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Human Settlement, 1850–2040

ABSTRACT

This assessment of human settlement characterizes the extent of development, its historical levels and spatial distribution, and the factors driving it; makes projections of population growth and alternative land conversion estimates for alternative human settlement patterns; assesses the likely impacts associated with development and the degree to which existing institutional mechanisms anticipate and mitigate them; and sets forth alternative growth management policies that could mitigate those impacts. The importance of human settlement as a factor in the future health and sustainability of Sierra Nevada ecosystems cannot be overstated. The human population of the Sierra Nevada is forecast to triple from 1990 to 2040, while the land area developed for human settlement could potentially quadruple if current patterns of development continue.

The population of the Sierra Nevada more than doubled from 1970 to 1990, and its current population is approximately four times the peak population during the gold rush (1849–1852). Most of the new residents have settled near the historic centers of the gold rush, but modern patterns of human settlement have resulted in much more extensive land conversion. Three out of five Sierra Nevada residents lived on less than 300 mi^2 (less than 1%) in 1990, but human settlement was spread across nearly 1,741 mi^2 at an average density of at least one housing unit per 32 acres. This constituted 5.44% of the entire Sierra Nevada, or nearly 14% of all private land (including industrial timberlands). Up to one-eighth of the entire Sierra Nevada (3,905 mi^2) may have been affected by human settlement in 1990 at an average density of at least one housing unit per 128 acres. There is no clear threshold density at which human settlement results in significant impacts on the health and sustainability of Sierra Nevada ecosystems.

The Sierra Nevada is likely to undergo significant more land conversion to accommodate continuing population growth over the next half-century. Population growth in the metropolitan centers of California is forecast to double the state's population between 1990 and 2040, leading to expansion of the emerging metropolitan centers of the Central Valley that are within commuting distance of the Sierra Nevada foothills. Metropolitan areas near the Sierra Nevada in the state of Nevada are also forecast to continue growing. This growth would create new employment opportunities on the urban edge and extend the reach of reasonable commute times into areas that have not yet faced significant settlement by commuters. The result is likely to be continuing in-migration by commuters, retirees, and former metropolitan-area residents who are seeking a rural or exurban lifestyle offering natural and social amenities. Many of these latter immigrants are likely to accept lower incomes in exchange for these amenities, but they also generally bring human and financial capital with them. They therefore have the potential to generate new employment in the Sierra Nevada.

Because these new residents are likely to have higher incomes than most existing residents, their arrival will put pressure on land and housing prices. The factors driving the exodus to exurbia over the past three decades are likely to continue, resulting in an increasingly homogeneous population of affluent, white, well-educated residents in the commuter and retiree communities near the Central Valley and the Lake Tahoe region. More isolated communities in the northern and eastern Sierra are likely to grow relatively slowly, however, with less pressure on land and housing prices. Existing patterns of human settlement are more stable in these areas, where lower land prices make significant investments in centralized infrastructure uneconomic. Large higher-density developments are likely in the Gold Country, however, where proximity to the Sacramento metropolitan area has already increased land and housing prices significantly. Nonlocal landowners have already consolidated parcels in these areas and have proposed development of several planned communities in the region. Tens of thousands of individuals and corporations own parcels in the Sierra Nevada, but relatively few landowners control most of the private land. Private industrial timber companies control the bulk of the private land in those counties where data are available.

The social, economic, and ecological ramifications of future development will depend upon specific spatial patterns of human settlement in relationship to existing communities, infrastructure services, vegetation and habitat types, and watershed boundaries. Our under-

Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources, 1996.

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standing of those relationships is still poor at this time. It is therefore impossible to characterize the specific impacts that population growth and human settlement will have in the Sierra Nevada. The range of impacts could be quite significant, however, if existing development patterns continue. Continuing the existing pattern of “sprawl” development with a high-growth scenario could result in human settlement on nearly half the private land in the Sierra Nevada (6,846 mi^2) at an average density of at least one housing unit per 32 acres. A low-growth scenario with the existing pattern of sprawl development would reduce that figure by 44%, to just 3,817 mi^2. This is still significantly greater than the 1,741 mi^2 affected by human settlement at that average housing density in 1990.

Even modified settlement patterns are forecast to result in significant land conversion from 1990 to 2040, suggesting that the scale of population growth alone could lead to significant impacts. A high-growth scenario with a more “compact” form of settlement would result in nearly a doubling of land converted to human settlement, from 1,741 mi^2 to 3,363 mi^2 at an average density of at least one housing unit per 32 acres. A low-growth scenario with a more “compact” form of settlement, on the other hand, could nearly be accommodated within the land area already converted to human settlement at an average density of at least one housing unit per 32 acres in 1990. Through infill and carefully targeted density transfers, the low population forecast for 1990–2040 would require only 1,875 mi^2 (only 8% more than in 1990). Both the scale and pattern of human settlement will therefore affect—and must therefore be considered by—local, state, and federal land and resource management agencies with responsibilities for the health and sustainability of Sierra Nevada ecosystems.

Existing institutional arrangements for land use and environmental planning in the Sierra Nevada appear inadequate for managing rapid population growth and the land conversion process associated with human settlement. Comprehensive updates of both the Nevada County and El Dorado County General Plans appear to have either significantly underestimated the likely future impacts of “buildout” or failed to mitigate significant impacts under the “overriding considerations” provision of the California Environmental Quality Act. Many of these impacts are associated with existing substandard parcels, most of which were established through subdivisions that preceded most of current state planning law.

Innovative growth management strategies to coordinate and consolidate development across these parcels may therefore be necessary if the impacts of future population growth are to be mitigated. Appropriate policies cannot be selected without a better understanding of the relationships between alternative patterns of human settlement and impacts, but creative “open space development design” through site-specific clustering could mitigate some of the likely effects. Other rural and exurban regions have adopted some of these policies, but they have not yet been embraced in the Sierra Nevada. There are a number of social, political, economic, and institutional factors that may explain why growth management has generally been ineffective in the region, but further study is necessary before specific policies are likely to be adopted. The effectiveness of those policies, in turn, will depend upon a wide range of similar factors. Some dimensions of the health and sustainability of Sierra Nevada ecosystems are likely to face significant threats, however, in the absence of successful growth management. It is therefore critical that local, state, and federal land and resource management agencies assess the management implications of continuing extensive and intensive human settlement in the Sierra Nevada. This is particularly true in the western Sierra Nevada foothills, where nearly five out of every six Sierra Nevada residents lived in 1990. This fraction is expected to increase from 1990 to 2040 as regional employment centers in the Central Valley grow, increasing growth pressures in those Sierra Nevada foothill communities within commuting distance of these centers. In contrast, the more remote northern and eastern Sierra Nevada regions are forecast to have relatively slow growth.

INTRODUCTION

Human settlement in the Sierra Nevada has had and will continue to have a profound impact on Sierra Nevada ecosystems. The distribution and abundance of natural resources in the Sierra Nevada, in turn, have had an enormous effect on patterns of human settlement and the types of human activities that have taken place in the Sierra Nevada landscape. This assessment report characterizes the current pattern of human settlement, the historic pattern of human settlement from 1850 to 1990, and a range of future population projections for the Sierra Nevada and alternative scenarios of human settlement patterns. We also discuss the factors driving human settlement in the region and a range of policy alternatives to mitigate the environmental impacts of expanding human settlement.

Our analysis begins with the entire Sierra Nevada, where we describe historic population figures for the region from 1850 to 1990, which are reported for all of the California counties in the Sierra Nevada.[1] These data are not available at a subcounty level until 1970, however, so it is impossible to determine the population of the Sierra Nevada proper (as a subset of the overall population of the Sierra Nevada counties) from 1850 to 1970. More detailed data are available for selected years for some incorporated cities in the Sierra Nevada.

We then summarize subcounty population figures by county census division (CCD) from 1970 to 1990, a period in which the population of the Sierra Nevada more than doubled. That population is only about one-fourth of the population of the counties in the Sierra Nevada, however, highlighting the importance of differentiating the Sierra Nevada proper from the much larger county totals.

We follow with a discussion of the factors driving the explosion of population growth in the Sierra Nevada from 1970 to 1990. These include a wide range of factors outside the Sierra Nevada itself, linking the fate of future population growth to broader state, national, and global trends. The importance of metropolitan expansion in the Bay Area and Sacramento is highlighted. This expansion has been a key factor driving the concentration of population growth occurring in the west-central-north subregion of the "Gold Country" in Nevada, Placer, and El Dorado Counties. Highway access into and across the Sierra Nevada is also critical for higher-density development linked to metropolitan areas, along with access to water, sewers, and power.

We next present projections by the California state Department of Finance (DOF) for county-level population projections for the 1990–2040 period. We then describe a simple model for allocation of these county-level projections to the Sierra Nevada portion of each county based upon the 1970–90 share of county population growth that each Sierra Nevada CCD received. Alternative forecasting methods are discussed, and the reasonableness of the DOF forecasts is evaluated. Likely changes in the subregional distribution of the Sierra Nevada population are then described for 1990–2040. Due to data limitations, however, these changes are presented for only the large aggregate spatial units (CCDs) in the Sierra Nevada. This coarse-scale analysis is inadequate for analysis of the ecological impacts of alternative spatial patterns of human settlement. We therefore examine current and historical patterns of settlement with greater spatial resolution.

Changes in average housing densities are then reported by census block group (CBG) from 1940 to 1990 through a series of maps that graphically illustrate the expansion of human settlement throughout the Sierra Nevada over the past half-century. We then characterize the distribution of human settlement by eleven broad classes of housing density as of 1990 based upon over 50,000 census blocks, the smallest unit available for analysis. This distribution is reported here by CCD, county, and river basin.

In order to get a more detailed understanding of the processes and patterns of human settlement, we next focus on a subregional analysis of population growth and land use patterns in a five-county region that includes Amador, Calaveras, El Dorado, and Nevada Counties and portions of Placer County. This analysis focuses on the distribution of parcel sizes by frequency and area in the five-county area. More detailed analysis is then reported for Nevada and El Dorado Counties, both of which are currently updating their General Plans. Land use patterns and policies under consideration in those General Plans are evaluated in terms of social, economic, and environmental impacts as described in their associated draft environmental impact reports (DEIR's) and based upon our own independent analysis. Both Nevada and El Dorado Counties' human settlement patterns in 1990 and alternative plans for the future are then compared with prevailing patterns of land use throughout the rest of the Sierra Nevada. We also evaluate the feasibility of infrastructure investments assumed in the General Plans. The role of infrastructure is critical in determining future settlement patterns. The General Plan development process and the associated EIR analysis are then reviewed for their capacity to mitigate impacts.

The potential impacts of 1990–2040 population growth on land conversion in each of the counties and CCDs are then estimated based upon a range of alternative assumptions about future population growth and human settlement patterns. Four alternative population growth forecasts and six alternative settlement patterns are considered through four scenarios of future development based upon low- and high-population forecasts and compact versus sprawl settlement patterns. Total land area converted to human settlement under each of the resulting four scenarios is then presented for a range of threshold settlement densities. We also present the unsuccessful results of preliminary attempts to model the spatial patterns of human settlement with finer spatial resolution for the entire Sierra Nevada. Alternative modeling approaches are outlined that hold promise for future assessment. The ecological consequences of settlement are then discussed, including limitations in our present knowledge about the relationships between alternative patterns of human settlement and specific ecological consequences in the Sierra Nevada.

The assessment report concludes with a discussion of alternative policy options available to local, state, and federal land and resource management agencies to mitigate the potential impacts of conversion associated with expanding residential development. The institutional setting for adoption of those policies is then described and evaluated to determine the likelihood of alternative mitigation measures being adopted in the future. Due to significant data limitations, however, we were unable to reach firm conclusions about the efficacy of alternative policy options to mitigate the impacts of human settlement. Suggestions for further research are therefore presented to guide future assessments.

The Setting for Human Settlement in the Sierra Nevada

The Sierra Nevada core region as defined by SNEP is vast and highly heterogeneous in terms of human settlement. Some parts of it are remote and inaccessible, while others are within easy commuting distance of rapidly growing metropolitan regions. Just across the region's western boundary lies the Central Valley, where there are least six rapidly growing urban centers, each with a population greater than 100,000 in 1990. The northern and eastern boundaries of the Sierra Nevada, in contrast, are against the sparsely populated high desert of the Great Basin biogeographical province. These areas are often isolated for months every year as winter snows close the mountain passes linking these rural areas to the rest of California. There are thirty-two counties (twenty-seven in California and five in Nevada) with all or part of their territory within the SNEP study region, but only twenty-two of these counties include portions of the Sierra Nevada proper. Eighteen of these counties are in California, and four are in Nevada. Of these, only nine counties (all in California) lie entirely within the boundaries of the region (figure 11.1).[2]

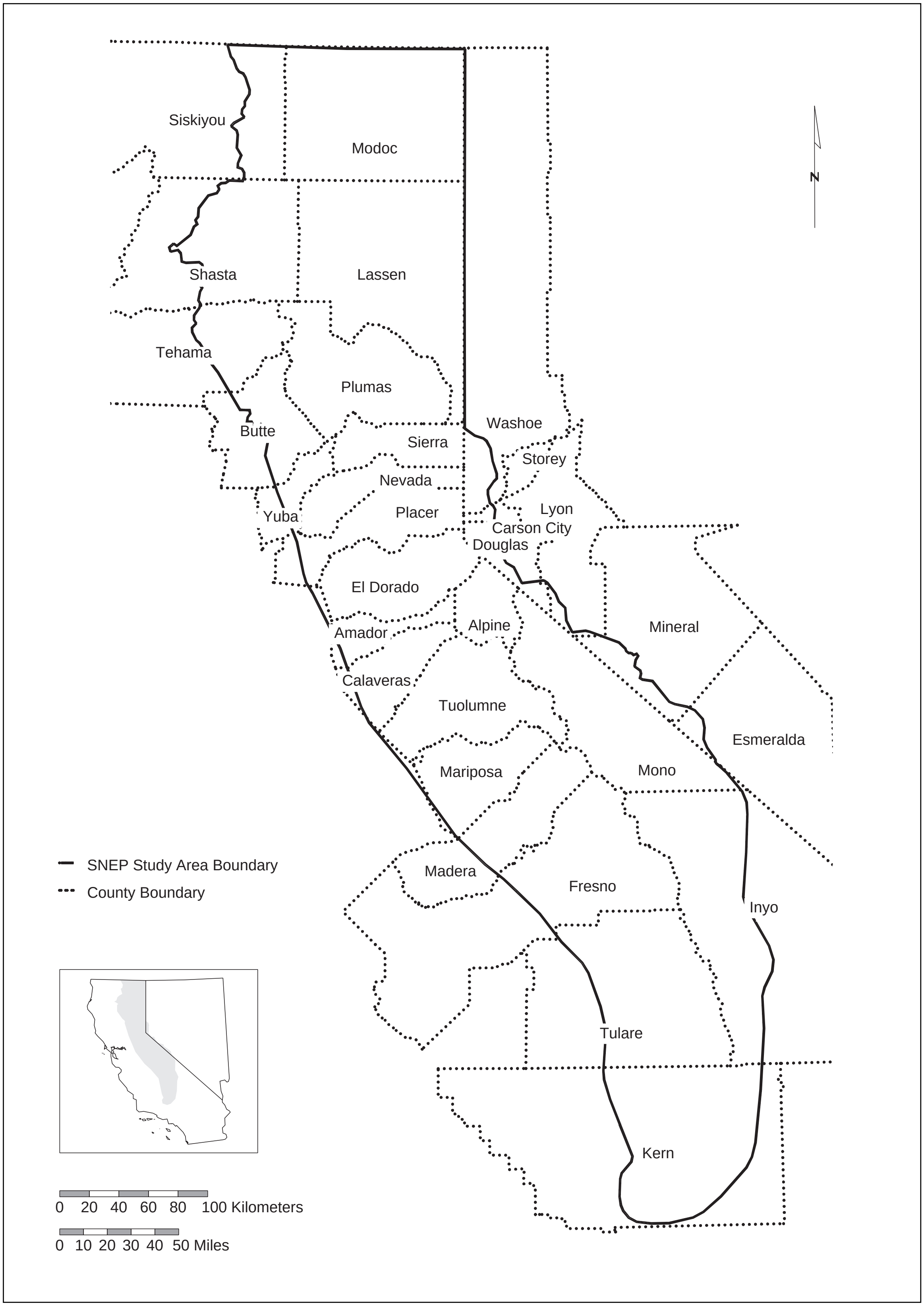


FIGURE 11.1

Counties in the Sierra Nevada region.

Beyond the Central Valley lie the major metropolitan centers of San Francisco and Los Angeles, both within 100 miles of the Sierra foothills. The only major urban centers near the eastern flank of the Sierra are Reno and Carson City, both in the vicinity of Lake Tahoe. Interstate 80 and U.S. Highway 50 connect the Reno, Carson City, and Lake Tahoe regions to the Sacramento metropolitan area and the rest of northern California. The Sierra Nevada is also crossed by state highways: from north to south, 70 (Feather River canyon), 49 (Yuba Pass), 88 (Carson Pass), 4 (Ebbetts Pass), 108 (Sonora Pass), 120 (Tioga Pass), and 178 (Walker Pass). Also providing access from the Central Valley into the Sierra Nevada are Highways 20 (Marysville to Interstate 80 via Grass Valley and Nevada City), 140 (Merced to Yosemite National Park via Mariposa), 41 (Fresno to Yosemite National Park via Oakhurst), 180 (Fresno to Sequoia and Kings Canyon National Parks), 245 and 198 (Visalia to Sequoia and Kings Canyon National Parks), and 190 (Porterville to Sequoia National Forest). Highway 49 traverses the western foothills (from Oakhurst in the south to Sierraville and Loyalton in the north), while Highway 89 cuts across Monitor Pass south of Lake Tahoe and extends north through Truckee and Quincy to Lake Almanor. U.S. Highway 395 skirts the eastern edge of the Sierra Nevada from Susanville in the north through Reno, Carson City, the Mono Basin, and the Owens Valley to southern California. Carson, Ebbetts, Sonora, Tioga and Monitor Passes are all closed seasonally in the winter, from around Thanksgiving until Memorial Day. U.S. Highway 99 connects the string of Central Valley towns west of the Sierra Nevada. Figure 11.2 shows these primary transportation corridors in and near the Sierra Nevada.

This complex pattern of road networks links the Sierra Nevada to social and economic activity throughout California and the world. It brings recreational visitors to access the wonders of the Sierra Nevada and provides for the export of the natural resources that are extracted in the range and sold as commodities in metropolitan markets. The transportation network is therefore a primary determinant of the pattern of human settlement in the Sierra Nevada. Our assessment therefore highlights the linkages between the Sierra Nevada and other parts of California.

