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Land Use and Development in the Mojave Desert Region of San Bernardino County, California: The Impact of Changing Demographic Trends

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LAND USE AND DEVELOPMENT IN THE MOJAVE DESERT REGION

OF SAN BERNARDINO COUNTY, CALIFORNIA:

THE IMPACT OF CHANGING DEMOGRAPHIC TRENDS

by

Peter Christopher Gomben

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ABSTRACT

Land Use and Development in the Mojave Desert Region

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by

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Utah State University, 2008

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This research contributes to the field of land use planning by examining the effects of demographic trends—also known as *demographic futures*—on growth and development projections for seven communities in the Mojave Desert region of San Bernardino County, California. Demographic trends based on California Department of Finance projections and land development data supplied by the Southern California Association of Governments were obtained for each of the communities for the period between 1990 and 2001. By using a spatially explicit urban growth model, these trends and data were then used to allocate community-specific future growth for Adelanto, Apple Valley, Barstow, Hesperia, Twentynine Palms, Victorville, and Yucca Valley.

The research compared three projected settlement densities for each community. These three densities were based on settlement trends between 1990 and 2001, on existing densities as of 2001, and on densities that had been derived from prior research in the Mojave Desert region as a whole.

The overall effect of using demographic trends to estimate settlement densities results in less development of open space and undeveloped lands than under existing densities or densities derived from prior research. Indeed, using demographic trend-derived densities in place of existing densities resulted in nearly 3,900 more acres of vacant land in the seven communities remaining undeveloped by the year 2020. Similarly, using demographic trend-derived densities in place of densities developed by prior research resulted in nearly 22,000 more acres of vacant land in the seven communities remaining undeveloped by the year 2020.

Differences in projected land use patterns based on demographic trends are a key point for land use planners to consider when determining future development in each of these seven communities. Accounting for these demographic trends provides a way of "fine tuning" projections to ensure that they are more representative of the needs and expectations of future populations.

(136 pages)

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So these acknowledgments are being drafted with a faulty pen and good spirits at City Lights Books in San Francisco because, well, why not? Sometimes having no reason at all is perfectly fine. This is one such time. In my drab green cargo pants and denim jacket in the Beat section I stick out like a peacock. Who knew that black was still *de rigueur* among angelheaded hipsters? Shamble always. Howl when it suits you.

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their kindness, guidance, and friendship.

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And thanks especially to Petras and Adam, Sophie and Erma, who couldn't be around to share in my small victories as an adult, but who will always hold special places in my heart.

Now, to quote the greatest song in rock and roll history:

"Sure as your born they bought me a silk suit and put luggage in my hand
And I woke up high over Albuquerque on a jet to the Promised Land.
Working on a t-bone steak a la carte flying over to the Golden State
The pilot told us in thirteen minutes he would set us at the terminal gate.
Swing low chariot, come down easy, taxi to the terminal zone
Cut your engines and cool your wings and let me make it to the telephone.
San Diego, give me Hammond, Indiana, Tidewater-four-ten-oh-nine
Tell the folks back home it's the Promised Land calling
and their poor boy is doing fine."

Let's get the party started, shall we?

Peter Christopher Gomben

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CHAPTER 1

INTRODUCTION

The Mojave Desert Region (the Region) of San Bernardino County (Fig. 1.1) traditionally has been used for military training and testing operations, mining, outdoor recreation, ranching, and limited agriculture. The Region lies approximately 80 miles east of the city of Los Angeles. Like many locations in the United States that are within commuting distance of major metropolitan areas, the Region is subject to high levels of growth and development due to rapidly increasing populations. This pressure, which threatens to alter the ecologically fragile desert landscape and which will result in the loss of open space, takes the form of residential development as well as increases in the manufacturing, commercial, industrial, and retail sectors that accompany residential growth (Gonzalez and others 2000). Often this growth results in sprawl that reduces open space as well as encroaches on military installations and diminishes the ability of those installations to adequately meet their missions (National Governors' Association 2002).

In 1990, 223,779 persons lived in the Region (Gonzalez 2001). Some 192,682, or 86 percent, lived in the seven Mojave Desert communities of Adelanto, Apple Valley, Barstow, Hesperia, Twentynine Palms, Victorville, and Yucca Valley (SCAG 2004) (Fig. 1.2). By 2000, the population of the Region had increased by 25 percent, to 279,909. Some 251,728, or 90 percent, lived in these seven communities, representing a 31 percent increase in the total population of the communities since 1990 (SCAG 2004). While these seven communities gained in population, the seven "census-designated places" in the Region—Joshua Tree, Lenwood, Morongo Valley, Mountain View Acres, Nebo

Fig. 1.1 Mojave Desert Region of San Bernardino County locator map

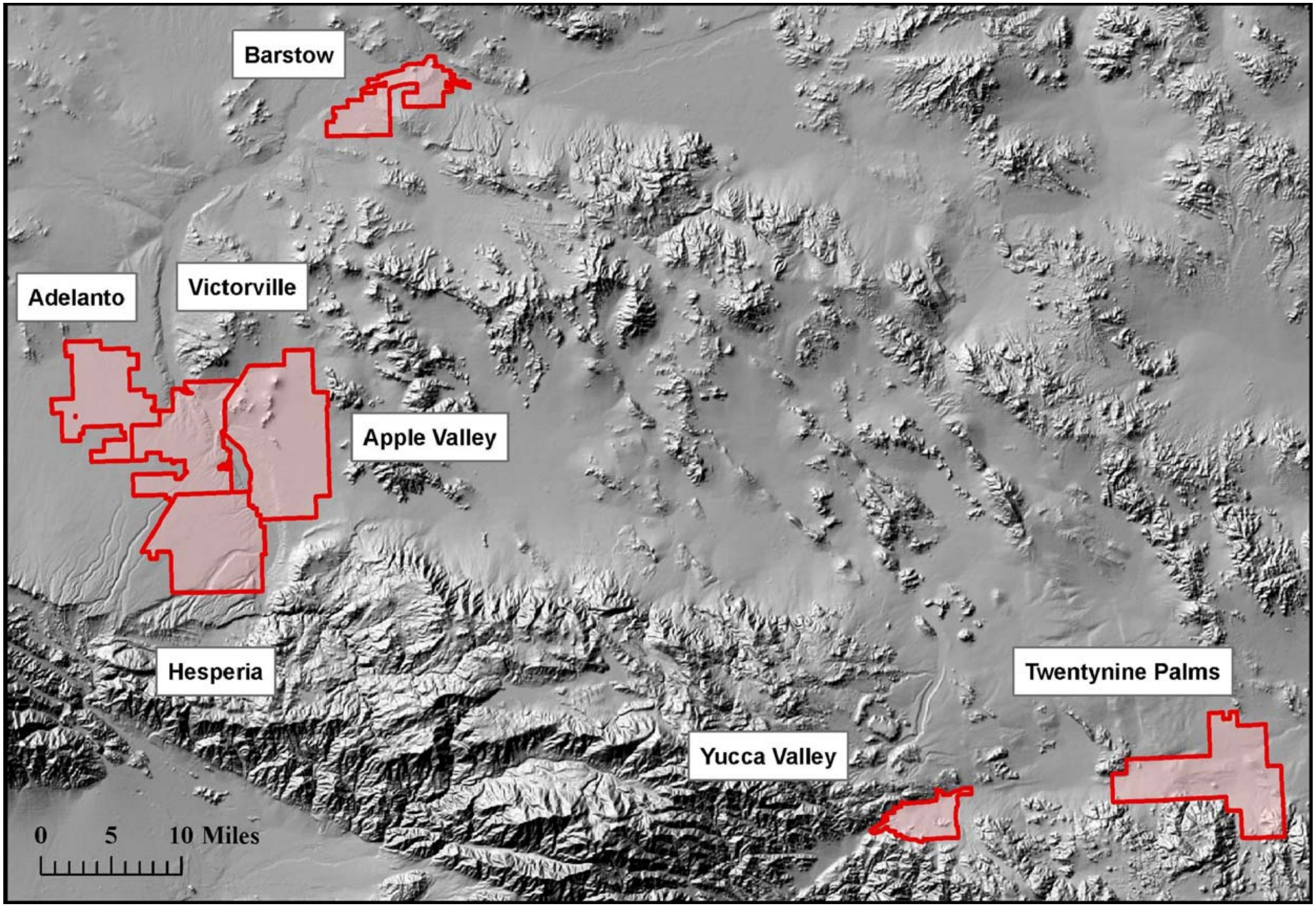

Fig. 1.2 Shaded relief map of study area

Center, Searles Valley, and Twentynine Palms Base—declined in population, dropping from an aggregate of 25,906 persons in 1990 to 23,351 persons in 2000 (SCAG 2004).

The Southern California Association of Governments (SCAG) projects the population of the seven communities will be 331,000 by 2010, and will reach nearly 425,000 by 2020, a 52-percent increase over the population at the turn of the 21st Century (SCAG 2004). Careful planning is required to ensure that this population growth will not detract from nor damage the Mojave Desert's unique characteristics, including open space and cultural values, biodiversity, quality of life, natural systems value, popularity for recreation of all kinds, and the viability of military bases.

Past Research in the Mojave Desert Region

Past research has evaluated the effects of humans and human activities on biodiversity and the landscape within the California portion of the Mojave Desert, including portions of Inyo, Kern, Los Angeles, and Riverside counties in addition to San Bernardino County (Mouat and others 1998; Hunter and others 2003). Specific objectives of this past research were to:

1. Evaluate the ways humans and human activities have altered the landscape;
2. Develop and evaluate approaches to predict the effects of human activities on biodiversity; and
3. Use the information that has been obtained to assess the consequences of future alternative land-use scenarios.

These alternative land-use scenarios provided a way to compare and contrast a variety of possible development "futures" that may occur in the Region based on different input data, which included human population growth, settlement densities, and potential land use planning regulations.

Gonzalez (2001) developed a logistic regression model to estimate the probability of future development on each hectare of private land in the Region. The model compared areas that were undeveloped in the early 1970s to areas that became developed between 1970 and 1990 and uses six independent variables to estimate the probability of development of each privately owned hectare, which is the binary dependent variable.

The independent variables are:

1. Distance of new development (i.e., development that occurred between 1970 and 1990) to development that existed in 1970;
2. Whether or not the hectare was within current municipal boundaries;
3. Distance of new development to primary roads or highways;
4. Distance of new development to secondary roads (e.g., residential streets);
5. Percent of surrounding 20 x 20 grids of one hectare cells that were developed; and
6. Percent slope of the terrain.

Gonzalez (2001) found that all six independent variables were highly significant indicators of the likelihood that a given hectare of private land would be developed. For example, for two hectares equal in all other regards, the one nearer to existing development was more likely to be developed than the one more distant. Similarly, a hectare that was on level terrain was more likely to be developed than a hectare on steep terrain.

Research into Demographic Trends

Planners are beginning to recognize that as the "clientele" they serve changes, so will the types of housing and living conditions demanded by that clientele (Myers 2001). The concept of demographic trends, or "demographic futures," addresses the necessity of modeling a future human environment that is based not on a snapshot of current conditions, but on current trends (Myers and Pitkin 2001; Myers and others 2005).

Over the projected future, the demographic composition of California's population will shift from a plurality of White non-Hispanic residents to Hispanic residents (U.S. Census Bureau 2004). This shift indicates that the Hispanic population will have a large role to play in shaping the future of development in California, especially with regard to the creation and maintenance of compact urban areas. Myers (2001) identified three characteristics of the Hispanic population that indicated a propensity for more compact urban dwelling: average household size, compact commuting, and residence in multi-family housing. Across all income levels studied, one-third fewer units are needed to house Hispanics, as opposed to the same number of non-Hispanics (Myers 2001). In addition, Hispanics were almost twice as likely to use public transportation, bicycles, or walking as a method of traveling to work than non-Hispanics (Myers 2001). Although at higher income levels this behavior decreased, Hispanics still were more likely to use compact commuting methods than non-Hispanics of equal income. Finally, Hispanics were also more likely to live in multi-family housing

(Myers 2001).

Research Objectives

This research addresses the question of how demographic trends in the population that is projected to settle the Mojave Desert Region may affect future growth and development patterns in the area. In particular, the research seeks to measure effects due to the shift from a population that is predominantly White non-Hispanic to one that is predominantly Hispanic by estimating the amount of open space, in the form of currently vacant land, that may be developed. To accomplish this task, a version of the logistic regression model developed by Gonzalez (2001) was used. The model was modified to account for a shift in the beginning of the time period of interest—in this case, based on available data, the year 2001 was used. The model projected potential development for each undeveloped hectare based on six factors:

1. Distance to development that existed in 2001;
2. Whether the hectare was within current municipal boundaries;
3. Distance to primary roads;
4. Distance to secondary roads;
5. Percent of surrounding 20 x 20 grid of one-hectare cells that were developed; and
6. Percent slope of the terrain.

To establish the framework for the research and analysis, the discussion below first summarizes the strengths and weaknesses of urban growth models, then discusses open space preservation and loss, and finally provides an overview of the Hispanic and White non-Hispanic populations in the U.S.

Urban Growth Models

Urban growth models can provide “narrative stories” on how cities *may* develop—but not necessarily *will* develop—by portraying projected growth as a “sequence of connected events” that evolves through time (Guhathakurta 2001; Guhathakurta 2003). One of the biggest benefits of models is that they allow urban and land-use planners the opportunity to examine, compare, and contrast a suite of potential development scenarios (Landis 1995).

Even though patterns of growth and urban development are influenced heavily by variables such as public policy, government subsidies, and technology that are difficult to incorporate into quantitative models, urban growth models nevertheless can be useful predictors of the probability of whether or not a given unit of land will be developed within a given time period (Landis 1994; Landis 1995; Batty and others 1999; Agung 2000). Although no model predicts growth with complete certainty, having a model that produces output that is even moderately accurate and useful is far better than having no output at all, especially as the size of the urban population in the U.S. increases and pressure to develop heretofore undeveloped lands grows. Between 1990 and 2000, for example, the population of the U.S. grew by 13.2 percent, from 248.7 million to 281.4 million, while over that same period the total population living in urban areas grew by 18.9 percent, from 187.1 million to 222.4 million, a trend that is predicted to continue

(U.S. Census Bureau 2004).

Results obtained from urban growth models should be filtered through a series of caveats. Models are, after all, merely representations of reality, abstractions that are created to provide "conceptual clarity" (Lee, C. 1973), and information derived from models is only as valid as the information on which they are based. Models should abet, not replace, expert judgment (Lee, C. 1973).

One shortcoming of urban growth models is that they are limited to evaluating measurable data and by nature are unable to incorporate information derived from the professional, and often non-quantifiable, experience of planners themselves (Guhathakurta 2001). Another shortcoming is that models are often insensitive to changes in zoning, urban growth boundaries, and tax incentives and cannot themselves be used to evaluate scenarios that vary based on different policy alternatives (Waddell and others 2003).

Although models are useful tools for urban planning, D. Lee (1973) lists the "seven sins of large-scale models" that influence the efficacy of models or the results that models produce, and by extension the validity of any conclusions that may be drawn from those results. When using models to predict development, hypercomprehensiveness, grossness, hungriness, wrongheadedness, complicatedness, mechanicalness, and expensiveness should be considered (Lee, D. 1973). Each of these is discussed briefly below.

Hypercomprehensiveness involves designing a model that must replicate too complex of a system in a "single shot." *Grossness* involves models that are too coarse to provide meaningful comparisons. *Hungriness* involves models that require too much data as input. *Wrongheadedness* involves using models for which claimed outputs exceed what the models actually can and cannot do. *Complicatedness* involves the increase in the potential interactions between components as the number of components increases. *Mechanicalness* involves potential problems with rounding errors and iterations used to execute a model. Finally, *expensiveness* involves an imbalance between the high cost of gathering particular data and the low benefits the model provides to decision makers.

Many processes exist for choosing the proper model to use when estimating or projecting land use changes—in other words, there are no hard-and-fast rules. As an example, the EPA (2000) lists a five-step process to use when selecting a land use change model. The process involves first understanding the proposal that the model will evaluate, then asking the proper questions to refine the desired output, after which informational needs must be identified. Fourth, financial, computational, and staff resources must be assessed. Only then can the "best" model be selected (EPA 2000).

A number of different models and methods exist to predict urban growth and development. A few of these are summarized below. This list is not intended to be exhaustive, but only illustrative of the variety of models and methods that are found.

Cellular automata. Cellular automata models have been used to predict future growth based on standard "if-then-else" statements (Batty 1997). Typically, cellular automata models are constructed to "develop" a given cell based on conditions found in neighboring cells. For example, one cell might be chosen for development if four of the eight adjacent cells have already been developed. Likewise, if only two or three of the eight adjacent cells are developed, the center cell may remain undeveloped. Finally, if only one adjacent cell is developed, the status of the center cell may be changed from developed to undeveloped.

The number of adjacent cells that are required for a center cell to be either developed or emptied can be changed as assumptions about development in a given urban area change. Clarke and others (1997) utilized a cellular automata model to predict urban growth in the San Francisco Bay Area. Fritz (2002) provided an independent verification of the Clark model for the Philadelphia/Wilmington metropolitan area.

Logistic regression models. Logistic regression models are useful when evaluating data or phenomena that are discrete instead of continuous (Pampel 2000). These models are often used in instances where the dependent variable has one of two different values—for example, male or female, presence or absence, developed or undeveloped, and so forth (Zar 1999).

Agung (2000) compared the predicted allocation of development using a logistic regression model with a “no model” simulation, and then compared both to actual development. The results showed that the “no model” simulation predicted new development with a mean distance of approximately 950 meters from actual development, while the logistic regression model predicted new development with a mean distance of approximately 490 meters from actual development. In the same research, Agung (2000) found that the logistic regression model provided more accurate allocation of development than a multi-criteria model.

UrbanSim. UrbanSim is an example of an "urban simulation system" designed to account for interactions between transportation and land use (Waddell and others 2003). UrbanSim, which is a disaggregate model, uses components that include data from individual households, jobs, and location choices to "microsimulate" the changes in real estate and jobs in an area of interest. The system has been applied to three urban areas thus far—Eugene-Springfield, Oregon; Honolulu, Hawaii; and Salt Lake City, Utah (Waddell 2002; Waddell and others 2003). In the case of the Eugene-Springfield application, the system performed well overall but had difficulty predicting isolated events such as downsizing of a mill and construction of a shopping mall (Waddell 2002).

Less complex predictive models. In addition to the models discussed above, less complex models may provide adequate information to planners regarding predicted future allocation of development so that more complex models, such as logistic regression, are unnecessary. In a study of alternative futures along Utah's Wasatch Front, for example, Toth et al. (2002) developed a plan trend model that predicted likely future development in a five-county area. The model used slope, municipal boundaries, proximity to existing roads and development, and exclusion of federal and state lands as factors affecting the likelihood of future development. Areas within 120 meters of existing roads, for example, were assigned higher probabilities of development than areas further from existing roads due to the tendency of development to occur around existing infrastructure. Whereas the outputs of less complex models may be coarser than the results of more complicated models, the results may nevertheless provide an acceptable level of information on which to base land-use planning decisions.

Open Space

Open space defined. As a concept, *open space* has been defined or classified in a number of different ways, some of which are fairly narrow while others are broad. In a study of suburbanization and wilderness parks in Orange County, California, for example, Rhodenbaugh (1998) used a definition of open space that included developed local and neighborhood parks. Fausold and Lilieholm (1999), on the other hand, define open space as "undeveloped land that retains most of its natural characteristics," a definition that includes forest lands, most lands used for agriculture and livestock, and some parks and other recreational areas. The EPA (2001b) defines open space as that part of a development site "permanently set aside for public or private use and [that] will not be developed." For this research, open space land will be considered as those private lands not currently used for residential, commercial, industrial, or other such developed uses.

The California state government has recognized the need for identifying and preserving open space for recreational and aesthetic use by humans as well as for habitat preservation for flora and fauna. State code broadly defines *open space* as "any parcel of land or water which is essentially unimproved and devoted to an open-space use," such as the "preservation of ... areas required for the preservation of plant and animal life."[1]

California state code further defines open space as areas on which there is "managed production of resources, including but not limited to, forest lands, rangeland

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[1] California government code SEC 65560(b)(1).

[and] agricultural lands,"[2] and areas for "outdoor recreation, including ... areas of outstanding scenic, historic and cultural value ... and areas which serve as links between major recreation and open-space reservations, including utility easements, banks of rivers and streams, trails, and scenic highway corridors."[3]

The California legislature, introducing aesthetics into the definition of open space, recognized that "the preservation of open-space land [as defined above] is necessary not only for the maintenance of the economy of the state, but also for the enjoyment of scenic beauty."[4] The legislature also recognized that "discouraging premature and unnecessary conversion of open-space land to urban uses is a matter of public interest and will be of benefit to urban dwellers because it will discourage noncontiguous development patterns" which result in increased costs of infrastructure and community services.[5]

Value of open space. The value of open space can often best be measured by delineating the use or function of the land in question. Frequently different values overlap, so that one parcel of land has value for a variety of different reasons. For example, when asked to help choose which lands in metropolitan Philadelphia were most valuable for open space, McHarg (1969) noted that on some lands nature "performed work for man without his investment and that such work did represent a value." In addition to identifying land that provided ecological services, McHarg (1969) noted that

[2] California government code SEC 65560(b)(2).

[3] California government code SEC 65560(b)(3).

[4] California government code SEC 65561(a).

other areas were prone to natural events—e.g., floods and earthquakes—that might injure humans and damage their structures, and that these areas also should be regulated for public safety. Much agricultural land falls into both categories. Protecting or regulating both types of areas would ensure that society protects both itself and the natural processes on which it relies.

A model zoning ordinance for Hamburg Township, Michigan, notes that preserving open space is valuable because it can preserve an area's "traditional rural character" and provide benefits to both the residents of open space communities as well as maintain or increase the overall quality of life in the township (EPA 2001a). In its model ordinance language, the EPA (2001b) recognizes that clustered development that preserves open space also reduces the capital cost of that development and may reduce the cost of public services.

Values attributed to open space preservation can be lumped into groups or split into discreet categories depending on needs of the person making the classifications. For example, Berry (1976) lists six values of open space preservation. These include utility, functional, contemplative, aesthetic, recreational, and ecological values. Fausold and Lilieholm (1999) identified four ways to categorize the value of open space, many of which overlap Berry's (1976) six values and the values described by McHarg (1969). These are:

Market value, which is the value of a piece of property in the real estate market.

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[5] California government code SEC 65561(b).

Enhancement value, which is the added value that a piece of open space property conveys to the market value of surrounding land.

Production value, which is the value of the goods and services—including agricultural crops and livestock—produced on open space land.

Natural systems value, which is the value of the ecosystem functions—such as flood control and groundwater recharge—provided by open space land and which may be lost if the land were developed.

In addition to these direct benefits, open space land also provides use and non-use values to society (Fausold and Lilieholm 1999). These include consumptive, non-consumptive and indirect use values, as well as option and existence non-use values.

Studies of the amenity value of open space lands include research by Brandenburg and Carroll (1995). Their research examined the interactions of various user groups and individuals with nearby public land open space in Washington state. Although they used semi-structured interviews to gather data and had no quantifiable means of comparison, they nevertheless found that interviewees had developed emotional ties to the surrounding landscape and had often moved away from areas of denser human development to areas that were more sparsely populated and contained more open space (Brandenburg and Carroll 1995). Studies have also examined the potential for preserving open space as a method of preserving valuable wildlife habitat (Rubino and Hess 2003).

The monetary value that open space lands provide to society is often difficult to quantify. Much of the value of such lands lies in their aesthetic appeal and cannot be easily translated into dollars. However, a few empirical studies have examined the value of open space lands and translated that value into monetary terms.

For example, open space in the form of regional parks near residential housing projects in Orange County, California, has been used as an amenity by land developers to attract home buyers; homes that were built adjacent to developed areas that included preserved open space, including neighborhood parks, sold for a premium price (Rhodenbaugh 1998). A study of the open space value of grazing lands near Steamboat Springs, Colorado, found that by using the travel cost method of valuation, the total annual benefit of open space in the Yampa River valley was between $4.7 million and $5.9 million (Walsh and others 1994). In addition, the study found that survey respondents place value in the simple presence of western ranch culture in the area. Residential property values were significantly higher for areas of Boulder, Colorado, that were nearer to greenbelts that those that were more distant (Correll and others 1978). In the study, residential property decreased in price by $4.20 per foot (adjusted to approximately $13 per foot for 2006) as distance away from the greenbelt increased.

Open space in legislation and in general plans. Two California state laws discourage the development of agricultural or otherwise undeveloped lands. The Agricultural Exclusion Act, passed by the legislature in 1955, was designed to reduce the leapfrog development that often accompanies urban sprawl (Fulton 1999). The legislature also passed the Williamson Act in 1965 to provide tax relief to owners of agricultural land who choose to keep their property in agricultural end uses for a decade or more (Fulton 1999). Both pieces of legislation were geared more toward preservation of land in agriculture as opposed to outright preservation of land as open space for non-commodity end uses.

California state law requires that general plans developed by communities or local governing agencies contain seven sections, or "elements," two of which directly pertain to open space conservation (Fulton 1999). The *open space* element directly provides for the long-term conservation of open space in the affected community. The *conservation* element deals with issues such as flood control and the need to conserve natural resources, including agricultural land. General plans for each city or county must address open space within their jurisdictional boundaries.

Due in part to an influx of immigrants from other parts of southern California, San Bernardino County has become one of the fastest growing large metropolitan areas in the nation (Fulton 1999). San Bernardino County has incorporated open space considerations into its general plan (San Bernardino County 1998). The general plan notes that the county contains an "abundant amount" of open space but recognizes that most of the county's large open space areas are in the Mojave Desert Region of the county and not accessible to large numbers of citizens, most of which live on the west side of the San Bernardino Mountains in the city of San Bernardino itself, as well as in surrounding municipalities such as Rialto.

In addition to the more functional and economic aspects of open space mentioned above, the general plan for San Bernardino County recognizes the value of maintaining certain areas as open space in order to protect the public health and safety (San Bernardino County 1998). Earthquake fault zones and soils that have limited use for septic tank leach fields are classified in the general plan as areas better left undeveloped. In addition to such natural features, the general plan also classifies landscapes around dams, aqueducts, and landfills as areas on which development would not serve the public health or safety.

Given the guidelines set forth in the general plan, and the stated need for open space areas to be maintained or created in areas that are readily accessible to the majority of the population, there is an opportunity to gauge the amount of current open space that will be lost as the population of San Bernardino County increases. Current open space managed by federal or state agencies is listed in Table 1.1. This land, which lies outside the boundaries of the seven communities, is expected to remain in an "open space" condition and is not available for development.

Open space loss and urban sprawl. Open space can be lost due to direct development of an entire parcel of previously open land or by fragmented development, often in a checkerboard pattern, that reduces or eliminates the amenities and ecological functions associated with open land. Much open space is lost to urban sprawl, which

Table 1.1 Public ownership of land in the Mojave Desert Region of San Bernardino County

Entity with jurisdiction	Area (hectares)
U.S. Bureau of Land Management	1,917,915
U.S. Department of Defense	758,877
U.S. Forest Service	15,088
U.S. Fish and Wildlife Service	1,361
National parks and preserves	670,615
State land, parks and wildlife reserves	100,912
Native American reserves	1,384
County/local	369
Other	159
Total Mojave Desert Region open space lands	*3,466,671*

Source: Modified GIS data supplied by the Southern California Association of Governments.

typically involves development of land at relatively low settlement densities (Persky and Wiewel 1996). Correll and others (1978) noted that "many communities have become acutely aware of the twin phenomena of sprawl and a decimated stock of open space." Typically, sprawl has its greatest impact on locations that are on the periphery of metropolitan areas; however, sprawl can also have negative impacts on the quality of life in rural areas (Brown 2001).

