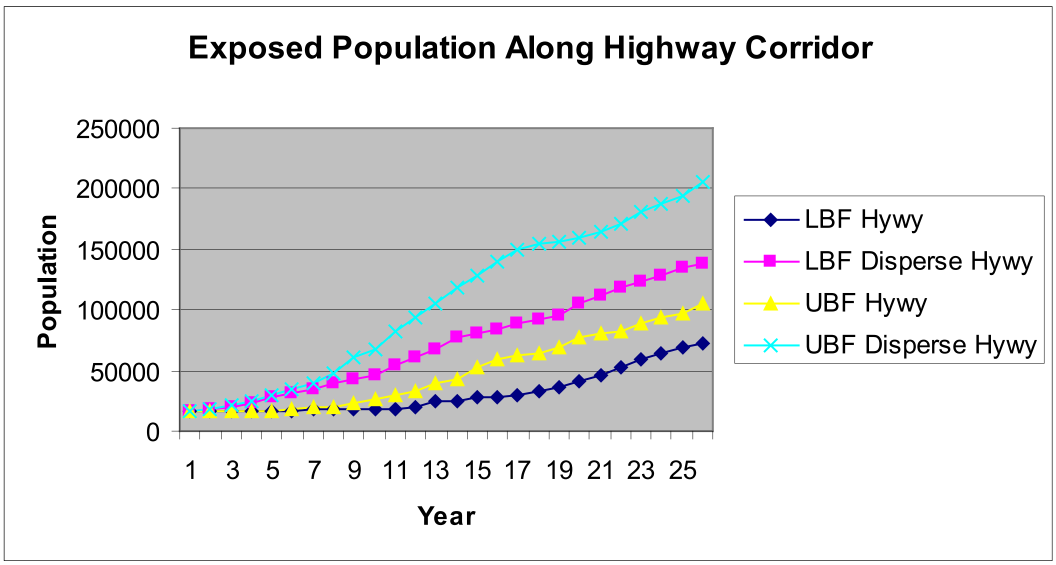


Figure 76: Exposed Population Along Highway Corridor (Clark County)

Table 10 Exposed Population Along Rail Corridor (Clark County)

Year	LBF Rail	LBF Disperse Rail	UBF Rail	UBF Disperse Rail
2000	39707	39707	39707	39707
2001	47619	49614	48368	50806
2002	51478	59637	52150	63026
2003	62839	72707	69604	79583
2004	69026	79783	78654	97246
2005	76104	92731	87525	106678
2006	93611	106714	109024	127544
2007	117075	136306	140179	152503

2008	129099	154242	155126	166870
2009	139484	166779	169150	177289
2010	156689	180531	180520	188732
2011	159925	189371	184781	198171
2012	162009	193281	190416	208472
2013	165576	194711	189674	217281
2014	169696	196430	199295	225651
2015	173063	202400	197004	235446
2016	171886	208566	198005	239139
2017	184902	210996	199892	236785
2018	190728	213611	200465	237401
2019	193084	215982	205316	235255
2020	191882	216972	207107	233063
2021	192358	219219	211030	243299
2022	192051	219305	213717	250383
2023	195197	219210	213462	254978
2024	196395	219878	212712	258678
2025	198141	221210	215326	263467

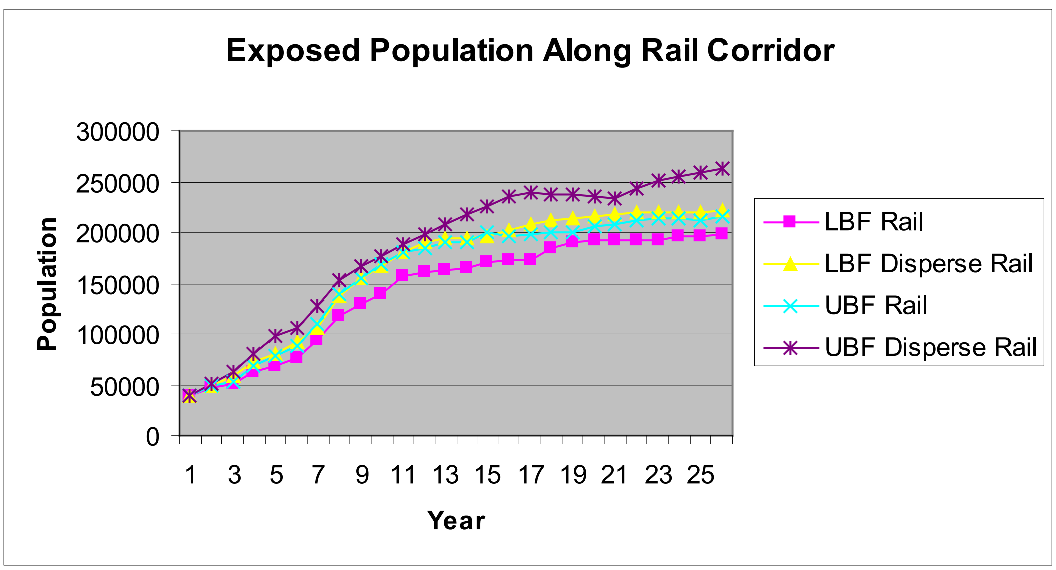


Figure 77: Exposed Population Along Rail Corridor (Clark County)

7.4 Summary

Studies from the Department of Energy indicate that there are potential health risks and socioeconomic impacts to Clark County residents and visitors resulting from the transportation of nuclear waste to Yucca Mountain (Comprehensive Planning, 2006). The results of the STEP3 Model can be useful by aiding in the assessment of those likely to be directly impacted by such a scheme. Our preliminary exploration above indicates that in all four of our scenarios there will be large numbers of people living within ½ mile of the planned routes. There is also an overall increase year-on-year in the number of people within these zones, reflecting the likely case of more of the population being exposed to risk over-time.

8 Conclusion and Recommendations

Clark County is one of the most rapidly growing areas in the United States and has proven to be a highly attractive destination for new residents in addition to being a major tourist destination. Consequently, the settled land area in Clark County has grown enormously over the last decade and is expected to continue to grow significantly in the future. Many planning problems and issues can be better addressed if forecasts are available to predict in advance where people will live and work. Long range planning for everything from school districts to hazardous waste routing is greatly aided by forecasts that can be modified flexibly in response to changes on the ground and alternative development scenarios.

The STEP3 Small Area Demographic Forecasts Model has been designed to meet the needs of planners in Clark County. The interface is user friendly while offering the ability to easily modify the multitude of parameters underlying the structure of the models. New construction such as hotel-casinos can be added using a visual interface, while the otherwise complex output from such models is much better appreciated with the graphical user interface of the TransCAD GIS software package that STEP3 runs within. In addition, regional trends can be changed to reflect factors such as more or less visitors which fuel immigration and the growth of the economy.

Using synthetic databases enables an extremely detailed simulation to be run whereby individual decision makers are modeled in terms of their household relationships and employment characteristics. By streamlining the efficiency of the handling of every aspect of these processes over time, STEP3 can provide a complete run for twenty five model years in only twenty four hours of actual computer processing time.

STEP3 can be helpful in the interpretative decision making process that is involved in better determining likely future demographic and landuse projections for Clark County. Such analyses have been demonstrated in this report in terms of quantifying the likely impact that transporting hazardous waste to Yucca Mountain will have on the local populace. This is one of the many scenarios that can be better understood using STEP3, any of which will be of benefit to the existing and future residents of Clark County.

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