Key Questions

This chapter attempts to answer the following key questions about the patterns of human settlement in the Sierra Nevada and the forces shaping future human settlement:

- What were the historic patterns of population growth and human settlement by county from 1850–1990?
- What were the primary factors driving exurban population growth over the past quarter-century?
- What is the likely spatial distribution of future population growth from 1990 to 2040 by county and CCD?
- What is the current spatial pattern of population distribution and housing density by density class?
- What are the relationships between development density and other 1990 Census variables?
- What are the relationships between development patterns and infrastructure access and costs?
- What are the relationships between development patterns and environmental constraints?
- What is the relationship between settlement patterns and land use designations and policies in local General Plans?
- What are the environmental impacts of land use patterns under proposed General Plans?
- What are the infrastructure needs and financing mechanisms available to support proposed General Plans?
- What is the impact of land ownership patterns on the applicability of General Plan policies to development patterns?
- What are the ecological, social, and economic impacts of population growth and alternative human settlement patterns from 1990 to 2040?
- What are the growth management policy options available for mitigating future impacts of growth or modifying its spatial pattern?
- What is the likelihood of and what are the constraints to adoption of such policy options in the current institutional setting?
- What further research is necessary to answer key questions that we have been unable to answer in this assessment of human settlement in the Sierra Nevada?

Each of these questions has implications for the degree to which human settlement and its associated activities have affected Sierra Nevada ecosystems and will continue to affect them. Each of them is also affected by the character and quality of Sierra Nevada ecosystems, which in turn affect the social and economic conditions of the human communities located in the Sierra Nevada. Answers to these questions therefore have importance for nearly every aspect of the Sierra Nevada Ecosystem Project's assessment. Human settlement per se is not necessarily of interest, but it represents a vital intermediate variable for assessment of the social, economic, and ecological state of the Sierra. This SNEP assessment focuses on the processes driving human settlement itself.

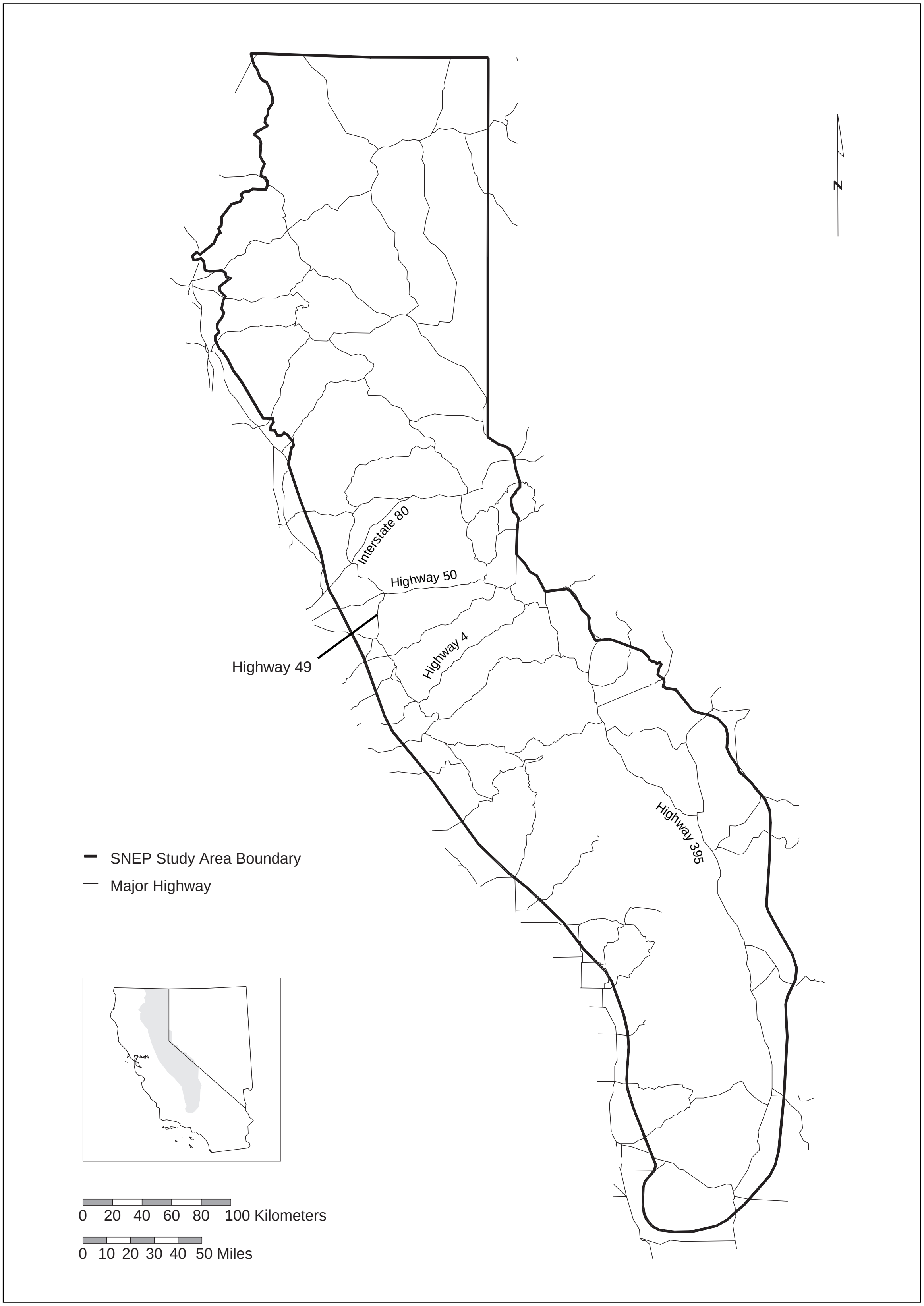


FIGURE 11.2

Major highways in the Sierra Nevada region.

BACKGROUND

Human beings have lived in and utilized the natural resources of the Sierra Nevada for millennia. The focus of this assessment, however, is on patterns of human settlement in the region since 1850. Only four ships dropped anchor in San Francisco Bay in 1848, the same year that James Marshall discovered gold at Sutter's Mill near Coloma and the South Fork of the American River. The next year brought nearly seven hundred ships through the Golden Gate. Most of their passengers unloaded in the ports of northern California and promptly set out for the gold fields of the Sierra Nevada foothills. The region has been intensely inhabited ever since, and the patterns of settlement reflect the geography of both natural and human resources. The pattern of towns, roads, waterways, and related infrastructure established by the forty-niners continues to constitute the framework within which a new wave of migration has swept over the Sierra Nevada during the past three decades. This assessment focuses on that recent migration wave and its implications for the future. The historical effects of the first century of postcontact settlement in the Sierra Nevada are described briefly in the history chapter by Beesley (1996). Our data sources provide only a broad outline of population levels by county from 1850 to 1970, so we will not attempt to delineate in fine spatial detail the historical pattern of settlement or its impacts. A more detailed analysis at the subcounty level is possible only from 1970 to 1990. We therefore focus on the factors driving recent population changes in the area. Figure 11.3 shows the eighteen California counties in the Sierra Nevada included in our analysis.

Several things stand out in the historical census record from 1850 to 1970. The first is that the overall population of the Sierra Nevada counties was relatively stable throughout the nineteenth century, although individual counties went through significant fluctuations. The population of the Sierra Nevada counties peaked in 1852 at around 150,000, which was also the peak year of gold production in California. The southernmost counties in the Sierra Nevada then began to grow rapidly throughout the twentieth century, but most of that growth took place in the Central Valley rather than the Sierra Nevada proper. Because subregional data are not available before 1970 (except for forty towns, most of which are incorporated), it is impossible to determine the precise population of the Sierra Nevada or the distribution of population within the Sierra Nevada with any accuracy from 1850 to 1970. The overall population roughly doubled between 1860 and 1960. Figure 11.4 shows the total population for all of the eighteen California counties in the Sierra Nevada from 1850 to 1990.

The population within those counties that are entirely within the Sierra Nevada grew and fell slightly as commodity prices and business cycles brought residents into and out of the range. California's population roughly doubled every two decades during this period, while it took a century for the Sierra Nevada population to double. California's population growth was primarily concentrated in the coastal regions within and near the emerging metropolitan regions of the San Francisco Bay Area, greater Los Angeles area, and San Diego County. The Central Valley towns of Sacramento, Stockton, Modesto, Merced, Fresno, Visalia, and Bakersfield also grew not far from the Sierra Nevada foothills. Reno and Carson City grew moderately in Nevada, with a drop in population following the end of the silver boom not unlike the fluctuations in the gold camps of the Sierra Nevada. Industrialization of the hardrock gold mining practices maintained population stability in the northern Sierra Nevada community of Grass Valley until the mines finally shut down in 1956. There was some increase in local gold prospecting in the foothills during the Great Depression, but most miners did not stay on. Because the census is completed only every decade, it is impossible to correlate fluctuations in population levels with annual changes in economic conditions. Figure 11.5 shows the 1850–1990 time series in more detail for Nevada County, including a breakdown for the communities of Grass Valley, Nevada City, and Truckee where available. Similar data are available for other counties and cities in the Sierra Nevada from the California Environmental Resource Evaluation System (CERES) project of the Resources Agency of the State of California (http://ceres.ca.gov/snep), and the Alexandria Project at the University of California, Santa Barbara (http://alexandria.sdc.uscb.edu/). Note that the unincorporated portion of Nevada County grew most rapidly from 1970 to 1990.

The second thing that stands out in the 1850–1970 population data is how quickly the counties of the southern Sierra Nevada grew after the turn of the century. This is in stark contrast with the other subregions of the Sierra Nevada, which did not experience rapid growth until after World War II. California became an agricultural powerhouse in the soil of these counties, which was nourished with water from the Sierra Nevada and the Sacramento River watershed in the northern Central Valley. The population growth in these counties was therefore concentrated in the San Joaquin valley rather than the Sierra Nevada proper. The data since 1900 are dominated by those southern Central Valley counties, so it is difficult to discern clear patterns for the Sierra Nevada proper during the twentieth century. The population of the Central Valley itself overwhelms the totals. Figure 11.6 shows 1850–1990 population growth by subregion.

The third feature of population patterns from 1850 to 1970 is how significant the nonwhite portion of the population was in 1850 to 1900 compared with today. In particular, the Chinese constituted a large fraction of the population of the Sierra Nevada counties from 1860 to 1900. Together with Native Americans and African-Americans ("Black" in the census), ethnic minorities accounted for over 22% of the total population of the region at their peak in 1860. This is despite the collapse of the California Indian population between the special census of 1852 and 1860 (from roughly one in eight Sierra Nevada residents to less than 4%). The collapse was most

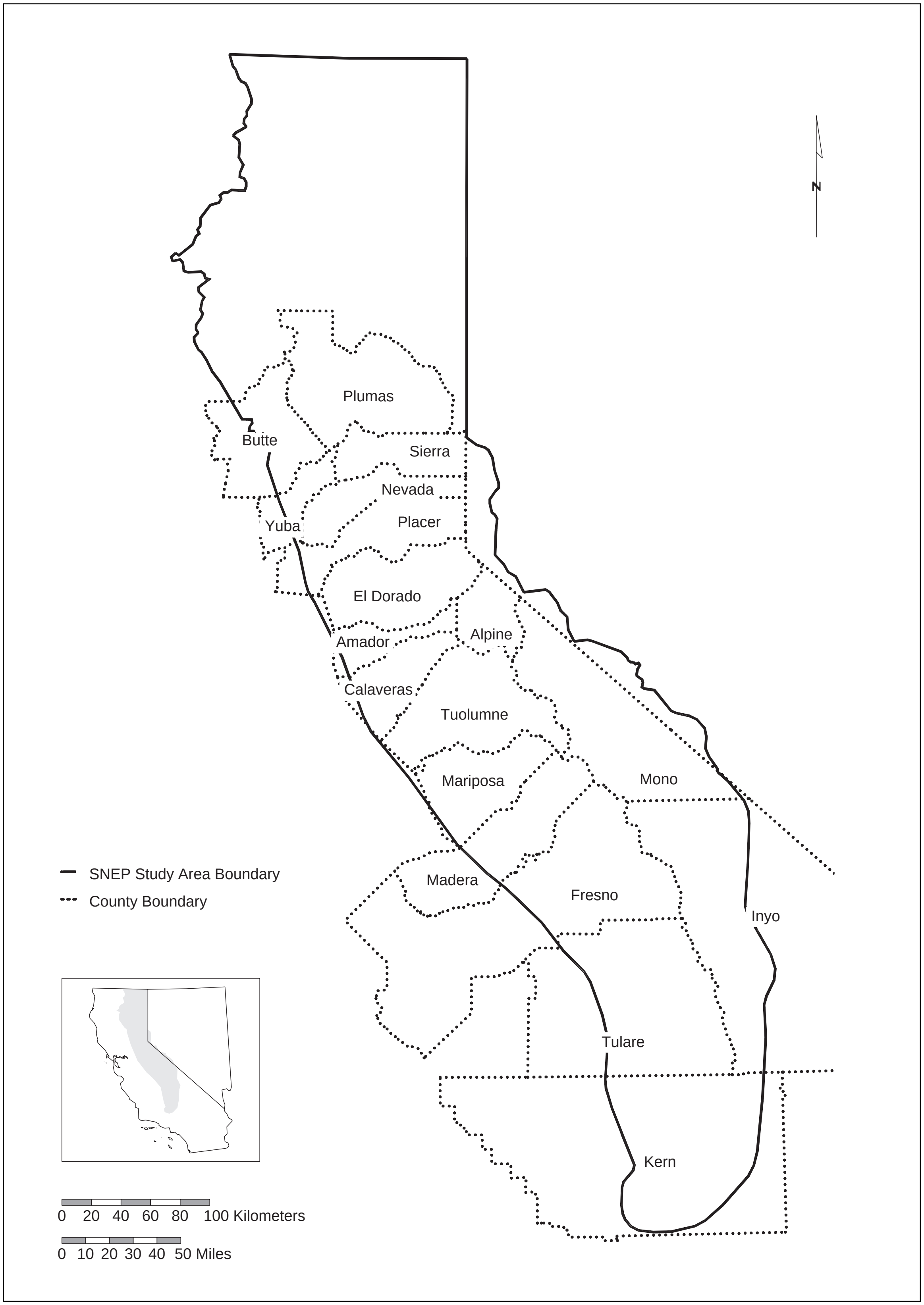


FIGURE 11.3

Counties included in historical analysis.

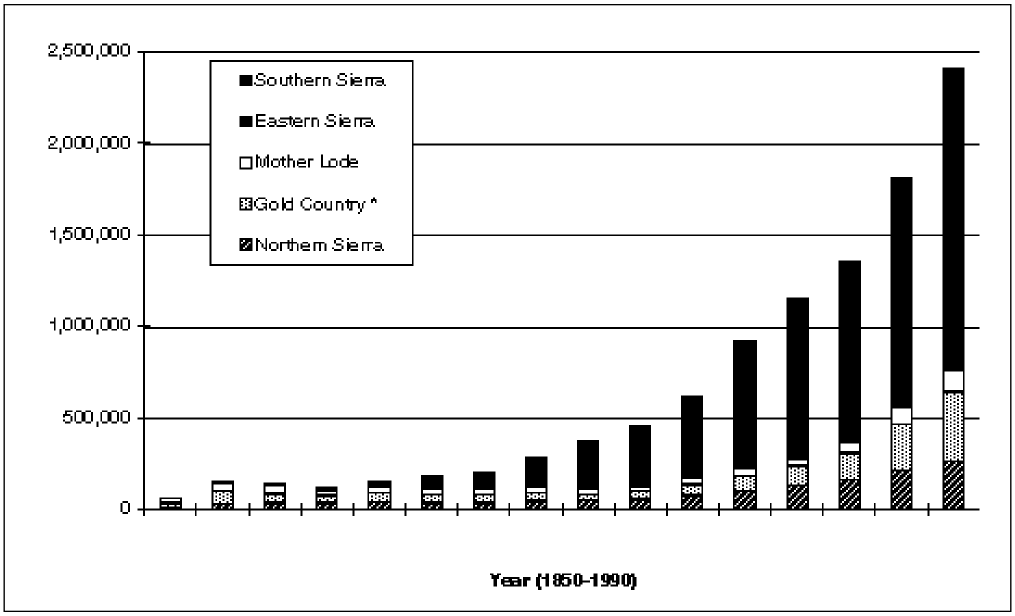


FIGURE 11.4

Population of Sierra Nevada counties, 1850–1990.

pronounced in the Mother Lode region of the west-central Sierra Nevada, where much of the gold mining activity took place. Estimates of ethnicity are difficult during the 1850s, however, due to the high fraction of residents born in Mexican California. These residents automatically became citizens of the United States under the terms of the Treaty of Guadalupe Hidalgo. Up to one-third of the gold miners may have been foreign-born from outside pre-treaty Mexican Alta California, the new state of California, or any other territories or states of the United States of America. A large fraction of the white miners are also believed to have left the Sierra Nevada in 1859 to 1860 for the Comstock Lode of Nevada, where a silver strike presented new opportunities. This exodus may have also increased the relative share of the population by ethnic minorities in 1860. Today the population of the Sierra Nevada is overwhelmingly white and differs significantly from the rest of California.