With regard to land use planning, the word "sprawl" has been used as an adjective, a verb, and a noun (Hess and others 2001). Urban sprawl may best be defined by the forms it assumes. Scattered or leapfrog development is a discontinuous form of development that moves outward from a central core (Clawson 1962; Ewing 1997; Harvey and Clark 1965; Hess and others 2001). This form of sprawl is characterized by developed areas interspersed with land that remains undeveloped. If current land use patterns continue unaltered, as California's population continues to grow, the state will continue to lose open space to low-density development unless active measures are taken to reduce the extent of sprawl (Snyder 2001).

Perhaps more than any other device, the automobile has assisted the development of sprawl (Jackson 1985), especially since the end of the Second World War. Guttenberg (1993) notes that the automobile has altered the time-distance relationship between urban centers, resulting in the economic viability of decentralized urban areas. Citizens were able to live farther from a central business district and still enjoy the amenities that such an area provided. As residential settlements move farther from central business districts, for example, vacuums are created in the supply of goods and services that are typically provided by the business districts. These vacuums are filled by new businesses, around which a new urban center may eventually form. Wiewel and Schaffer (2001) note that federal highway subsidies as well as the deductibility of mortgage interest on homes have encouraged the suburbanization of the U.S. population and, with it, the proliferation of urban sprawl.

Loss of open space that brings urban sprawl in its wake may result in higher-than-necessary monetary costs to society. Reducing sprawl by increasing development densities brings with it lower environmental and economic costs, in addition to reducing consumption of natural resources. In areas characterized by sprawl, investment tends to be focused on creating infrastructure at the metropolitan fringes instead of on maintaining infrastructure already in place (Goldman 2001; Real Estate Research Corporation 1974). Widespread sprawl may lead to increased costs for water-delivery and sewer infrastructure (Colorado Public Interest Research Foundation 2002). In addition, areas that suffer from sprawl require more funding for roads and emergency services (Coyne

2003; Sierra Club 2000). In California, laws such as Proposition 13 that constrain local government's ability to collect revenue may provide incentive for communities to develop open space because doing so opens up more land for the tax base (Goldman 2001).

Urban sprawl and low density development are not without their advocates. In the wake of the al-Qaeda attacks on the U.S. in September 2001, O'Toole (2001) argues that decentralizing the population would make it less prone to such concentrated acts of terrorism, hypothesizing that one reason that terrorists themselves are hard to capture is because they tend not to "bunch up." Gordon and Richardson (1997) argue that suburbanization and sprawl serve to reduce congestion by shifting road demand away from central cities, although their argument carries with it the unspoken assumption that the automobile is the most efficient form of transportation.

Methods of encouraging and preserving open space. A wide range of methods can be used to encourage the preservation of open space in the form of agricultural or recreational lands, whether the preservation is in perpetuity or for a specified length of time. Fausold and Lilieholm (1999) identified a number of methods that employed economic incentives and zoning laws to preserve open space. While traditional zoning methods perform well when used to maintain control of development, they are difficult to apply to open space preservation. Because zoning for open space results in heavy restrictions on a landowner's ability to use property in the future, successful legal challenges against such zoning can be made on the grounds that it constitutes a taking of private property (Fischel 1985). A few methods of encouraging or preserving open space are discussed below. This list is not intended to be exhaustive, but is meant to give examples of the variety of methods of open space preservation that are available to urban and land-use planners.

Differential assessment. Many local governments use differential assessment of taxes as ways of maintaining land in *de facto* open space. These programs typically assess land based on current use rather than market value, resulting in a lower tax (Blewett and Lane 1988; Pruetz 1993, Snyder 2001; Thorsnes and Simons 1999; Wolfram 1981; Wunderlich 1997;).

Urban growth boundaries. Urban growth boundaries have been used in California communities such as San Jose and Novato, and elsewhere across the nation, to reduce urban sprawl but have met with mixed success (Burby and others 2001; Daniels 2001). Snyder (2001) notes that in Sonoma County, California, for example, low density residential development in the form of "hobby farms" has increased. Staley and Mildner (1999) note that Portland, Oregon—in which urban growth boundaries have been in place for decades—ranks among the 10 percent least affordable areas in the nation for housing, and that by the year 2040 the city is projected to have a housing deficit of nearly 9,000 units. However, in California urban growth boundaries have been successful tools to use when protecting agricultural land and environmentally sensitive areas (Snyder 2001).

Cluster zoning. Cluster zoning and higher density development can be used to preserve open space in the form of agricultural land, forests or parks, and can preserve rural amenities in an urban area (McCarthy 1990; Wright and Webber 1978). With regard to agricultural land, a portion of a farm or ranch is allotted for cluster development, while the remaining land is preserved for farming or open space uses (Bowler 1997). A benefit of cluster zoning is that prime agricultural land that would otherwise be developed can be maintained in crop production as well as maintain ecological function, such as flood control.

The Hispanic and White non-Hispanic Populations in the United States

Hispanics comprise a growing percentage of the U.S. population. Results of the 2000 census show that the Hispanic population in the United States increased by 57.9 percent between 1990 and 2000, from approximately 22.4 million to 35.3 million (U.S. Census Bureau 2004). During that same period, the U.S. population as a whole grew by 13.2 percent, from roughly 248.7 million to 281.4 million, while the population of White non-Hispanics grew by 3.4 percent, from 188.1 million to 194.6 million.

Between 1990 and 2000, persons of all categories of Hispanic origin gained in overall population, although shifts occurred in the percentage breakdowns in each category. In 1990, persons claiming Mexican origin accounted for 60.4 percent of all Hispanics in the U.S., while by 2000 that number had declined to 58.5 percent. Between 1990 and 2000, persons claiming Puerto Rican origin declined from 12.2 percent to 9.7 percent of the Hispanic population, and persons claiming Cuban origin declined from 4.7 percent to 3.5 percent. The “other Hispanic” category—which includes persons from Central and South America, the Dominican Republic, and other locations—increased from 22.8 percent of the Hispanic population in 1990 to 28.4 percent in 2000.

The Hispanic and White non-Hispanic populations are not homogeneous across the nation. Nearly half—44.7 percent—of the Hispanic population in the U.S. is in the West, compared with 19.8 percent of the White non-Hispanic population. In contrast, 27.1 percent of White non-Hispanics and only 7.9 percent of Hispanics live in the Midwest (Therrien and Ramirez 2001). Differences also exist between Hispanics and White non-Hispanics with regard to urban vs. non-urban living. Some 46.4 percent of Hispanics lived in a central city area, while only 21.2 percent of White non-Hispanics did so (Therrien and Ramirez 2001). Only 8.5 percent of Hispanics lived in non-metropolitan areas, while 22.5 percent of White non-Hispanics did.

Hispanics are more likely to work in service occupations (19.4 percent) than White non-Hispanics (11.8 percent), and are nearly twice as likely—22.0 percent compared to 11.6 percent—to work as laborers or operators as are White non-Hispanics (Therrien and Ramirez 2001). Hispanics are also more likely to be unemployed, less likely to have at least a high school education, more likely to have less than a ninth-grade education, and more likely to live in poverty than White non-Hispanics (Therrien and Ramirez 2001).

Foreign-born Hispanics also differ from other foreign-born residents of the U.S. In 2000, 28.3 percent of residents from Latin America were naturalized, while 47.1 percent of residents from Asia and 52.0 percent of residents from Europe were naturalized (Schmidley 2001). Foreign-born Hispanics also have a shorter median length of residence—13.5 years—than foreign-born persons from Europe or Asia, indicating that they tend to be recent immigrants (Schmidley 2001). Indeed, Hispanics accounted for less than seven percent of all legal immigrants into the U.S. between 1931 and 1940, but during the period 1961 to 1970 exceeded 20 percent, and by 1981 to 1990 accounted for nearly 30 percent of the total (Borjas 1994). Unlike immigrants from Africa, Asia, or Europe, immigrants from Mexico, Puerto Rico, and Central America often have the option of returning to their native countries if they choose.

CHAPTER 2

STUDY AREA

Human Environment

California traditionally has been perceived as a place where dreams come true, leading to the great numbers of both domestic and international immigrants that have relocated to the state over the past century. At the beginning of the 20th Century the state's population was less than two million; by the end of the century the population had grown to approximately 35 million, an increase of more than 1,750 percent (Public Policy Institute of California 2002c). No other developed area in the world had growth rates as high as the state did during the last century (Johnson 2003). In comparison, over the same period of time the population of the U.S. itself grew from 76 million to nearly 280 million, a 370 percent increase.

As a proportion of total population, the U.S. has gone from having approximately one in twenty of its residents living in California in 1940 to approximately one in eight Americans living in the state at the end of the 20th Century, giving the state unprecedented importance in the national economy and great political power in the U.S. Congress. Population growth in the state has been a historical given: Even in times of economic downturn, such as the recession that affected the state in the early 1990s, California's population continued to grow.

Nationally, in the 1990s most population growth occurred in urban areas (Mackun and Wilson 2000). Metropolitan areas grew by 9.1 percent, from 198.5 million to 216.5

million. In contrast, non-metropolitan areas grew by 7.0 percent, from 50.3 million to 53.8 million. Growth in population for the state of California reflected this national trend. Between 1990 and 2000, 82.4 percent of the increase in population occurred in the 456 urban areas that existed in 1990. Some 12.4 percent of the growth occurred in areas that were incorporated after 1990, while the remaining 5.4 percent of the growth occurred in unincorporated areas (Public Policy Institute of California 2002d).

California's population is projected to increase rapidly over the first half of the 21st Century, both from natural increase (i.e., number of births minus number of deaths) as well as from international migration; increases in population resulting from domestic migration are projected to be minimal over that period (Campbell 1997; Johnson 2000; Myers 2001; Pitkin 2001). Indeed, natural increase will become the main driver behind the state's population growth to the extent that it is projected to grow to three times the level of domestic and international migration by the period 2030 to 2040 (Hill and Johnson 2002).

Domestic migration. The 1990s saw a shift in domestic migration patterns into and out of California. The state historically has had net gains in domestic migration, but in the 1990s approximately two million more people moved from California to other states than moved to California from elsewhere in the U.S. (Gabriel and others 1995; Johnson 2000). The states of Washington, Oregon, and Nevada were the biggest net gainers in migrants from California (Gabriel and others 1995).

A higher percentage of White non-Hispanics left the state during the 1990s than is found in California in general—71 percent of out-migrants were White non-Hispanic while the state's total population is approximately 50 percent White non-Hispanic. Domestic migrants who relocated to California during that decade reflect the racial and ethnic composition of the U.S. itself. Much of the out-migration occurred during the early part of the decade, when the state was in a severe recession that affected military contractors in particular, and tapered off toward the end of the 1990s (Johnson 2000). The California Department of Finance projects that domestic in-migration and out-migration may be relatively balanced in the near future (Johnson 2000).

International immigration. Since 1970, a large portion of the immigration into California has taken the form of international immigrants—1.8 million Californians were foreign born in 1970, while by 2000 that number had reached 8.9 million (Public Policy Institute of California 2002b). Overall, more than a quarter of Californians were born outside the U.S. Approximately 56 percent of all immigrants to California (international and domestic combined) are from Latin America, including Mexico and El Salvador, while 33 percent of total immigration is from Asia, including the Philippines and Vietnam (Public Policy Institute of California 2002b).

International immigrants to California are typically younger than the state's population at large. In 2000 half of the international immigrants to California were between 22 and 44 years of age, as compared to less than 30 percent of native-born Californians. Nearly 80 percent of the state's population growth during the 1990s was due to increases in the Hispanic population (Myers 2001; Myers and Pitkin 2001), which may be one of the causes of the increase in average household size from 2.78 to 2.87 during that decade (Myers and Park 2002).

Population Projections

State of California. A number of agencies and organizations project long-term population growth for the state, including the California Department of Finance, the U.S. Census Bureau (which has two projection series, A and B), the U.S. Bureau of Economic Analysis, the UCLA Anderson Forecast, and the Center for Continuing Study of the California Economy (which has high, medium, and low projections). Table 2.1 lists the growth projections for the coming decades.

Every method of projecting long-term population growth is predicated on a specific suite of methodologies and assumptions (Johnson 1999; Myers 2001). For example, Johnson (1999) noted that the U.S. Census Bureau and the U.S. Bureau of Economic Analysis projections were made when California was undergoing a period of high out-migration. However, because out-migration has declined since the time those projections were made, some of the assumptions that were used may be less valid. The other three projections call for higher populations over the short term because they were made subsequent to the end of the out-migration period.

Table 2.1 Population projections in millions for California by various sources

Source		**Year**				
		2005	**2010**	**2020**	**2030**	**2040**
California Department of Finance		37.4	40.0	45.5	51.9	58.7
U.S. Census Bureau	Series A	34.4	37.6	45.3	-	-
	Series B	33.5	35.0	39.0	-	-
U.S. Bureau of Economic Analysis		36.7	38.7	-	-	-
UCLA Anderson Forecast		-	42.3	49.1	56.5	63.4
Center for Continuing Study of the California Economy	High	38.8	42.0	49.1	54.7	61.0
	Medium	37.8	40.0	45.0	49.0	53.3
	Low	36.8	38.3	41.4	44.0	46.8

Source: Johnson (1999).

Despite some discrepancies, Johnson (1999) noted that all growth projections for California agree that:

1. The state's absolute growth level will be high, but growth rates will be lower than past years.
2. Natural increase will provide more growth than net migration.
3. Domestic migration will be less than in the past, and international migration will continue to be strong.
4. The state's growth rates will exceed rates for the rest of the U.S.

State agencies in California are required to use the projections provided by the Department of Finance when, for example, planning for maintenance and construction of infrastructure (Hill and Johnson 2002). As a result, and to be consistent with other planning activities in the state, Department of Finance numbers will be used here to summarize growth projections for the state and for San Bernardino County.

According to the Department of Finance, population growth in the state of California in the coming decades will see the state grow from approximately 34 million in the 2000 census to a projected 40 million by 2010, 45 million by 2020, and 59 million by 2040 (Table 2.2).

When making population projections, the Department of Finance uses a baseline cohort-component method (California Department of Finance 2002). Baseline projections assume people may move wherever they want to move and that no wars or natural disasters will impact the nation; a cohort-component method follows persons born

Table 2.2 Projected population growth in thousands by White non-Hispanic and Hispanic ethnicity for California and San Bernardino County

	California		San Bernardino County	
	Total	**% of total**	**Total**	**% of total**
2000 U.S. Census Bureau results[1]	33,872		1,709	
White non-Hispanic	*15,817*	*46.7*	*752*	*44.0*
Hispanic	*10,967*	*32.4*	*669*	*39.2*
2010 population projections[2]	39,958		2,188	
White non-Hispanic	*17,902*	*44.8*	*958*	*43.8*
Hispanic	*13,964*	*34.9*	*871*	*39.8*
2020 population projections[2]	45,449		2,747	
White non-Hispanic	*18,123*	*39.9*	*1,016*	*37.0*
Hispanic	*17,778*	*39.1*	*1,258*	*45.8*
2030 population projections[2]	51,869		3,426	
White non-Hispanic	*18,222*	*35.1*	*1,065*	*31.1*
Hispanic	*22,547*	*43.5*	*1,761*	*51.4*
2040 population projections[2]	58,731		4,202	
White non-Hispanic	*18,005*	*30.7*	*1,093*	*26.0*
Hispanic	*28,091*	*47.8*	*2,375*	*56.5*

[1] – Source: U.S. Census Bureau (2004).
[2] – Source: California Department of Finance (2002).

in a given year throughout their lives, factoring in annual mortality and migration patterns (California Department of Finance 2002).

San Bernardino County. Much as with the state of California as a whole, San Bernardino County is projected to gain in population over the coming decades. From a population of just over 1.7 million in the 2000 census, the county is expected to add nearly half a million persons by the year 2010 and nearly 560,000 between 2010 and 2020. By 2040, the projected population of the county will be 4.2 million. The city of San Bernardino itself will grow from approximately 190,000 in 2000 to over 260,000 by 2020, a projected increase of 37 percent over the 20-year period.

Mojave Desert Region of San Bernardino County. As with the state of California and San Bernardino County, the Region is expected to experience rapid population growth in the coming decades. All communities are projected to grow; some communities are projected to grow at higher rates than others. Table 2.3 illustrates actual growth for the seven Mojave Desert communities from 1980 through 2002, as well as the projected growth in 2010 and 2020. Actual population figures are from the U.S. Census Bureau; projected growth figures are from the Southern California Association of Governments.

When projecting future populations at the sub-county level, SCAG uses the three-step "housing unit" method. First, this method estimates occupied housing units in the locality of interest. Second, the method makes population estimates by multiplying the number of occupied housing units by the projected mean household size in the locality. Finally, the projected size of the group quartered population is added to the total (SCAG 2004).

From 1990 to 2002, the communities grew by 84,268 persons, representing an increase of 44 percent in the 12-year period and an annual growth of approximately 3 percent. Projections call for the communities to add over 147,000 new persons between 2002 and 2020, for an increase of 53 percent, or roughly 2.4 percent annually, over the 18-year period.

Table 2.3 Population for communities in the Mojave Desert Region

Location	US Census Bureau Actual[1]			SCAG Projections[2]	
	1990	2000	2002	2010	2020
Adelanto	8,517	18,130	18,650	22,278	30,980
Apple Valley	46,079	54,239	56,800	63,314	71,406
Barstow	21,472	21,119	22,150	27,639	34,528
Hesperia	50,418	62,582	65,100	87,108	116,536
Twentynine Palms	11,821	14,764	27,500	18,228	22,473
Victorville	40,674	64,029	69,300	91,551	125,700
Yucca Valley	13,701	16,865	17,450	20,834	22,793
Totals	*192,682*	*251,728*	*276,950*	*330,952*	*424,416*

[1] – Source: U.S. Census Bureau (2004).
[2] – Source: SCAG (2004).

Demographic Trends

State of California. In 2000 the total population of the state of California was 46.7 percent White non-Hispanic, 32.4 percent Hispanic, 10.8 percent Asian, 6.4 percent African American, and 0.5 percent Native American and Alaska native. The state will not experience population growth that is equal across all ethnic groups, giving rise to an increase in the state's ethnic diversity (Sandoval and others 2002). The total number of White non-Hispanics in California is expected to stay relatively constant at approximately 18 million, but the proportion of White non-Hispanics in the total population is projected to shift from 47 percent in 2000 to 31 percent in 2040. Conversely, the total number of Hispanics will nearly triple, from approximately 11 million in 2000 to over 28 million in 2040 (California Department of Finance 2002). Hispanics will comprise a plurality of the population by 2040, accounting for nearly 48 percent of persons in the state (Table 2.2). Persons of Asian, African American, and Native American ethnicity will increase in number but in aggregate will continue to comprise approximately 20 percent of the total population. In general, the number of younger and less affluent households in California will increase and, over time, the state's White non-Hispanic population will grow comparatively older and more wealthy (Goldman 2001).

San Bernardino County. Legal immigration to San Bernardino County in the 1990s remained fairly constant. From 1990 to 1998, 42,708 persons immigrated to the county from outside the U.S., ranging from a low of 3,858 immigrants in 1990 to a high of 5,681 immigrants in 1993 (California Department of Finance 2002). In 2000 San Bernardino County had a total population of 1.709 million persons. Approximately 44 percent of the population was classified as White non-Hispanic, 39.2 percent was Hispanic, 8.8 percent was African American, 4.6 percent was Asian, and 0.6 percent was Native American.

The White non-Hispanic portion of the population will continue to grow, but White non-Hispanics will form a smaller percentage of the total population in the county—44 percent in 2000 dropping to 37 percent by 2020. In contrast, the Hispanic portion of the population will grow in both real numbers and as a percentage, and will account for approximately 46 percent of the county's population by 2020. By 2040, White non-Hispanics will account for 26 percent of the population in the county and Hispanics will account for 57 percent. Other ethnic groups—including African Americans, Asians, and Native Americans—will grow in number but will remain stable as a function of overall percentage.

Mojave Desert Region of San Bernardino County. The ethnic composition of the Region currently has a higher percentage of White non-Hispanic persons and a lower percentage of Hispanic persons when compared to the demographic composition of both the county itself as well as the state of California. Of the 251,728 persons in the seven communities, approximately 28 percent are Hispanic, 58 percent are White non-Hispanic, and eight percent are African-American.

Table 2.4 lists the change in ethnic demographics for each of the seven communities. In 2000, the Hispanic component was highest in Adelanto, which accounted for 46 percent of the local population. The Hispanic component was lowest, at 11 percent, in Yucca Valley. Overall, between 1990 and 2000, White non-Hispanics dropped from 72 percent of the population to 58 percent. Hispanics grew from 18 percent of the population to 28 percent. Hispanics accounted for 59 percent of the population growth between 1990 and 2000—34,889 of the 59,046 new residents were Hispanic. The population of African Americans grew by 82 percent, rising from 6 percent of the population in 1990 to 8 percent in 2000. In aggregate, other ethnic groups, including Native Americans and Asians, more than doubled in number but still represent a small portion of the population in the Region, growing from 3 percent to 6 percent between 1990 and 2000.

Income, Housing, Economy, and Other Demographics

Income. Table 2.5 lists comparisons for levels of income and poverty for the seven Mojave Desert communities, San Bernardino County, California, and the U.S. for 1999. Median household income is lower in each of the communities than it is for the

Table 2.4 Change in ethnic demographics in the Mojave Desert Region, 1990 to 2000

Location	**Year**	**Total**	**Hispanic *(%)***	**White non-Hispanic *(%)***	**African-American *(%)***	**Other *(%)***
Adelanto	1990	8,517	1,475 *(17)*	5,430 *(64)*	1,156 *(14)*	456 *(5)*
	2000	18,130	8,299 *(46)*	6,616 *(36)*	2,305 *(13)*	910 *(5)*
Apple Valley	1990	46,079	5,813 *(13)*	37,059 *(80)*	1,727 *(4)*	1,480 *(3)*
	2000	54,239	10,067 *(19)*	36,710 *(68)*	4,141 *(8)*	3,321 *(6)*
Barstow	1990	21,472	6,726 *(31)*	11,550 *(54)*	2,120 *(10)*	1,076 *(5)*
	2000	21,119	7,708 *(36)*	9,163 *(43)*	2,349 *(11)*	1,899 *(9)*
Hesperia	1990	50,418	9,573 *(19)*	38,612 *(77)*	1,183 *(2)*	1,050 *(2)*
	2000	62,582	18,400 *(29)*	39,057 *(62)*	2,388 *(4)*	2,737 *(4)*
Twentynine Palms	1990	11,821	1,219 *(10)*	8,959 *(76)*	998 *(8)*	645 *(5)*
	2000	14,764	2,202 *(15)*	9,548 *(65)*	1,313 *(9)*	1,701 *(12)*
Victorville	1990	40,674	9,353 *(23)*	25,827 *(63)*	3,750 *(9)*	1,744 *(4)*
	2000	64,029	21,426 *(33)*	30,382 *(47)*	7,431 *(12)*	4,790 *(7)*
Yucca Valley	1990	13,701	976 *(7)*	12,229 *(89)*	191 *(1)*	305 *(2)*
	2000	16,865	1,922 *(11)*	13,829 *(82)*	350 *(2)*	764 *(5)*
Total	*1990*	*192,682*	*35,135* (18)	*139,666* (72)	*11,125* (6)	*6,756* (4)
	2000	*251,728*	*70,024* (28)	*145,305* (58)	*20,277* (8)	*16,122* (6)
Change	#	59,046	34,889	5,639	9,152	9,366
	%	31	99	4	82	139

Source: U.S. Census Bureau (2004).

county, the state or the nation. Yucca Valley has the lowest median household income, $30,420, which is 72 percent of the county and national medians, and only 64 percent of the state median. Apple Valley has the highest median household income, $40,421, which is 96 percent of the county and national medians and 85 percent of the state median.

Median family income is lower in each of the communities than it is for the county, state, or the nation as well. Twentynine Palms had the lowest median family income at $32,251, which was 69 percent of the county level, 61 percent of the state level, and 64 percent of the national level. Apple Valley had the highest median family income at $45,070, which was 97 percent of the county level, 85 percent of the state level

Table 2.5 Median household, median family, and per capita incomes and percentage of persons living in poverty for Mojave Desert Region communities, the county, the state, and the nation, 1999

Location	Income ($)			% below poverty level	
	Median		Per capita		
	Household	Family		Families	Individuals
Adelanto	31,594	35,254	10,053	21.4	24.5
Apple Valley	40,421	45,070	17,830	13.3	17.3
Barstow	35,069	40,160	16,132	15.6	20.3
Hesperia	40,201	43,004	15,487	11.1	14.1
Twentynine Palms	31,178	32,251	14,613	13.6	16.8
Victorville	36,187	39,988	14,454	15.3	18.7
Yucca Valley	30,420	36,650	16,020	16.2	19.5
San Bernardino Co.	*42,066*	*46,574*	*16,856*	*12.6*	*15.8*
California	*47,493*	*53,025*	*22,711*	*10.6*	*14.2*
United States	*41,994*	*50,046*	*21,857*	*9.2*	*12.4*

Source: U.S. Census Bureau (2004).

and 90 percent of the national level.

Per capita income is lower in all seven communities than it is in the remainder of the county, the state, and the nation with the exception of Apple Valley, which has a per capita income of $17,830, which exceeds the county level but is only 79 percent of the state level and 82 percent of the national level. With a per capita income of $10,053—less than half the national and state levels—Adelanto ranks lowest among the seven communities.

The percentage of families and persons living below the poverty level as defined by the U.S. Census Bureau (2004) is mostly higher in the seven Mojave Desert communities than it is in the rest of San Bernardino County, the state of California, and the nation. Six of the seven communities—Hesperia being the exception—have family poverty levels higher than the rest of the county. All seven communities have family poverty levels higher than the state and the nation. Six of the seven communities—again, Hesperia is the only exception—have individual poverty levels higher than the rest of San Bernardino County. Hesperia is also the only community with an individual poverty level lower than the state—14.1 percent of individuals in that community live below the

poverty line while 14.2 percent of all Californians live below the poverty line. No community has a lower percentage of people living in poverty than the nation as a whole. The general trend, then, is that there is a higher percentage of people living in poverty in the communities than in the county, there is a higher percentage of people living in poverty in the county than in the state, and there is a higher percentage of people living in poverty in California than there is in the U.S.

Housing. A "housing unit" is defined by the U.S. Census Bureau as "a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied as separate living quarters" (U.S. Census Bureau 2004). Housing unit occupancy in the Region was slightly higher than the rate of occupancy for San Bernardino County, 90 percent compared to 88 percent (Table 2.6). Occupancy varied from a high of 93 percent in both Hesperia and Victorville to a low of 81 percent in Twentynine Palms. The region as a whole had a somewhat higher rate of housing unit owner occupancy than did the county. Within the region, owner occupancy ranged from a high of 72.3 percent in Hesperia to 43.3 percent in Twentynine Palms.

Median housing unit values in each of the seven communities fell well below the county median of $131,500 and the state median of $211,500. The median value was

Table 2.6 Selected housing statistics

Location	**Housing units**		**% owner occupied**	**Median value $**	**% units built 1990 to 3/2000**	**% rental vacancy**
	Total	**Occupied (%)**				
Adelanto	5,547	4,714 *(85)*	63.8	81,700	58.8	22.3
Apple Valley	20,163	18,557 *(92)*	70.0	112,700	22.2	7.8
Barstow	9,153	7,647 *(83)*	54.1	75,700	7.9	20.4
Hesperia	21,348	19,966 *(93)*	72.3	95,900	21.8	7.3
Twentynine Palms	6,952	5,653 *(81)*	43.3	75,400	19.8	13.6
Victorville	22,498	20,893 *(93)*	65.1	98,700	34.5	7.9
Yucca Valley	7,952	6,949 *(87)*	68.0	83,200	9.0	10.9
Region total	***93,613***	***84,379 (90)***	***65.6***	--	--	--
San Bernardino Co.	***601,369***	***528,594 (88)***	***64.5***	***131,500***	***17.3***	***7.3***
California	***12,214,549***	***11,502,870 (94)***	***56.9***	***211,500***	--	--

Source: U.S. Census Bureau (2004).

highest in Apple Valley at $112,700 and lowest in Twentynine Palms at $75,400. The rate of housing construction in five of the seven communities surpasses the rate of new housing unit construction for San Bernardino County. For example, nearly 60 percent of the homes in Adelanto in 2000 were built after 1990. The rate of new housing unit construction was lowest in Barstow, where only 7.9 percent of housing units had been built after 1990. As one would expect, the areas that had the highest growth in population also had the highest percentage of homes built after 1990.

Rental vacancy rates were mostly higher than the rate for San Bernardino County as a whole. Over one-fifth of rentals were vacant in both Adelanto and Barstow, while in Hesperia, the rental vacancy rate was 7.3 percent, which matched the county rate.

Economy and jobs. California's economy is not only the largest of all states in the U.S., it is one of the largest in the world. In 1999 the total gross state product was over $1.2 trillion, and the state had 785,000 private non-farm establishments and private non-farm employment of 12.4 million, a 9.2 percent increase over 1990 employment (U.S. Census Bureau 2004). Total retail sales in 1997 were $263 billion. San Bernardino County had 26,735 private non-farm establishments in 1999 and private non-farm employment of 441,000, an 18.0 percent increase over 1990 (U.S. Census Bureau 2004). Total retail sales in 1997 were over $11 billion.

Table 2.7 shows data for the civilian labor force, both as raw numbers and as percentages of the total population over age 16, for each of the communities, for the Region as a whole, for the county, the state, and the nation. All communities had a lower participation rate in the civilian labor force than San Bernardino County as a whole, the state of California, and the United States. Unemployment was higher in each of the communities, as well as in the Region, than in San Bernardino County, California, and the U.S. Direct employment by the armed forces tends, as one would expect given the presence of military bases in the Region, to be slightly higher in the communities than in the state and the nation. Indeed, in Twentynine Palms, nearly 17 percent of the

Table 2.7 Civilian labor force, unemployment, and employment in the armed forces

Location	Civilian labor force		Unemployed		Armed forces	
	%	Number	%	Number	%	Number
Adelanto	47.1	5,587	12.6	702	0.2	19
Apple Valley	55.6	21,690	8.9	1,932	0.1	58
Barstow	57.4	8,769	10.4	908	1.7	252
Hesperia	56.9	25,193	10.6	2,660	0.1	39
Twentynine Palms	48.4	5,073	9.6	485	16.8	1,764
Victorville	56.1	24,853	9.9	2,468	0.1	65
Yucca Valley	47.5	6,223	8.4	521	1.3	164
Region total	***54.6***	***97,369***	***9.9***	***9,676***	***1.3***	***2,361***
San Bernardino Co.	***59.4***	***721,185***	***8.3***	***59,913***	***1.2***	***14,404***
California	***61.8***	***--***	***7.0***	***--***	***0.6***	***--***
United States	***63.4***	***--***	***5.8***	***--***	***0.5***	***--***

Source: U.S. Census Bureau (2004).

population over 16 years of age is in the military. In addition to persons directly involved in the armed forces, civilians are undoubtedly employed at military bases or at businesses

that owe their existence to the military presence in the Region. However, there are no data examining the number of civilian persons employed in such a capacity.

Table 2.8 uses the industrial categories of the U.S. Census Bureau to compare the Region, San Bernardino County, California, and the United States. The largest sectors of the Region's economy in terms of numbers of employed persons are the educational, health, and social services sector, with over one-fifth of all employed persons, and the retail trade sector, with 14.1 percent of all employed persons.

Other demographics. Table 2.9 compares demographic variables of the Mojave Desert communities with the county, the state, and the nation. Median age is lowest in Adelanto at 26.9 years and highest in Yucca Valley at 41.6 years. The county median is

Table 2.8 Employment in major economic sectors

Category	Region		County	State	U.S.
	Number	%	%	%	%
Agriculture, forestry, fishing, hunting, and mining	766	0.9	0.9	1.9	1.9
Construction	6,695	7.6	7.5	6.2	6.8
Manufacturing	8,254	9.4	12.7	13.1	14.1
Wholesale trade	2,451	2.8	4.1	4.1	3.6
Retail trade	12,341	14.1	12.8	11.2	11.7
Transportation and warehousing, and utilities	7,689	8.8	7.1	4.7	5.2
Information	1,811	2.1	2.3	3.9	3.1
Finance, insurance, real estate, rental and leasing	4,350	5.0	5.6	6.9	6.9
Professional, scientific, management, administrative, and waste management services	5,471	6.2	7.7	11.6	9.3
Educational, health, and social services	18,834	21.5	21.2	18.5	19.9
Arts, entertainment, recreation, accommodation, and food services	7,525	8.6	7.5	8.2	7.9
Public administration	6,343	7.2	5.6	4.5	4.8
Other services	5,163	5.9	5.2	5.2	4.9
Total	*87,693*	--	--	--	--

Source: U.S. Census Bureau (2004).

Table 2.9 Comparison of selected demographic variables, 2000

Location	Median Age	< 18 (%)	Hispanic (%)	Mean household size	Mean family size	> 25 with HS degree or higher (%)	Foreign born (%)	Diversity index (%)
Adelanto	26.9	38	45.8	3.53	3.89	67.1	18.3	74.57
Apple Valley	35.5	32	18.6	2.90	3.27	82.4	7.6	51.38
Barstow	32.1	31	36.5	2.71	3.27	77.6	12.0	72.52
Hesperia	32.0	33	29.4	3.12	3.47	72.6	9.8	55.74
Twentynine Palms	26.9	31	14.9	2.60	3.12	82.0	6.0	56.28
Victorville	30.7	34	33.5	3.03	3.47	76.7	12.3	69.29
Yucca Valley	41.6	25	11.4	2.38	2.94	81.9	5.2	33.19
San Bernardino Co.	*30.3*	*32*	*39.2*	*3.15*	*3.58*	*74.2*	*18.6*	*70.14*
California	*33.3*	*27*	*32.4*	*2.87*	*3.43*	*76.8*	*26.2*	--
United States	*35.3*	*26*	*12.5*	*2.59*	*3.14*	*80.4*	*11.1*	--

Source: U.S. Census Bureau (2004).

30.3 years, the state median is 33.3 years, and the national median is 35.3 years. Some 32 percent of all persons in the county are younger than 18, 27 percent of all Californians are younger than 18, and 26 percent of all Americans are younger than 18. Of the seven communities, Adelanto has the highest percentage of persons younger than 18 (38 percent); Yucca Valley has the lowest percentage of persons younger than 18 (25 percent), which is approximately the state and national levels.

Hispanic ethnicity varies in the seven communities, ranging from a high of nearly 46 percent of persons in Adelanto to a low of 11.4 in Yucca Valley. Countywide, 39.2 percent of the population is Hispanic, statewide 32.4 percent is Hispanic, and nationally 12.5 percent is Hispanic. Over 18 percent of persons in Adelanto were born outside the U.S., roughly approximating the countywide percentage. Some 5.2 percent of persons in Yucca Valley are foreign born. Over a quarter of all Californians are foreign born, while 11 percent of all Americans were born outside the U.S.

Six of the seven communities have educational levels that approximate the county, state, and national levels. The outlier is Adelanto, in which only two-thirds of persons over the age 25 have at least graduated from high school or passed a high school equivalency exam. With regard to secondary education, in 1998 in California as a whole, Hispanic females had higher graduation rates than males, with roughly 138 females graduating for each 100 males who graduated (Danenberg 2001). In comparison, approximately 130 White non-Hispanic females graduated for each 100 White non-Hispanic males.

Mean household sizes and mean family sizes in each of the seven communities tend to be variable around the corresponding county, state, and national levels. Finally, the diversity index, which measures the probability that two persons selected at random in each community will be of a different race or ethnic background, is highest in Adelanto and Barstow and lowest in Yucca Valley.

Natural Environment

Land ownership. San Bernardino County covers approximately 5.2 million hectares (Table 2.10), making it larger than nine U.S. states. It is the largest county in the 48 contiguous states and accounts for more than one-eighth of the land area of California.

The Mojave Desert Region examined here is approximately 4.4 million hectares in size, or 85 percent of the county total. Federal land accounts for 76 percent of the total in the Region, private land accounts for 22 percent, and state land accounts for 2 percent. Most federal land—1.9 million hectares—is managed by the Bureau of Land

Table 2.10 Land ownership/management in the Mojave Desert Region

Owner	Hectares owned or managed	Percent
Private	951,915	21.5
U.S. Bureau of Land Management	1,917,906	43.4
U.S. Department of Defense	758,877	17.2
U.S. Forest Service	15,088	0.3
U.S. Fish and Wildlife Service	1,361	< 0.1
National parks and preserves	670,615	15.2
State land, parks and wildlife reserves	100,912	2.3
Native American reserves	1,384	< 0.1
County/local	369	< 0.1
Other	159	< 0.1
Mojave Desert Region total	*4,418,586*	*100.00*
San Bernardino County total	*5,208,882*	----

Source: Modified GIS data supplied by the Southern California Association of Governments.

Management (BLM), which is scattered throughout the region. The Department of Defense manages 11 properties in the area totaling nearly 760,000 hectares, including Edwards Air Force Base. National parks and preserves account for 670,000 hectares. The San Bernardino National Forest manages 15,100 hectares, all of which is located along the extreme southwestern boundary of the Region. The State of California manages 101,000 hectares.

The majority of private land is aggregated in the southern and southwestern portions of the Region, near the seven communities and within commuting distance of the Los Angeles Basin. Private land in the northern and eastern portions of the Region is mostly found in checkerboard tracts intermixed with BLM land, resulting from 19th Century federal grants to railroads.

Geology. The California portion of the Mojave Desert is generally defined as the area bordered to the east by the Colorado River and the Nevada state line, to the north by the Garlock Fault, and to the southwest and south by the San Gabriel and San Bernardino mountains and the San Andreas Fault (Burchfiel and Davis 1981; Harden 1997; Oakeshott 1971; Woodburne and others 1982). In contrast to the basin-and-range topography of the Great Basin Desert, which abuts the Mojave to the northeast, mountains in the Mojave Desert tend to be shorter and lower in elevation while basins are typically wider (Harden 1997).

Mountain ranges in the Region—including the Calico, Granite, Newberry, and Ord mountains that lie east of Victorville and Adelanto and south of Barstow—are comprised of igneous or metamorphic materials and of Tertiary volcanic material (Harden 1997; Reed 1933). Many of the volcanic features are relatively unweathered, suggesting they are of recent volcanic origin (Harden 1997). Within these mountain ranges are many basins and dry lakes, including Coyote, El Mirage, Harper, Lucerne, Rabbit, and Troy, which serve as evaporation basins and recharge areas for run-off water. Sediment that has eroded from mountains has accumulated in these basins, as well as formed alluvial fans and bajadas. Recent surficial sediments near Barstow, considered typical for the Region, consist of windblown sand, gravel and sand, and clay and silt, beneath which is a layer of older alluvium consisting of gravel and sand (Oakeshott 1971).

A number of geologic faults run through the Region (Harden 1997; Reed 1933), among them the Helendale, Waterman, and Calico-Newberry faults. These faults tend northwest and run roughly parallel to the larger San Andreas Fault to the west and perpendicular to the Garlock Fault. Geologic faults can influence the flow of groundwater, affecting groundwater levels and acting as barriers to the flow of water underground (Densmore and others 1997; Faunt 1997; Stamos and Predmore 1995; Stamos and others 2001). Along the Mojave River's course, groundwater may be forced to the surface along many reaches upstream from faults, and the Helendale Fault's southern extension near Rabbit Lake is a barrier to subsurface flow and acts as a boundary to the groundwater basin (Stamos and others 2001).

Climate. The climate of the Region is characterized by low precipitation, low humidity, and often exceedingly high summer temperatures. Indeed, the hottest temperature ever measured in North America—134 degrees Fahrenheit—was recorded at Death Valley in the northern portion of the Mojave Desert in 1913. Throughout the Mojave Desert, which has an annual evaporation rate of nearly 100 inches, the mean annual precipitation is typically less than 6 inches, though there have been some years during which no measurable precipitation has fallen at all. Approximately two-thirds of all annual precipitation in the Region falls between December and March. Only trace amounts of precipitation, typically totaling less than half an inch, occur during the summer months. Annual precipitation in the San Bernardino Mountains is often in excess of 20 inches, much of it in the form of snow.

Barstow, which is approximately 2000 feet in elevation, is in the center of the Region. Mean annual precipitation in Barstow is 4.4 inches. The average annual maximum temperature is 80.2 degrees Fahrenheit; the average annual minimum is 47.5 degrees. Average maximum temperatures for both July and August are in excess of 100 degrees. Twentynine Palms, which is approximately 2050 feet in elevation, is in the southern portion of the Region. Mean annual precipitation is 6.5 inches. The average annual maximum temperature is 87 degrees Fahrenheit; the average annual minimum is 58 degrees. The hottest month is July, with an average maximum temperature of 107 degrees. Victorville, which is approximately 2900 feet in elevation, is in the southwestern portion of the Region. Mean annual precipitation in Victorville is 5.4 inches. The average annual maximum temperature is 77.3 degrees Fahrenheit; the average annual minimum is 44.3 degrees. The hottest month is July, with an average maximum temperature of 98 degrees.

Water in the Mojave Desert Region

Overall, the state of California is not water deficient. An average of approximately two feet of precipitation falls across the state annually (Littleworth and Garner 1995). California's water problems are not so much a matter of supply as of location (Fulton 1999). Northern coastal ranges receive upwards of 100 inches of precipitation per year. The Region, as mentioned above, has been known to go more than a year without measurable rainfall. Unlike other parts of the state that have a supply of water that can be readily stored in reservoirs—such as the Sacramento Valley or the western slope of the Sierra Mountains—the Region has no practical and reliable source of surface water that can be impounded and kept in reserve to satisfy current or future demands.

Were it not for the historic availability of water from the Mojave River itself for urban and agricultural uses, the Region may not have been initially settled by humans. A subgroup of the Native American Paiutes—the Chemehuevis—were among the first recorded humans to live in the Mojave Desert Region (Darlington 1996). The Chemehuevis were hunter-gatherer nomads who never settled in any single location, but instead migrated seasonally from the lowlands in the winter to the mountains in the summer. The first known European to visit the Mojave Desert was Father Francisco Hermenegildo Tomas Garces, a Spanish priest who passed through the area in the 18th Century (Peirson 1970).

Human development began in earnest in the 1860s, when Victorville and Hesperia were settled. Apple Valley and Adelanto were established later (Peirson 1970). Completion of the railroad in the mid 1880s established Barstow as a regional hub (Mojave Water Agency 1994). Due to the alluvial soils near the Mojave River and the long growing season, the area was well suited for agricultural development. Water initially was taken from surface flow in the river; however, due to the unreliability of seasonal flows, groundwater wells were dug to ensure reliable water supplies (Mojave Water Agency 1994). Historically, agriculture has been the major water use in the region in terms of volume. By 1995, though, urban use—including municipal, industrial, domestic, recreational, and golf course uses—surpassed agricultural use (Mojave Water Agency 2002b).

The California State Legislature established the Mojave Water Agency (MWA) in 1959 to manage the surface and groundwater resources in the 4,900 square-mile high desert area of San Bernardino County. The MWA service area includes the majority of the Mojave River drainage basin as well as most of the population centers in the Region.

The Mojave River is formed by the confluence of two streams in the San

Bernardino Mountains: the West Fork of the Mojave River and Deep Creek. The river, which is the primary source of surface water in the Region, is a mostly seasonal water body that carries significant surface flows generally only after storm events, although during years of peak discharge (e.g., 1969, 1983, and 1993) stream flow can last for months (Stamos and others 2001). Historically, portions of the Mojave River had perennial flow—as pumping of groundwater for agricultural purposes increased, however, the water table lowered and the riverbed now remains dry except for storm runoff (Stamos and others 2001).

The roughly 100-mile long river originates in the San Bernardino Mountains and flows northward and then eastward before terminating at Soda and East Cronese lakes, which typically pond with water only after major storm events (Mojave Water Agency 2002a; Oakeshott 1971). All drainage in the Region is interior—surface water from the region never flows into the sea (Oakeshott 1971). The river's drainage basin for surface water is approximately 3,800 square miles; the groundwater basin is approximately 1,400 square miles (Stamos and others 2001). The cleanest groundwater in the basin is found in the area above which the Mojave River flows out of the mountains. Levels of dissolved minerals increase further downstream (Mojave Water Agency 1994). Inflow from the headwaters, measured at the confluence of the two streams, is variable (Stamos and others 2001). In 1963, a low of 6,380 acre-feet inflow was measured at the confluence; in 1993, a high of nearly 430,000 acre-feet of inflow reached the river at that point. Between 1931 and 1994 the median annual inflow at the confluence was 28,000 acre-feet.

The MWA obtains all its water from groundwater in the Mojave River basin. Historically, water supply exceeded water demand in the basin, but as a result of rapid growth in the 1950s and 1960s, the basin began to lose more water through urban and agricultural consumption than was replenished by nature (Mojave Water Agency 1994; Stamos and others 2001). In one location in the eastern portion of the MWA, groundwater elevation—that is, the distance between the top of the groundwater aquifer and sea level—fell from a measured historical high of 1870 feet above sea level in the late 1940s, to 1800 feet by 1990.

The groundwater basin has an estimated operational storage capacity of 4.9 million acre-feet. By the end of 1990, roughly 3.0 million acre-feet of water was still in storage. If annual overdrafts continue, by the end of the projection period in 2015 an additional 1.86 million acre-feet of water will have been removed, leaving 1.14 million acre-feet in storage (Mojave Water Agency 1994). This water may be both more difficult and more expensive to pump.

The Mojave River area has an annual water supply of approximately 72,000 acre-feet and a total annual use of approximately 140,000 acre-feet, leading to an annual overdraft on the groundwater resource of 68,000 acre-feet (Mojave Water Agency 1994). By 2015 the annual overdraft is projected to be approximately 89,000 acre-feet.

In addition to groundwater in the Mojave River basin, the MWA has a water entitlement from the State Water Project (SWP) of a maximum of 50,800 acre-feet per year—however, due to problems with the SWP, actual water reliably delivered to the MWA is projected to average 40,000 acre-feet annually (Mojave Water Agency 1994).

The water supplied to the MWA from the SWP will reduce overdraft on the basin somewhat, but would still result in a projected annual overdraft of 53,000 acre-feet by 2015. Water delivered by SWP to the MWA has been used for groundwater recharge, most of which has been released into the Mojave River channel from Silverwood Lake (Mojave Water Agency 1994).

Water is removed from the basin by non-human means as well as by groundwater pumping. DeMeo and others (2003) studied the evapo-transpiration rates—that is, the rate at which water is either evaporated from the earth's surface or transpired by vegetation—in the Death Valley area in the northern part of the Mojave Desert. Evapo-transpiration rates varied from 0.17 feet per year for salt-encrusted playa to 3.90 feet per year for a mixed grass cover type.

Water supply. As mentioned above, water for urban and agricultural use is extracted from underlying aquifers; water that is not lost through evaporation, transpiration, or otherwise transferred from the groundwater basin essentially returns to the aquifers for future use (Mojave Water Agency 1994; Stamos and others 2001).

Runoff from the San Bernardino and San Gabriel mountains is the main source of "new" groundwater recharge to the basin—indeed, some estimates are that 92 percent of the total recharge comes from the San Bernardino Mountains (Hardt 1971). New groundwater recharge also occurs from storm runoff via ephemeral stream channels in the mountains that do not drain into the headwaters of the Mojave River.

"Used" groundwater recharge occurs as irrigation-return flow, flow from the two fish hatcheries in the area, and from treated sewage effluent (Stamos and others 2001).

The majority of wastewater generated in the Mojave River groundwater basin—an estimated 40,000 acre-feet in 1990—is returned to the basin via individual septic tanks (Mojave Water Agency 1994). Wastewater is also treated by the Victor Valley Wastewater Reclamation Authority, which releases the treated water into the river channel. In the 1980s and early 1990s, approximately 2,450 acre-feet of treated wastewater per year was imported into the Mojave River area by the Big Bear Area Wastewater Reclamation Authority, most of it used to irrigate alfalfa fields (Mojave Water Agency 1994).

A number of areas in the Region are suitable for groundwater recharge (Mojave Water Agency 1994). Most of these areas are along the course of the Mojave River or in the vicinity of the California aqueduct in the southwest corner of the region. The principal source of recharge to the groundwater basin comes from the Mojave River. Water from the river percolates to alluvial deposits underlying its channel (Mojave Water Agency 1994).

Factors Not Considered that May Affect Development

Many factors dealing with economics and demographics may have implications on development and growth in the Region but lie beyond the scope of this research. One such factor is income inequality—Weinberg (1996) noted that income inequality across the U.S. has grown since 1968; Daly and others (2001) concluded that between 1969 and 1999 international immigration accounted for approximately one-third of the growth in family income inequality in California, as well as more than half of the higher income inequality in the state when compared to the rest of the U.S. The Public Policy Institute of California (2002b) noted that the poverty rate for international immigrants to California was 50 percent higher in 2000 than it was for native-born Californians—18 percent compared to 12 percent. No measure of the specific effects of income inequality or poverty rates on settlement densities in southern California is known.

Along similar lines, Daly and others (2001) noted that if the children of immigrants do not have adequate education, they will not be able to climb the economic ladder, which may lead to continued or greater levels of income inequality in the future. For example, only two-thirds of persons over age 25 in Adelanto graduated from high school or have passed a high-school equivalency exam, compared to approximately 80 percent of persons in the other seven Mojave Desert communities. This may be due to the large number of foreign-born persons in Adelanto compared to the other communities. Whatever the case, if this lower level of educational attainment continues, it may affect settlement densities in the region.

California's voting population currently does not reflect the state's age and ethnic composition (Public Policy Institute of California 2002a). Thirty-five percent of the state's likely voters are over age 55. California's voters are predominantly White non-Hispanics despite the fact that more than half the state's population is Hispanic, Black, or Asian (Public Policy Institute of California 2001). Many Hispanics have not yet reached voting age and nearly one-third of persons in San Bernardino County are under 18, while approximately one-quarter of other Californians and other U.S. residents are under 18. When these citizens do become eligible to vote, they may form a bloc that has potential to alter statewide or local politics, especially in areas such as San Bernardino County with growing Hispanic populations. This potential shift in the political landscape could result in corresponding shifts in human demands on and expectations for the natural landscape and open space.

In addition, the effects of the current budgetary problems the state faces cannot be modeled in this research. California's budget tends to be more volatile than other states because it relies more heavily on taxes as a source of funding, tying it to fluctuations in the business cycle (Public Policy Institute of California 2003).

Also, this research will not account for potential shifts in transportation methods or costs. Current growth has occurred under the auspices of a generally fixed transportation system. However, changing travel patterns by constructing new highways or new modes of transportation—such as the proposed high-speed rail currently being considered for the Region—may alter the economic decisions persons make when choosing a place to live or to work.

CHAPTER 3

METHODOLOGY

Gonzalez (2001) and Hunter and others (2003) used two sets of satellite imagery—one from the early 1970s, one from the mid 1980s and/or early to mid 1990s—to determine urban expansion on private lands in the Mojave Desert of California. The 91,431 new hectares of development were classified as areas that were not developed in the earlier data but that had been developed in the later data. Hunter and others (2003) hypothesized that the probability of a hectare being developed between the two time periods was a function of the following six independent variables:

1. Distance to existing early 1970s developed hectares;
2. Distance to primary roads;
3. Distance to secondary roads;
4. Percent of surrounding hectares that were developed;
5. Whether or not the hectare was within a city boundary; and
6. Slope of the hectare.

Using a logistical regression model, Hunter and others (2003) concluded that the data fit the model "relatively well," suggested by the R^2 of 0.32. Using the results of the model, Hunter and others then projected future development by first determining the probability of an undeveloped hectare becoming developed using the six independent variables listed above, and then allocating the projected population growth on the landscape at a uniform settlement density of 3.76 persons per hectare for private lands across the entire 73,989 km^2 Mojave Desert area. The uniform settlement density was determined by dividing the number of persons (469,697) in the Mojave Desert area in 1990 by the area that was considered developed (124,725 hectares) at that time, which included roads, schools, parks, businesses, and residential areas.

Research Topic: Effect of Demographic Trends on Future Development Patterns in the Mojave Desert Region of San Bernardino County

Gonzalez (2001) and Hunter and others (2003) assumed that all projected development would occur at the same region-wide population density that existed in 1990—3.76 persons per hectare. One drawback of this assumption is that it does not differentiate between geographic and temporal variations that may exist in the settlement densities of Mojave Desert population centers. Although the population for the entire area in 1970 is unavailable (though Hunter and others (2003) noted that the population of incorporated cities in 1970 was nearly 70,000), the total developed area was 33,294 hectares. Assuming there were 3.76 persons per hectare in 1970, then the total population of the area would have been approximately 125,000. This may or may not have been the actual population. If the average density in 1970 was lower than 3.76, one might argue that the current trend is toward higher densities because newer settlement between 1970 and 1990 would have increased the average density. Conversely, if the average density in 1970 was higher than 3.76, one might argue that the densities are trending lower due to a decrease in settlement density between 1970 and 1990.

A more accurate way of estimating projected settlement densities is to divide the total change in population between 1970 and 1990 by the 91,431 hectares of new development within that period. Given that the population of incorporated cities in the Mojave was approximately 70,000 in 1970, and assuming that the population of non-incorporated areas was negligible, the trend settlement density between 1970 and 1990 would be approximately 4.4 persons per hectare at the highest—that is, an increase in population of approximately 400,000 and a growth in new development of 91,431 hectares. Still, however, this forces the assumption that instead of projected development being allocated at 3.76 persons per hectare, it would be settled at 4.4 persons per hectare—17 percent higher—on private lands across the entire Mojave Desert Region.

Another concern with using the 3.76 persons per hectare settlement density is that it does not account for locational differences based on demographic or socio-economic factors. The 3.76 figure averages all variation in settlement due to ethnicity, for example, or due to differences in income or wealth. The use of *demographic futures* to target the needs of future populations is a valuable, if not necessary, tool for planners (Myers 2001; Myers and Pitkin 2001; Myers and others 2005). Using demographic futures helps planners identify the fact that different ethnic groups have different household sizes and different domestic habits. Others have recognized the differences in economic preferences between native-born groups and immigrants (Borjas 1994; Hill and Johnson 2002).

Considerable differences in family size and household size exist between the Hispanic and the White non-Hispanic components of the population. In San Bernardino County, for example, the average family size is 3.58 persons (U.S. Census Bureau

2004)—roughly the same as the settlement density per hectare used by Gonzalez (2001). However, the average family size for White non-Hispanics is 3.12 persons, while the average family size for Hispanics is 4.26 persons—a difference of 37 percent. Likewise, the average household size for White non-Hispanics is 2.63 persons, while the average household size for Hispanics is 4.09 persons, a difference of 55 percent.

As Hispanics form an increasingly larger percentage of the population in the Region, the overall average family size and average household sizes will likely increase (Myers 2001). The average number of persons per hectare of developed land therefore may also increase, resulting in significantly higher settlement densities and a potentially smaller area of future development. If there is correlation between ethnicity and settlement density, then as Hispanics form a progressively higher proportion of the population, land utilized for new development may decrease on a per-person basis due to larger household and family sizes.