Chinese laborers are well known to have been a critical workforce for the transcontinental railroad (exceeding 12,000 workers at the famous "Chinese Wall" near Donner Pass)[3] and actively participated in gold mining and other activities after the initial gold rush period. They were also already present before work on the railroad began. A series of anti-Chinese activities drove many of the Chinese out of the Sierra Nevada and California around the turn of the century, however, with Nevada County's Chinese population dropping from a high of around 2,000 in 1880 to only 100 by 1910 (Grass Valley Union 1995a).[4] Japanese immigrants first appeared as a significant element of the population for the eighteen counties in the region during the same period. Once

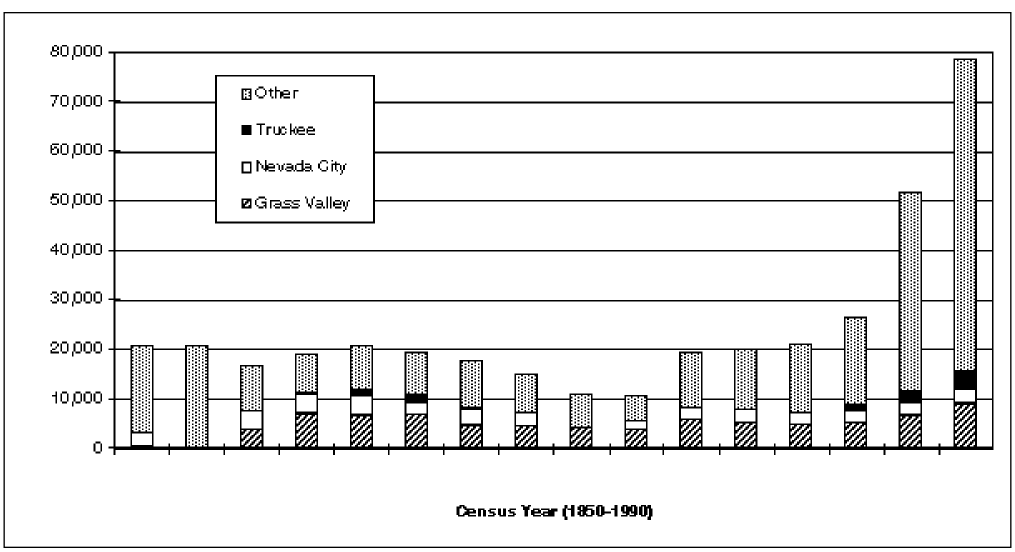
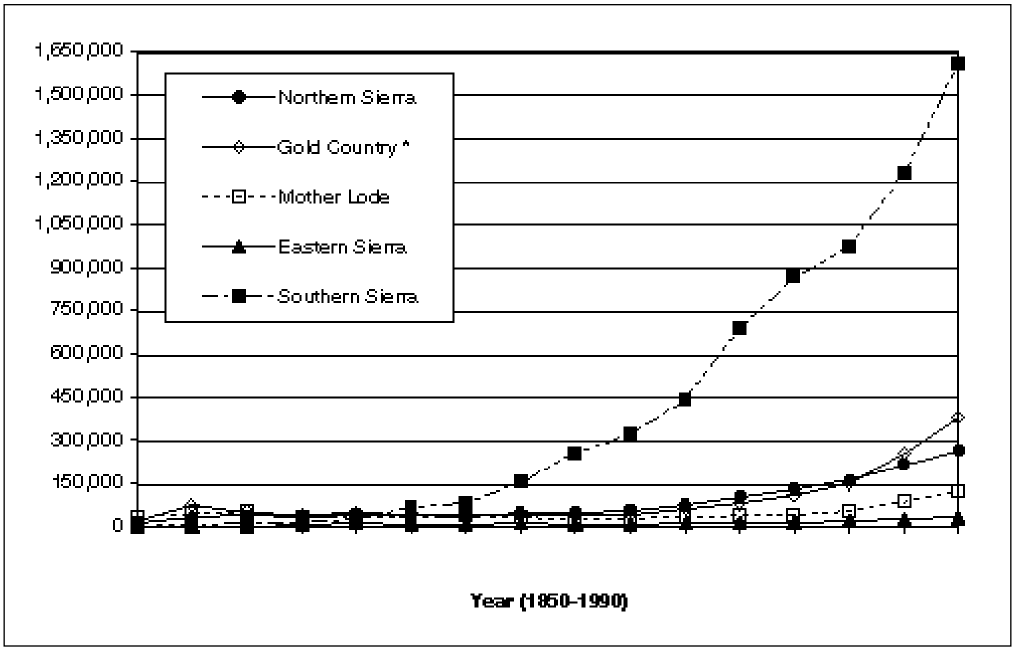


FIGURE 11.5

Population of Nevada County, 1850–1990.

FIGURE 11.6

Population of Sierra Nevada subregions, 1850–1990.



again, however, the Japanese migrants seem to have been concentrated in the southern San Joaquin valley, and it is unclear how significant they were as an element of the population in the Sierra Nevada proper. Many Japanese-Americans were also transferred to the Manzanar Relocation Camp during World War II in the Owens Valley (Inyo County), but no census was conducted between 1941 and 1945. The census record does show several thousand residents of Japanese ancestry in the Sierra Nevada throughout the twentieth century but does not capture this significant influx of forced migrants during World War II (Koda 1995). The county-level figures also show a significantly higher fraction of nonwhite residents from 1900 to 1990 than there was for the Sierra Nevada portion of the Sierra Nevada counties. In particular, the census data show a high fraction of black (African-American) residents primarily in communities in the Central Valley. Figure 11.7 shows the ethnicity of the nonwhite population recorded in the census from 1850 to 1990.

The historical records contained in the Census of Population are full of rich detail about individual counties, communities, and ethnic groups. Unfortunately, we do not have room to discuss those records in detail here. We have entered raw population figures from 1850 to 1990 for each county, identified community, and identified ethnic group in the Sierra Nevada into a spreadsheet that is available from the California Environmental Resource Evaluation System (CERES) project of the Resources Agency of the State of California (http://ceres.ca.gov/snep), and the Alexandria Project at the University of California, Santa Barbara (http://alexandria.sdc.ucsb.edu/). This database should be useful for more detailed queries about the history of human settlement in the Sierra Nevada. A five-page description of the census data and the history of changing county boundaries is also included for reference. The focus of our remaining assessment of census records will be on the recent doubling of the population in the Sierra Nevada portion of the counties during the period 1970–90. We will then use that analysis as the basis for allocating county-level population forecasts to the Sierra Nevada portion of counties for the period 1990–2040.

METHODOLOGY

Our methodology for assessing patterns of human settlement in the Sierra Nevada relied upon the development of a geographic information system (GIS) on a UNIX workstation using the GIS software package Arc/Info. This GIS served as the framework for making spatially explicit queries about the distribution of human settlement in relation to the natural and human factors. Where possible, information was georeferenced to other spatial data through the GIS. Some information was either nonspatial or was not available in a digital form, however, so we did not limit our analysis to those data sources that could be integrated into the GIS. At times we relied upon statistical analysis of nonspatial data, literature review and interviews with key informants, and consultations with academic and professional colleagues familiar with the processes of population growth, human settlement, and land use planning in the Sierra Nevada. We also reviewed planning documents, real estate advertisements and marketing materials, and media reports on planning-related issues from throughout the Sierra Nevada.

We attended public meetings and public hearings related to land use and development in the Sierra Nevada for our

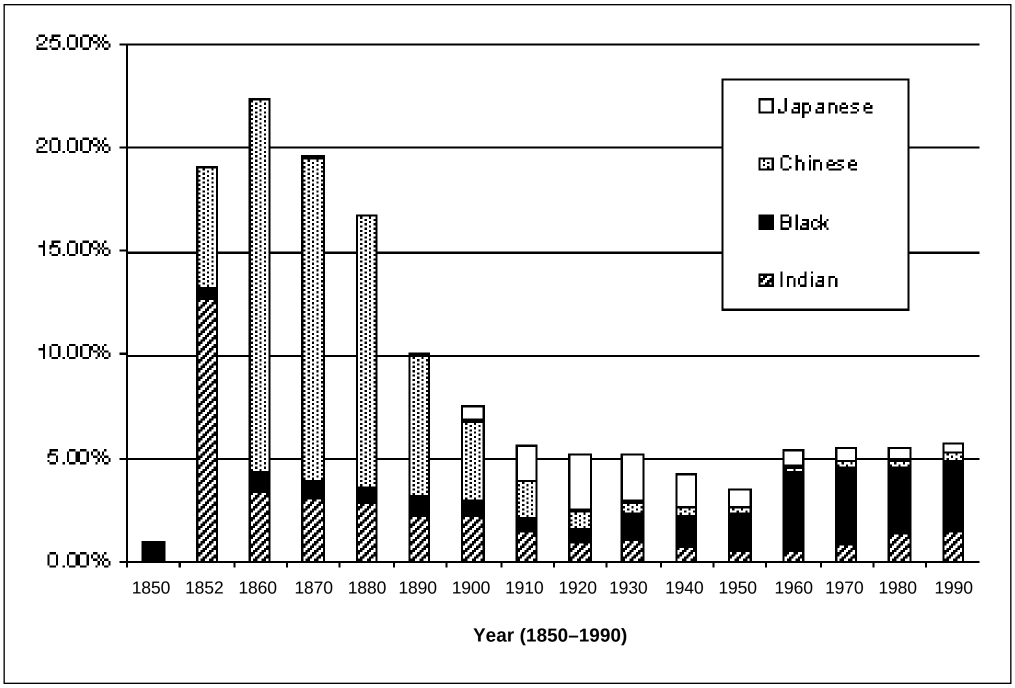


FIGURE 11.7

Minority population by ethnicity as a percentage of total Sierra Nevada population, 1850–1990.

more detailed case studies of the General Plan update processes in Nevada and El Dorado Counties. Graduate students in the Environmental Planning Studio at the University of California, Berkeley (taught by the author), studied these two General Plans in detail in January–May 1993 and January–May 1994, respectively. We relied upon specific studies completed in those classes for insights into specific aspects of the General Plans now under review. The author also worked as assistant city planner for the city of Grass Valley in 1982 and was already familiar with the 1980 Nevada County General Plan. We also reviewed General Plans for Plumas, Placer, Amador, Calaveras, Mono, and Inyo Counties and the Wildlife Habitat Management Plan for Tuolumne County, but only the General Plans for El Dorado and Nevada Counties were analyzed in any detail. These were the only two counties in the Sierra Nevada with sufficiently developed land use maps to allow GIS analysis. We also had other data available for those counties in digital form that were not generally available for the rest of the Sierra Nevada. Moreover, these two counties have experienced the greatest rates and absolute numbers of population growth in the Sierra Nevada. Assessing policies in these two counties therefore gives us some insight into how counties facing extreme growth pressures may plan for additional growth in the current institutional context. Together they have spent at least $4 million on their efforts to update their General Plans over the past five years (Rivas 1993–95; Boivin 1991–95). This presented an opportunity to build on extensive existing work rather than trying to create a database from scratch.

Specific methods are discussed in more detail in each section of this chapter.

SOURCES

Specific sources are discussed in detail in each section of the chapter.

RESULTS

The results of each of our individual analyses are described in detail in this section. The significance of the results of each analysis is then discussed in relation to the other results in the conclusion of the assessment, along with management implications.

The Second Gold Rush: 1970–90

The Sierra Nevada region grew by more than 65% in the 1970s and 39% in the 1980s, and by a total of 130% from 1970 to 1990 (an average annual rate of approximately 3.5%). This compares with overall growth of 49% for all of California and 22% for the entire United States from 1970 to 1990 (U.S. Bureau of the Census 1970, 1980, 1990). This rapid population growth boosted the population of the Sierra region from just under 273,000 in 1970 to around 618,000 in 1990.[5] More people moved into the Sierra Nevada from 1970 to 1990 than migrated into the area during the entire gold rush through the 1850s. This second gold rush resulted in a dramatic change in the social, demographic, and economic characteristics of Sierra

Nevada residents (Duane 1993a). This change in turn continues to alter the economic and social relationships between those residents and Sierra ecosystems. Rapid population growth has become the dominant factor of change for many Sierra Nevada communities.

Many rural communities in North America have experienced rapid population growth during this same period, beginning with the "rural renaissance" in the 1970s and continuing with a flood of "equity refugees" in the 1980s. As reported in a 1993 cover article in Time magazine, "Boom Time in the Rockies" (Bonfante 1993), this trend is continuing in the 1990s (New York Times 1993; Diringer 1994; Weiss 1995; High Country News 1993, 1994; Starrs and Wright 1994).[6] The counties of the Sierra Nevada have experienced slower growth rates in the past few years, but they are still among the fastest-growing counties in California. A combination of economic, social, demographic, and technological factors has fueled this urban-to-rural migration, and those factors are now expected to sustain the trend well into the twenty-first century. The rapid population growth being experienced in some rural areas has the potential to transform radically the physical and the social environments of those regions, including significant fragmentation of habitat and the likely loss of native biological diversity. This is certainly true in the Sierra Nevada (Duane 1993b). It is not limited to the Sierra Nevada, however, for many other nonmetropolitan communities are experiencing rapid population growth. The experience of rapid growth in the Sierra Nevada could therefore be a harbinger for the rest of the rural West.

There is no political jurisdiction with boundaries that coincide with the ecosystem or bioregional boundaries of the Sierra Nevada mountain range, but the 1991 Biodiversity Memorandum of Understanding (MOU), signed by ten state and federal land and resource management agencies, delineated rough boundaries for the Sierra Nevada bioregion that are consistent with those used by SNEP and others. Understanding the social, demographic, and economic characteristics of the Sierra Nevada population and the transformation that is occurring within the region requires a bioregional analysis of census data from 1970, 1980, and 1990. The Sierra Nevada region delineated in the MOU lies within portions of eighteen California counties and three Nevada counties, but only nine of the California counties are completely within the Sierra Nevada bioregion.[7] We therefore took the census data boundaries and included only those county census divisions (CCDs) that were largely within the Sierra Nevada bioregion, creating a composite of CCDs that was approximately coterminous with the boundaries of the Sierra Nevada bioregion and with the SNEP core area.[8] With the exception of the population within the Lake Tahoe Basin, residents of the three counties in Nevada live outside the Sierra Nevada proper. For a number of reasons discussed later, this analysis addresses only the Sierra Nevada portion of the eighteen California counties. Portions of other counties (e.g., Lassen County) were included in the social assessment work completed for SNEP (Doak and Kusel 1996). Our analysis builds on previous work by Timothy P. Duane and Philip Griffiths, who selected the original list of CCDs based on the Biodiversity MOU (Duane 1993a; Griffiths 1993). The SNEP "core" study region is slightly larger, but the CCDs outside the original forty-six in the eighteen California counties include significant populations that are not in the "core" study region. We have therefore retained the forty-six Sierra Nevada CCDs as the primary units of our assessment. Figure 11.8 shows the Sierra region portion of the eighteen California counties.

Our analysis determined that only 26% of the population in the eighteen Sierra region counties in California actually resided within the Sierra region of those counties. The Sierra region population also differed from both the overall population of Sierra region counties and California's statewide population in social, demographic, and economic characteristics (Duane 1993a, 1993c). This difference has important implications for land and resource management and planning, because the primary locus of political power and decision making within the eighteen-county region lies outside the Sierra Nevada. Moreover, the 32,000 mi^2 Sierra region was home to only about 2% of California's population in 1990 (despite accounting for roughly 20% of the land area in the state).

Population growth in the Sierra region of the eighteen California counties in the Sierra Nevada was nearly exactly the same in absolute terms in the 1970s (175,472 people) as in the 1980s (174,101 people). In contrast, the eighteen-county region grew faster in the 1980s than the 1970s (597,935 versus 452,241). This was in the context of much greater growth in California in the 1980s than the 1970s (6,092,000 versus 3,697,000). Due to the larger base population in 1980 than 1970, however, the percentage growth rate was lower in the 1980s than in the 1970s in the Sierra region. Table 11.A1 in appendix 11.1 shows growth patterns by county and subregion of the Sierra region, which are discussed in the next section.

Population growth is not evenly distributed across individual counties, however; some areas experience more rapid growth and/or population turnover than other areas, and this has social, economic, and ecological implications for the Sierra Nevada. Figure 11.9 illustrates the pattern of county inmigration for the central Sierra Nevada region of Nevada, Placer, El Dorado, Amador, and Calaveras Counties. The western part of Placer County, including the cities of Roseville and Rocklin, is technically outside the boundaries of our study area but is included here for reference purposes. This map shows that more than 30% of the population moved to each of the respective counties between 1985 and 1990 for many of the census block groups. Note that this was not generally true around many of the established communities, such as Grass Valley and Nevada City in Nevada County, but was generally true in the unincorporated areas.

Fully 12.68% of California residents in 1990 did not live in California in 1985, but only 7.01% of Sierra region residents were from outside the state. State-level population growth is dominated by three sources: (1) natural increases; (2) foreign

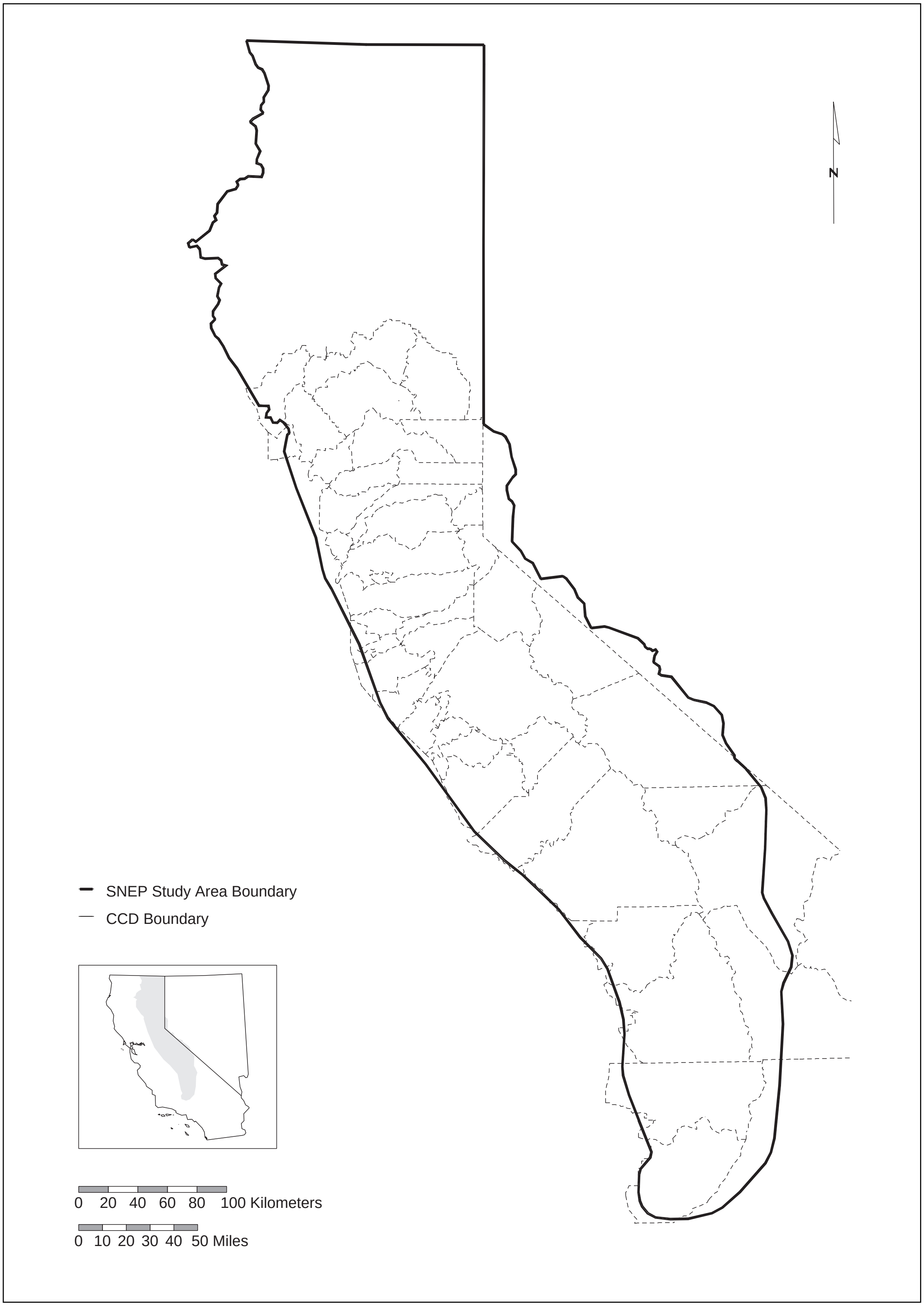


FIGURE 11.8

Census civil divisions included in growth analysis.