Community size. Ideally, to project future development using settlement densities, one would segregate each community of interest into as small of a geographical area as possible. Hunter and others (2003), for example, used private land in the entire Mojave Desert area of California—some 1.5 million hectares scattered among 7.4 million total hectares—as a community of interest. This coarse approach may have blurred the predictive capability of the research. A more accurate way of allocating growth would be to project growth based on both ethnicity, as discussed above, and by each of the seven communities found in the Region. This approach may provide a way to capture the effects of subtle differences between each community.

Mean household and family sizes. Mean household and family sizes vary for each of the seven Mojave Desert communities, though in all cases the sizes are larger for Hispanics than for White non-Hispanics (Table 3.1). Adelanto has the highest mean household and family sizes for Hispanics—4.08 and 4.40, respectively. Yucca Valley has the lowest mean household size for Hispanics, 2.69; Twentynine Palms has the lowest mean family size for Hispanics, 3.37. For White non-Hispanics, Adelanto has the highest mean household and mean family size, 3.00 and 3.41, respectively. Yucca Valley has the lowest mean household size for White non-Hispanics, 2.30, as well as the lowest mean family size, 2.85.

Percentages are a better way of making comparisons between the means for the seven communities. For mean household size, the differences range from Hispanic households being 17 percent larger than White non-Hispanic households in Yucca Valley to 39 percent larger in Hesperia. For the state of California, Hispanic households are 71 percent larger than White non-Hispanic households (Table 3.1). Nationally, Hispanic households are 49 percent larger than White non-Hispanic households (Table 3.1). With regard to mean family size, Hispanic families range from being 10 percent larger than White non-Hispanics in Twentynine Palms, to 29 percent larger in Adelanto. Corresponding figures are 45 percent for the state of California and 33 percent for the nation.

Table 3.1 Mean household and family sizes for Hispanics, White non-Hispanics, and overall, 2000

Location	Mean household size			Mean family size		
	Hispanic	**White non-Hispanic**	**Overall**	**Hispanic**	**White non-Hispanic**	**Overall**
Adelanto	4.08	3.00	3.53	4.40	3.41	3.89
Apple Valley	3.60	2.72	2.90	3.86	3.10	3.27
Barstow	3.11	2.35	2.71	3.56	2.98	3.27
Hesperia	3.93	2.83	3.12	4.11	3.22	3.47
Twentynine Palms	2.99	2.52	2.60	3.37	3.07	3.12
Victorville	3.61	2.72	3.03	3.93	3.17	3.47
Yucca Valley	2.69	2.30	2.38	3.39	2.85	2.94
San Bernardino Co.	*4.09*	*2.63*	*3.15*	*4.26*	*3.12*	*3.58*
California	*4.06*	*2.38*	*2.87*	*4.27*	*2.95*	*3.43*
United States	*3.62*	*2.43*	*2.59*	*3.93*	*2.97*	*3.14*

Source: U.S. Census Bureau (2004).

Median and per capita incomes. Similar differences are found between Hispanic and White non-Hispanic incomes (Table 3.2). Nationally, median household income for Hispanics is 74 percent of median household income for White non-Hispanics. Statewide and in San Bernardino County the numbers are 68 percent and 84 percent, respectively. In the seven communities, Hispanic median household income ranges from being 74 percent of median household income for White non-Hispanics in Twentynine Palms to 88 percent in Barstow.

Across the U.S., Hispanics have a per capita income that is 49 percent of the per capita income for White non-Hispanics. In California and San Bernardino County the numbers are 37 percent and 52 percent, respectively. Per capita income differences are less in the seven communities than they are for the county as a whole, the state, and the U.S. When measured against per capita income for White non-Hispanics in each

Table 3.2 Median household, median family, per capita income, and median home value (owner occupied), 1999

Location	Median household income		Median family income		Per capita income		Median home value (owner occupied)	
	Hispanic	White non-Hispanic	Hispanic	White non-Hispanic	Hispanic	White non-Hispanic	Hispanic	White non-Hispanic
Adelanto	29,236	36,724	29,851	40,933	8,153	12,527	78,600	81,500
Apple Valley	35,554	42,179	36,460	48,044	12,202	19,451	99,300	113,200
Barstow	33,533	38,171	37,880	48,595	12,920	20,281	71,000	76,900
Hesperia	35,229	41,684	34,704	46,986	11,079	17,639	91,100	97,000
Twentynine Palms	23,810	32,200	24,583	33,463	9,813	16,578	65,600	75,500
Victorville	31,029	39,094	31,727	46,231	10,016	17,984	96,800	98,600
Yucca Valley	24,184	30,775	27,143	37,259	9,512	17,080	82,500	84,000
SB County	*38,068*	*45,555*	*38,070*	*53,495*	*11,395*	*22,033*	*118,000*	*136,200*
California	*36,532*	*53,734*	*35,980*	*65,342*	*11,674*	*31,700*	--	--
U.S.	*33,676*	*45,367*	*34,397*	*54,698*	*12,111*	*24,819*	--	--

Source: U.S. Census Bureau (2004).

community, Hispanic per capita income ranges from a low of 56 percent in Victorville and Yucca Valley to a high of 65 percent in Adelanto.

Finally, median values of owner-occupied homes are lower for Hispanics than for White non-Hispanics in all communities in the Region. The median value of a Hispanic-owned and occupied home ranges from a low of 86.9 percent of the median value of a White non-Hispanic-owned home in Twentynine Palms, to a high of 98.2 percent in both Victorville and Yucca Valley. Each of the communities has greater equity in median home values than the county as a whole, in which the median value of a Hispanic-owned and occupied home is 86.7 percent of the median value of a home owned and occupied by White non-Hispanics.

Throughout California and across all income levels, White non-Hispanics have a mean of 2.55 persons per household, U.S.-born Hispanics have a mean of 3.21 persons per household, and foreign-born Hispanics have a mean of 4.57 persons per household (Myers 2001). The Hispanic population has a propensity for lifestyles that are compatible with higher density settlements, including higher rates of habitation in multi-family housing and using public transportation or walking to places of employment (Myers 2001).

Hispanic women in California have a total fertility rate of 2.8, far above the replacement rate of 2.1 (Hill and Johnson 2002). In comparison, the fertility rate for African-American women is 2.0, for Asian and Pacific Islander women is 1.8, and for White non-Hispanic women is 1.7. Overall, the total fertility rate for women in California is 2.2. However, the fertility rate for Hispanics who have recently immigrated is higher than that of Hispanic women who are second- or third-generation Californians (Hill and Johnson 2002).

Given the population projections shown earlier in Chapter 2, as Hispanics form an increasingly larger percentage of the state's and the county's population, the overall average family and average household sizes likely will increase (Myers 2001). The average number of persons per hectare therefore may also increase, resulting in significantly higher settlement densities and a potentially smaller area of future development. If there is correlation between ethnicity and settlement density, then as Hispanics form a progressively higher proportion of the population, land utilized for new development would decrease on a per person basis. This research provides a prediction of land development using differential settlement densities based on such demographic factors.

Determining settlement densities for projected development. Because population projections do not account for ethnic variation below the county level (Matyas 2004), forecasting the proportion of new residents in each of the Region's communities that are likely to be Hispanic or White non-Hispanic is difficult. Methods of determining the ethnic breakdown of projected growth include assuming that population growth in, say, Adelanto, will proportionally equal population growth in San Bernardino County. Total population growth in the county between 2000 and 2010 is projected to be approximately 479,000. Some 202,000 of this is projected to be due to an increase in the Hispanic population. Therefore, assuming that 42 percent of the new growth countywide is due to an increase in the Hispanic population, one may extrapolate that 42 percent of projected growth in Adelanto itself would be due to the Hispanic population. If this were the case, of the 4,148 new residents projected to inhabit Adelanto between 2000 and 2010, 1,742 of them would be Hispanic.

However, given the variation in demographic growth between 1990 and 2000—when Hispanics accounted for over a half of the new population in five of the seven communities and roughly a third of the new growth in the other two—it is doubtful future growth will conform to countywide levels. Along similar lines, differences in fertility rates between White non-Hispanics (1.62) and all categories of Hispanics (ranging from a high of 2.80 for White Hispanics to 1.68 for American Indian Hispanics) would make using projections based on countywide proportions unwise.

In the absence of an exceptionally fine-scale methodology that would account for all variation in ethnicity and fertility in each community, a reasonable way to determine the proportion of future growth allocated to Hispanics and White non-Hispanics may be to adopt the current trends in each community. Thus, using the trend in settlement density for each community over the most recent period for which data are available would better reflect changing demographics than using an existing population density that does not account for such a trend.

Methodology. The methodology used in this research is similar to that of Gonzalez (2001), who used a logistic regression model to determine the probability of a given hectare of land being developed over time, as discussed above. Logistic regression models are used when the dependent variable is binary or dichotomous and when the dependent variable will not follow a normal distribution. This type of regression has been used to analyze many social phenomena that are measured by the presence or absence of an outcome, for example, when an event occurs or when it does not occur (Pampel 2000). For further information about logistic regression, see the Appendix.

GIS data of all land use classifications for San Bernardino County in 1990 and 2001 were obtained from the Southern California Association of Governments (SCAG). Anderson and others (1976) developed a land use and land cover classification system to be used with remotely sensed data. The data obtained from SCAG were part of a southern California aerial land use study and utilized a modified Anderson land use classification.

Unlike previous land use research in the Mojave Desert Region (Gonzalez 2001; Hunter and others 2003) which separated the landscape into only two categories—

developed and undeveloped—the finer-scale GIS data provided by SCAG are divided into approximately 100 land use classifications. These land use classifications were grouped into the four general categories found in Table 3.3. These four categories formed the occupied land that was considered to be unavailable for future development or preservation.

For the purposes of this research, a “vacant” condition was assigned to all other lands, public and private, that were not in the four categories in Table 3.3. A parcel of land that is considered vacant does not necessarily lack evidence of development or urbanization and, in fact, may have been considered “developed” in previous studies. It does, however, fall into a category that would allow it to be either preserved as future open space or developed into residential, commercial, or industrial end uses. These vacant lands included:

- Open, undeveloped land surrounded by development;
- Cropland;
- Pastureland;
- Orchards and vineyards; and
- Other agricultural lands, including dairy operations.

Using ArcMap (Minami 2000), land use data from 1990 and 2001 were analyzed.

Summaries of the number of hectares for each of the selected land use groupings in 1990 and 2001, and the changes that occurred in the 11-year period for each of the seven communities are found in Table 3.4.

Table 3.3 Examples of land use groupings not available for new development

General category	**Examples of land use classifications included in each grouping**
Designated open space	Golf courses and driving ranges; local parks and recreational facilities; regional parks and recreational facilities; cemeteries; wildlife preserves; and arboreta.
Residential	Low and high density single family housing; low and high density mobile homes; duplexes, triplexes, and two- or three-unit condominiums; low, medium, and high rise apartments; mixed residential housing; low and high density rural housing; and mixed multi-family housing.
Commercial/industrial	Low, medium, and high rise offices; regional shopping centers; non-strip contiguous retail centers; modern and older strip development; metal and chemical processing facilities; hotels and motels; public and educational facilities; manufacturing and assembly facilities; storage facilities; warehouses; airports and rail yards; freeways and major roads; and areas under construction.
Other developed	Areas with no photo coverage and water bodies.

Source: Modified GIS data supplied by the Southern California Association of Governments.

Because no reliable methodology exists to estimate settlement densities based on demographic variables, the best available estimates of changes in settlement densities due to the sharp expected increase in the Hispanic population of the seven communities may be reflected in the changes in persons per hectare between 1990 and 2001. During this period, the Hispanic population increased in all seven communities in raw numbers as well as in percentage, a trend which is projected to continue into the foreseeable future. During the period 1990 to 2001, the trend in settlement density was greater than the existing settlement density in all communities except Barstow, which added only 1.1 new persons for each newly developed hectare of land. This is largely due to the fact that 85.3 percent of the new development in Barstow during that period was in commercial and

Table 3.4 Occupied hectares per land use grouping, 1990 and 2001

Location	Land use grouping	Occupied hectares		Change	
		1990	2001	Hectares	Percent
Adelanto	Designated open space	10.4	11.5	1.1	10.6
	Residential	282.3	577.1	294.8	104.4
	Commercial/industrial	598.0	943.8	345.8	57.8
	Other developed	0	0	0	0
	Total	**890.7**	**1532.4**	**641.7**	**72.0**
Apple Valley	Designated open space	83.9	149.6	65.7	
	Residential	5034.4	5553.0	518.6	
	Commercial/industrial	719.0	801.3	82.3	11.4
	Other developed	17.6	15.7	(1.9)	(11.0)
	Total	**5854.9**	**6519.6**	**664.7**	**11.4**
Barstow	Designated open space	43.3	54.8	11.5	26.6
	Residential	689.2	708.2	19.0	2.8
	Commercial/industrial	813.0	990.2	177.2	21.8
	Other developed	0	0	0	0
	Total	**1545.5**	**1753.2**	**207.7**	78.3
Hesperia	Designated open space	84.2	97.1	12.9	10.3
	Residential	5700.6	6246.0	545.4	9.6
	Commercial/industrial	1015.1	1171.4	156.3	15.4
	Other developed	4.4	4.4	0	0
	Total	**6804.3**	**7518.9**	**714.6**	**10.5**
Twentynine Palms	Designated open space	50.9	73.4	22.5	44.2
	Residential	1283.9	1370.2	86.3	6.7
	Commercial/industrial	248.6	274.2	25.6	10.3
	Other developed	0	0	0	0
	Total	**1583.4**	**1717.8**	**134.4**	**8.5**
Victorville	Designated open space	125.5	134.6	9.1	7.3
	Residential	2135.8	2524.8	389.0	18.2
	Commercial/industrial	1683.2	1748.3	65.1	3.9
	Other developed	26.4	11.4	(15.0)	(56.8)
	Total	**3970.9**	**4419.1**	**448.2**	**11.3**
Yucca Valley	Designated open space	54.0	58.4	4.4	8.1
	Residential	1271.5	1314.1	42.6	3.4
	Commercial/industrial	259.2	285.7	26.5	10.2
	Other developed	0	0	0	0
	Total	**1584.7**	**1658.2**	**73.5**	**4.6**

industrial categories of land use change, reinforcing Barstow's position as a retail and commercial trade center. In comparison, only 9.1 percent of new development in Barstow was in residential categories. New residential development in the other six communities ranged from a low of 46.0 percent in Adelanto to a high of 86.8 percent in

Victorville; new commercial and industrial development in the other six communities ranged from a low of 12.4 percent in Apple Valley to a high of 53.9 percent in Adelanto.

Table 3.5 shows the number of persons per developed hectare in 1990, the trend settlement density between 1990 and 2001, and the existing density as of 2001.

GIS data. In addition to the land use classification data obtained from SCAG that showed the changes in land uses between 1990 and 2001, geospatial data were obtained from a number of other sources. Digital elevation models (DEMs) were obtained from the California Spatial Information Library (CASIL). These DEMs were initially in a 30-meter grid but were projected to a 100-meter grid for consistency with previous research. City boundaries were obtained from CASIL. Primary and secondary road geospatial data were obtained from U.S. Census Bureau TIGER files via CASIL.

To maintain consistency with terminology, the six independent variables were assigned the same names as in previous research: Devdist, Primdist, Secdist, Pctdev, Citycat, and Slope (Gonzalez 2001). Each of these variables is discussed below. Variables were not clipped to the boundaries of each community until the probability layer was generated because, for example, proximity to secondary roads or current

Table 3.5 Persons per developed hectare in 1990, between 1990 and 2001, and in 2001

Location	Persons per developed hectare			Percent change between 1990 and 2001
	1990	1990 to 2001 (Trend)	2001 (Existing)	
Adelanto	9.7	15.5	12.1	24.7
Apple Valley	8.0	16.8	8.8	10.0
Barstow	14.3	1.1	12.8	(10.5)
Hesperia	7.5	20.0	8.7	16.0
Twentynine Palms	7.7	29.4	9.2	19.5
Victorville	10.7	62.2	15.9	48.6
Yucca Valley	9.0	52.6	10.8	20.0
All communities	8.8	31.0	11.3	28.4

development in one community might influence the probability for new development of a hectare in another community. In addition, proximity to secondary roads or current development outside the community boundary might influence the probability for new development of a hectare within that community.

Devdist. This variable is the distance of each hectare of vacant private land to the nearest hectare of occupied land. This variable was calculated in ArcMap using Spatial Analyst (McCoy and Johnston 2001) to generate a raster file that contained the distance from each hectare to the nearest "developed" hectare from the SCAG data. In general, a vacant hectare would be more likely to be developed in the future if it were nearer current development than if it were further away.

Primdist. This variable is the distance of each hectare of vacant private land to the nearest primary road. Primary roads for this research were considered interstate, federal, and state highways. This variable was calculated in ArcMap using Spatial Analyst (McCoy and Johnston 2001) to generate a raster file that contained the distance from each hectare to the nearest primary road. In general, a vacant hectare would be more likely to be developed in the future if it were nearer a primary road than if it were further away.

Secdist. This variable is the distance of each hectare of vacant private land to the nearest secondary road. Secondary roads for this research were considered residential and local-access roads. This variable was calculated in ArcMap using Spatial Analyst (McCoy and Johnston 2001) to generate a raster file that contained the distance from each hectare to the nearest secondary road. In general, a vacant hectare would be more likely to be developed in the future if it were nearer a secondary road than if it were further away.

Pctdev. This variable is the percent of occupied hectares in a 20-by-20-hectare grid surrounding the vacant hectare. This variable was calculated in ArcMap using Spatial Analyst (McCoy and Johnston 2001) to generate a raster file that contained the percentage of surrounding development for each hectare. In general, a vacant hectare would be more likely to be developed if it were surrounded by a higher percentage, rather than a lower percentage, of currently developed hectares.

Citycat. This variable is categorical, with a value of 1 for each vacant hectare that was located within a city boundary and 0 for each hectare that is located outside a city boundary. Because this research was designed to examine only areas that are already within municipal boundaries, all hectares were assigned the value of 1. This independent variable was included in the analysis to maintain consistency with the model as applied in previous research.

Slope. This variable is expressed as a percent. This variable was calculated in ArcMap using Spatial Analyst (McCoy and Johnston 2001) to generate a raster file that contained the slope of each hectare. In general, a hectare would be more likely to be developed if it has a lower slope than a higher slope.

Newdev. This is the dependent variable and represents the probability of a hectare becoming developed. Newdev was determined using the following equation, which was developed by Gonzalez (2001):

$$\text{Newdev} = \frac{1}{\left(1 + e^{-[(-1.5500) + (4.4691)(\text{Pctdev}) - (0.0502)(\text{Slope}) - (0.00003)(\text{Devdist}) + (0.8992)(\text{Citycat}) - (0.00467)(\text{Secdist}) - (0.00017)(\text{Primdist})]}\right)}$$

A new raster file was generated using the Newdev equation in the raster calculator function in ArcMap. This raster file was then converted to a shapefile that showed the development probability of each hectare in the seven communities. Areas of development present in 2001 were then erased from the shapefile, leaving only non-developed hectares. This shapefile was then clipped to the boundary of each community.

Alternative futures for settlement in the region. Alternative settlement densities were examined for each of the seven communities. Trend settlement density, which varies for each community, is the number of new persons added for each new hectare of development between 1990 and 2001 (Table 3.5). This density assumes future settlement will match recent densities and thus reflect an increasing proportion of Hispanics. Existing settlement density is the overall number of persons per hectare in 2001 and varies for each community (Table 3.5). This density assumes future settlement will reflect the demographic proportions present in 2001. Projected population growth was then allocated for each of the seven communities at both settlement densities, beginning with the cells that had the highest probability of development and continuing until the projected population increase for each time period was exhausted.

CHAPTER 4

RESULTS AND DISCUSSION

As one would expect by altering the settlement densities of persons per hectare, the amount of land developed decreases as the number of persons per hectare increases. The results discussed here assume that the boundaries remain static until 2020 and that the communities do not incorporate or annex lands beyond their current extent. Table 4.1 shows the projected hectares of land that would be developed in 2010 and 2020, as well as the projected hectares of land that would remain vacant in 2020. As a means of comparison, projected hectares of development under past research (Gonzalez 2001) are included.

For the purposes of this research, excess population from one community was not applied to another. Using Hesperia as an example, persons in excess of the maximum build-out at existing density were not "re-settled" in the surrounding communities of Adelanto, Apple Valley, Victorville, or elsewhere, because doing so would have introduced a source of additional growth not accounted for in the SCAG projections.

Results for each specific community are discussed below. In summary, Table 4.1 shows that the overall effect of the different settlement densities results in less development of vacant lands under trend densities that incorporate demographic changes than under either existing densities or densities derived from past research. The only exception is Barstow, which underwent a small growth in population during the period between1 1990 and 2001 while undergoing a fairly robust increase in developed lands.

Table 4.1 Projected hectares of developed and vacant land under existing, trend, and past research settlement densities

Location	Total	Developed			Vacant
		2001, actual	**2010, projected**	**2020, projected**	**2020, projected**
Adelanto	9558	1532.4			
Existing			1849.0	2568.2	6989.8
Trend			*1779.6*	*2341.0*	*7217.0*
Past research[1]			3102.5	6668.9	2889.1
Apple Valley	17404	6519.6			
Existing			7334.0	8253.5	9150.5
Trend			*6946.2*	*7427.9*	*9976.1*
Past research[1]			9456.9	12,773.1	4630.9
Barstow	5961	1753.2			
Existing			2218.2	2756.4	3204.6
Trend			*7164.1*	*13426.8*	*(7465.8)*
Past research[1]			4192.5	7015.8	(1054.8)
Hesperia	12513	7518.9			
Existing			10120.4	13502.9	(989.9)
Trend			*8650.6*	*10122.0*	*2391.0*
Past research[1]			16794.7	28855.3	(16342.3)
Twentynine Palms	13999	1717.8			
Existing			2056.7	2518.1	11480.9
Trend			*1823.9*	*1968.3*	*12030.7*
Past research[1]			2995.7	4735.4	9263.6
Victorville	10838	4419.1			
Existing			5901.7	8049.4	2788.6
Trend			*4798.1*	*5347.1*	*5490.9*
Past research[1]			14080.3	19771.0	(8933.0)
Yucca Valley	3591	1658.2			
Existing			1982.1	2163.5	1427.5
Trend			*1724.7*	*1761.9*	*1829.1*
Past research[1]			3091.8	3894.7	(303.7)

[1] – Source: Gonzalez (2001).

Adelanto

By 2001, a total of 1532.4 hectares had been developed in Adelanto (Fig. 4.1). Under the trend density, by 2010 approximately 247.2 additional hectares would be developed; between 2010 and 2020, an additional 561.4 hectares would be developed (Fig. 4.2). Some 7217.0 hectares—75.5 percent of the total area—would remain in a vacant status in 2020 under the trend density.

Under the existing density, by 2010 approximately 316.6 additional hectares would be developed; between 2010 and 2020, an additional 719.2 hectares would be developed (Fig. 4.3). Some 6989.8 hectares—73.1 percent of the total area—would remain in a vacant status in 2020 under the existing density.

Under the settlement density used for past research (Gonzalez 2001), by 2010 approximately 1570.1 additional hectares would be developed, and between 2010 and 2020 an additional 3566.4 hectares would be developed. Only 2889.1 hectares—30.2 percent of the total area—would remain in a vacant status in 2020 at the settlement density used in past research.

Apple Valley

By 2001, a total of 6519.6 hectares had been developed in Apple Valley (Fig. 4.4). Under the trend density, by 2010 approximately 426.6 additional hectares would be developed; between 2010 and 2020, an additional 481.7 hectares would be developed (Fig. 4.5). Some 9976.1 hectares—57.3 percent of the total area—would remain in a vacant status in 2020 under the trend density.

Under the existing density, by 2010 approximately 814.4 additional hectares would be developed; between 2010 and 2020, an additional 919.5 hectares would be developed (Fig. 4.6). Some 9150.5 hectares—52.6 percent of the total area—would remain in a vacant status in 2020 under the existing density.

Under the settlement density used for past research (Gonzalez 2001), by 2010 approximately 2937.3 additional hectares would be developed; between 2010 and 2020, an additional 3316.2 hectares would be developed. Only 4630.9 hectares—26.6 percent of the total area—would remain in a vacant status in 2020 at the settlement density used in past research.

Barstow

By 2001, a total of 1753.2 hectares had been developed in Barstow (Fig. 4.7). Under the trend density, by 2010 no vacant land would remain available for development (Fig. 4.8). This projection is likely anomalous due to the relative high number of hectares developed between 1990 and 2001 and the correspondingly low increase in population during that period.

Under the existing density, by 2010 approximately 465.0 additional hectares would be developed; between 2010 and 2020, an additional 538.2 hectares would be developed (Fig. 4.9). Some 3204.6 hectares—53.8 percent of the total area—would remain in a vacant status in 2020 under the existing density.

Under the settlement density used for past research (Gonzalez 2001), by 2010 approximately 2439.3 additional hectares would be developed. By 2020 no vacant land would remain available for development.

Hesperia

By 2001, a total of 7518.9 hectares had been developed in Hesperia (Fig. 4.10). Under the trend density, by 2010 approximately 1131.7 additional hectares would be developed; between 2010 and 2020, an additional 1471.4 hectares would be developed (Fig. 4.11). Some 2391.0 hectares—19.1 percent of the total area—would remain in a vacant status in 2020 under the trend density.

Under the existing density, by 2010 approximately 2601.5 additional hectares would be developed. By 2020 no vacant land would remain for development (Fig. 4.12).

Under the settlement density used for past research (Gonzalez 2001), by 2010 no vacant land would remain for development.

Twentynine Palms

By 2001, a total of 1717.8 hectares had been developed in Twentynine Palms (Fig. 4.13). Under the trend density, by 2010 approximately 106.1 additional hectares would be developed; between 2010 and 2020, an additional 144.4 hectares would be developed (Fig. 4.14). Some 12030.7 hectares—85.9 percent of the total area—would remain in a vacant status in 2020 under the trend density.

Under the existing density, by 2010 approximately 338.9 additional hectares would be developed; between 2010 and 2020, an additional 461.4 hectares would be developed (Fig. 4.15). Some 11480.9 hectares—82.0 percent of the total area—would remain in a vacant status in 2020 under the existing density.

Under the settlement density used for past research (Gonzalez 2001), by 2010 approximately 1277.9 additional hectares would be developed, and between 2010 and 2020, an additional 1739.7 hectares would be developed. Only 9263.6 hectares—66.1 percent of the total area—would remain in a vacant status in 2020 at the settlement density used in past research.

Victorville

By 2001, a total of 4419.1 hectares had been developed in Victorville (Fig. 4.16). Under the trend density, by 2010 approximately 379.0 additional hectares would be developed; between 2010 and 2020, an additional 549.0 hectares would be developed (Fig. 4.17). Some 5490.9 hectares—50.7 percent of the total area—would remain in a vacant status in 2020 under the trend density.

Under the existing density, by 2010 approximately 1482.6 additional hectares would be developed; between 2010 and 2020, an additional 2147.7 hectares would be developed (Fig. 4.18). Some 2788.6 hectares—25.7 percent of the total area—would remain in a vacant status in 2020 under the existing density.

Under the settlement density used for past research (Gonzalez 2001), by 2010 all available land in Victorville would be developed.

Yucca Valley

By 2001, a total of 1658.2 hectares had been developed in Yucca Valley (Fig. 4.19). Under the trend density, by 2010 approximately 66.5 additional hectares would be developed; between 2010 and 2020, an additional 37.2 hectares would be developed (Fig. 4.20). Some 1829.1 hectares—50.9 percent of the total area—would remain in a vacant status in 2020 under the trend density.