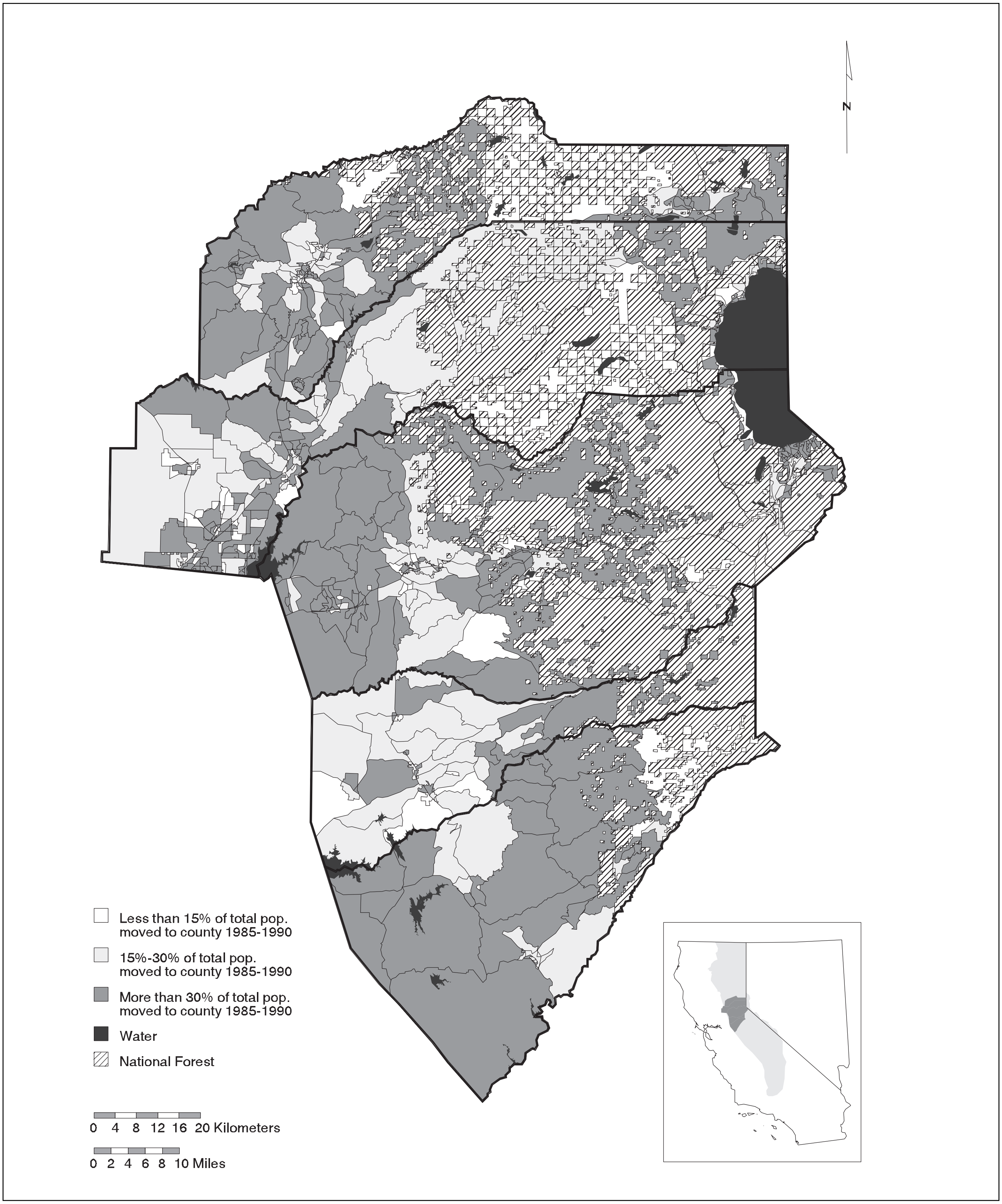


FIGURE 11.9

County in-migration, central Sierra Nevada region (based on 1990 Census of Population Summary Tape File 3A).

immigration (both legal and illegal); and (3) domestic immigration from other states (Teitz 1990). Since the 1990 census, the state has experienced relatively high natural increases and continues to accommodate from one-fourth to one-third of the legal foreign immigration to the United States. Illegal immigrants are much more difficult to account for, but California also clearly has a disproportionate share of the nation's illegal immigration. Domestic migration has literally reversed itself: whereas the state grew by up to 453,000 people per year at the peak in 1990 through domestic migration from other states, it is believed to have had a net domestic population loss for some years from 1990 to 1993 through emigration to other states. There was a net gain of 33,000 domestic migrants in 1994, however, as lower real estate costs and a slight upturn in the California economy began to draw new immigrants. This small net gain was nevertheless overwhelmed by a net natural increase of more than 361,000 births over deaths. The age structure, birth rates, and demographic momentum of California's current population now ensures that the state will continue to grow even without significant net domestic immigration. This demographic momentum has profound implications for future population projections, which will increasingly be dominated by natural increases. Most of that natural increase is expected to occur in metropolitan areas.

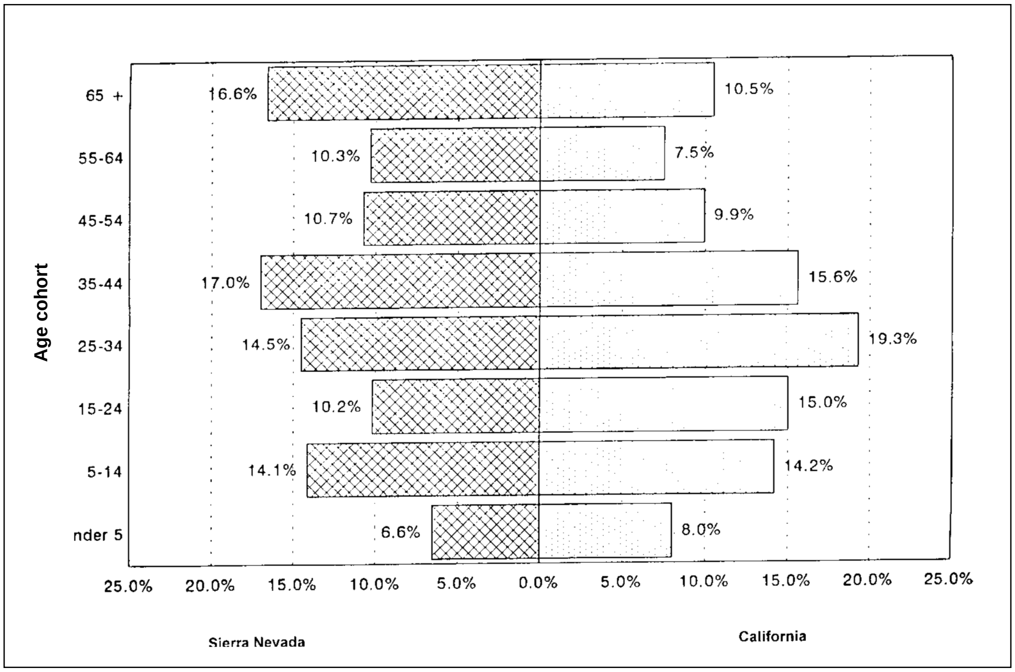
Unlike the rest of California (in particular, the metropolitan areas and the Central Valley), the Sierra region experienced low natural increases, low foreign immigration, and low domestic migration from other states from 1970 to 1990. Most of the population growth in the Sierra region during this period was due to immigration from other parts of California. More than one-fourth (27%) of the Sierra region residents in 1990 lived in a different county within California in 1985. Given that the population of the entire Sierra region grew by 39% in the 1980s, we would expect that about 14% of the 1990 Sierra region population would have been nonresident in 1985 based on population growth alone (half of the 1980–90 total immigration total divided by the 1990 total). Combined with the 7% of 1990 Sierra region residents who were out of state in 1985, however, more than one-third of 1990 Sierra region residents (27% plus 7% equals 34%) were not residents of the same county just five years earlier. Some Sierra region residents may have moved across county lines and remained within the Sierra region, but these data suggest that the turnover rates among migrants are much greater than the net changes in population would suggest. A large fraction of new migrants may therefore not be staying in Sierra Nevada communities for more than five years. Fully 40% of the residents of the Tahoe Basin and Truckee areas in 1990 were not residents of the same county in 1985 (Griffiths 1993).[9]

This is partially explained by the demographic characteristics of the Sierra region population and its new migrants. The population of the Sierra Nevada in 1990 was considerably older than the population of California. The percentage of people over 55 years of age in the Sierra region (27%) was 50% greater than the percentage for the state (18%). The proportion of people 15 to 24 years of age was also lower in the Sierra region (25%) than in California as a whole (34%). The percentages of people under 15 and from 35 to 54 were similar for the Sierra region and the state. A coarse regional analysis of age-cohort changes from 1980 to 1990 suggests there is a net out-migration of young adults from 15 to 34 years of age and a net in-migration of adults 35 to 54 and over 55 years of age. Despite the common perception that it is only retirees moving into the Sierra region, therefore, the source of population growth appears to be both retirees and working-age adults. The 35 to 54 age cohort grew by 6.6% in the Sierra region from 1980 to 1990, while the over 55 age cohort remained relatively stable. This contrasts with a 3.7% increase in the 35 to 54 cohort and a 1.5% decline in the over 55 age group for the state as a whole. Despite the larger proportion of older residents, then, in-migration by additional retirees during the 1980s merely replaced those in the same cohort who had moved out of the region or died. Because the Sierra region has a disproportionately larger share of persons over 55 and a disproportionately smaller share of persons under 5 years of age, natural increase accounts for a very small fraction of annual population increases. Differences between the Sierra region and California's age structure are shown in figure 11.10 (Griffiths 1993).[10]

A more detailed cohort survival analysis of data for Nevada County shows that the working-age adults are also bringing with them young school-age children. Indeed, it appears that the arrival of kindergarten for a member of the household may be a critical factor driving migration to the Sierra region. Fewer children are projected to migrate to Nevada County by the model either under 5 years of age or between 15 and 19 than in the 5 to 9 and 10 to 14 age groups. Following graduation from high school, the young adults appear to leave the area either for school, employment, or the attractions of urban life and are not replaced by immigrants in the same age cohort. Young families in their thirties then appear to move to the area with young children who have reached school age. Similar numbers of migrants in the 30 to 34, 35 to 39, 40 to 44, 45 to 49, and 50 to 54 age cohorts are projected by the model to migrate to Nevada County. Finally, a much larger cohort of retired and semi-retired migrants over the age of 55 are projected to move into the area based upon the 1980–90 trends.[11] The projected migration patterns for Nevada County and the state as a whole are quite different, as shown by figure 11.11 and figure 11.12. The projection for California shows emigration for all age classes from 60 to 84, while immigration is strong in the 20 to 29 age class (age cohorts showing net emigration for Nevada County). In addition to migration characteristics, however, it is important to note that Nevada County's general fertility rate was only 62 per 1,000 females, compared to an average of 73 per 1,000 females for all of California. Migration is therefore a more significant factor for population growth in the Sierra region than it is for the state as a whole (Collados and Griffiths 1993).

FIGURE 11.10

Percentage of population by age, Sierra Nevada and California.



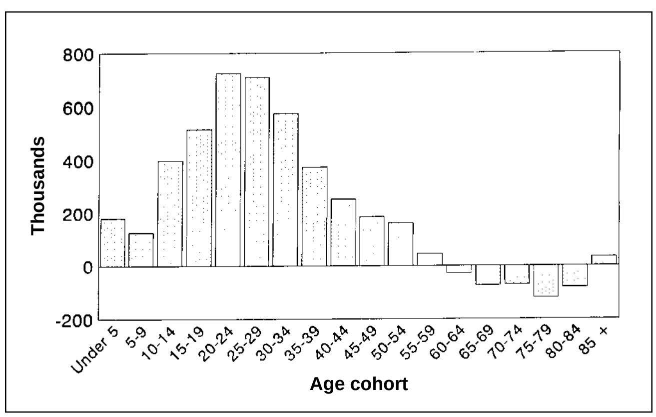
The characteristic that most distinguishes the Sierra region from the rest of California, however, is that its population is overwhelmingly white. This ethnic homogeneity of the region's population has even been cited by some as the primary reason for migration to the Sierra region (Walsh 1991). While the state of California is becoming increasingly heterogeneous in cultural and ethnic terms, approximately 92% of the Sierra region was white in 1990. The comparative figure for the state was 69%. Three of the Sierra region counties, Amador, Tuolumne, and Kern, also have state correctional facilities that account for a significant fraction of each county's population (approximately 10% of Amador).[12] The inmates at these state prisons are much more ethnically heterogeneous, so their presence tends to overstate the ethnic heterogeneity of the Sierra Nevada population.[13] Nevada County (which has no state correctional facility) was over 97% white in 1990, which made it the most ethnically homogeneous county in the entire state of California. The nonincarcerated population of the Sierra Nevada was therefore probably somewhere between 92% and 97% white in 1990.

The 1990 census is likely to have undercounted some nonwhite ethnic groups, however, and there appears to have been an increase in nonwhite residents of the Sierra region in the 1990s. The 1990 undercounting is likely to have been most significant for Hispanics or Latinos, and that is also the group that appears to have increased since 1990. South Lake Tahoe resort casinos are increasingly employing Latinos and Filipinos in low-wage kitchen and maintenance jobs instead of young, seasonal white workers. This is a phenomenon that is most evident by the predominance of Spanish behind the kitchen door or among the maids cleaning rooms on any hallway of a high-rise casino. Bilingual education has also increased dramatically in South Lake Tahoe schools, while communities near both North Lake Tahoe (e.g., King's Beach) and Stateline (e.g., South Lake Tahoe) have significant pockets of poverty. An informal economy has also appeared in some areas (e.g., Truckee) where Latinos gather at a regular spot each day for day wage labor. It is unclear whether or not undocumented aliens are a significant part of this underground labor pool. Most appear to be legitimate residents, either with citizenship or a "green card" allowing work on a permanent resident visa. This is certainly true for the more formal employment sector in the tourism industry and parts of the construction industry.[14]

The dominant ethnicity of the nonwhite population of the Sierra region also varies by subregion. Portions of the Sierra

FIGURE 11.11

California projected migration by age group, 1990–2000.



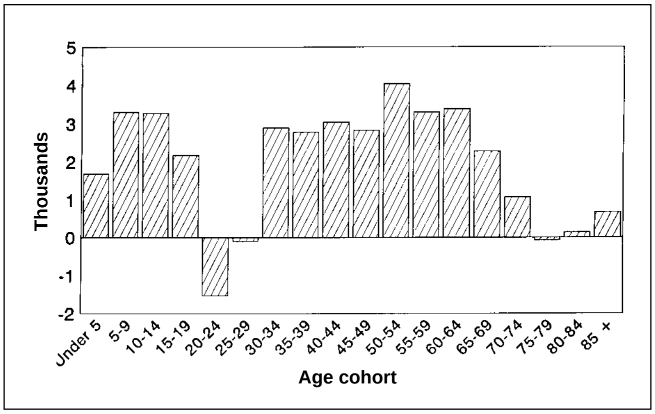


FIGURE 11.12

Nevada County projected migration by age group, 1990–2000.

Nevada have significant Native American populations, for example, as a percentage of the relatively small total subregional population. This is particularly true for the eastern Sierra subregion. The greatest ethnic heterogeneity appears in the southern Sierra subregion, with its strong ties to the agricultural communities of the southern Central Valley. There is a higher percentage of Hispanics in this portion of the Sierra region and a lower percentage of whites than in any other subregion. These differences are even more pronounced by community, as reported in Doak and Kusel (1996). Even those subregions with apparent ethnic homogeneity have communities within them that are quite different.

We use slightly different subregional boundaries and names in this chapter than those used by Doak and Kusel (1996). This difference reflects the specific emphasis of our assessment, which is human settlement and its relationship to the forces driving population growth in the Sierra Nevada. Here is a brief summary of the subregional groupings and names used by each of our respective assessments:

- Northern Sierra in this chapter includes Plumas, Butte, Yuba, and Sierra Counties. The social assessment chapter adds some parts of Lassen County.
- Lake Tahoe in this chapter includes eastern Nevada, Placer, and El Dorado Counties. The social assessment chapter uses the name Greater Lake Tahoe Basin and adds Alpine and parts of Washoe and Douglas Counties in Nevada.
- Gold Country in this chapter includes western Nevada, Placer, and El Dorado Counties. The social assessment chapter uses west-central north for the same area.
- Mother Lode in this chapter includes Amador, Calaveras, Tuolumne, and Mariposa Counties and the eastern portion of Madera County. The social assessment chapter uses west-central south for the same area.
- Southern Sierra in this chapter includes portions of Fresno, Tulare, and Kern Counties. The social assessment chapter uses southwest for the same area minus a small part of Tulare County.
- Eastern Sierra in this chapter includes Inyo, Mono, and Alpine Counties. The social assessment chapter uses southeast for the same area minus Alpine County and plus a small part of Tulare County.

All of the Sierra Nevada subregions used in this assessment and their relationship to one another are shown in figure 11.13. Note that the area covered in our CCD-based analysis does not coincide precisely with the SNEP core study area boundary.

Maps showing each of the subregions used in this assessment of human settlement and all of the associated CCD units appear in figures 11.14–11.19. In contrast to our CCD-based assessment of human settlement, the social assessments group developed its "community aggregations" from the 1990 "census block groups" (CBGs), which are a smaller unit of analysis than the CCD. These smaller CBG units were not delineated for the 1970 census, however, forcing us to rely upon the larger CCD units as the basis for our analysis of population growth from 1970 to 1990 below the level of the county.

These CCD units will be referred to again in our projections of 1990–2040 population and human settlement patterns in the Sierra Nevada. They are our primary units of analysis at the scale of the entire Sierra Nevada and across multiple decades. We will nevertheless translate these CCD-based estimates into more spatially explicit patterns of human settlement through analysis of the Nevada and El Dorado County General Plans.