Under the existing density, by 2010 approximately 323.9 additional hectares would be developed; between 2010 and 2020, an additional 181.4 hectares would be developed (Fig. 4.21). Some 1427.5 hectares—39.8 percent of the total area—would remain in a vacant status in 2020 under the existing density.

Under the settlement density used for past research (Gonzalez 2001), by 2010 approximately 1433.6 additional hectares would be developed; between 2010 and 2020, an additional 802.9 hectares would be developed, which would require the addition of 303.7 hectares to the community. No land would remain in a vacant status at this settlement density.

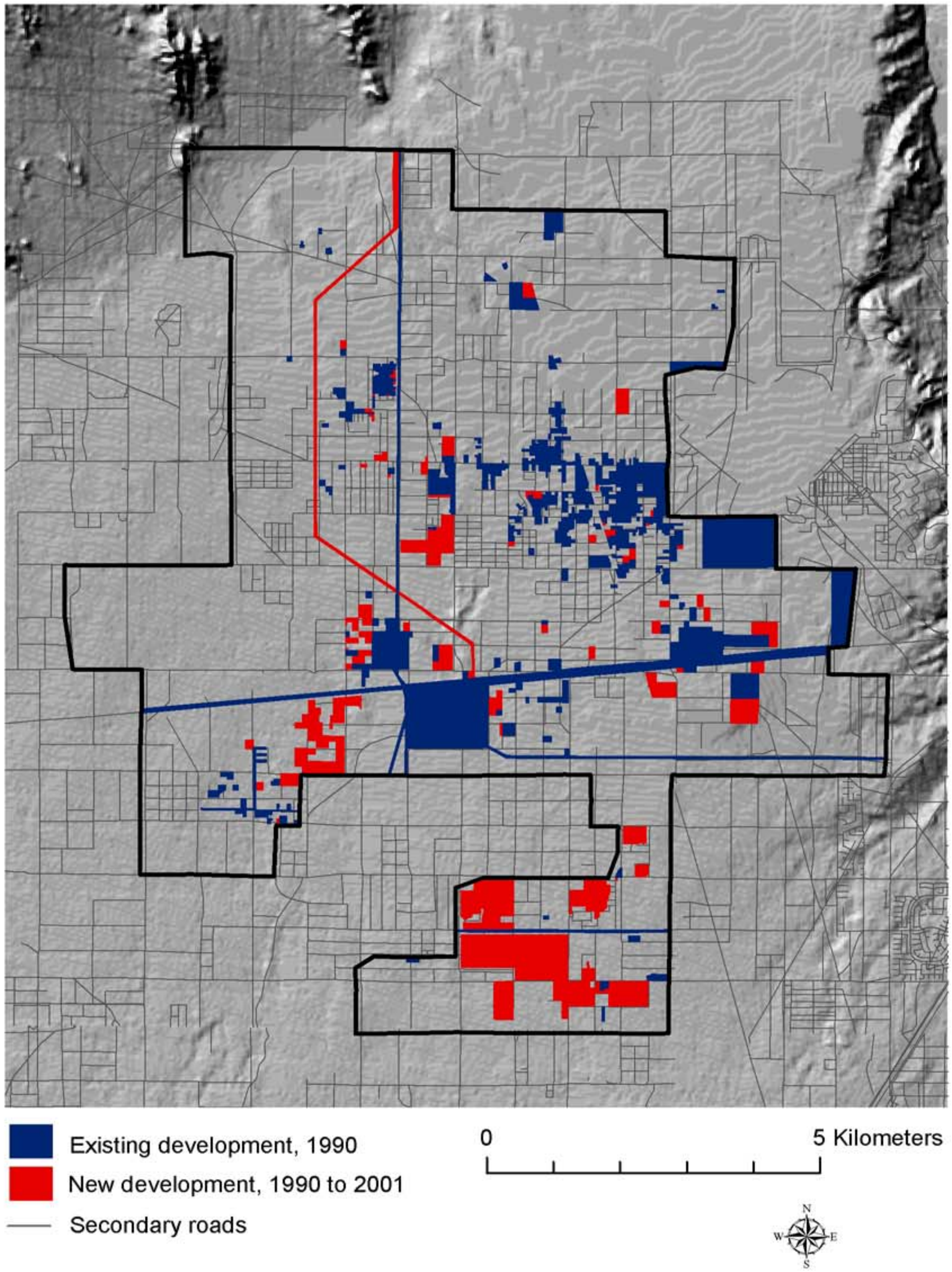

Fig. 4.1 New development between 1990 and 2001, Adelanto

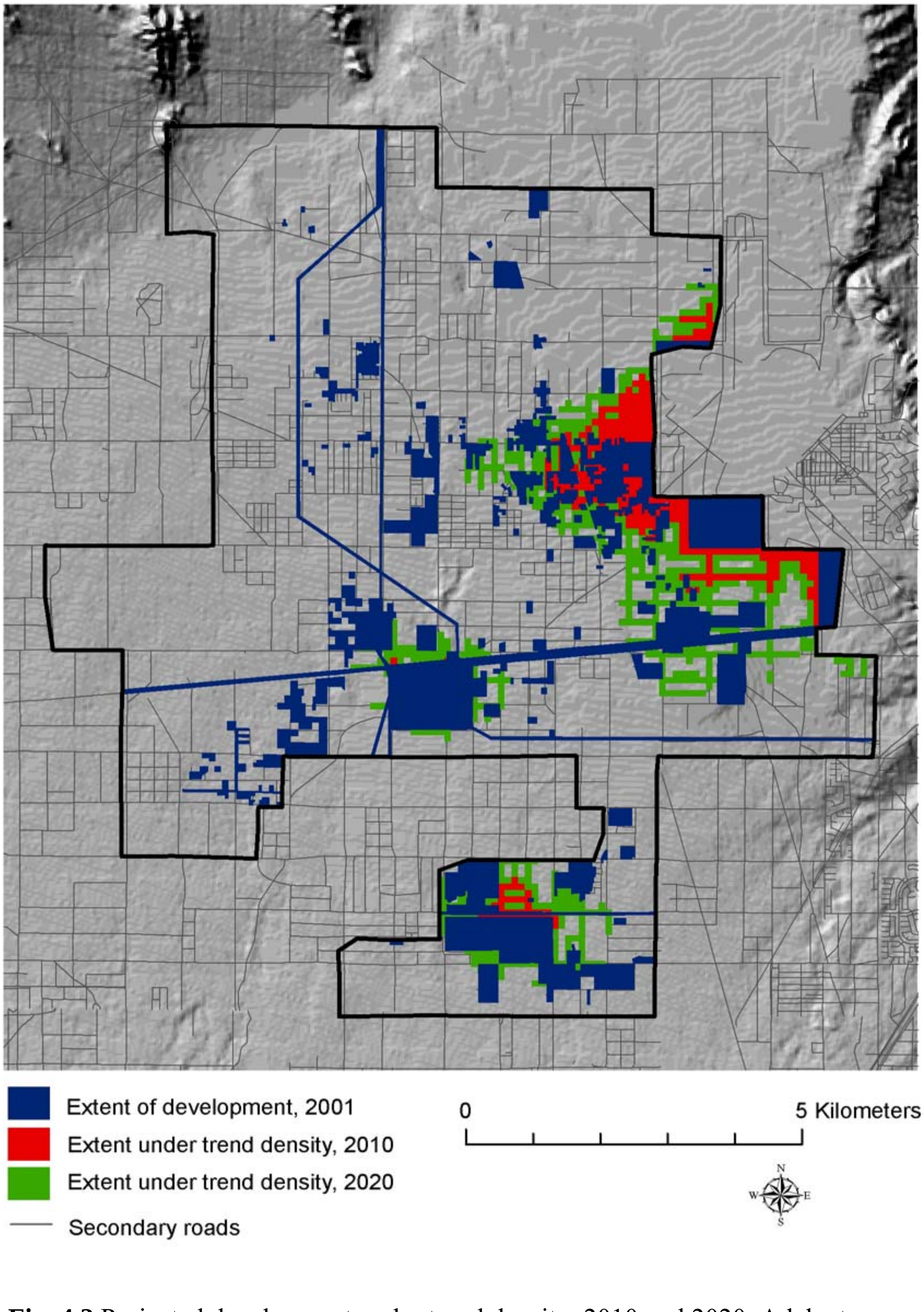

Fig. 4.2 Projected development under trend density, 2010 and 2020, Adelanto

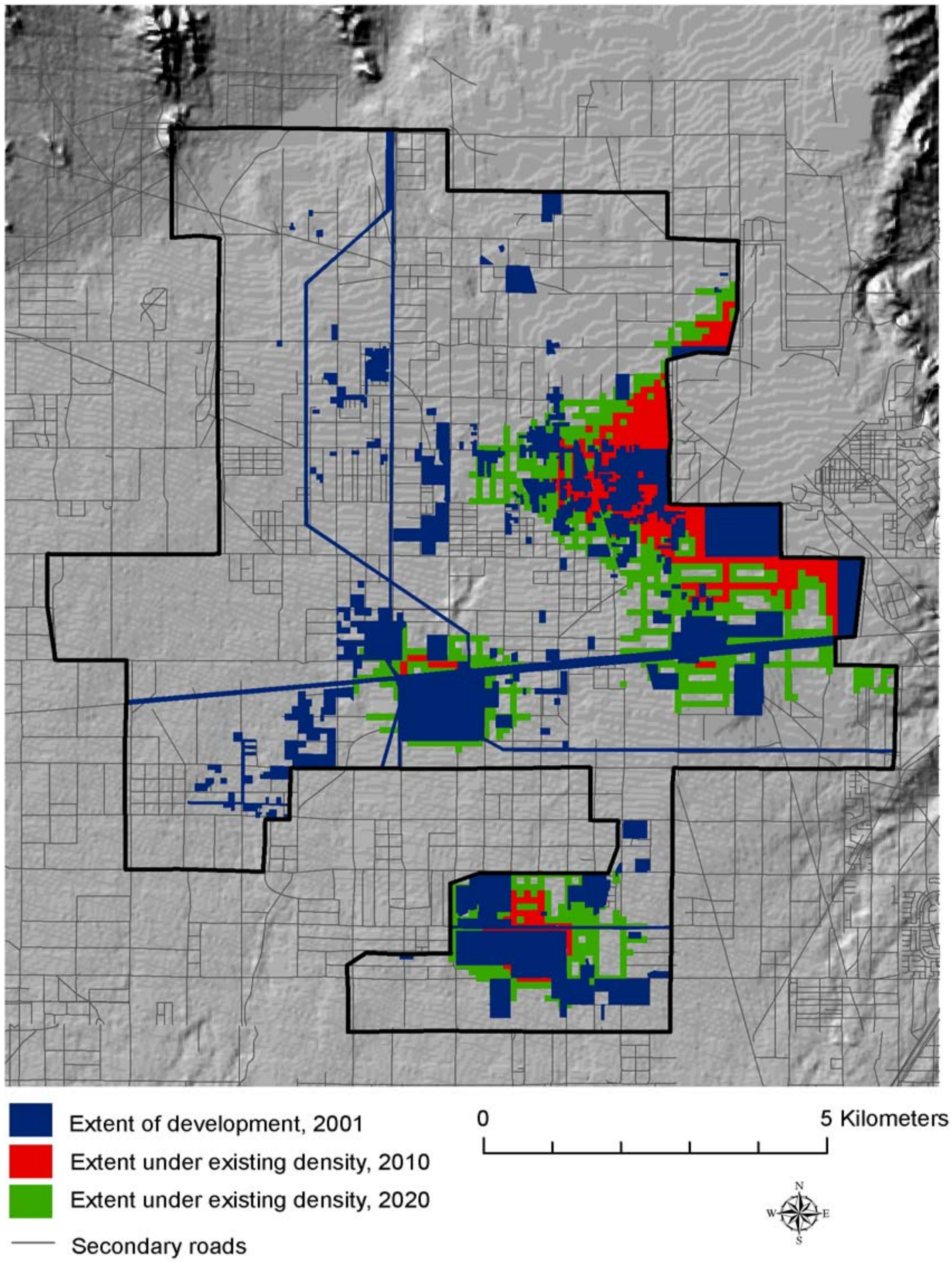

Fig. 4.3 Projected development under existing density, 2010 and 2020, Adelanto

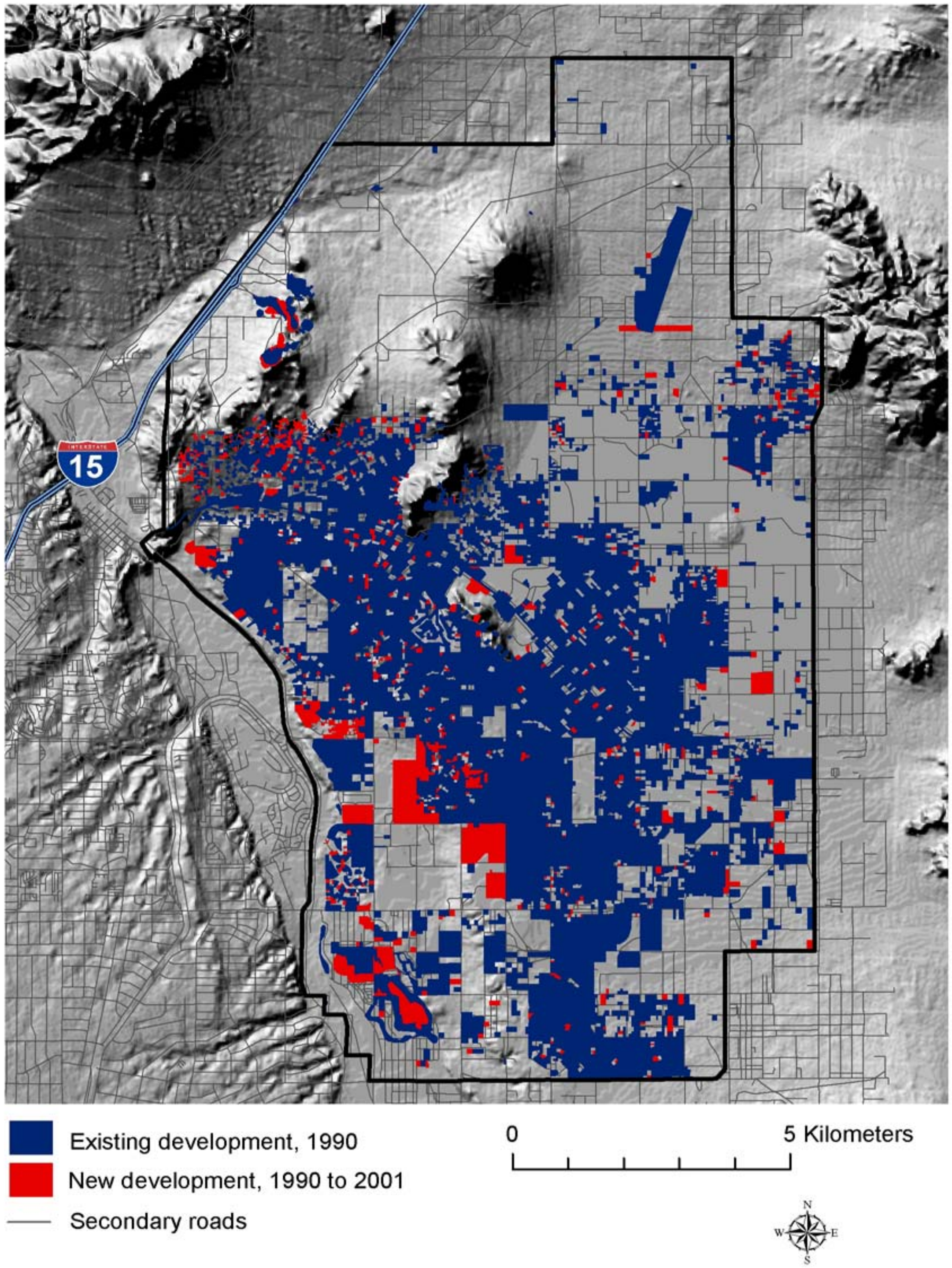

Fig. 4.4 New development between 1990 and 2001, Apple Valley

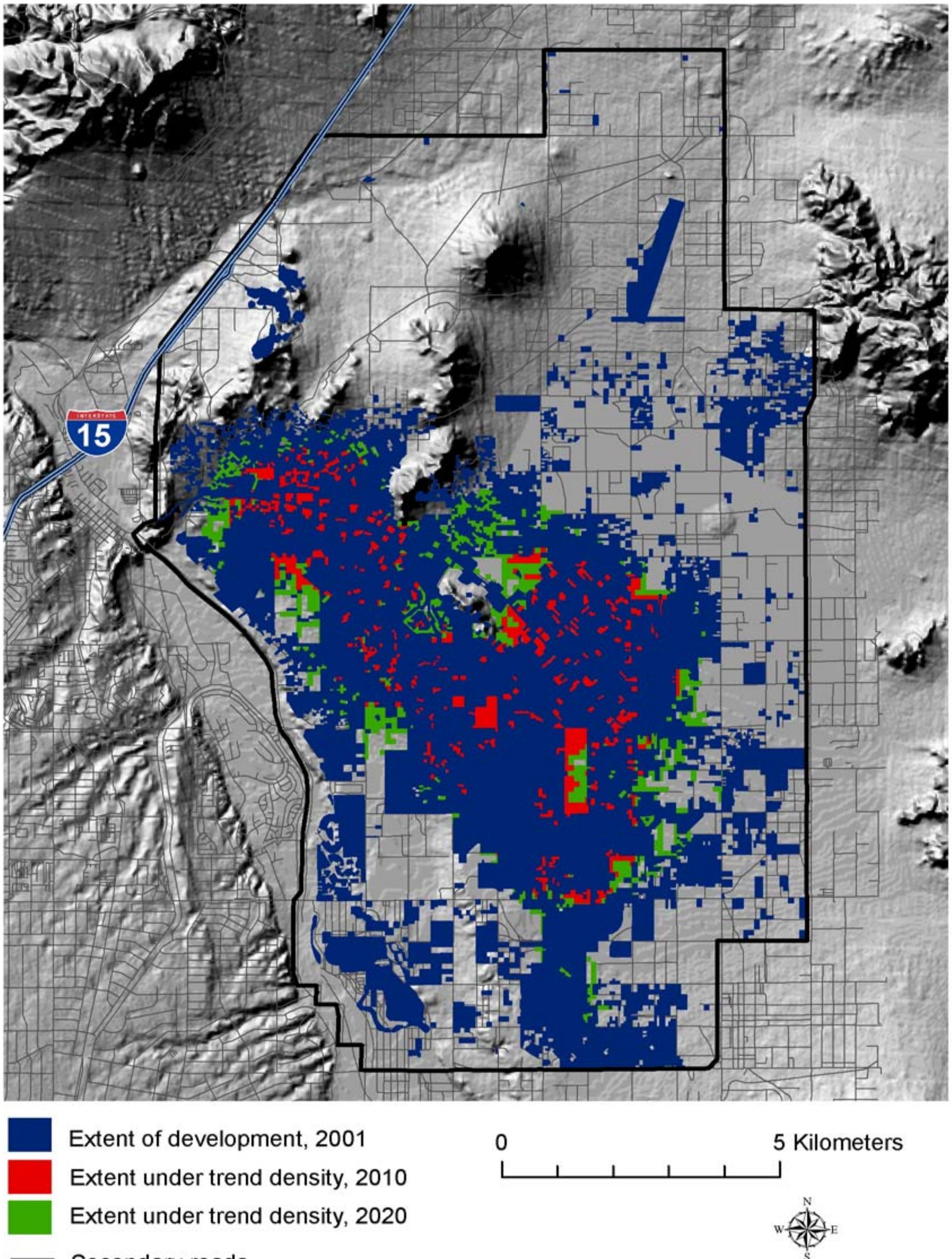

Fig. 4.5 Projected development under trend density, 2010 and 2020, Apple Valley

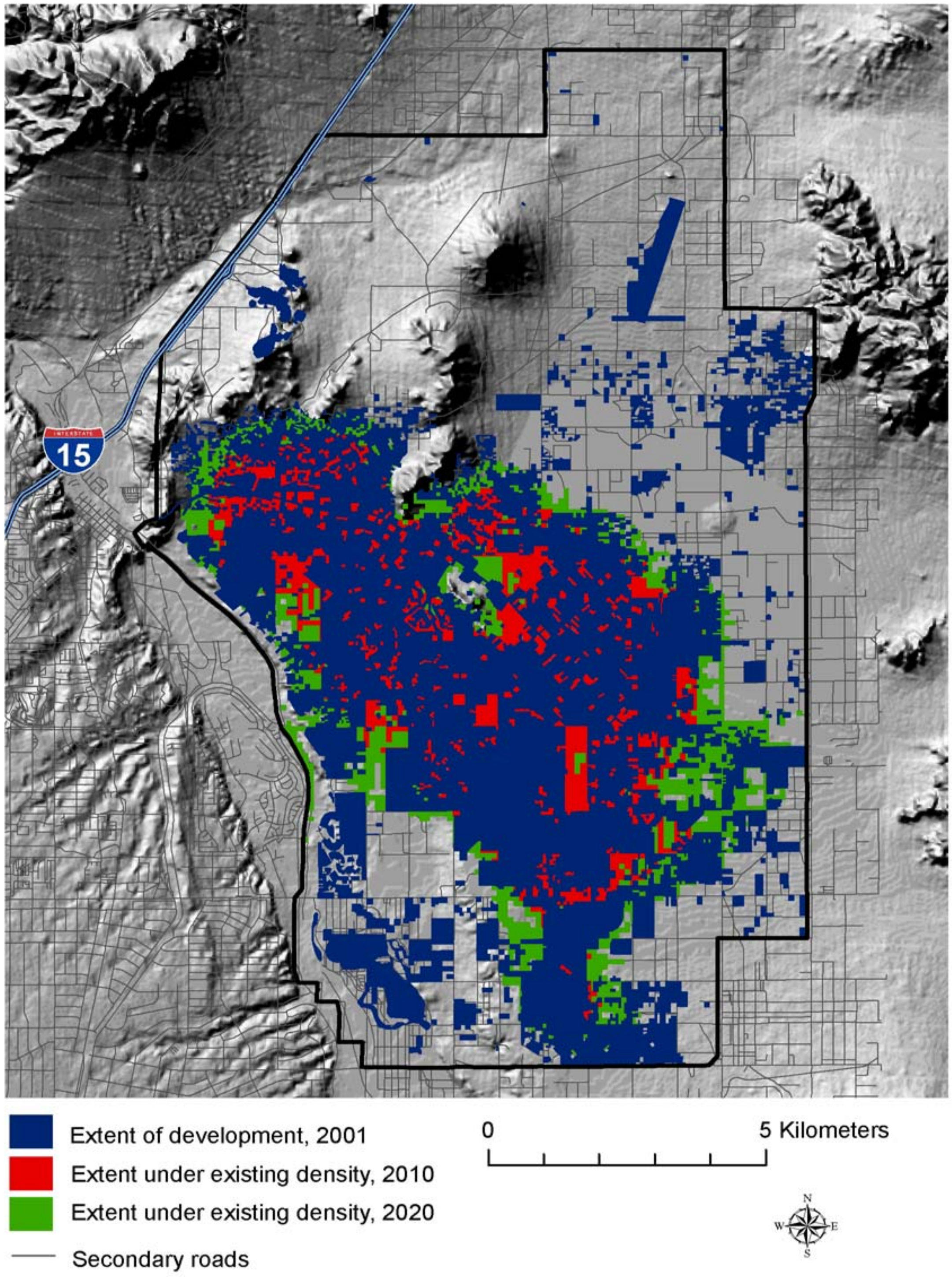

Fig. 4.6 Projected development under existing density, 2010 and 2020, Apple Valley