Analysis of population growth from 1970 to 1990 shows that some subregions and some CCDs grew much faster than others. Moreover, some experienced more rapid growth in the 1970s than the 1980s and vice versa. Finally, the unincorporated areas in the Sierra Nevada accommodated the vast majority of the population growth. The dominant pattern of development was therefore beyond the service boundaries of existing water and sewer infrastructures, which are important factors influencing patterns of development. This pattern of growth also made counties (rather than incorporated cities) the dominant planning and regulatory entities with jurisdiction over land use and human settlement in the Sierra Nevada. California has a strong "home rule" tradition regarding land use, with local governments exercising planning and regulatory authority within the context of general state policies. Those state policies include specific requirements for the preparation of General Plans, consistency requirements calling for zoning to be consistent with those General Plans, and environmental review procedures under the California Environmental Quality Act (CEQA). Other state and federal regulations regarding water quality and air quality can impose constraints upon land use decisions by local governments,

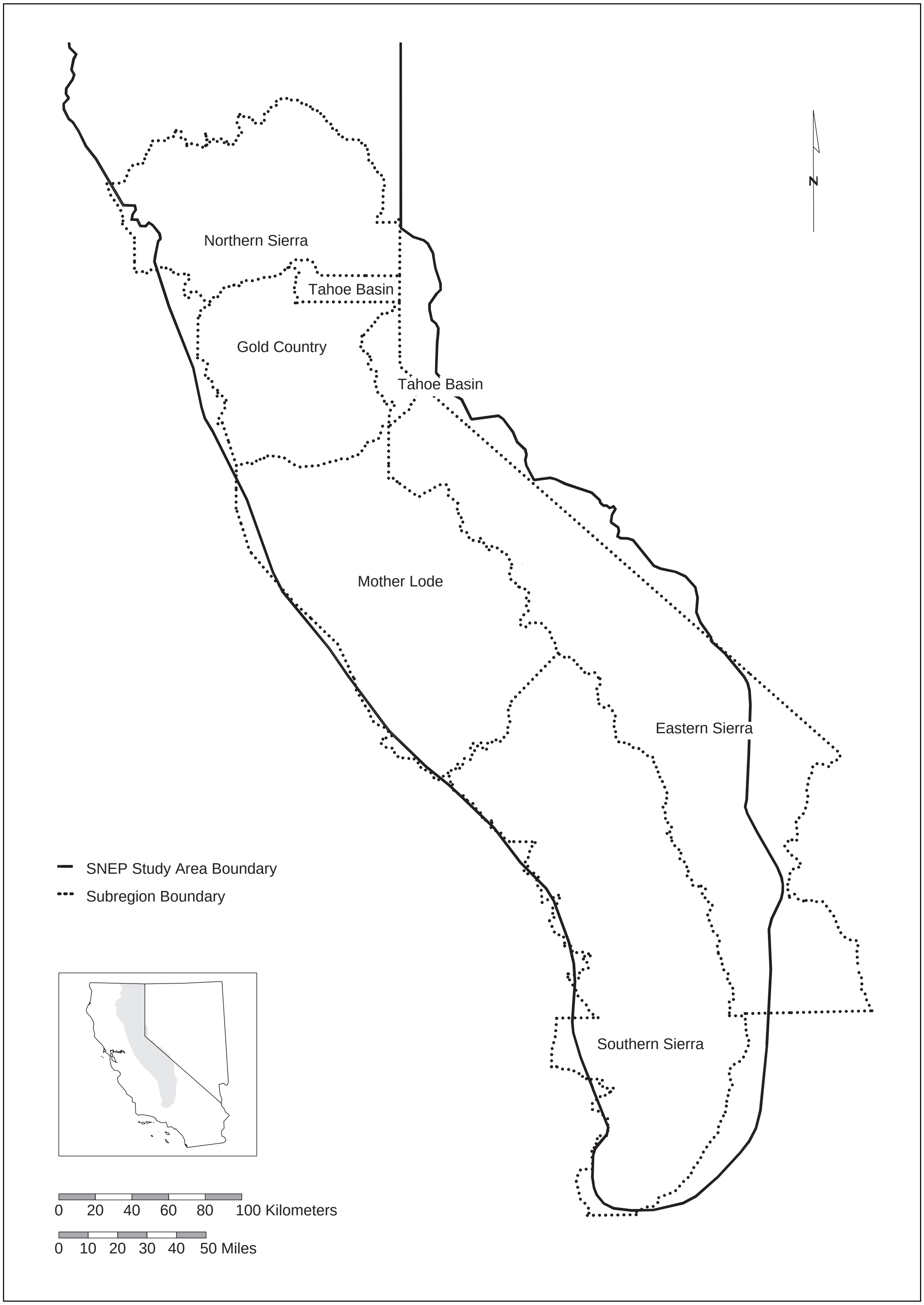


FIGURE 11.13

Subregions of the Sierra Nevada (SNEP core area).

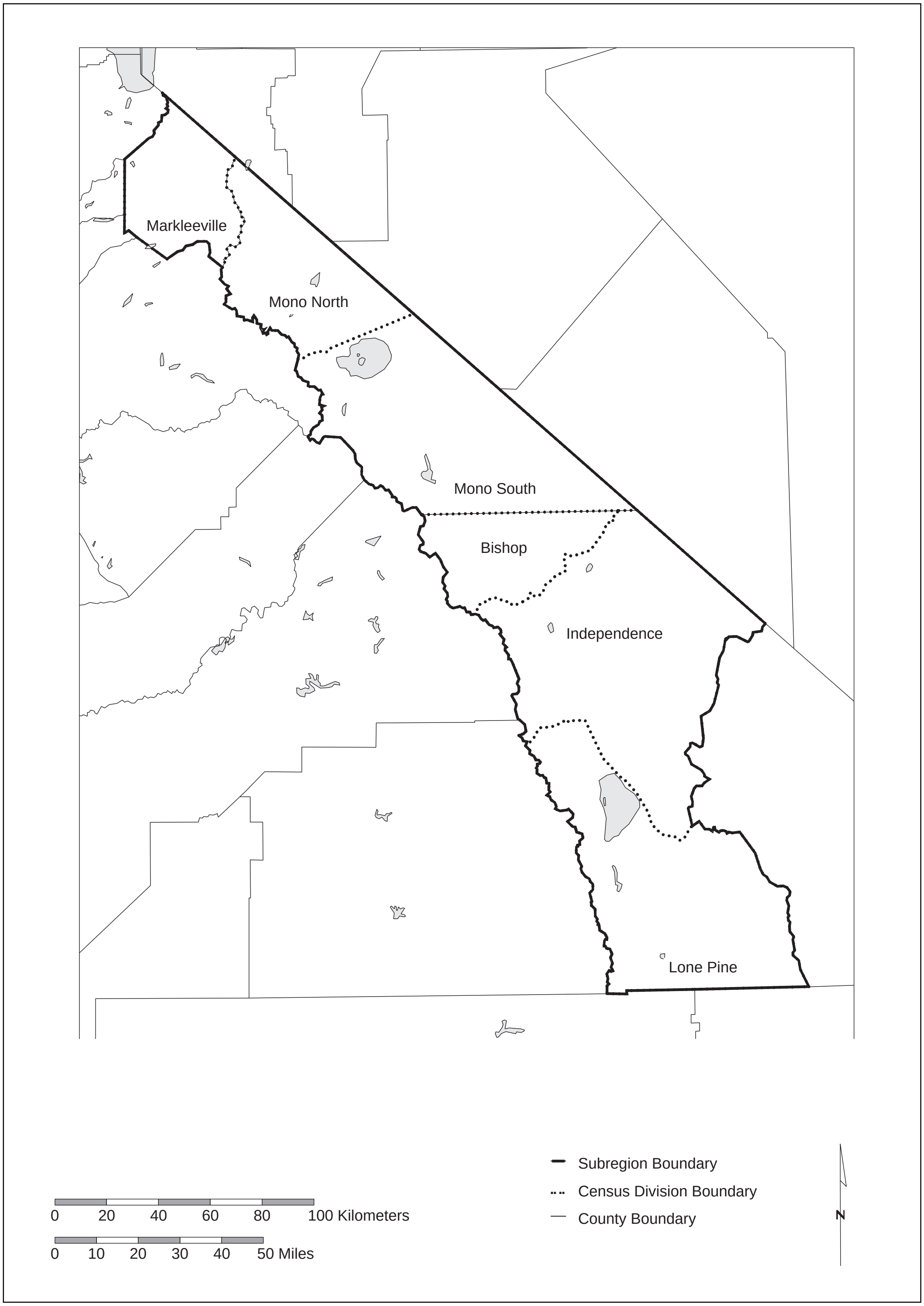


FIGURE 11.14

Eastern Sierra subregion.

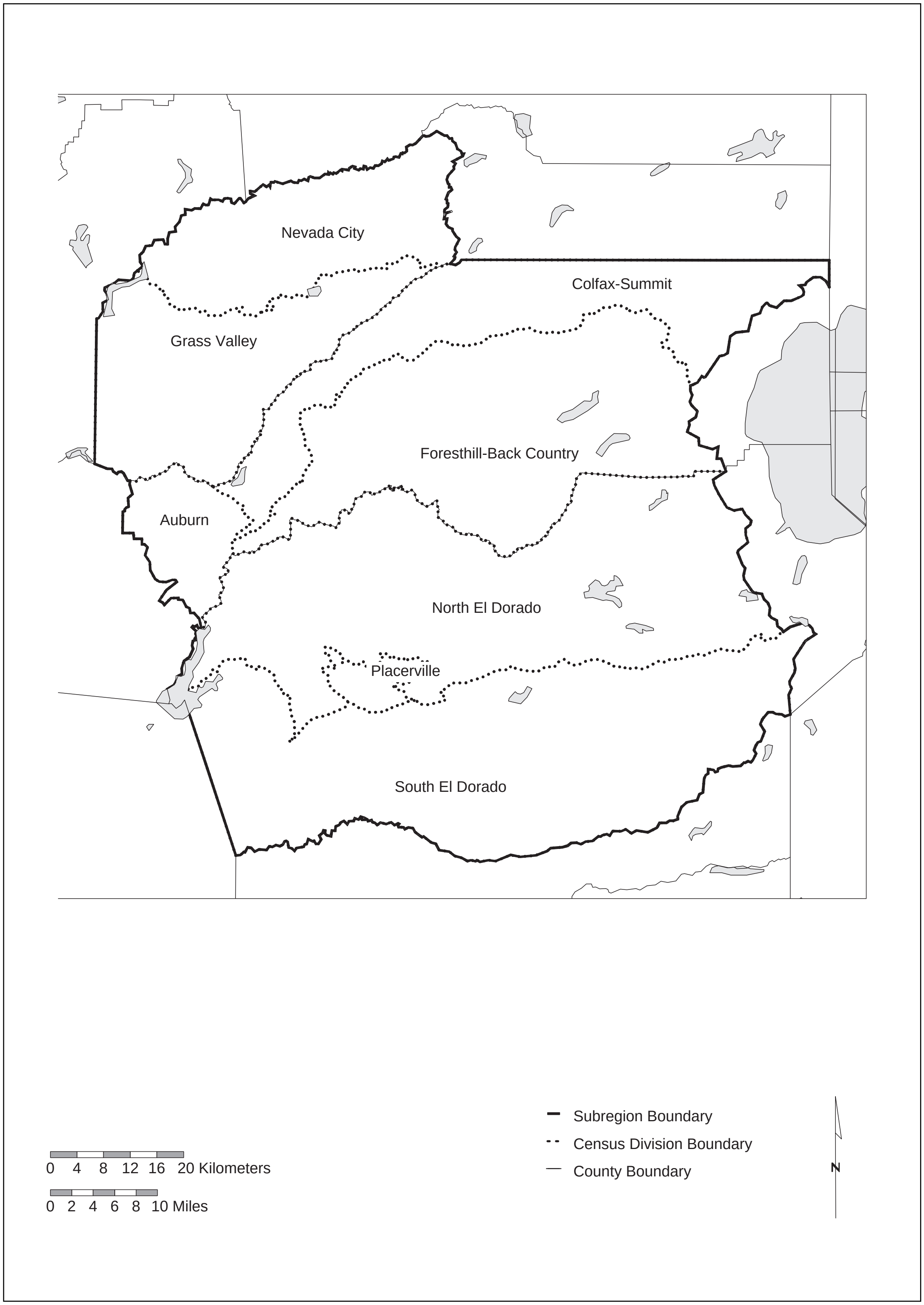


FIGURE 11.15

Gold Country subregion.

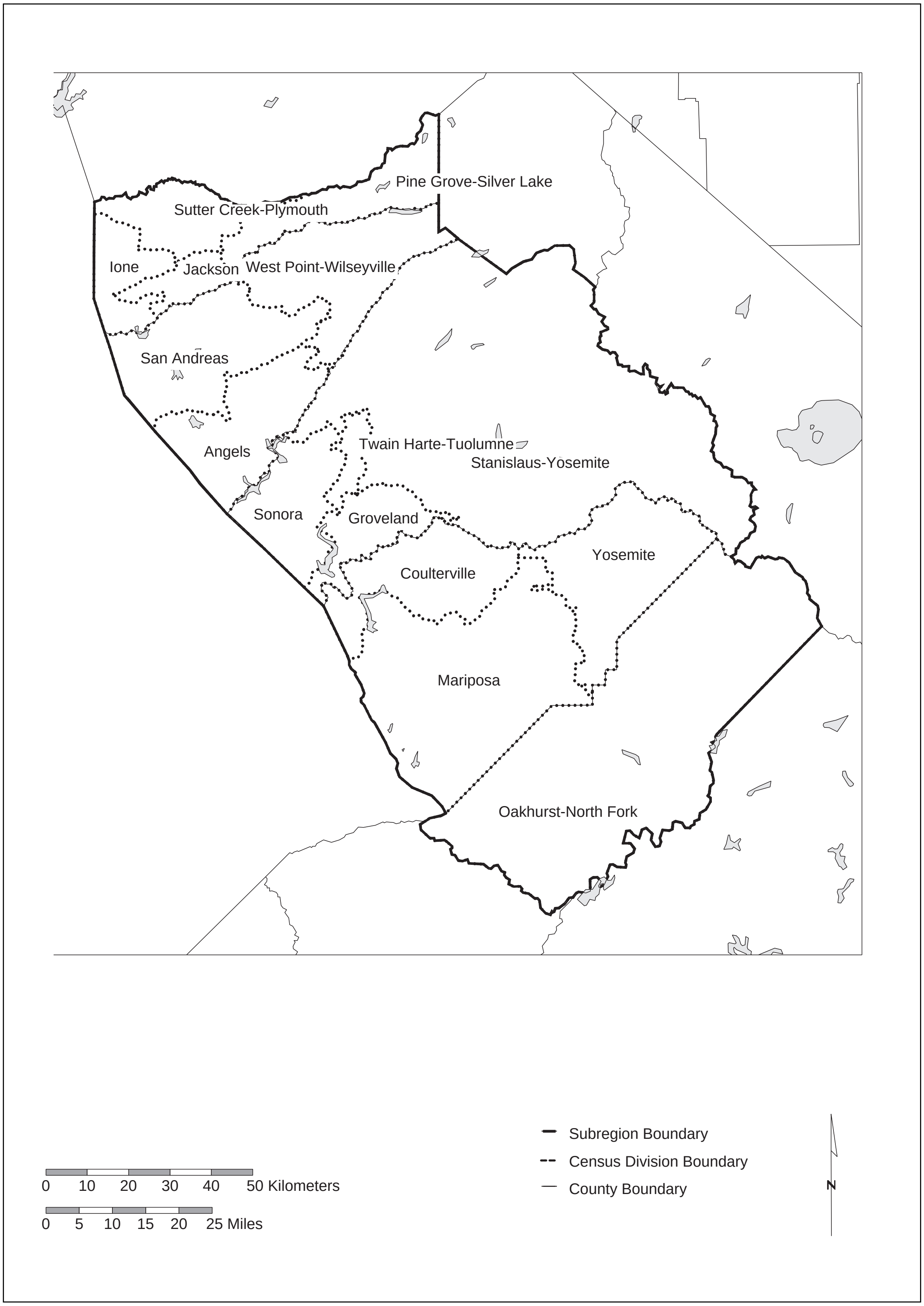


FIGURE 11.16

Mother Lode subregion.

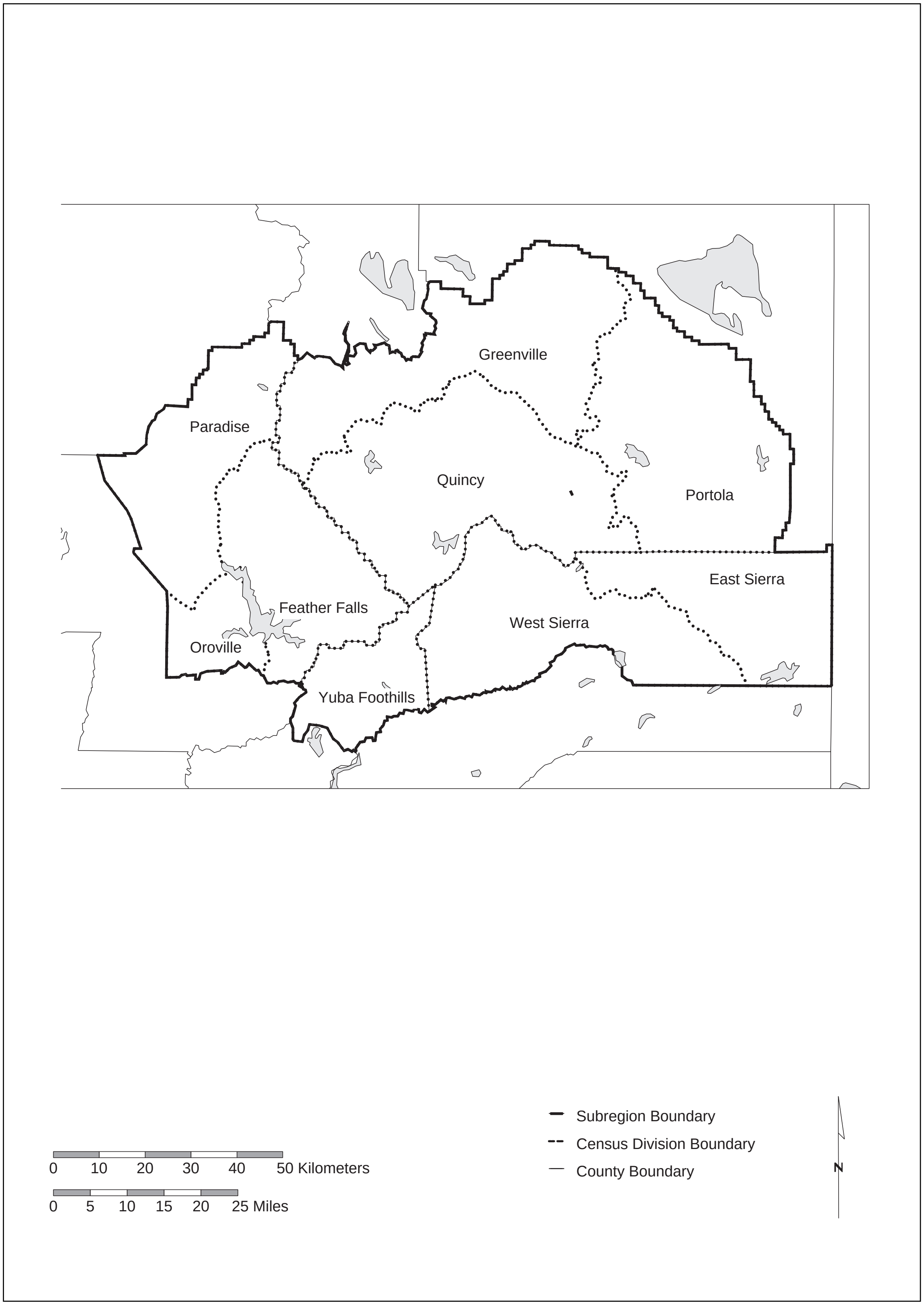


FIGURE 11.17

Northern Sierra subregion.

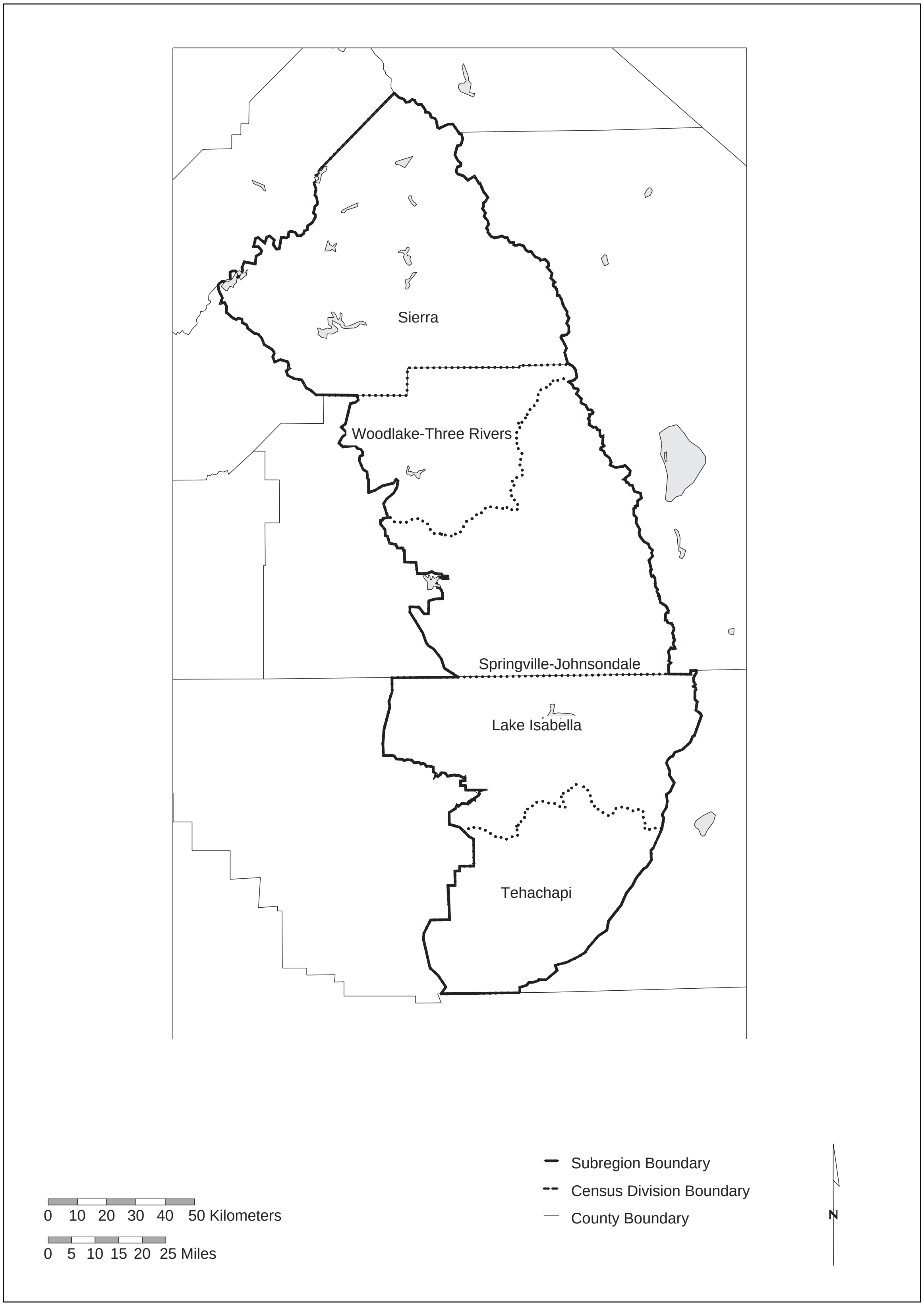


FIGURE 11.18

Southern Sierra subregion.

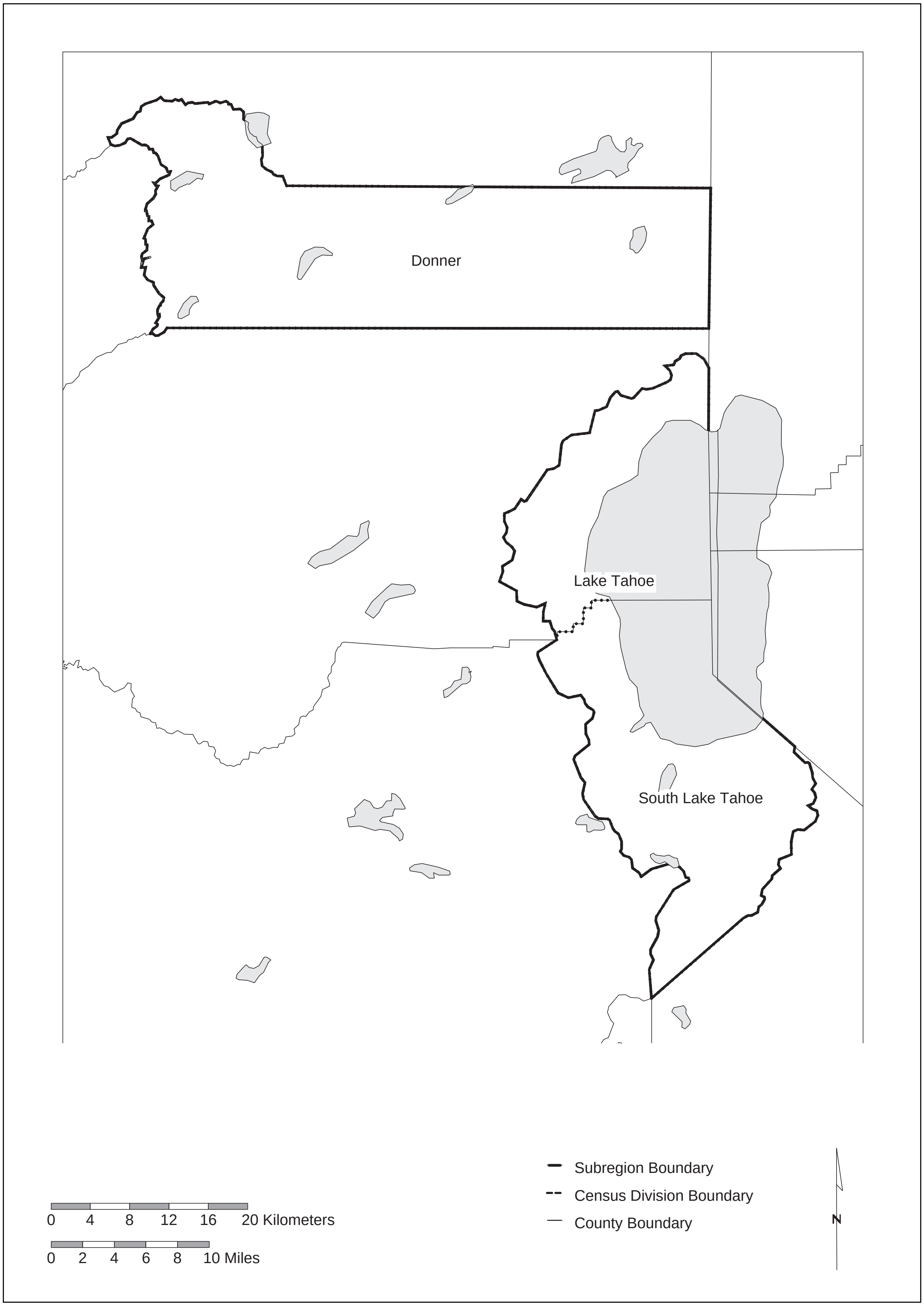


FIGURE 11.19

Tahoe Basin subregion.

and the state has recently imposed new requirements regarding fire safety near wildland areas. Primary planning authority continues to rest with local governments, however, and the county governments of the Sierra Nevada were responsible for land use where most of the development took place in the 1970s and 1980s. Incorporated cities accounted for a relatively small share of growth or land conversion associated with human settlement. As we will discuss later, however, much of the template for recent development patterns was set by policy decisions dating back to the late 1960s and early 1970s.

Nonmetropolitan Population Growth and the Exodus to Exurbia

Arthur C. Nelson offers a comprehensive discussion of exurban regions in his 1992 article "Characterizing Exurbia" (Nelson 1992). The term first appeared in a 1955 book called The Exurbanites, which described a group of people living farther out in the metropolitan orbit than existing rail lines (Spectorsky 1955). Webster's New World Dictionary offered a definition of the exurbs in 1972: "a region, generally semirural, beyond the suburbs of a city, inhabited by persons in the upper income group . . . commuting to the city as a business or professional person" (Nelson 1992). This is also approximately the time that rapid growth pressure began in the Sierra Nevada foothills of California. Most writers emphasize the economic dependence of exurbanites upon nearby urban areas that are accessible via a daily automobile commute (Nelson 1992; Joseph and Smit 1981). This theme is repeated in Thomas W. Sanchez and Nelson's 1994 paper "Exurban and Suburban Residents: A Departure from Traditional Location Theory?" which suggests that exurbanization may simply be an expansion and extension of suburbanization (Sanchez and Nelson 1994). Resolving this issue is of central importance to our understanding of the factors driving rapid nonmetropolitan population growth, for it influences our interpretation of the relative importance of different factors driving human settlement. Relevant data have generally been too aggregated to allow a definitive conclusion, however, because counties (especially in the West) are generally large. Many different types of communities and economic activities may therefore be dispersed throughout a county, making it a heterogenous unit. Judy Davis and her colleagues recognized this distinction in their 1994 study of the "The New 'Burbs" in the Portland, Oregon, metropolitan area, but even their analysis focused on exurban development in relationship to the metropolitan orbit (Davis et al. 1994). Their primary contribution was some hard data that distinguished between "rural," "exurban," and "small town" residents. We do not have similar data for Sierra Nevada residents, but it is clear that all three types of residents are present in the rapidly growing exurban landscape.

Due to the focus on exurban residents' need to commute to metropolitan employment on some regular basis, however, all of these definitions of the exurban landscape imply some degree of physical proximity to metropolitan regions. This model views exurban development as an extension of the urban sphere just beyond the metropolitan periphery,[15] which reflects to some degree the metropolitan orientation of academic departments of city and regional or urban planning. This perspective is predicated in part on an industrial model of economic activity, however, that may no longer be an accurate characterization of economic relationships in a postindustrial information economy. A series of trends in the 1970s and 1980s converged to reduce the need for physical proximity while retaining the need for some type of economic integration with metropolitan areas in the 1990s. The "space of flows" (economic, social, cultural, and informational [Castells 1989]) has now become central to the cultural, and economic geography of a region: its ties to other regions (and even its residents' conception of their "sense of place") are decreasingly constrained by physical geography and their proximity to the metropolitan core. Exurban regions can therefore have economic and cultural links to metropolitan centers and the global capitalist economy even when they are well beyond commuting distance. At the same time, of course, limited access to new technologies could isolate rural areas further from the economic mainstream. The spatial structure of economic activity both within the metropolitan region and between the metropolis and the hinterlands is likely to be affected by such technological and economic changes. The forecasting challenge is to identify how those changes will translate into spatial patterns of economic activity and residential location choice. There is still considerable debate about this, of course, so it is difficult to offer definitive forecasts about exurban settlement patterns (Castells 1989).

There is nevertheless some evidence in the patterns of exurban development in the Sierra Nevada that metropolitan access is only important for a subset of individuals migrating into the region. That subset accounts for a significant fraction of overall population growth, but it is also associated with a pattern of human settlement that is higher in density and therefore results in less land conversion per housing unit. The total land area directly affected by exurban growth is therefore not dominated by commuters. The associated patterns of commuter-dependent human settlement are at present concentrated primarily along the western foothills zone in the Gold Country east of Sacramento. Other factors have dominated human settlement in other parts of the range, so we must address the full range of settlement patterns to address the impact of exurban growth on the Sierra Nevada landscape. Each of these factors is discussed in detail later.

The most important patterns of population growth in the Sierra Nevada are likely to be dominated by changing patterns of economic activity and industrial location within metropolitan areas. There is strong evidence that the boom in nonmetropolitan population growth has been most pronounced near existing metropolitan areas, for example, so we can not discount the importance of proximity to metropolitan regions as a critical driving force in the growth of exurbia (Blumenfeld 1954, 1986; Hart 1991; Nelson and Dueker 1990). The west-central Sierra Nevada counties of Nevada, Placer, and El Dorado accounted for 40% of the population growth in the Sierra region from 1970 to 1990, and they all have a significant population of commuters to the greater Sacramento metropolitan area. Expansion of that metropolitan area will tend over time to include portions of those counties, just as suburban regions in the past were once small towns or rural areas. In fact, increases in population density in these three counties is highly correlated with increases in population density in Sacramento County. Population growth in Sacramento County, in turn, is highly correlated with population growth trends in the greater San Francisco Bay Area. This reflects the phenomenal growth that has occurred in California's population in the twentieth century. The state averaged a doubling of population roughly every twenty years through 1970 and then added ten million more people from 1970 to 1990 (Teitz 1990). Those ten million people settled primarily in metropolitan areas, setting the stage for the exodus to exurbia by previous metropolitan residents.

Nelson has estimated that approximately one-fourth of all American residents lived in exurban counties in 1985, and those exurban counties accounted for nearly 30% of all population growth between 1965 and 1985. He also estimated that the land area of those counties covers nearly a third of the United States. This pattern appears to have accelerated since 1985. As Nelson notes, however, this assessment at the county level was limited by the structure of census data available at the time of his analysis. Many counties include subareas that are urban, suburban, exurban, and rural. It is therefore difficult to associate the gross land area of the county categories cited above with the net land area that may reflect an exurban pattern of settlement. This is particularly true in the western United States, where counties are generally much larger in area than those found in other parts of the country. Placer County, for example, is classified as "metropolitan" by the census because it has one city (Roseville) with a population greater than 50,000 persons. Roseville is outside of the Sierra Nevada proper, however, and it is doubtful that the presence of Roseville within the jurisdictional boundaries of Placer County makes Squaw Valley near north Lake Tahoe part of the Sacramento "metropolitan" region. Portions of nearby El Dorado County are much closer to Sacramento than Squaw Valley in terms of commuting times, yet all of El Dorado County is classified as "nonmetropolitan." Further spatial analysis of the 1990 census data is therefore necessary to determine actual patterns of density and sprawl and the relationship between growth in "urban," "rural," and "exurban" areas. Differentiation between types of exurban growth patterns is also necessary.[16] Our disaggregation of county-level data down to the CCD level has allowed us to assess the phenomenon of exurban development in the Sierra Nevada with less interference from "spillover" data from metropolitan centers within or adjacent to Sierra Nevada counties. This level of analysis is still quite coarse, however, so it has also been necessary to analyze patterns at the block-group and block levels of the U.S. census to understand spatial patterns more accurately. It is the specific spatial pattern of human settlement on the landscape that determines the ecological consequences of development in the Sierra Nevada, so we cannot rely upon broad generalities about urban-to-rural migration patterns derived from nationwide assessments at the county level.

Based upon county-level analysis, the evidence for a broad "reverse migration" from urban to rural areas was strong throughout the United States for the 1970s. It was first identified by demographer Calvin Beale in 1975 (Beale 1975) and confirmed by the 1980 census. For the first time in American history, the 1980 census showed that nonmetropolitan areas grew faster than metropolitan areas during the previous decade.[17] This so-called rural renaissance brought great hope to residents and planners in many rural areas, which had experienced consistent decline throughout the previous century (Vining and Strauss 1977). A general sense of opportunity in rural areas came from this macro-level reading of the census data: rural areas might have more economic opportunities in the 1980s. The 1990 census showed that urban areas again grew faster than rural areas in the 1980s, however, and the serious economic difficulties of many agriculture-dependent regions highlighted how short-lived and illusory the rural renaissance had been for many areas (Barringer 1993).[18] Many planners therefore concluded that the 1970s were just an aberration. Others argued that the apparent "reverse migration" was just a statistical anomaly due to either the reclassification of counties from "rural" to "urban" between the 1970 and 1980 censuses or to "spillover" growth from metropolitan regions to adjacent nonmetropolitan counties (Nelson 1992). This interpretation argued that the historical rural-to-urban migration pattern had not been reversed but that there had simply been a shift within metropolitan regions to the outlying urban edge. After controlling for adjacency, however, the counterurbanization pattern was still evident for the 1970s: rural counties not adjacent to metropolitan areas also experienced net in-migration (Nelson 1992). This debate and the difficulty of differentiating "rural" from "urban" counties led to a number of recommendations for reformation of the Census Bureau's definitions of rural and urban areas to avoid the problem of "moving targets" through reclassification every ten years (Nelson 1992; Lang 1986). Nelson argued in 1992 that the Census Bureau should go even further and categorize counties as either urban, rural or "exurban" (Nelson 1992).

Whether or not the historical pattern of rural-to-urban migration in the United States has been reversed in aggregate for the country, however, net statistics for migration between "rural" and "urban" or "metropolitan" and "nonmetropolitan" regions do not reveal the uneven distribution of population growth occurring within and among rural areas. Kenneth M. Johnson made this important distinction in his 1993 article

"Demographic Change in Nonmetropolitan America, 1980–1990" (Johnson 1993). He characterizes counties as retirement, recreational, adjacent to a metropolitan area, and not adjacent to a metropolitan area. He also evaluated the importance of an urban place of at least 10,000 people within the county. As suggested by the commuter-oriented perspective on exurban growth, many of the nonmetropolitan counties showing rapid growth in the 1970-90 period were adjacent to "suburban" counties that were part of an adjacent metropolitan region. Many of the other nonmetropolitan regions that grew rapidly during this period were quite distant from metropolitan regions, but they were adjacent to large areas of contiguous public lands. These are areas generally judged to have high scenic amenities, clean air, and ready access to recreational opportunities. Many other rural areas—in particular, those whose economies continued to be exclusively dependent upon agriculture , forestry, or mineral extraction—continued to experience the historical pattern of decline, masking the emergence of a strong exodus from urban areas to exurban regions offering amenities. Among nonadjacent counties, those without an urban place of at least 10,000 were much more prone to decline than those with a large urban place. This factor is less influential for adjacent counties, although there was a tendency for counties with the smallest places to grow more rapidly. This latter finding suggests that other attributes, including amenity characteristics of small-town life, may be important factors driving growth.

The "exodus to exurbia" therefore appears to be associated with both a classic process of suburbanization and an ongoing transformation of rural economies from a commodities-oriented, natural resource–extractive industrial base to a services-oriented, amenity-driven base. Even as aggregate national statistics show a slowdown of urban-to-rural growth (from 14.1% in the 1970s to 3.7% in the 1980s [Johnson 1993]), growth continued rapidly in many desirable small towns and nonmetropolitan areas not adjacent to metropolitan areas. Moreover, as Kenneth Johnson notes, it is important to distinguish between natural increase and migration as sources of change in the total population of a region. Many agriculturally dependent regions had significantly greater gross emigration than the net emigration figures. Both gross and net migration patterns were masked by relatively high natural increases, which have historically been greater in rural than urban areas. Even in areas with net growth, however, the exodus of local residents of childbearing age (coupled with the in-migration of older retirees) meant that "natural increase" was negative in many areas. This means that the net increase due to migration was even greater than net population change. There also appears to be significant turnover among new residents, suggesting that the total number of immigrants is much greater than net inmigration.[19]

This is only a summary of the key literature on the processes of exurban growth. For a detailed annotated bibliography on the literature of exurban growth, nonmetropolitan employment, and rurality, see Barry and Duane (1994).