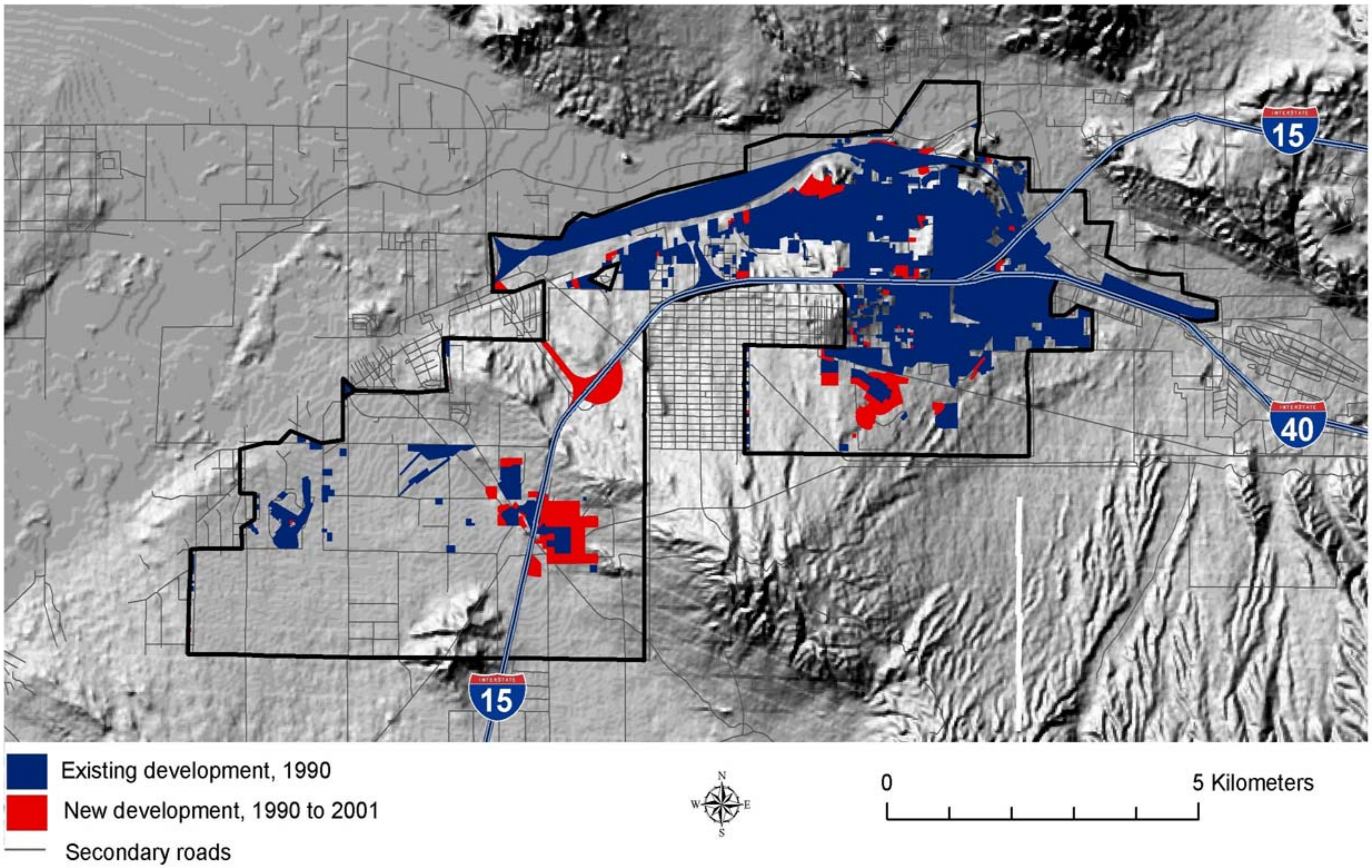

Fig. 4.7 New development between 1990 and 2001, Barstow

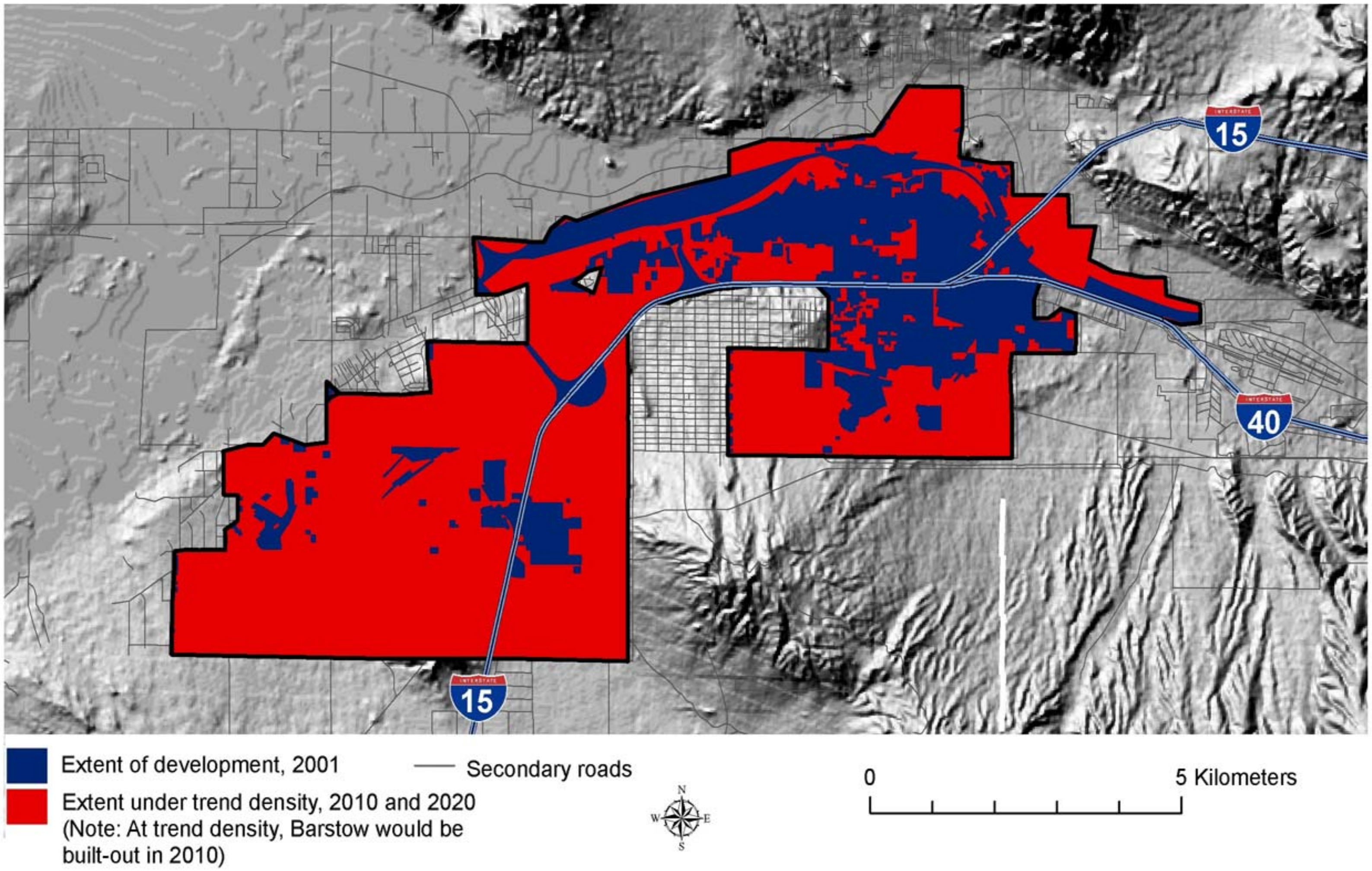

Fig. 4.8 Projected development under trend density, 2010 and 2020, Barstow

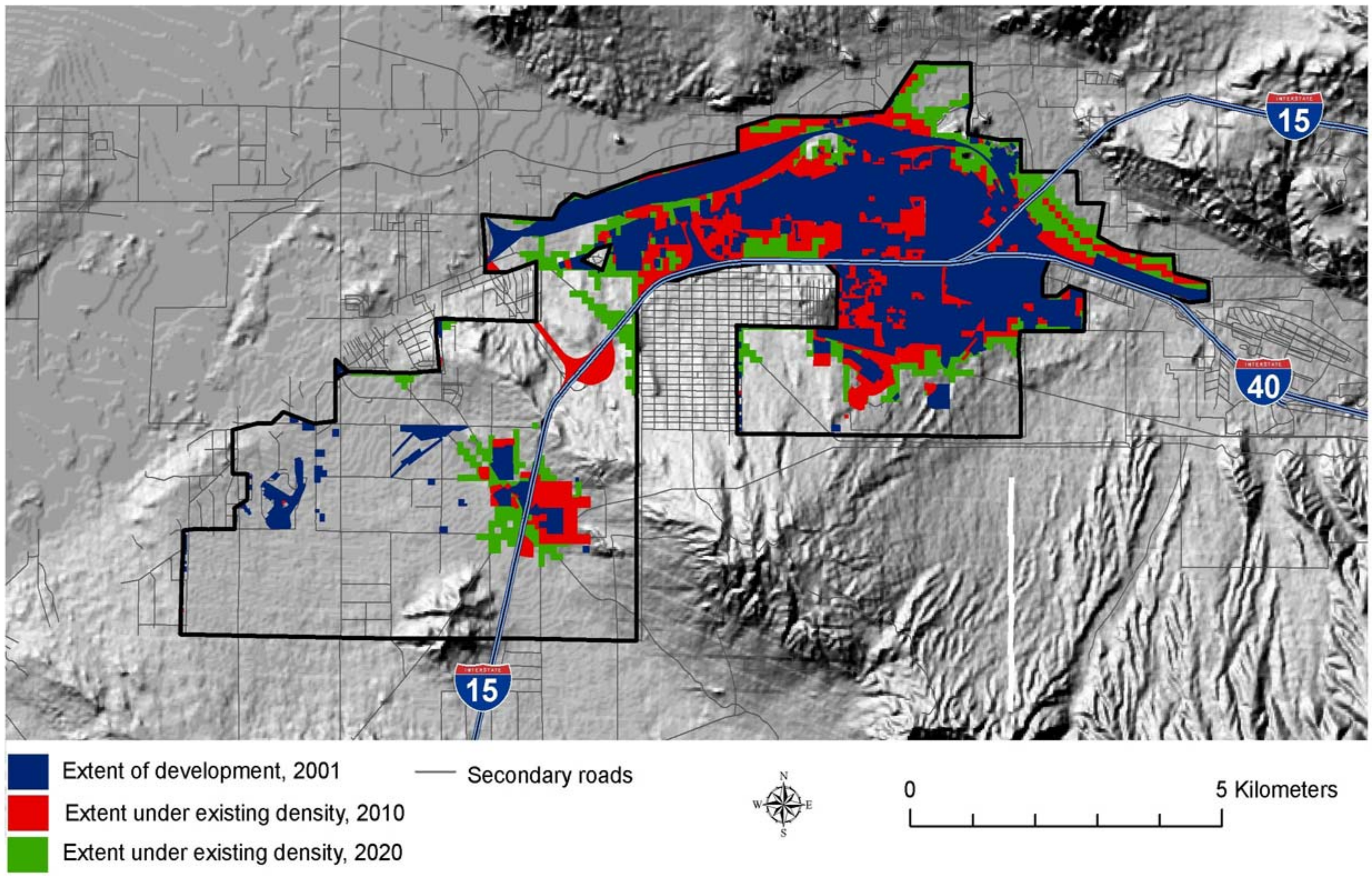

Fig. 4.9 Projected development under existing density, 2010 and 2020, Barstow

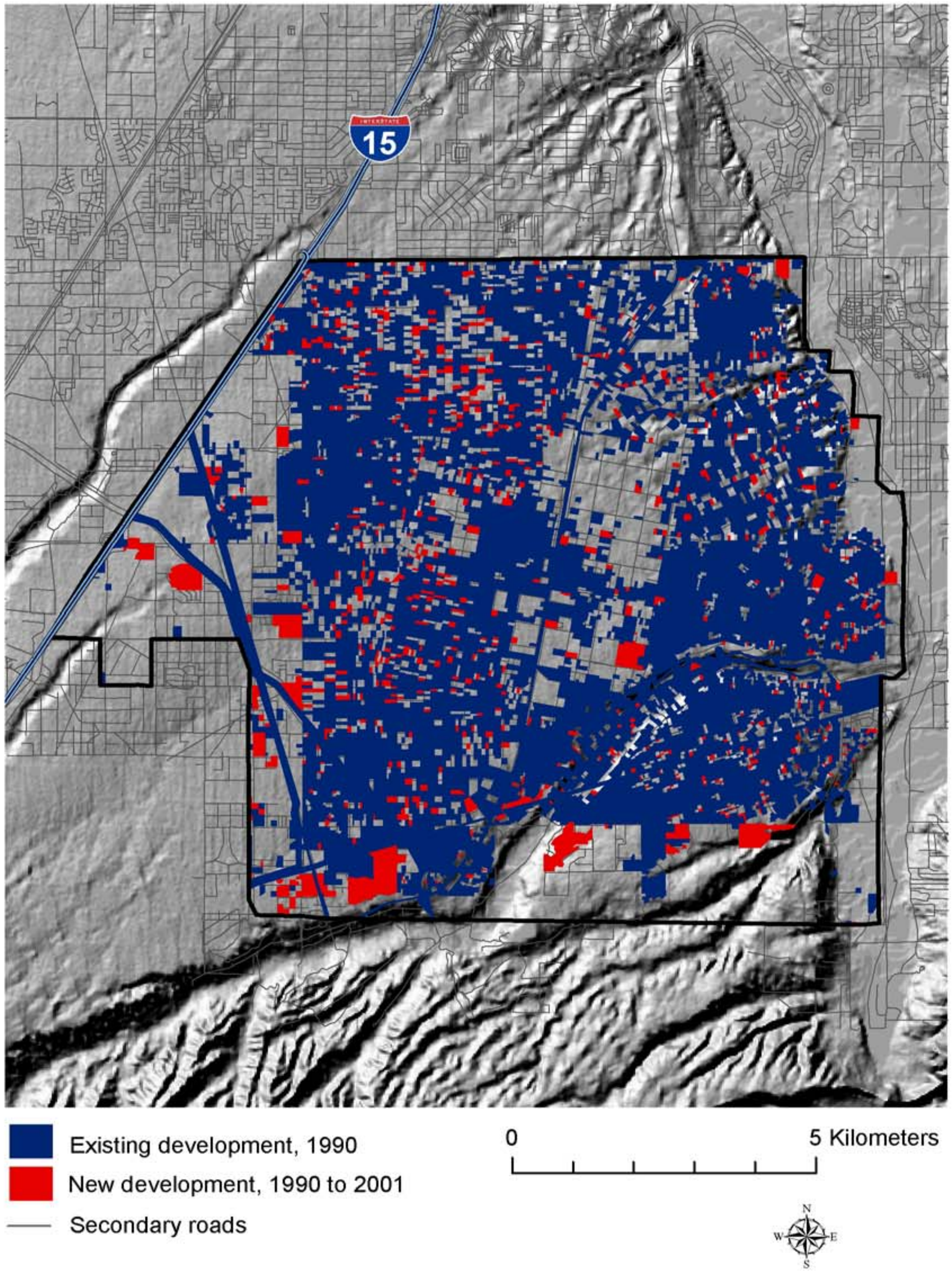

Fig. 4.10 New development between 1990 and 2001, Hesperia

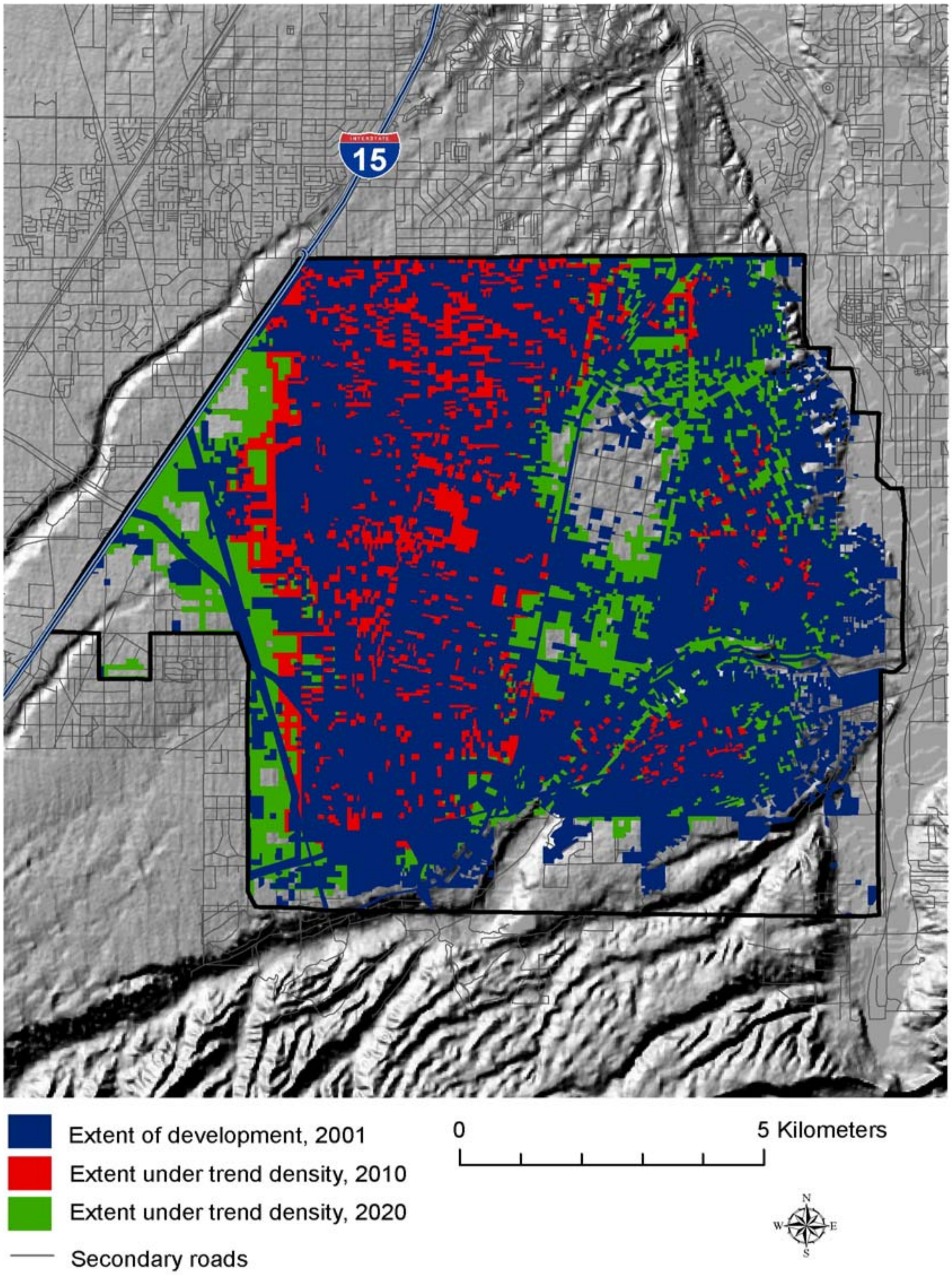

Fig. 4.11 Projected development under trend density, 2010 and 2020, Hesperia

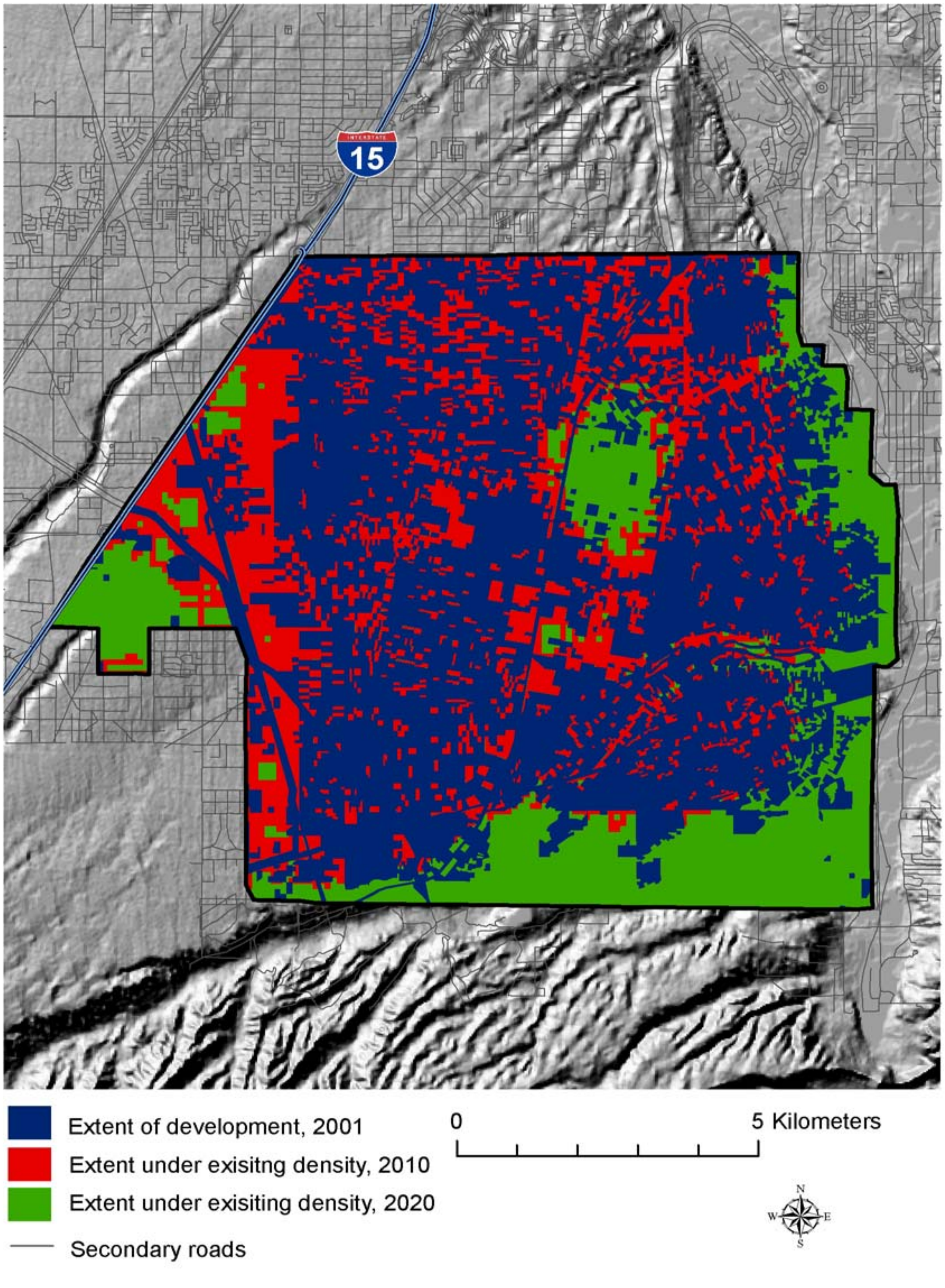

Fig. 4.12 Projected development under existing density, 2010 and 2020, Hesperia

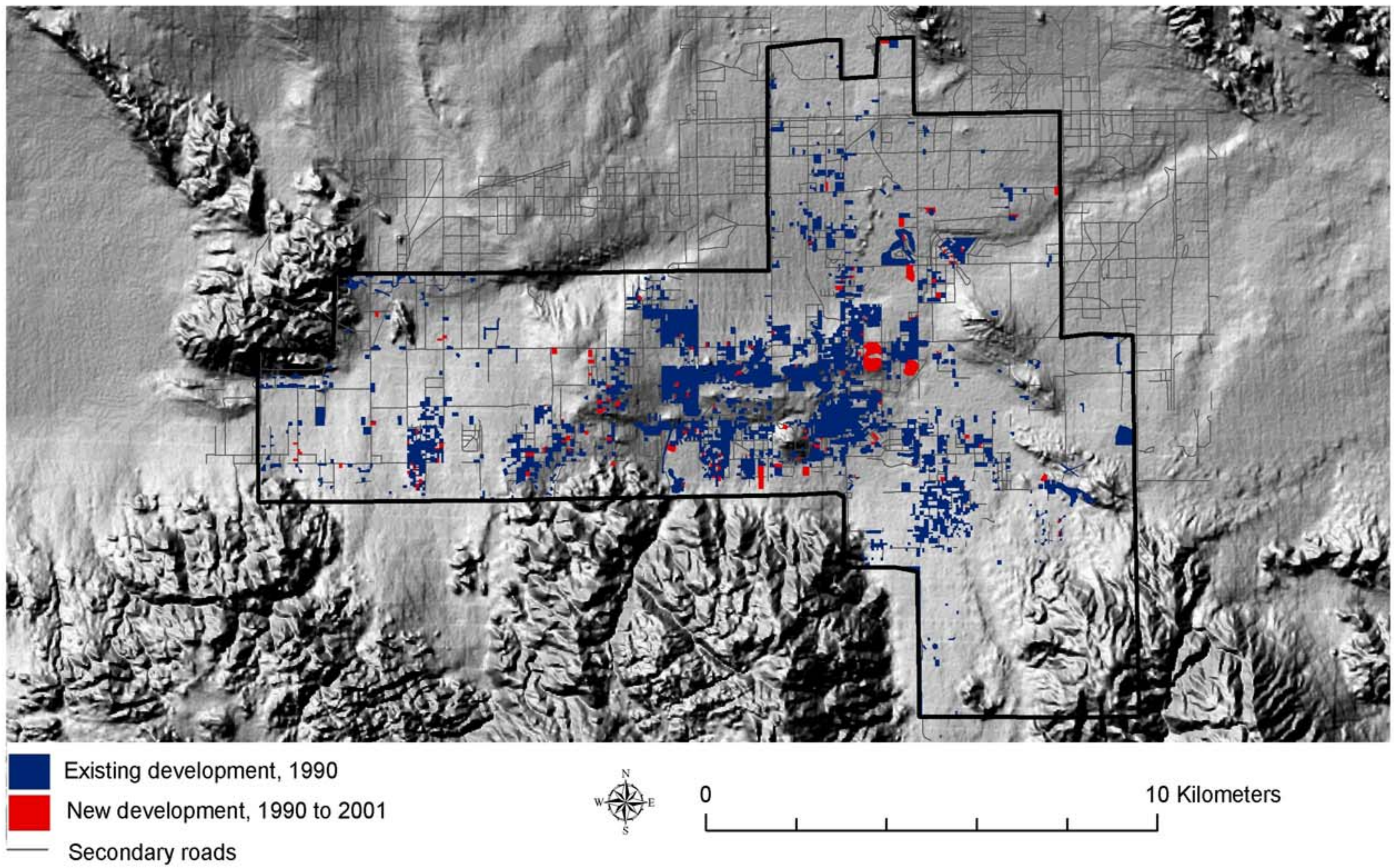

Fig. 4.13 New development between 1990 and 2001, Twentynine Palms

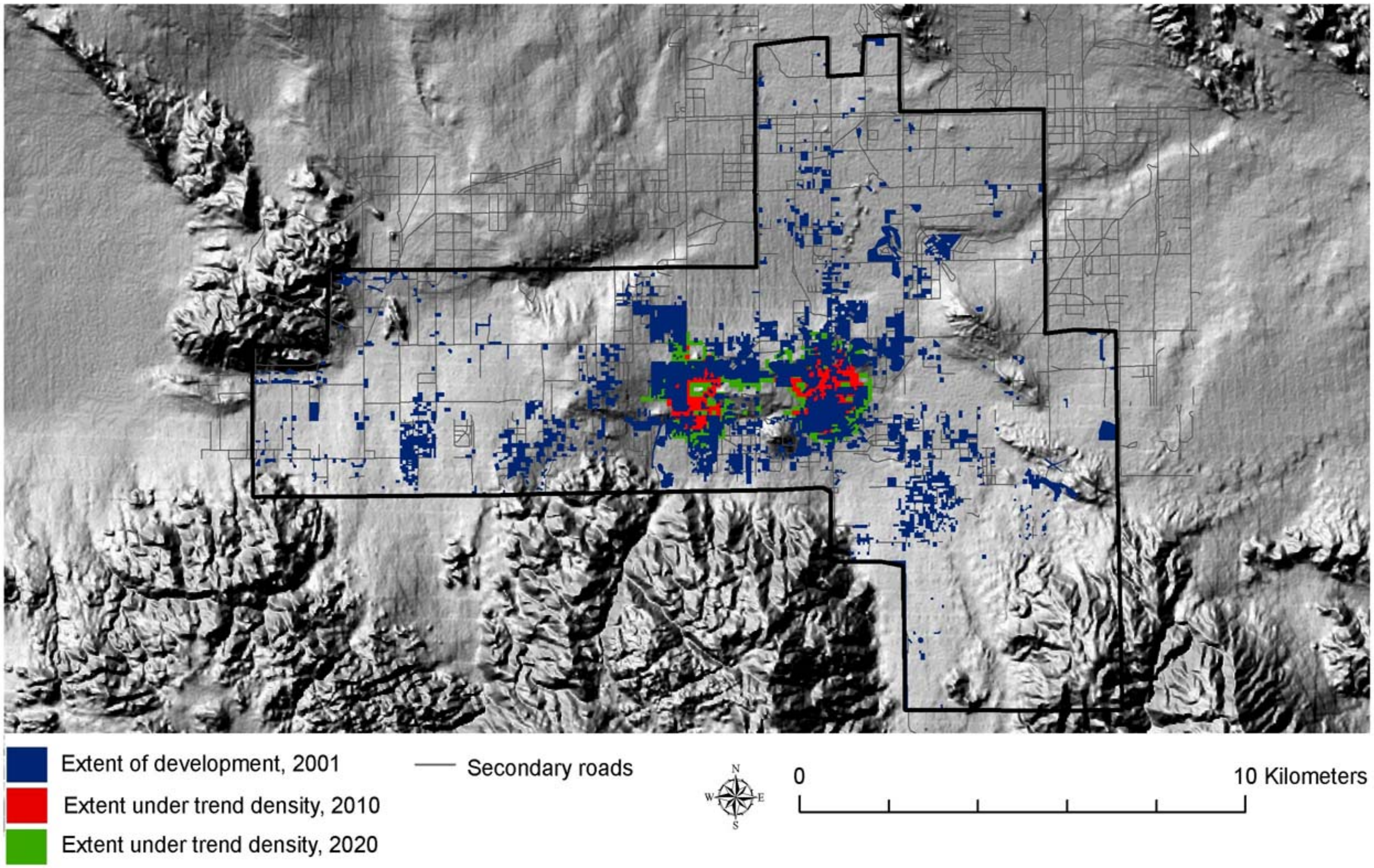

Fig. 4.14 Projected development under trend density, 2010 and 2020, Twentynine Palms