Factors Driving Population Growth in the Sierra Nevada

Most traditional approaches to economic development in rural regions would predict rapid growth in a rural region only if there is an expansion of resource extraction. This reflects a "base" view of the economy, in which exports of primary commodities are the foundation for all local economic activity. Indeed, this appears to be what drove population growth in most rural and exurban regions before the 1960s. While some economic expansion of extractive industries did occur for subperiods of the 1970s and 1980s (e.g., the western slope Rocky Mountain energy boom of the late 1970s and early 1980s; the increase in timber harvesting in the Pacific Northwest during the middle to late 1980s), these traditional rural industries generally decreased their employment over the 1970–90 period. Some of this decrease was associated with improved labor productivity and consolidation of operations, while some was driven by contraction of production (caused by either market forces or environmental restrictions). In either case, however, those communities that grew the fastest generally grew despite the decline of employment in the extractive sectors. An extraction boom was therefore not driving population growth. The most timber-dependent communities were the slowest-growing areas in the Sierra Nevada from 1970 to 1990, while rapidly growing areas decreased timber-sector employment. Expansion of the extractive industrial base was clearly not driving the exodus to exurbia.

If not driven by extractive industry, what was the economic foundation for this growth? What allowed people to move to these areas, and why did they choose to move there in the 1970s and 1980s? Unlike the traditional resource-extractive base of these rural areas, the base for the subtle yet profound transformation of the 1970s and 1980s has been increasing recognition of the amenity value of natural resources. In some situations this has made resources more valuable in situ than they would be if extracted and exported as commodities for sale in the urban marketplace. This new valuation reflects a broad social change in the environmental values of Americans that has simultaneously challenged traditional approaches to land and resource management over the past three decades. The new values are nevertheless not yet reflected in many of the public land and resource management policies of federal, state, or local agencies. Traditional approaches to land and resource management may therefore sometimes conflict with local social values that are newly emerging as a result of amenity-driven migration and economic diversification.

Those values are readily apparent in a detailed survey of El Dorado County residents conducted in January 1992 as part of the El Dorado County General Plan update. The survey makes it clear that exurbanites are not driven to the Sierra Nevada primarily by traditionally defined economic opportunities but instead seek a way of life (J. Moore Methods 1992). Less than one-fourth of the respondents cited "to work or to find employment" as a major reason for choosing to live in the county, while nearly half said it was to raise their family. "To get away from urban, city life" and "to live in a rural environment" were cited as major reasons by an overwhelming three-quarters of the respondents. This is the primary appeal of the Sierra Nevada. Open space, air quality, and views were cited by 72%, 65%, and 62%, respectively. At least two out of every five respondents listed recreational opportunities as a major reason, while 36% considered "affordable housing" a major reason. Just over one-fourth listed "the quality of the public schools" and fewer than one-fifth mentioned water quality as a major reason for living in the county. Nearly one-fourth of the residents specifically moved to the county to retire, and just over one-fourth mentioned the desire to be near their families as a major reason (J. Moore Methods 1992).[20]

There were no questions about specific "negatives" or "disamenities" that local residents were trying to "escape" by moving from metropolitan areas to the region. These could include several of the factors described below as important factors driving the exodus to exurbia: concern about urban crime, poor urban schools, and increasing racial heterogeneity in metropolitan areas.[21] No comprehensive survey data exist on these issues for the entire Sierra Nevada, and we were unable to undertake such a survey for this assessment. The results of the El Dorado County survey should therefore be viewed as primarily representative of Sierra Nevada residents who live in similar areas in the rapidly growing Gold Country of Nevada, Placer, and El Dorado Counties. We cannot necessarily extrapolate the results more generally to all residents of the Sierra Nevada.

Based upon our review of the literature, twenty-five years of interviews with Sierra Nevada residents, and the quantitative data in the El Dorado County General Plan survey, we believe the following factors have converged to fuel the exodus to exurbia: quality-of-life preferences, the deconcentration of metropolitan employment, information technologies, telecommunications technologies, the shift from manufacturing to services, globalization of the economy, aging of the population, equity gains of urbanites, the lower cost of living in nonmetropolitan areas, the decline of urban schools, increases in urban violence, the ethnic and racial homogeneity in nonmetropolitan areas, and recreation and tourism. This exodus has occurred within the context and against the backdrop of a transportation system that has reduced the cost and time of commuting from the Sierra Nevada foothills. In particular, the construction of Interstate 80 and improvements in U.S. 50 and U.S. 395 have made some parts of the Sierra Nevada much more accessible now to metropolitan areas.

Quality of Life Preferences

Americans have always indicated a preference for small towns and rural lifestyles in surveys, but they have generally settled in urban areas due to the greater range of economic opportunities in metropolitan regions. As Nelson notes, "The latent desire of Americans for the Jeffersonian rural life-style drives exurban development" (Nelson 1992; Carlino 1985; Elazar 1987; Wardwall 1982). Due to the factors outlined later, "the latent preference can now be expressed" (Nelson 1992; Blackwood and Carpenter 1978). It is against this prior background—of American preferences for rural regions—that exurbia has boomed.[22] Many Americans clearly prefer cities and metropolitan life, but they remain a minority of the population except in the case of young, single individuals. Based on survey data, most would prefer to live in a small town or rural area (Nelson 1992; Jackson 1985; Fishman 1987). Most Americans actually choose to live in metropolitan areas, however. This raises an important question about whether or not survey respondents accurately characterize their location preferences.

Deconcentration of Metropolitan Employment

The shape and extent of the American metropolis have changed dramatically ever since World War II and the initial investments in the interstate highway system in the late 1950s, and these changes have clearly affected the desirability and feasibility of exurban development. In part, the exurban growth of the 1970s and 1980s simply reflects the expansion of the American population and economy during the 1950s and 1960s, creating new opportunities to live in the "country" while working in the "city." What is more important, however, is that deconcentration of employment within metropolitan regions shifted to the periphery during the 1970s and 1980s. This put many exurban locations within commuting distance of new employment opportunities (Cervero 1986, 1993; Garreau 1991). In the Sierra Nevada, completion of Interstate 80 and expansion of U.S. 50 have had the most profound affect on expansion of the Sacramento metropolitan area and commuter relocation to Nevada, Placer, and El Dorado Counties.

Information Technologies

The microchip and the personal computer have diminished the need for traditional forms of organizational structure, eliminating the need to have a large critical mass of resources to take advantage of economies of scale in information management. What could once be done only by a large corporation with a specialized data processing department can now be accomplished by an individual with a thousand-dollar personal computer. This change has opened up the structure of business, creating new opportunities for smaller organizational structures that can respond to the need for flexible production systems. In some cases these small groups—no longer dependent upon employment in the downtown headquarters of a major corporation—have chosen to relocate based upon other criteria that reflect residential location preferences.

Telecommunications Technologies

The computer modem, facsimile machine, cellular phone, and cable television have made it possible to modify many of the historic relationships between economic activity and location. Just as the personal computer allowed individuals to analyze data without relying upon the corporate bureaucracy, these technologies allow the analysis to be completed anywhere within communications range. The establishment of overnight delivery services has made small towns in rural areas just as "close" to markets as urban areas in terms of shipping important documents and products. Overnight shipping services have also made mail-order and phone-order shopping much more convenient for exurban residents. Moreover, access to cultural material that was historically only available in urban areas—such as timely news, opera or symphony, and major-league sporting events—is now made possible with satellite-dish or cable television and same-day, West-Coast publishing of the Wall Street Journal and the New York Times. One need no longer live in a metropolitan area to gain many of its amenities and access to its wide choices and specialized consumer markets.

Shift from Manufacturing to Services

Just as globalization has reduced the relative importance of an urban location, a shift in the relative importance of services and value-added manufacturing (with relatively low material intensity, such as computer software) makes proximity to markets and/or raw materials less important than before. There are now a number of economic activities that do not have significant transportation costs associated with them. This shift is, of course, made possible partly by the other social, demographic, technological, and economic trends described here. Growth in the service sector also reflects a general trend in the structure of maturing, postindustrial economies (Powers 1996).[23] That shift increases the viability of economic activity in exurban regions.

Globalization of the Economy

The expansion of global markets and the relative decline of American dominance of the domestic market have combined to create new opportunities for business outside the United States. Because an increasing share of business is with customers who are far from domestic urban centers it is less necessary to be in those urban centers than it was when the customer base was primarily located nearby. One may need to be based in New York if all of one's customers are there, but if one's customers are spread from New York to Tokyo to London, one can just as well be in a small town in the Sierra Nevada. This is especially so for many service industries or high value-added manufacturing activities that depend on international markets. Proximity to a major airport is then an important consideration.

Aging of the Population

The aging of the U.S. population, together with the increasing wealth of urban retirees (due to both equity gains and stronger retirement savings), has created a new pool of "empty nesters" able to live wherever they want. This group then lives off the so-called mailbox economy, bringing outside income into the local economy and generating a multiplier effect as well as a demand for specialized services (e.g., health care and financial advising). This is "base" economic activity. Exurban areas experiencing rapid growth tend to have a disproportionate share of retirees, and this generally reflects inmigration rather than a natural increase for that age group (Collados and Griffiths 1993). The Sierra Nevada shows significant gains for immigrants over 55 years of age.

Equity Gains of Urbanites

Rapid population growth in urban areas during the 1970s and 1980s—particularly in California—created strong consumer demand for housing. Many of the existing homeowners were therefore able to sell their urban homes for significant capital gains based upon the difference between their investment and appreciation. These "equity refugees" were able to move from urban areas with high housing costs to rural areas with relatively low housing costs—in some cases buying new houses mortgage-free. In many cases the desire to avoid capital gains taxes compelled investment in a new home of comparable value, however, driving up the cost of housing in the rural area facing growth. The collapse of metropolitan housing markets in the early 1990s has therefore translated into a drop in demand for housing in exurbia.

Lower Cost of Living

Housing values (and the overall cost of living) are generally lower in nonmetropolitan areas than metropolitan areas. This differential therefore creates incentives to move from urban to rural regions that are consistent with strictly economic models of human behavior. Among nonmetropolitan areas, however, housing values (and therefore costs) are now generally highest in those amenity-oriented regions experiencing rapid growth. While they are certainly an important factor, lower housing values alone are unable to explain the migration pattern to exurban areas. Moreover, wages are also generally lower than in metropolitan areas. The specific location choices being made by exurban migrants appear to reflect other criteria. Those amenities therefore translate into significant economic value and activity.

Decline of Urban Schools

Declining quality in and public support for public schools in urban areas have led many urban families with school-age children to send their children to private schools. The increased costs of private education exacerbate the gap between the costs of housing and other services in urban areas and their costs in rural areas. Moving to rural areas is now therefore more cost-effective than it was with good urban public schools, for many families are able to get by with significantly less household income in rural areas. Private schools in urban areas can cost from $5,000 to $10,000 per student per year. Avoiding those costs alone can translate into savings for a mortgage of approximately $80,000–$170,000 for a family with two children. The mean of this range was comparable to median housing values in the Sierra Nevada in 1990.[24]

Increase in Urban Violence

Significant increases in urban violence occurred throughout the 1980s in the United States, despite more than a doubling of the incarceration rate. This violence has decreased the perception of security and well-being that many metropolitan residents still maintained throughout the 1960s and 1970s, when suburban communities were generally deemed safe from the crime of the central city. The increasing concern about safety has led some urban and suburban residents to flee to rural and exurban areas, which are generally viewed as safer. In some cases even that is not considered “safe enough,” however, and many wealthy exurbanites have moved into “gated communities” that offer the perception of even greater residential safety. Many of these communities emphasize safety and security in their real estate marketing campaigns,[25] although some evidence suggests that crime rates may actually be higher within gated communities than in neighboring rural and exurban communities in the Sierra Nevada.[26]

Ethnic and Racial Homogeneity

Racism in American society may also explain some degree of the exodus to exurbia. Urban and metropolitan regions in the United States are increasingly multiethnic, multiracial, and multicultural. At the same time that white populations have reached minority status in many cities (notably in California’s urban areas), the ethnic composition of the exurban areas experiencing rapid growth is overwhelmingly white. It is difficult to determine how important racism is as a determinant of migration, but the exodus to exurbia parallels the migration to suburbia of the 1950s and 1960s. Statistically valid survey data appear to be lacking on this issue (Walsh 1991). We do not believe that this factor dominates the exodus to exurbia, but we recognize it as a factor for some subset of immigrants moving to the Sierra Nevada from metropolitan areas.

Recreation and Tourism

One of the fastest-growing industries in the 1970s and 1980s was recreation and tourism, and Americans primarily travel domestically. Recreation and tourism is now a $35 billion industry in California alone, and Disney World in Florida receives more annual visitors than the nation of France. Increasing interest in outdoor recreation has in some cases focused on national parks and other public lands, but the small historic towns of the Sierra Nevada have also experienced significant increases in tourism. Increasing tourism in those areas has in turn exposed a great number of people to their associated communities, which then became the focus of residential relocation decisions when that became possible for those visitors.[27]

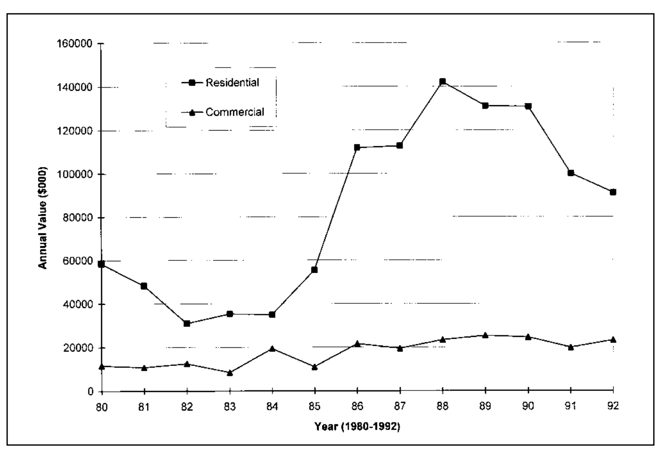
Many of these factors are difficult to consider explicitly in an economically based model of population migration. One quantifiable element of the Sierra region’s economic amenities, however, is the availability of relatively low housing costs (Inman 1992). The weighted average median value of owner-occupied houses in the Sierra region was $128,678 in 1990, only two-thirds the median value of $195,500 for California. Despite significant growth pressures, that value increased only 80% from 1980 to 1990, while the median value for the state went up by 131%. The median value of a Sierra region owner-occupied home therefore dropped from 84% of the state median to 66% from 1980 to 1990. In addition to these relatively low housing costs, a much higher fraction of Sierra region homes are seasonal units—16.5% versus only 1.8% for the state of California as a whole. Once again, the median values of owner-occupied homes, the rate of growth in those values from 1980 to 1990, and the fraction of all housing units that are occupied only seasonally varied widely across the counties and subregions of the Sierra Nevada.

It is also important to note that housing values from the 1990 census are already outdated. The lag in housing value growth between the metropolitan areas of California and the Sierra Nevada led to a surge of price pressures and real estate speculation in the late 1980s and early 1990s. Significant increases in prices during 1990 and 1991 are not reflected in the median values reported by the (April) 1990 census data. Many urbanites “cashed out” on this significant appreciation in urban markets and built their new “equity mansions” in the Sierra Nevada. The real estate development industry also built many new homes on speculation that the price feeding frenzy in urban markets would continue to support demand for high-end custom homes in the Sierra Nevada. Figure 11.20 shows how residential construction took off during the last half of the 1980s, more than doubling in total value in Nevada County in 1985–86 alone.

This phenomenon was greatest in those areas within commuting distance of the Sacramento metropolitan area, but it also occurred in more remote areas such as the Lake Almanor

FIGURE 11.20

Nevada County residential and commercial construction, 1980–92.



peninsula in the northern Sierra Nevada. Many of these equity refugees were not constrained by the need to maintain a job and wage or salary income. Extremely high appreciation in their urban houses gave them after-mortgage equity gains that sometimes exceeded the cost of buying a house in the lower-cost real estate market of the Sierra Nevada; without a monthly mortgage, these exurbanites could then get by with considerably less monthly income. The wealth of these exurban equity refugees is therefore considerably more than their income might suggest, and it has created a new crisis in affordable housing in the Sierra Nevada. There is now a "countercommute" of service workers going up Highways 50, 80, and 49 from the Sacramento metropolitan area every morning to work in the communities of the Sierra Nevada foothills. In the words of former El Dorado County Supervisor Bill Center, "The BMWs are going down the hill while the Pontiacs are going up the hill every morning," then they reverse direction and pass each other again each evening. Median housing values are now lower in the Sacramento metropolitan area than they are in the foothill communities within commuting distance (Drace 1993–95).[28] Nevada County experiences a similar two-way commute, with 30% of employed residents of the county working outside the county while 30% of the jobs in the county are held by nonresidents (Nevada County Transportation Commission 1995a; Nevada County Planning Department 1994a; Landon 1994–95). Many of these nonresident workers probably live in Placer County, however, so the pattern is not tied as directly to the Sacramento metropolitan area.

Prices dropped again slightly and average listing times on the market increased as the rest of the state dropped into recession, but they have not dropped as significantly as housing prices in the hyperinflated metropolitan markets (Marois 1995). The flood of equity refugees has subsided a bit nevertheless, demonstrating how dependent migration pressures are on the economic conditions in the metropolitan regions of California. The Rodney King riots of 1992, the Malibu fires of 1993, the Northridge earthquake of 1994, and the Los Angeles floods of 1995 all had a devastating effect upon the real estate market in southern California. What is perhaps more important, the end of the cold war and significant cutbacks in defense spending have disproportionately affected the California economy. Just as California boomed under the high level of military spending of the Reagan and Bush years, it suffered a bigger bust than most other states with the Clinton cutbacks. Part of the decrease is due to base closures (which have hit California disproportionately), but defense contractor spending cuts have been even more significant. Southern California has lost an estimated half-million jobs in the aerospace and defense sector since 1990. Many of these jobs were held by highly paid homeowners whose demand for housing helped to drive up housing prices in the metropolitan areas. That demand created the equity gains that then allowed other metropolitan residents to make their exodus to exurbia. The loss of those jobs has therefore helped to dry up equity gains over the past five years.