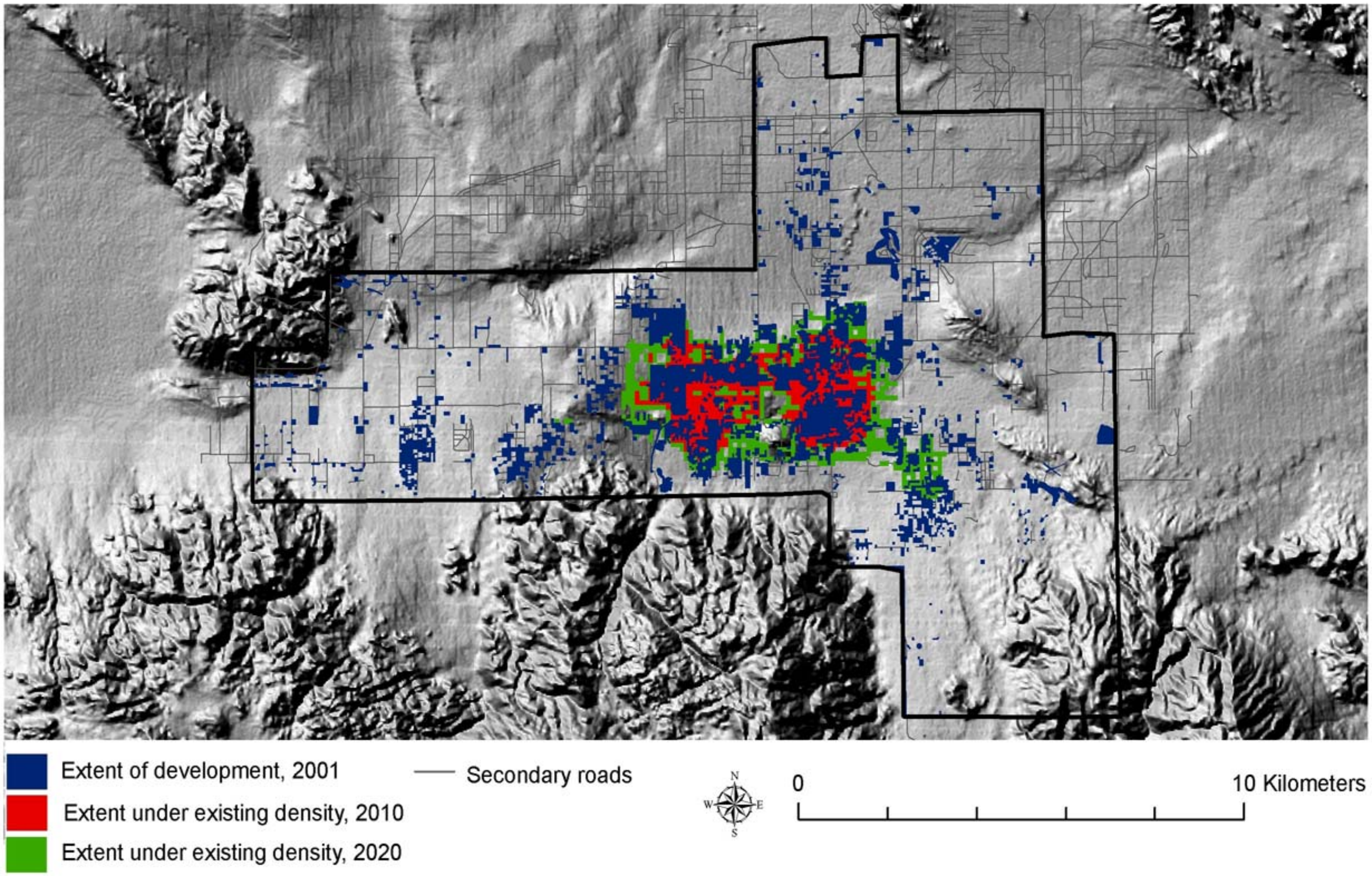

Fig. 4.15 Projected development under existing density, 2010 and 2020, Twentynine Palms

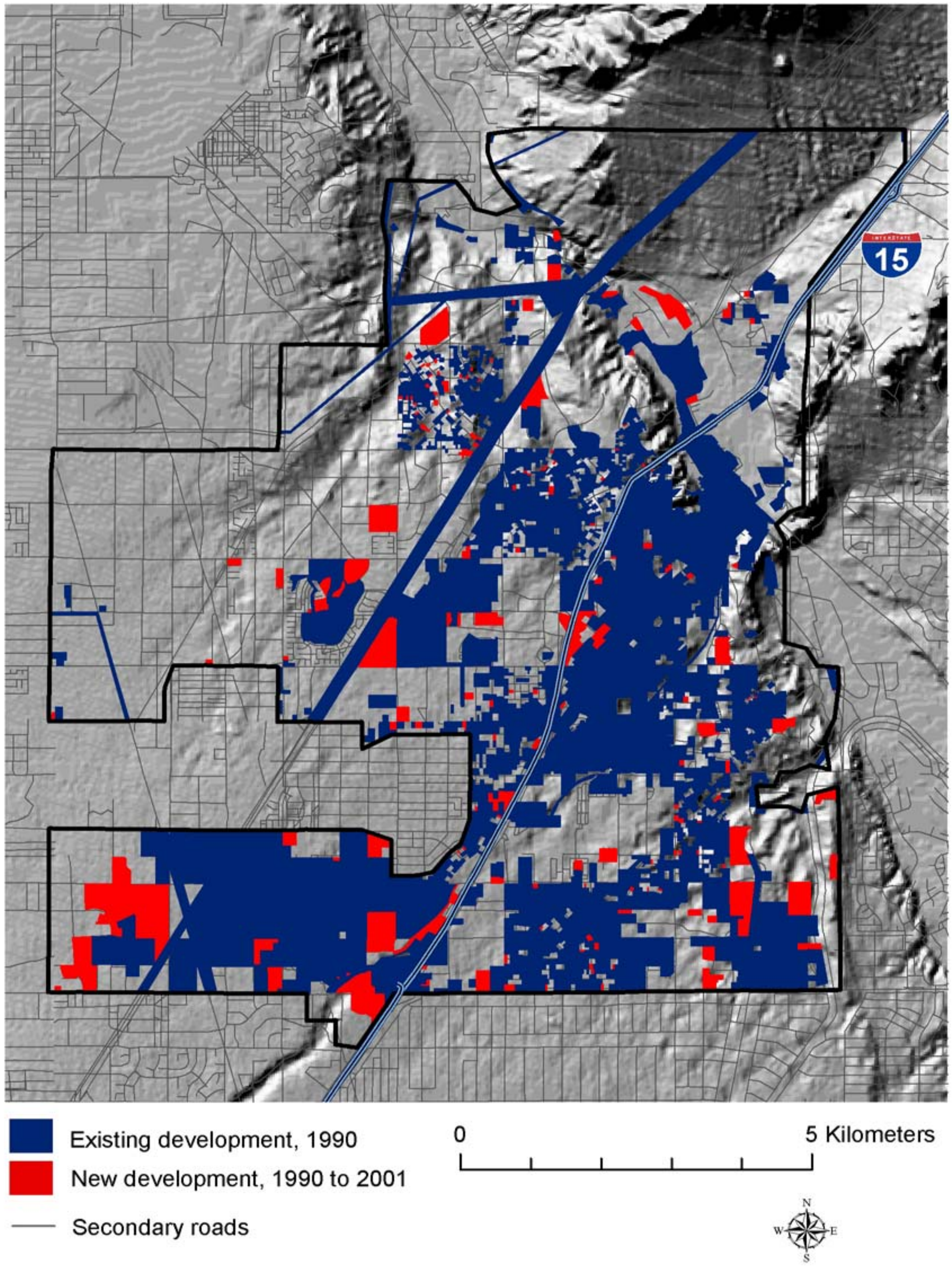

Fig. 4.16 New development between 1990 and 2001, Victorville

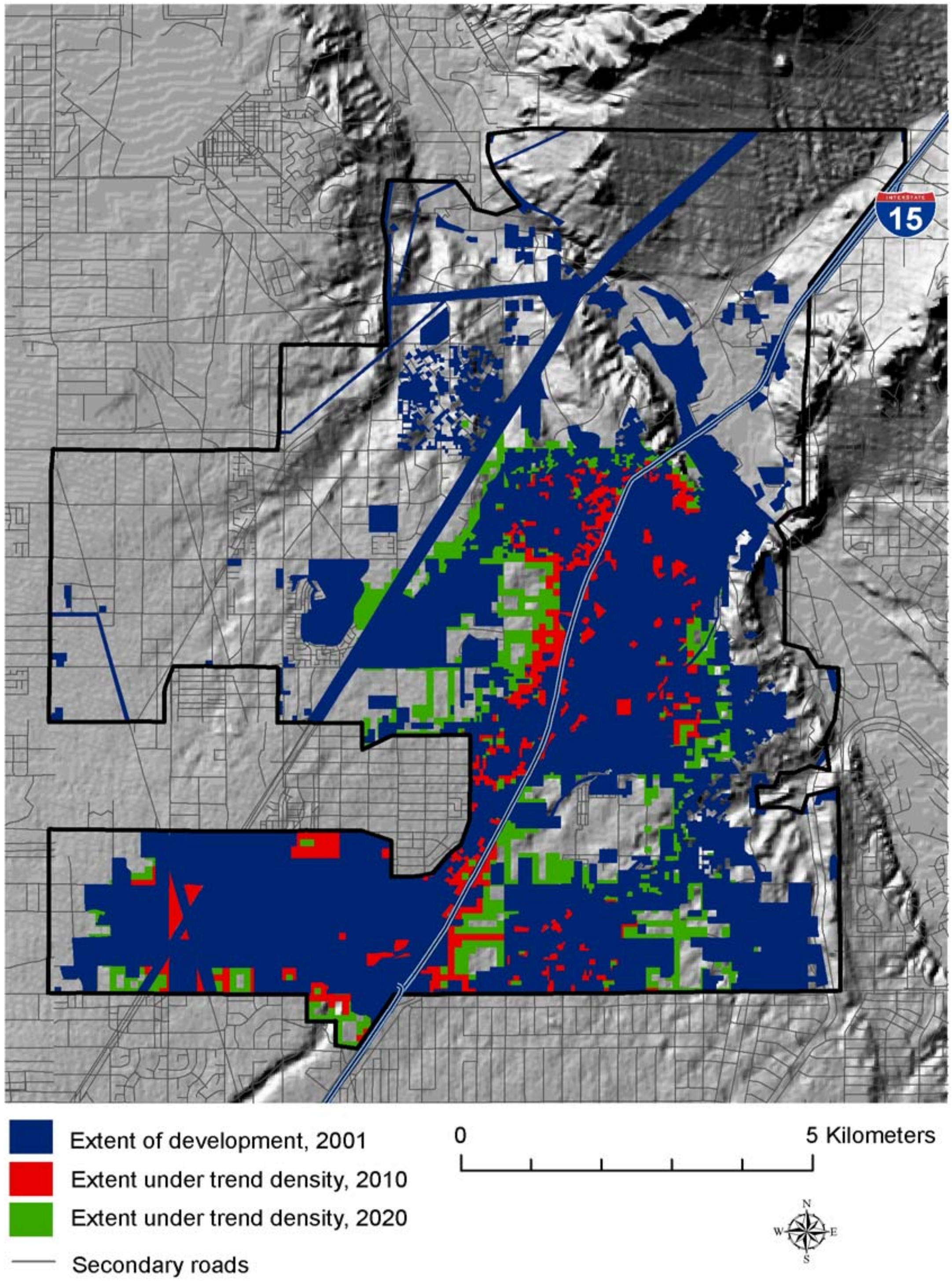

Fig. 4.17 Projected development under trend density, 2010 and 2020, Victorville

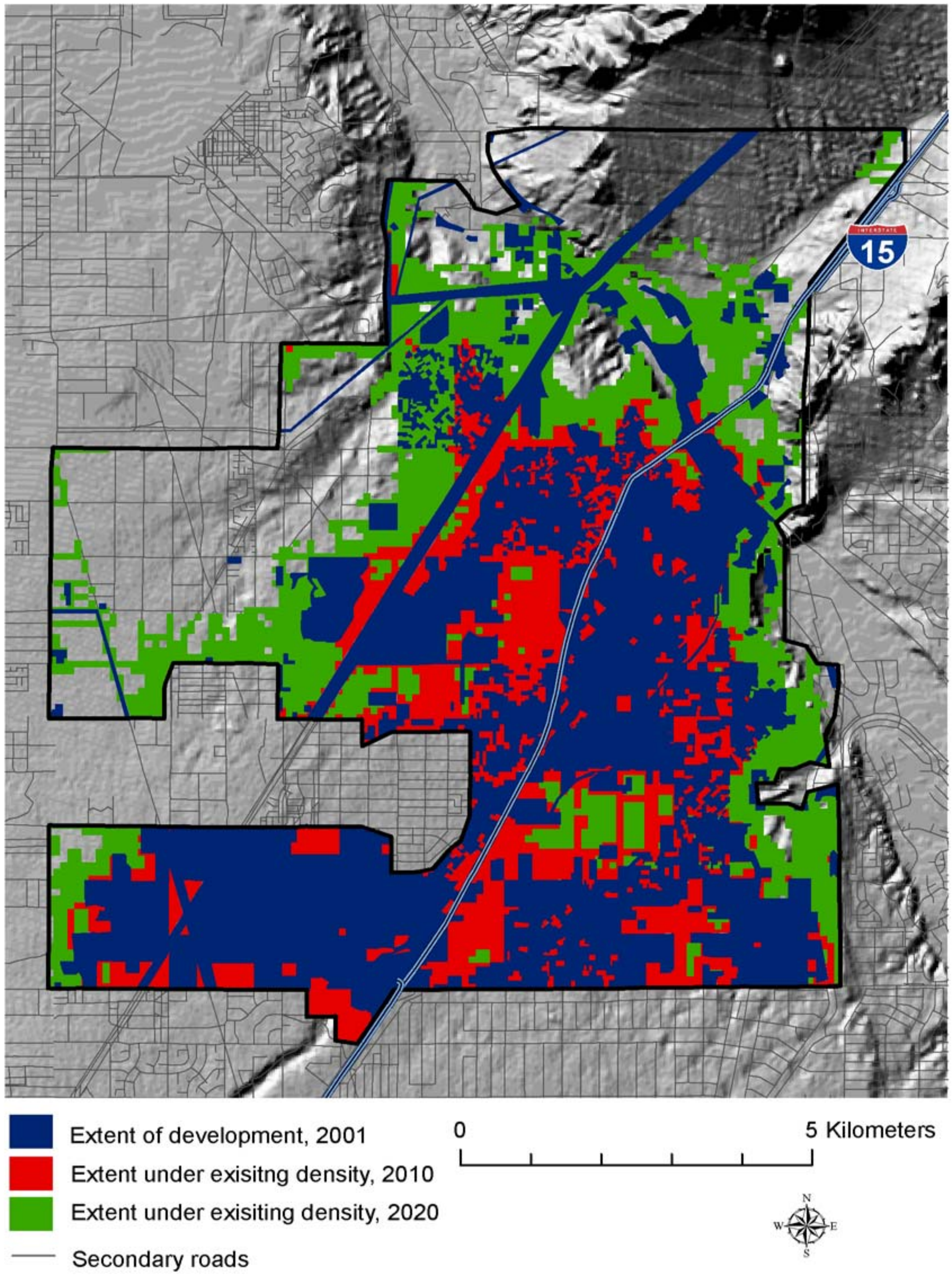

Fig. 4.18 Projected development under existing density, 2010 and 2020, Victorville

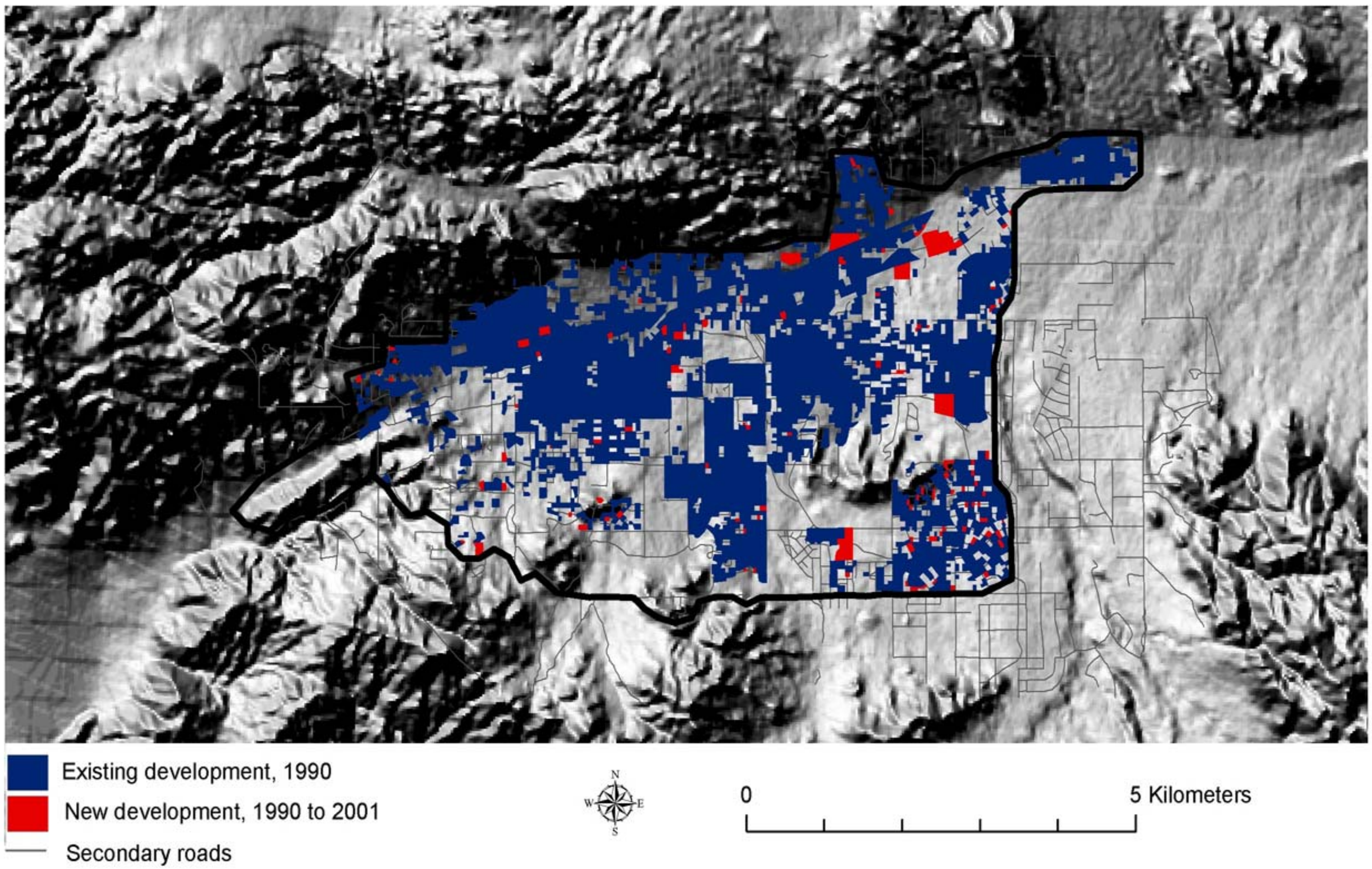

Fig. 4.19 New development between 1990 and 2001, Yucca Valley

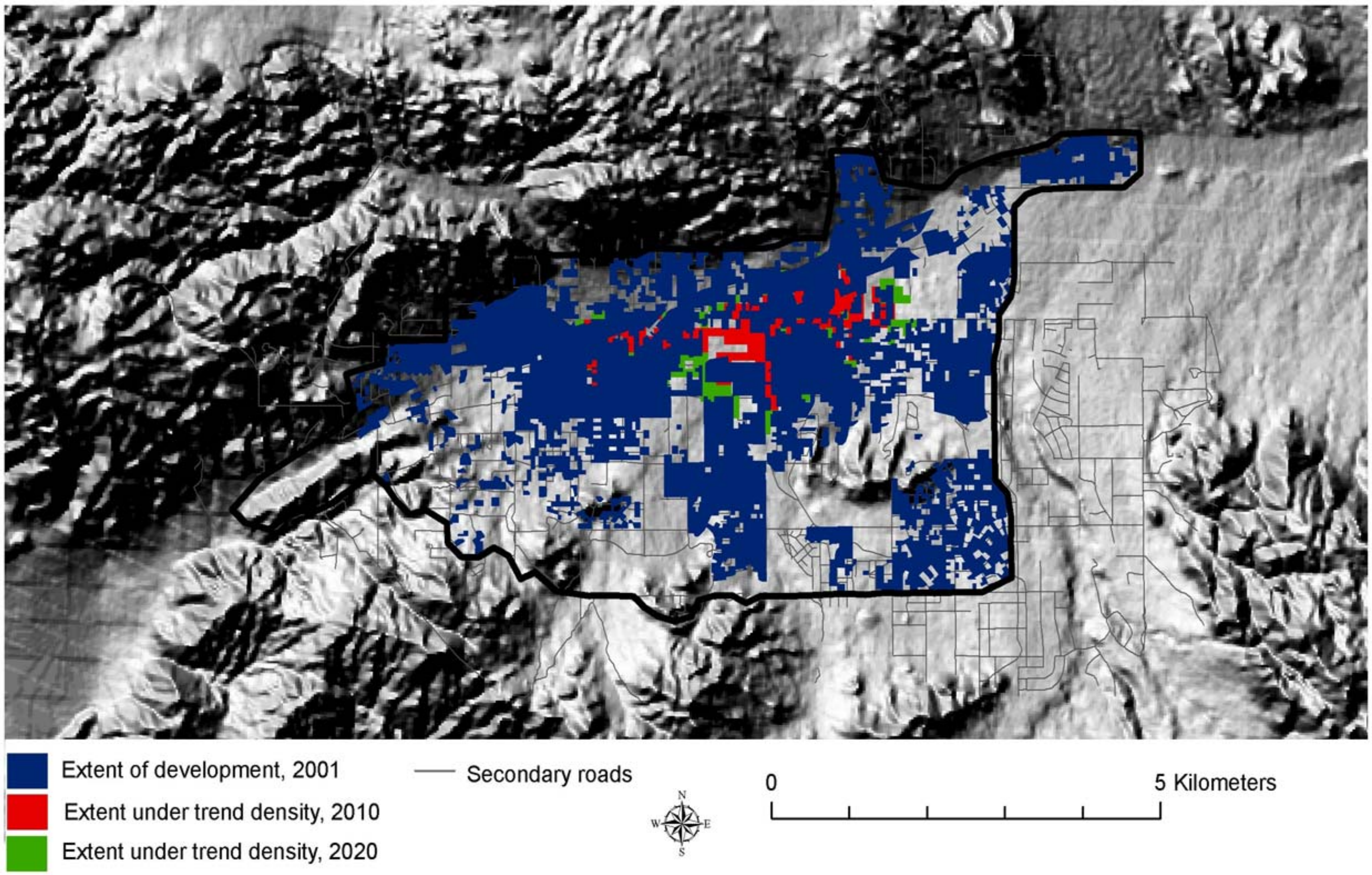

Fig. 4.20 Projected development under trend density, 2010 and 2020, Yucca Valley

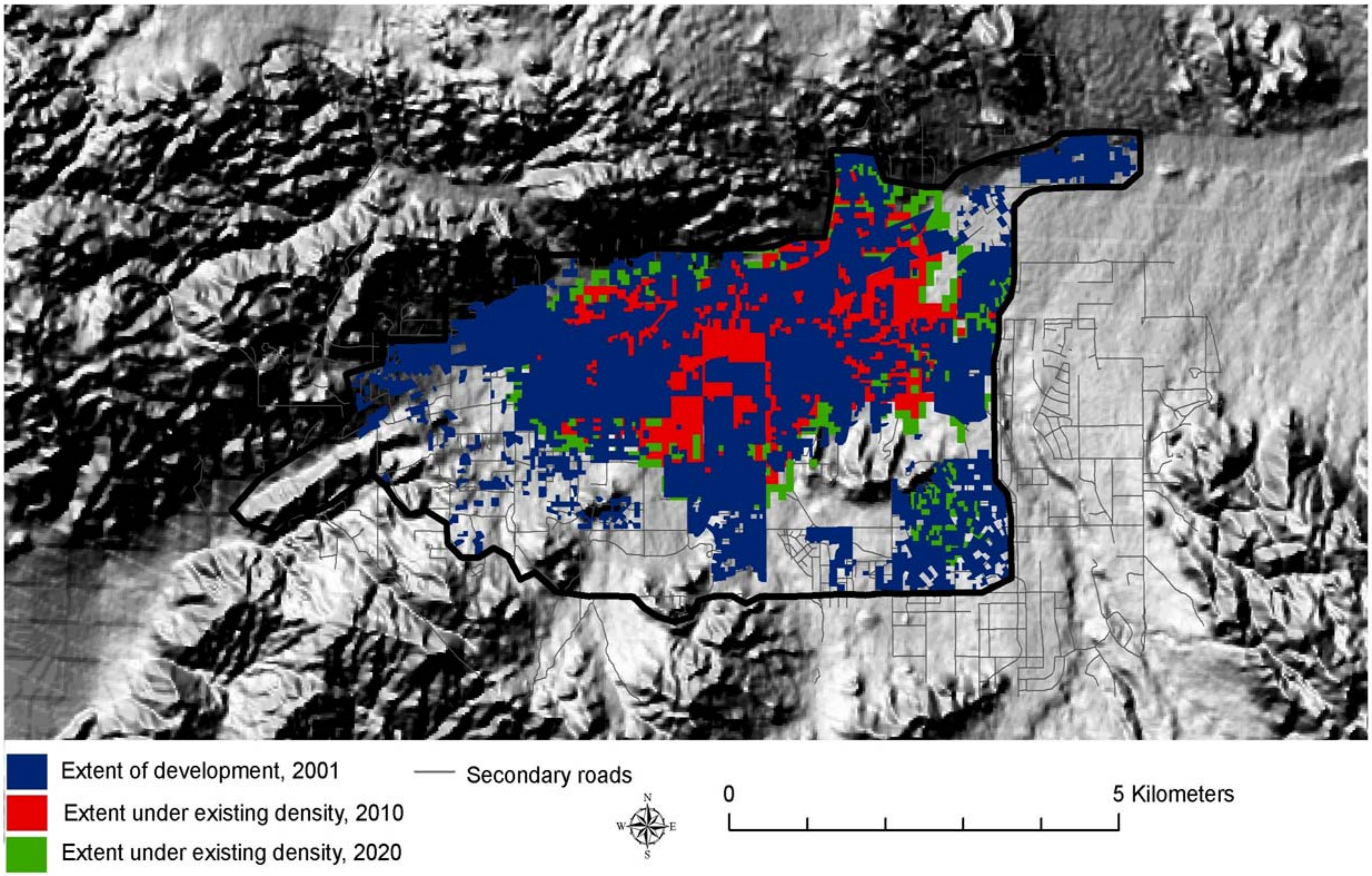

Fig. 4.21 Projected development under existing density, 2010 and 2010, Yucca Valley

CHAPTER 5

CONCLUSION

This research shows that the overall effect of the different settlement densities based on demographic trends results in less development of vacant lands under trend densities that incorporate demographic changes than under either existing densities or densities derived from previous research. Indeed, projecting settlement using trend densities as opposed to existing densities results in nearly 3,900 additional hectares of vacant land in the study area remaining undeveloped by the year 2020. Similarly, using trend densities as opposed to densities developed during past research results in over 22,000 additional hectares of vacant land in the study area remaining undeveloped by the year 2020.

Clearly, dividing a population into discrete categories based on projected demographic futures is one method of refining the data used to estimate settlement densities and the associated urban development. This sort of “fine-tuning” may provide a more accurate assessment of how a geographical region is settled by incorporating variables that have been unaccounted for in previous models. As one attempt at such fine-tuning, this research used demographics based on ethnicity, accounting for potential differences in settlement densities between Hispanics and White non-Hispanics. The model may be especially applicable for areas that are undergoing sizeable increases in projected population, such as the Mojave Desert region of San Bernardino County, for which that projected population can be separated into clear socio-demographic characteristics. The model may be less applicable for areas that have stagnant or small projected population growth and, therefore, a correspondingly small need for further development.

The research looked at the differential settlement densities based on current trends and demographic variables, and the loss of vacant land in the region due to population projections and associated development. Throughout this research, the implicit assumption was made that once a parcel of land became developed, it would remain developed. While this may be the overall tendency of land development, it is not an unbreakable rule. For example, if a cellular automata model were used, parcels of land could be shifted from a developed status to a non-developed status, as detailed above. Whereas most areas that have been developed remain in that condition, should parcels become redeveloped at sometime in the future, open space and altered settlement densities based on specific demographic variables could be incorporated into urban growth plans. As an example, parcels of land that once had a given settlement density could be altered so that the overall density remains the same, but new opportunities for open space creation are realized. Tools such as cluster zoning, as described above, which are used to preserve open space and vacant land may also be used to preserve "newly created" open spaces that may result from redevelopment.

Both a strong point and a shortcoming of this research is that it was limited to seven communities in the Mojave Desert region, so to some degree loss or preservation of vacant land are functions of decades of past planning and urban development in this area. However, this holds true for any similar research. City plans were developed and initiated at times when open space preservation may not have been of as much concern as it is today and before the state legislature required consideration of open space in county general plans.

If, however, in the course of planning for future growth in the region, construction of entirely new cities in currently unincorporated areas is proposed as one way of accommodating greater numbers of people, the sort of “fine-tuning” of data would be just as appropriate as it is in the case of the seven communities.

Suggestions for Further Research

This research altered projected settlement densities based on ethnicity. There are, however, many different variables that may be used to divide a population into discrete categories and then design a plan that would optimally accommodate new population growth. For example, economic differences could be used, given the hypothesis that persons of lower economic status may be more inclined to live in areas of high densities due to financial necessity.

This sort of economic differentiation could be refined even further by examining potential differences in settlement densities based on economic class as well as ethnicity, and perhaps even further refined by examining the differences in fertility, family size, and potentially household size based on the temporal distance between data collection and the period of a person’s or a family’s immigration. Fertility rates typically decline in the generations after a family immigrates to the U.S., so that family sizes decrease between, for example, first generation Americans and third generation Americans. If an area expected to receive a constant inflow of international immigrants, this declining fertility may be reflected in housing that provides higher-density options for immigrants but also lower-density options for the children and grandchildren of those immigrants.

Most research rests on assumptions that are functions of the available data. These assumptions often can be altered in ways that would cause the corresponding results to vary. This research is no different. Below are a few suggestions on altering or reexamining assumptions in ways that may lead to a more accurate depiction of how the Region is settled and how much land is converted from open space into a developed status.

Baseline year assumptions. When determining the timeframe in which to study urban development in the Mojave Desert of California, Gonzalez (2001) and Hunter and others (2003) were constrained by available data. Aside from the fact that data were available for the early and late periods, there was no *a priori* rationale for selecting those dates. Likewise with this research, 1990 and 2001 were used as beginning and ending years because the data for that time period were available.

Over time, urban development does not occur in a uniform trend, but rather a series of trends that depend on, among other things, resource availability, transportation routes, incomes, planning and zoning changes, and social factors. Indeed, Hunter and others (2003) noted that the "spatial pattern of … land-use changes is shaped by a framework of environmental regulations and planning restrictions, as well as being influenced by bio-physical characteristics and existing physical infrastructure."

Gonzalez (2001), Hunter and others (2003), and this research assumed that land development and population growth in the study area were uniform over the study period, ignoring the possibility and potential influences of intra-period variability—e.g., that the majority of growth may have occurred in the first five years or in the last five years of the time period that was examined. More detailed research may have determined urban development patterns before and after a significant economic or social event, such as the OPEC oil embargo in the early 1970s. Again, however, such data are not readily available and may be cost prohibitive to obtain if they exist at all.

A better method to use in understanding the development in the Mojave Desert may be to learn more about the drivers of growth in the past. This would entail research into development patterns over time and probably would be segregated most easily using discrete time periods based on, for example, economic cycles or technologies that would affect development.

A key technology to consider might be vehicle transportation. Before automobiles became readily available in the 1920s, the region may have had a distinct development pattern based on rail transportation. A new pattern may have predominated between the 1920s and the late 1940s and 1950s, when automobile use became widespread (Jackson 1985). The years between the 1950s, when the interstate highway system was developed, and the present could be split into segments that would exhibit individual trends. Whereas focusing on the triggering effects of automobile use and availability might not account for all temporal variation in development patterns, it may provide a more accurate assessment of the precursors of current development, and how development may change in the future.

The use of 1970 or 1990 as baseline years presumes that the reasons people chose to live in the Mojave Desert then resemble the reasons they choose to live there now. Darlington (1996) notes that in the past, the desert had the reputation of being a god-forsaken wasteland. Some, perhaps most, people avoided the Region for that reason. In the early 21st Century, however, given the rapid population growth in the Mojave Desert area (U.S. Census Bureau 2004), attitudes have changed. Hypothetically, growth in the Region may have increased over the years as people's perceptions of the attractiveness of desert living have softened and luxuries such as air conditioning have become more affordable. If the desirability of desert living continues to increase, the number of persons moving to the desert from other areas may continue to increase as well.

Demand for housing in the Region also may have shifted for economic reasons, as people who lived and worked in the Los Angeles Basin traded longer drive times to their places of employment for cheaper land available in the Region. Another possibility is that the Region has become economically independent and has undergone significant population growth, not because it is a satellite of Los Angeles, but because it has become an urban area unto itself. In this case, growth may be due to the fact the Region has crossed a given threshold of population, not because it serves mainly as a bedroom community for Los Angeles.

Adequate water assumption. Increased aggregate demand for water by a growing population, combined with a decrease in supply and/or an increase in water costs have not been accounted for in the model. Developing a model based on water availability may be difficult, if not impossible, due to the uncertainty in the water supply. An area with ample water probably would be developed, all else remaining equal, sooner than an area that has water shortages. However, there is no indication of how low a water supply has to go before triggering a slowing or stopping of development. The adage "water flows towards money" may be true up to a point, but there is no way to gauge adequately when that point is reached. That is, there is no way to predict the point at which supplying an area with sufficient water becomes so economically infeasible that growth and development are reduced if not eliminated.

In addition, a dwindling water supply may trigger the development of technologies that either make better use of the water or find more economical ways of recycling waste water for future use. These new technologies would increase the de facto supply of water, thereby, one can assume, increasing the number of persons who can settle in a given area.

Changes in transportation. The model does not account for changes in transportation routes or methods. Current research is examining the potential for using magnetic levitation (MAGLEV) systems to provide high speed transportation for commuters throughout the Los Angeles area. The MAGLEV system may link West Los Angeles to Ontario, California by 2018, and a link between the cities of San Bernardino and Victorville is projected over the long term. In addition, a link between Anaheim in Orange County and Las Vegas is currently being studied. The route would cross the Region from Victorville to Barstow and would closely follow the interstate highway corridor.

Even though the MAGLEV system might not reach Victorville for decades, it may still have an effect on development in the Region. One can imagine commuters driving personal vehicles or taking public transportation from the Region to MAGLEV stations in Ontario or San Bernardino, then taking high speed transportation to their final destinations in the Los Angeles Basin.

In addition to the proposed MAGLEV system, SCAG has developed highway and arterial improvement projects. The projects include high-occupancy toll lanes and other upgrades to highway systems to accommodate the increase in vehicular traffic that accompanies population growth. In the Mojave Desert Region of San Bernardino County, these projects will include expansion of highways I-15 and US-395.

Changes in military presence. The military presence in the Region has been noted above. Given the current geopolitical climate, the U.S. may choose to increase the number of active military personnel, which may in turn increase the number of military personnel living in the Region. If the military bases were to expand, the number of civilians who worked for the military would also expand, increasing the growth in the Region.

Likewise, the federal government from time to time examines military base reductions and closures as ways of streamlining the federal budget. Depending on the end uses of the potentially closed bases, growth in the area may plateau or even decline.

Changes in immigration policy. The political climate in southern California and the U.S. as a whole at the time of this research has made immigration, and especially illegal or undocumented immigration from Mexico and Central America, a volatile issue.

Changes in immigration policy that are currently being debated in Congress, including construction of a wall along the U.S.-Mexican border or a temporary guest worker policy that would allow immigrants to live and work in the U.S. without obtaining citizenship, may result in fewer or more immigrants, whether they are documented or undocumented. Corresponding differences in the proportion of the future population that is Hispanic may therefore result.

REFERENCES

Agung AAG (2000) Grid-based urban growth model. Unpublished doctoral dissertation. Camden, NJ: Rutgers University

Anderson JR, Hardy EE, Roach JT, Witmer RE (1976) A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964. Washington, DC: U.S. Government Printing Office

Batty M, Xie Y, Sun Z (1999) The dynamics of urban sprawl. Center for Advanced Spatial Analysis Working Paper Series. Paper 15

Batty M. (1997) Cellular automata and urban form: a primer. Journal of the American Planning Association 63(2):266-74

Berry D (1976) Preservation of open space an the concept of value. The American Journal of Economics and Sociology 35(2):113-124

Blewett R, Lane J (1988) Development fights and the differential assessment of agricultural land: fractional valuation of farmland is ineffective for preserving open space and subsidizes speculation. American Journal of Economics and Sociology 47(2):195-205

Borjas, GJ (1994) The economics of migration. Journal of Economic Literature 32(4):1667-1717

Bowler C (1997) Farmland preservation and the cluster zoning model. Journal of the American Planning Association 63(1):127-8

Brandenburg A, Carroll M (1995) Your place or mine?: The effect of place creation on environmental values and landscape meanings. Society and Natural Resources 8:381-398

Brown D (2001) Sprawl in rural America: What it is and how it affects communities. Small Town. March/April, 2001:4-11

Burby R, Nelson A, Parker D, Handmer J (2001) Urban containment policy and exposure to natural hazards: Is there a connection? Journal of Environmental Planning and Management 44(4):475-90

Burchfiel BC, Davis GA (1981) Mojave desert and environs. In The Geotectonic Development of California, edited by W.G. Ernst. Prentice-Hall, Inc. Englewood Cliffs, NJ: Prentice-Hall

California Department of Finance (2002) Population projections for California and San Bernardino County. http://www.dof.ca.gov

Campbell P (1997) Current populations report: population projections. U.S. Department of Commerce Economics Statistics Administration publication P25-1131

Clarke KC, Hoppen S, Gaydos L (1997) A self-modifying cellular automaton model of historical urbanization in the San Francisco Bay area. Environment and Planning B: Planning and Design 24:247-61

Clawson M (1962) Urban sprawl and speculation in suburban land. Land Economics 38(2):99-111

Colorado Public Interest Research Foundation (2002) Down the drain: the impact of sprawl on Colorado's water supply. Published by the CRIRF

Correll M, Lillydahl J, Singell L (1978) The effects of greenbelts on residential property values: Some findings on the political economy of open space. Land Economics 54(2):207-17

Coyne W (2003) The fiscal cost of sprawl: how sprawl contributes to local governments' budget woes. Environment Colorado Research and Policy Center, Denver

Daly MC, Reed D, Royer HN (2001) Population mobility and income inequality in California. California Counts: Population Trends and Profiles 2(4):1-15

Danenberg A (2001) Who's lagging now?: gender differences in secondary course enrollments. California Counts: Population Trends and Profiles. Public Policy Institute of California

Daniels T (2001) Smart growth: a new American approach to regional planning. Planning Practice and Research 16(3/4):271-9

Darlington D (1996) The Mojave. New York, NY: Henry Holt and Company

Demaris A (1992) Logit modeling: practical applications. Thousand Oaks, CA: Sage Publications

DeMeo GA, Laczniak RJ, Boyd RA, Smith JL, Nylund WE (2003) Estimated ground-water discharge by evapotranspiration from Death Valley, California, 1997-2002. U.S. Geological Survey. Carson City, NV: Water-Resources Investigations Report 03-4254

Densmore JN, Cox BF, Crawford SM (1997) Geohydrology and water quality of Marine Corps logistics base, Nebo and Yermo annexes, near Barstow, California. Sacramento, CA: US Geological Survey Water-Resources Investigations Report 96-4301

EPA (Environmental Protection Agency) (2000) Projecting land-use change: A summary of models for assessing the effects of community growth and change on land-use patterns. EPA/600/R-00/098. Cincinnati, OH: US Environmental Protection Agency, Office of Research and Development

EPA. 2001a. Zoning ordinance: Open space community, Hamburg Township, Michigan. http://www.epa.gov/owow/nps/ordinance/hamburg.htm.

EPA. 2001b. Model ordinance language for open space. http://www.epa.gov/owow/nps/ordinance/mol3.htm.

Ewing R (1997) Is Los Angeles-style sprawl desirable? Journal of the American Planning Association 63(1):107-126

Faunt CC (1997) Effect of faulting on ground-water movement in the Death Valley region, Nevada and California. Water-Resources Investigations Report 95-4132. Denver, CO: U.S. Geological Survey

Fausold C, Lilieholm R (1999) The economic value of open space: a review and synthesis. Environmental Management 23(3):307-20

Fischel W (1985) The economics of zoning laws: a property rights approach to American land use controls. Baltimore, MD: The Johns Hopkins University Press

Fritz A (2002) An independent verification of the Clarke Urban Growth Model: Are the cellular automatic transition rules working alone? Unpublished masters thesis. Logan, UT: Utah State University

Fulton W (1999) Guide to California planning. Point Arena, CA: Solano Press Books

Gabriel SA, Mattey JP, Wascher WL (1995) The demise of California reconsidered: interstate migration over the economic cycle. FBRSF Economic Review 1995(2) p. 30-45

Goldman T (2001) Consequences of sprawl: Threats to California's natural environment and human health. Working Paper 2001-06. University of California Institute of Urban and Regional Development

Gonzalez M (2001) Future scenarios of land use in the California Mojave Desert. Unpublished doctoral dissertation. Logan, UT: Utah State University

Gonzalez M, Lilieholm R, Edwards T, Toth R, Hunter L, Stevenson M (2000) Estimating the spatial probability of future land development in California's Mojave Desert. Unpublished report. Logan, UT: Utah State University

Gordon P, Richardson H (1997) Are compact cities a desirable planning goal? Journal of the American Planning Association 63(1):95-106

Grimm LG, Yarnold PR (1995) Reading and understanding multivariate statistics. Washington, DC: American Psychological Association

Guhathakurta S (2003) Advances in urban and environmental modeling: surveying the terrain and demarcating frontiers. In Integrated Land Use and Environmental Models: A Survey of Current Applications and Research, edited by S. Guhathakurta. New York, NY: Verlag

Guhathakurta S (2001) Urban modeling as storytelling: Using simulation models as a narrative. Environment and Planning B: Planning and Design 29:895-911

Guttenberg AZ (1993) The language of planning: Essays on the origins and ends of American planning thought. Urbana, IL: University of Illinois Press

Hamilton LC (1992) Regression with graphics: A Second Course in Applied Statistics. Belmont, CA: Duxbury Press

Harden DR (1997) California Geology. Upper Saddle River, NJ: Prentice-Hall

Hardt WF (1971) Hydrologic analysis of Mojave River basin, California using electric analog-model. US Geological Survey Open File Report

Harvey R, Clark W (1965) The nature and economics of urban sprawl. Land Economics 41(1):1-9

Hess G, Daley S, Dennison B, Lubkin S, McGuinn R, Morin V, Potter K, Savage R, Shelton W, Snow C, Wrege B (2001) Just what is sprawl, anyway? Unpublished report. North Carolina State University, Forestry Department

Hill LE, Johnson HP (2002) Understanding the Future of Californians' Fertility: The Role of Immigrants. San Francisco CA: Public Policy Institute of California

Hunter LM, Gonzalez M, Stevenson M, Karish KS, Toth R, Edwards TC, Lilieholm R, Cablk M (2003) Population and land use change in the California Mojave: Natural habitat implications of alternative futures. Unpublished report. Population Research and Policy Review. 22:373-397

Jackson K (1985) Crabgrass Frontier: The Suburbanization of the United States. Oxford: Oxford University Press

Johnson HP (1999) How many Californians? A review of population projections for the state. California Counts: Population Trends and Profiles 1(1):1-11

Johnson HP (2000) Movin' out: domestic migration to and from California in the 1990s. California Counts: Population Trends and Profiles 2(1):1-15

Johnson HP (2002) A state of diversity: demographic trends in California's regions. California Counts: Population Trends and Profiles 3(5):1-15

Johnson HP (2003) California's demographic future. Presentation at the Congressional California Delegation Retreat. December 5, 2003

Landis J (1994) Future tense. Planning. February 1994

Landis J (1995) Imagining land use future: applying the California urban futures model. American Planning Association Journal 61(4):438-57

Lee C (1973) Models in planning. New York, NY: Pergamon Press

Lee D (1973) Requiem for large-scale models. AIP Journal May: p. 163-78

Littleworth AL, Garner EL (1995) California Water. Point Arena, CA: Solano Press Books

Mackun PJ, Wilson SR (2000) Population trends in metropolitan areas and central cities. U.S. Census Bureau Population Report P25-1133

Matyas R (2004) Email from Ron Matyas, Land Use Services Department, San Bernardino County, August 4, 2004

McCarthy D (1990) Local Government Law in a Nutshell. St. Paul, MN: West Publishing Company

McCoy J, Johnston K (2001) Using ArcGIS Spatial Analyst. Redlands, CA: Environmental Systems Research Institute, Inc.

McHarg I (1969) Design with nature. Garden City, NY: Doubleday & Company

Menard S (2002) Applied logistic regression analysis. Thousand Oaks, CA: Sage Publications

Minami M (2000) Using ArcMap. Redlands, CA: Environmental Systems Research Institute, Inc.

Mojave Water Agency (2002a) Regional water management plan update: Phase 1 report. June 2002. Apple Valley, CA

Mojave Water Agency (2002b) 2002 strategic plan. Mojave Water Agency. Apple Valley, CA

Mojave Water Agency (1994) Regional water management plan. Apple Valley, CA

Mouat D, Keister R, Kaker J (1998) Analysis and assessment of impacts on biodiversity: a framework for environmental management on DOD lands within the California Mojave Desert: A research plan. Environmental Protection Agency Environmental Research Lab. Corvallis, OR

Myers D, Pitkin J, Park J (2005) California demographic futures: Projections to 2030, by nativity, immigrant generations, and time of arrival in the U.S. Full Report. Population Dynamics Research Group, School of Policy, Planning, and Development. Los Angeles, CA: University of Southern California.

Myers D, Park J (2002). The great housing collapse in California. FannieMae Foundation

Myers D, Pitkin J (2001) Demographic futures for California. Population Dynamics Group, School of Policy, Planning, and Development. Los Angeles, CA: University of Southern California

Myers D (2001) Demographic futures as a guide to planning: California's Latinos and the compact city. American Planning Association Journal 67(4):383-397

National Governors' Association (2002) Military installations pressured by sprawl. NGA Center for Best Practices Issue Brief

Oakeshott GB (1971) California's Changing Landscapes. New York, NY: McGraw-Hill

O'Toole R (2001) Is sprawl a defense against terrorism? Environment and Climate News 4(11):1,8-9

Pampel FC (2000) Logistic Regression: A Primer. Thousand Oaks, CA: Sage Publications

Peirson E (1970) The Mojave River and Its Valley. Norman, OK: A.H. Clark Company

Persky J, Wiewel W (1996) Central city and suburban development: who pays and who benefits? Great Cities Institute Working Paper. Chicago, IL: College of Urban Planning and Public Affairs, University of Chicago

Pitkin J (2001) Projecting the population of California by nativity and period of arrival to 2020. California Demographic Futures Working Paper

Pruetz R (1993) Putting transfer of development rights to work in California. Point Arena, CA: Solano Press Books

Public Policy Institute of California (2003) Just the facts: California's state budget. January. http://www.ppic.org

Public Policy Institute of California (2002a) Just the facts: California's likely voters. September. http://www.ppic.org

Public Policy Institute of California (2002b) Just the facts: immigrants in California. July. http://www.ppic.org

Public Policy Institute of California (2002c) Just the facts: California's population. June. http://www.ppic.org

Public Policy Institute of California (2002d) Just the facts: cities and growth in California. April. http://www.ppic.org

Public Policy Institute of California (2001) Just the facts: the age gap in California politics. March. http://www.ppic.org

Real Estate Research Corporation (1974) The costs of sprawl: environmental and economic costs of alternative residential development patterns at the urban fringe. Prepared for the Council on Environmental Quality

Reed RD (1933) Geology of California. Tulsa, OK: American Association of Petroleum Geologists

Rhodenbaugh RK (1998) Suburbanization and wilderness parks: An Orange County, California case study. Unpublished masters thesis. Long Beach, CA: California State University

Rubino MJ, Hess GR (2003) Planning open spaces for wildlife II: modeling and verifying focal species habitat. Landscape and Urban Planning 64(1):89-104

San Bernardino County (1998) General plan. San Bernardino, CA: Public Services Group, Land Use Services Department

Sandoval J, Johnson H, Tafoya (2002) Who's your neighbor?: Residential segregation and diversity in California. California Counts: Population Trends and Profiles 4(1):1-20

SCAG (2004) Southern California Association of Governments census data. http://www.scag.ca.gov/census/index.htm

Schmidley D (2001) Profile of the foreign-born population in the United States: 2000. Current Population Report P23-206. U.S. Census Bureau

Sierra Club (2000) Sprawl costs us all: how your taxes fuel suburban sprawl. San Francisco, CA: Sierra Club Foundation

Snyder MG (2001) Opportunity for all: Growth, equity and land use planning for California's future. University of California Institute of Urban and Regional Development Working Paper 2001-15

Staley SR, Mildner GCS (1999) Urban-growth boundaries and housing affordability: Lessons from Portland. Reason Public Policy Institute. http://www.rppi.org

Stamos CL, Martin P, Nishikawa T, Cox BF (2001) Simulation of ground-water flow in the Mojave River Basin, California. Water-Resources Investigations Report 01-4002. Version 3. Sacramento, CA: U.S. Geological Survey

Stamos CL, Predmore SK (1995) Data and water-table map of the Mojave River ground-water basin, San Bernardino County, CA. U.S. Geological Survey Water-Resources Investigations Report 95-4148

Therrien M, Ramirez R (2001) The Hispanic population in the United States. U.S. Census Bureau Population Report P20-535

Thorsnes P, Simons GPW (1999) Letting the market preserve land: The case for a market-driven transfer of development rights program. Contemporary Economic Policy 17(2):256-66

Toth RE, Edwards TC Jr, Lilieholm RJ, Bell DL, Buteau ER (2002) Alternative futures for Utah's Wasatch Front: Bioregional planning for the maintenance and conservation of open space. Report No. 2002-2, Utah Cooperative Fish and Wildlife Research Unit. Logan, UT: Utah State University

US Census Bureau (2004) The American Factfinder. http://factfinder.census.gov/home/saff/main.html?_lang=en

Wadell P (2002) UrbanSim: Modeling urban development for land use, transportation, and environmental planning. Journal of the American Planning Association 68(3):297-314

Waddell P, Borning A, Noth M, Freier N, Becke M, Ulfarsson G (2003) Microsimulation of urban development and location choices: Design and implementation of UrbanSim. Networks and Spatial Economics 3(1):43-67

Walsh RG, McKean JR, Rosenberger RS, Mucklow CJ (1994) Recreation value of ranch open space. Ft. Collins, CO: Colorado State University Cooperative Extension publication XCM-167

Weinberg DH (1996) A brief look at postwar U.S. income inequality. U.S. Census Bureau Current Population Report P60-191

Wiewel W, Schaffer K (2001) Learning to think as a region: connecting suburban sprawl and city poverty. European Planning Studies 9(5):593-611

Wolfram G (1981) The sale of development rights and zoning in the preservation of open space: Lindahl equilibrium and a case study. Land Economics 57(3):398-413

Woodburne MO, Miller ST, Tedford RH (1982) Stratigraphy and geochronology of Miocene strata in the central Mojave Desert, California. In Geologic Excursions in the California Desert, Volume and Guidebook, edited by JD Cooper. Cordilleran Society, 78th Annual Meeting

Wright R, Webber S (1978) Land Use in a Nutshell. St. Paul, MN: West Publishing Company

Wunderlich G (1997) Land taxes in agriculture: preferential rate assessment effects. American Journal of Economics and Sociology 56(2):215-28

Zar J (1999) Biostatistical Analysis. Upper Saddle River, NJ: Prentice Hall

APPENDIX

Appendix: Logistic Regression

Much social and land use planning research involves making predictions that are discrete or qualitative, as opposed to continuous or quantitative (Grimm and Yarnold 1995; Pampel 2000; Menard 2002). These discrete predictions are often binary in nature, with the dependent variable typically taking the form of a "1" if a condition is present and a "0" if the condition is absent, based on a logistic regression analysis of a series of independent variables that can themselves be either discrete or continuous (Demaris 1992; Pampel 2000;).

Despite the binary value of the dependent variable, the predicted values generated by a logistic regression may be probabilities, where a low probability indicates a correspondingly low chance that the condition is present and a high probability indicates a greater likelihood that the condition is present (Hamilton 1992; Grimm and Yarnold 1995; Pampel 2000).

The general equation of the model used in logistic regressions is:

$$P = 1 / (1 + e^{-(\alpha + \beta x)})$$

where:
P = the probability of an event of interest occurring;
e = the base of the natural logarithm;
α = the intercept parameter;
β = the vector of slope parameter; and
x = the vector of explanatory variables.

For the present research, the dependent variable (P in the equation above) is the probability of a vacant hectare of private land being converted to a developed status within the timeframe of the study. In the present research, this dependent variable is assigned the name *Newdev*. The six independent, or explanatory, variables that were regressed in order to determine *Newdev* include: the distance of each vacant hectare of private land to the nearest hectare of developed land (*Devdist*); the distance of each vacant hectare of private land to the nearest primary road (*Primdist*); the distance of each vacant hectare of private land to the nearest secondary road (*Secdist*); the percent of developed hectares in a 20-by-20-hectare grid surrounding the vacant hectare of private land (*Pctdev*); whether or not the vacant hectare of private land falls within a municipal boundary (*Citycat*); and the percent slope of the vacant hectare of private land (*Slope*).

Research by Gonzalez (2001)—which resulted in an R^2 of approximately 0.32—determined the values for the intercept and the slopes associated with each of the six independent variables that were used in the present research. These values are:

α = -(1.5500);
β for *Devdist* = -(0.00003);
β for *Primdist* = -(0.00017);
β for *Secdist* = -(0.00467);
β for *Pctdev* = (4.4691);
β for *Citycat* = (0.8992); and
β for *Slope* = -(0.0502).

As discussed in Chapter 3, the logistic regression model was run using the raster calculator function in ArcMap to determine all values for the dependent variable *Newdev* in the seven communities that comprise the study area. The resulting raster file was then converted to a shapefile that showed the values of *Newdev* for each hectare in the communities. Hectares that were already developed in 2001 were then filtered from the shapefile, leaving only probability values for hectares that were vacant in 2001.

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Publications

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Gomben, P., and T. Gorman. 1994. Treatability of lodgepole pine laminated veneer lumber. *Forest Products Journal* 44(2):39-41.

Gomben, P., T. Gorman, and R. Folk. 1991. Directory of Idaho Wood Products Manufacturers. *Idaho Forest, Wildlife, and Range Experiment Station Miscellaneous Publication 18*, University of Idaho, Moscow. 61p.

Gomben, P. 1998. Smoke Management Concerns Facing the BLM in Utah. Report prepared for the USU College of Natural Resources and the Bureau of Land Management. Unpublished. 31p.

Stewart, K.J., P. Gomben and D.C. Bragg. 1998. The role of graduate students in university education in natural resources: A view from within. Page 248 In C.G. Heister (compiler), Proceedings of the Second Biennial Conference on University Education in Natural Resources, March 7-10, 1998, Utah State University

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