The increases in Sierra Nevada housing prices have generally held at levels comparable to 1989–90, however, and this suggests that low-cost housing may no longer be a significant draw for new migrants in the 1990s and beyond. Median home prices jumped in Nevada County from around $120,000 in 1986 to a high of nearly $200,000 in 1990, and they are now at levels (around $160,000) comparable to 1989 (Marois 1995). Moreover, significant equity gains in metropolitan California real estate markets may be dampened by the hyperinflated values that existed in the late 1980s and their subsequent collapse in the early 1990s.[29] The combination of reduced metropolitan housing costs and increased Sierra Nevada housing costs means that equity refugees have less incentive to move based simply on the economic advantages associated with housing costs. Future exurbanites may therefore be more dependent upon employment income than recent migrants in order to make the move to exurbia. This raises important issues about future commute patterns, the traffic congestion and air quality impacts of the emerging patterns of exurban development, and the economic and social mix of the emerging communities of exurbia. All of these factors will affect the future of population growth in the Sierra region, for quality of life appears to be the primary driver of population growth.[30]

Population Projections from 1990 to 2040 for the Sierra Nevada

The Demographic Research Unit of the California Department of Finance (DOF) produced county-level population projections for the period 1990–2040 in April 1993 (California Department of Finance 1993). The Center for the Continuing Study of the California Economy (CCSCE), an independent research institution in Palo Alto, California, has also produced county-level population projections for the year 2005 (Center for the Continuing Study of the California Economy 1995). The CCSCE projections are consistent with the DOF projections, but the DOF projections extend much further into the future. We therefore focus here on the DOF projections and their implications for the Sierra Nevada. The CCSCE forecast for the eighteen counties in the Sierra region for the year 2005 is 3,671,300. This figure is slightly lower than the average of the DOF forecasts for 2000 (3,421,600) and 2010 (4,356,800), which is equal to 3,889,200 (approximately 6% higher than the CCSCE forecast). The CCSCE forecast is therefore within the range of four alternative forecasts that we developed for the Sierra region based on DOF forecasts. Because the DOF forecasts are available only at the county level, we had to estimate which portion of future growth in each county would occur within the Sierra region of each county. As noted earlier, we have detailed data for population growth at the CCD level for 1970, 1980, and 1990. Those data show that the Sierra region gained approximately 175,000 each decade between 1970 and 1990. Continuing that absolute growth from 1990 to 2040 would lead to a Sierra region population of approximately 1.5 million.

We developed a simple model for allocating shares of county-level DOF population growth forecasts to each of the Sierra region CCDs based upon one of three simple factors: (1) the fraction of county-level growth in each CCD from 1970 to 1980; (2) the fraction of county-level growth in each CCD from 1980 to 1990; or (3) the fraction of county-level growth in each CCD from 1970 to 1990. Individual CCDs in the Sierra region varied, with some CCDs having a greater share of county-level growth in one decade than the other. For the entire Sierra region, however, the 1970–80 share of aggregate county-level growth for the entire eighteen-county region was around 8% greater than the 1980–90 share. The estimates we present later are based upon the highest estimate for the entire Sierra Nevada (from 1970–80 shares). These population forecasts could therefore be as much as 14% greater than the CCSCE forecasts and up to a third greater than the level that would be reached if there were continued absolute population growth of 175,000 per decade in the Sierra region from 1990 to 2040.[31] The impact on specific areas will vary widely by CCD, however, and the forecasts based upon the 1970–80 factors do not represent the highest population forecast from 1990 to 2040 for each CCD individually. The combined total population of each CCD-specific highest-growth forecast would result in a Sierra region population of approximately 2.4 million in the year 2040. This is considerably higher than the Sierra region forecasts based upon the three factors described above, which result in a total population of about 1.8 million to 2.0 million by 2040.

The DOF projections are quite daunting, for they are based on a forecast that the entire state will grow from just under 30 million persons in 1990 to nearly 49 million in 2020 and more than 63 million by 2040. Such an increase would more than double California's population in just fifty years. At least in the short term, these forecasts appear to be plausible: at the midway mark between the 1990 census and the DOF forecast for the year 2000, California's population had already exceeded 34 million by the beginning of 1995. The forecast for the year 2000 is for a statewide population of 36,444,000. Net natural increase alone accounted for approximately 361,000 people (approximately 1%) in 1994. Even without significant net domestic in-migration (which totaled only 33,000 people in 1994), continued legal international immigration and natural increases could easily exceed the DOF forecast by the year 2000. The next two most populous states, Florida and Texas, had populations of about 18 million each in 1994. California alone could therefore equal the combined total of those two states' 1990 population by the year 2000.

Although it has only one-eighth the national population, California accommodates roughly one-fourth to one-third of all legal international immigration into the United States. It is likely to account for at least a similar amount of illegal immigration, although enforcement of Proposition 187 (passed by the voters of California in November 1994), together with stricter border patrols in recent years, could reduce the inflow of illegal immigrants. The 1990 census figures probably understate California's actual population by at least one million, however, for they significantly undercount illegal immigrants in California. The U.S. Census Bureau has also acknowledged that some ethnic groups were undercounted in 1990 within the population of legal residents. Underestimation errors are generally believed to be focused in metropolitan areas, however, so the 1990 census estimates for the Sierra region are probably not affected significantly by these errors. Other errors associated with collecting data in remote rural areas are probably more important in the Sierra region than in metropolitan areas. These include unmarked roads and many houses that are hidden from view on large parcels. The sheer inaccessibility of these residences and their low density reduces the likelihood of successful follow-up visits by census enumerators. For purposes of this analysis, however, we will assume that the 1970–90 census figures for the CCDs in the Sierra region are reliable.

Based upon those figures, the Sierra region population is forecast to more than triple from just over 600,000 in 1990 to nearly 2 million people (1,964,200) by the year 2040. The lower CCSCE estimation function (14% below the "high" DOF forecast) would yield a Sierra region population of 1,722,138 by the year 2040.[32] This total would be comparable to the entire San Francisco Bay Area's population in 1940 (1,734,308).[33] The overall growth rate for the Sierra Nevada from 1990 to 2040 (226%) would also be comparable to the growth rate experienced by the Bay Area from 1940 to 1990 (247%). The projections are therefore within the range of recent experience in northern California. The combined population of Sacramento and San Joaquin Counties (which include two of the primary commuter destinations for residents of the western Sierra Nevada foothills) grew by 400% from 1940 to 1990. Individual counties in the Bay Area experienced a wide range of growth rates during that same period. The densest county and employment center of the region, San Francisco, grew by only 14% (due to limited land area and existing high densities). Alameda County grew ten times as fast at 149%, Napa County grew by 289%, and Marin County's population expanded by 335%. Most of Marin County's growth occurred from 1940 to 1970, when the population jumped from 52,907 to 208,652. It grew only an additional 10% to 230,069 from 1970 to 1990. This low rate was the result of a complex set of growth management tools and a strict General Plan in the early 1970s (Teitz 1990). San Mateo County also truncated its growth after 1968, although it still grew by 481% from 1940 to 1990 (Teitz 1990). The experience of these two counties' aggressive growth management regimes from 1970 to 1990 may have relevance to other counties in the Sierra region, such as Nevada and El Dorado Counties, who are now facing rapid growth pressures and considering updates to their General Plans. This topic will be discussed in more detail in the discussion of management implications and policy options below.

With the exception of Marin County and San Mateo County, the Bay Area's suburban counties accommodated most of the growth in the region over the past fifty years and grew at rates comparable to those forecast for some Sierra region counties over the next fifty years. Napa County grew by 289%, Sonoma County by 462%, Solano County by 593%, and Contra Costa County by a remarkable 700% as the 1940 population of 100,450 mushroomed to 803,732 by 1990. Sacramento County grew by 511% during the same period, from 170,333 in 1940 to 1,041,219 by 1990. San Joaquin County, however, to the south of Sacramento County and containing the port city of Stockton on the San Joaquin River, grew at a much slower rate of 258% during this period. San Joaquin County's population of 134,207 was 79% of Sacramento County's population in 1940, but it grew to only 480,628 by 1990, only 46% of Sacramento County's population. This differential growth rate between Sacramento and San Joaquin Counties can be attributed both to the rapid growth in state government in Sacramento during this period (when California's population grew to more than 30 million), the substitution of capital and energy for labor in the agricultural sector, and the construction of Interstate 80 (I-80) through the Sacramento area. The latter effectively integrated Sacramento with the Bay Area, while Stockton and San Joaquin County remained more isolated from economic integration with the rapidly expanding Bay Area. Stockton therefore continued to function as only a regional center for the northern San Joaquin valley and the Delta region, while Sacramento emerged as not only the center of state government but also an economic extension of the Bay Area.

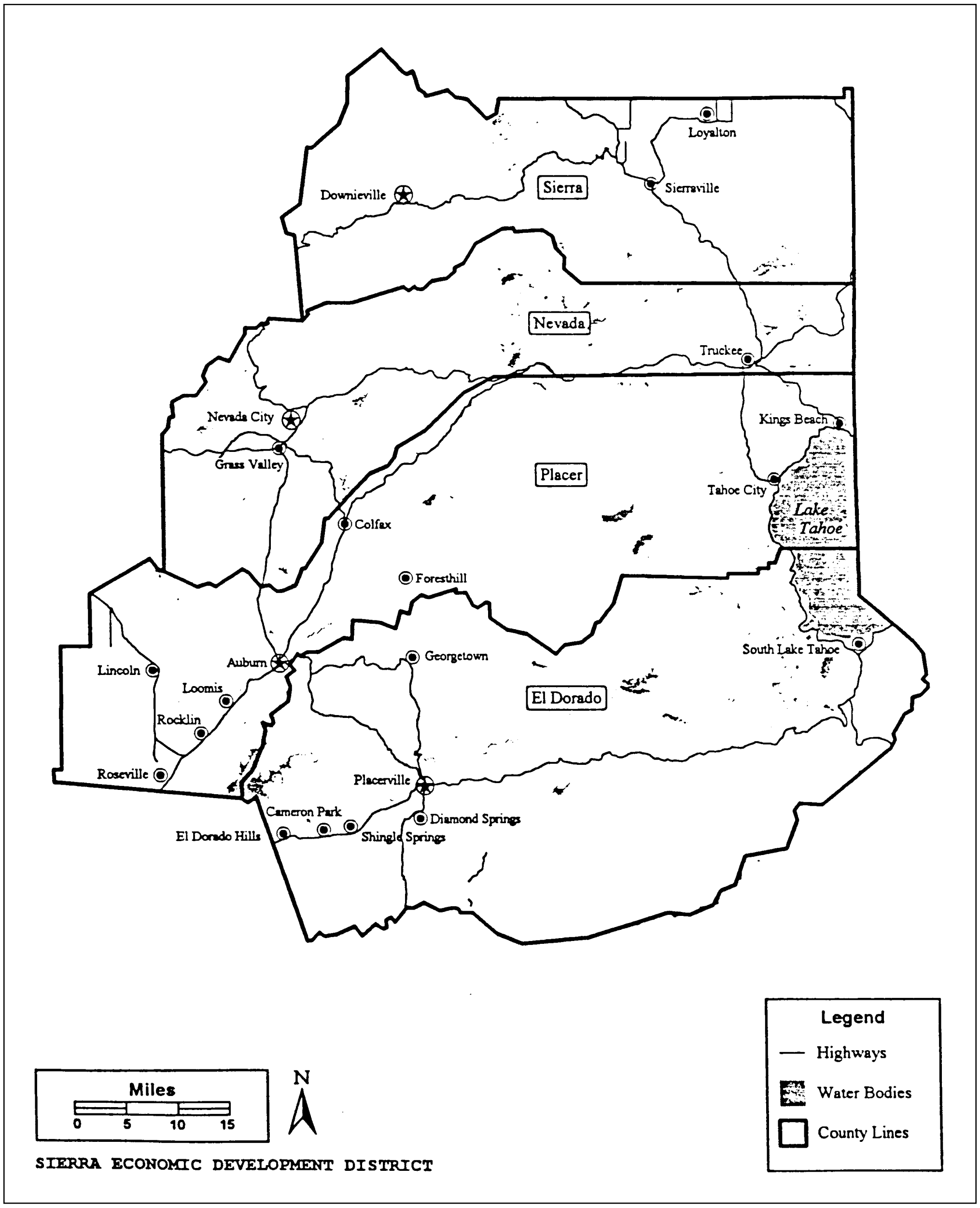
This latter point is critical, for it helps to explain the subregional concentration of growth within the Sierra region. Access to the Bay Area along I-80 allowed firms based in the Bay Area to locate manufacturing facilities in the greater Sacramento metropolitan area in the 1970s and 1980s, where land costs were considerably lower than in the rapidly urbanizing Bay Area. These business location decisions reflected both the economics of site development (i.e., each company's own facilities) and the economics of residential location choice (i.e., each company's employees' own residences). The former could have led to facility location decisions that shifted manufacturing activities out of the Bay Area (in particular, the Santa Clara valley for high-technology companies) to a wide range of locations with good transportation access. The latter, however, which includes both the cost of living and the amenity value of residential location, resulted in the location of manufacturing activities between Sacramento and the Sierra Nevada foothills. This location is actually less convenient than other relatively low-cost locations along I-80 between Sacramento and the Bay Area, because it requires additional travel time and additional risks of delays while crossing the Sacramento metropolitan area in order to reach the Bay Area. It is more convenient, however, for employees who want to live in the Sierra Nevada foothills or at least in that part of the Sacramento metropolitan area that will provide easy recreational access to the Sierra Nevada and the American River.[34] Access to the residential amenities of the Sierra Nevada appears to have been a primary factor in the location choices of Bay Area firms relocating manufacturing facilities outside the Bay Area. The original decision to relocate those facilities, in turn, was the result of rapid growth in the Bay Area that both increased the cost of land and housing and decreased the quality of life for many employees through increased traffic delays and decreased open space. The transformation of the Bay Area landscape therefore had a direct bearing on the forces that have begun to transform the Sierra Nevada landscape over the past quarter century. The fate of the Sierra Nevada is inextricably tied to California's metropolitan centers.

Examples of these new employment centers can be found along I-80 northeast of Sacramento in Placer County and along U.S. Highway 50 on the eastern edge of Sacramento County. The former includes facilities for Hewlett-Packard and NEC, both located in Roseville and fueling nearby residential development in Rocklin and Loomis. Perhaps the most extreme example of this relocation phenomenon exists in the eastern Sacramento County town of Folsom, however, where Intel has developed a large complex of buildings that employed nearly 2,750 employees in 1994 and is home to Intel's six major product divisions as well as Intel's North and South American Sales and Marketing Operation. It is also world headquarters for the company's Information Technology organization. The corporate headquarters remains in the so-called Silicon Valley, but new technologies now allow worldwide corporate activities to be coordinated from a satellite facility located 150 miles away. That satellite facility sits on a bluff above the American River just a few miles from El Dorado County and less than a thirty-minute drive from either the gold rush town of Placerville or the state capital. The 236-acre campus had a gross payroll of about $100 million in 1994. Construction of a new 320,000-square-foot building in 1994–95 cost $52 million and will house an additional 1,750 employees. The total employment at the Intel Folsom site will then be 4,500 employees and generate a payroll of between $150 million and $200 million per year (Intel Corporation 1994). This employment base, together with the multiplier effect of the site through subcontractors and employee expenditures in the community, is likely to fuel much of the nearby Sierra region's population growth.[35] High-technology employment in the greater Sacramento area now accounts for at least 15,200 direct jobs at Packard Bell, Hewlett-Packard, Intel, NEC Corporation, and Apple Computer (Grass Valley Union 1995b).

Figure 11.21 shows the relationship between the Sacramento metropolitan area and these emerging employment centers along Interstate 80 and U.S. Highway 50. The Sierra Economic

FIGURE 11.21

Proximity of Gold Country communities to Sacramento and Lake Tahoe.



Development District (SEDD) publishes this map to show its economic links to Sacramento and its service area of Sierra, Nevada, Placer, and El Dorado Counties.

Much of the overall population growth in the Sierra region from 1970 to 1990 nevertheless appears to be "suburban" rather than "exurban" in character. This is particularly true for higher-density single-family home developments along the I-80 and U.S. 50 corridors. The literature on suburbia is therefore relevant to our understanding of both historic growth patterns and the DOF population forecasts. This literature includes a wide range of population growth models that are based on a "gravity" concept of a nested hierarchy of "urban fields." In northern California, this model indirectly links the west-central Sierra Nevada foothills to the Bay Area through the Sacramento metropolitan area. San Francisco is the central city core of the Bay Area, with an urban field of lower-density employment centers throughout the Bay Area. Both those peripheral centers and the Sacramento metropolitan areas are effectively linked to and dependent upon the well-being of that central city core through transportation networks and economic flows. As Robert Cervero has demonstrated, however, employment on the periphery of the Bay Area metropolitan region is now comparable to that in the central cities of San Francisco, Oakland, and San Jose (Cervero 1986, 1993; Garreau 1991). This deconcentration of employment has created further opportunities for more dispersed residential locations that remain within commuting distance of Bay Area employment. A similar phenomenon in the Sacramento metropolitan area has in turn made some parts of the Sierra Foothills part of what Kenneth T. Jackson has called the "crabgrass frontier" (Jackson 1985). In that respect we have much to learn from his history of "the suburbanization of the United States." It has already had direct relevance to parts of the Sierra region over the past quarter-century.

Jackson documents how other "rural" regions on the periphery of metropolitan regions have been undergoing suburbanization since at least 1830. This process is neither a new phenomenon nor one dependent upon the automobile, although its particular form does seem to reflect the dominant transportation technologies of the time of initial development. Travel time has always been more important than travel distance or the specific means of travel in determining the maximum distance individuals are willing to commute between their residence and place of employment. The deconcentration of metropolitan employment in California, coupled with continuing population growth throughout the state, is therefore likely to continue to increase the attractiveness of the Sierra Nevada for residential location. Travel times are also reduced per unit distance traveled on less congested rural roads, so the maximum feasible commute distance is not a linear function of distance. Greater distances can be covered in the same amount of time as average settlement densities decrease and congestion delays are eliminated. Changing technologies and patterns of economic activity are, of course, highly uncertain over any fifty-year period, so we cannot assume today's structural relationships when forecasting future conditions. There is nevertheless strong historical precedent for continued settlement of the Sierra Nevada consistent with the DOF forecasts.

The rapid rates of growth forecast for the Sierra Nevada are not unusual historically and have also been experienced by other rural regions outside the San Francisco Bay Area or Sacramento. These rapid rates of growth on the suburban and exurban frontiers often accompany a slowing of growth due to density saturation in the metropolitan central city. Brooklyn, New York, was a sleepy rural village of just 7,125 people in 1820 (while nearby New York City, isolated across the East River, already had 123,706 residents). "In the next four decades, however, the town of Brooklyn was transformed. Regular steam ferry service to New York City . . . began in 1814" (Jackson 1985). Brooklyn more than doubled in population each of the next few decades, jumping to 15,384 in 1830; to 36,233 in 1840; to 96,838 in 1850; and to 266,661 in 1860. "Whether it was easy access, pleasant surroundings, cheap land, or low taxes," notes Jackson, "the suburb was growing faster than the city by 1800" (Jackson 1985). By 1890 the population of Brooklyn was 806,343, while New York City exceeded 2.5 million people. Brooklyn itself had grown from just 6% of New York City's population to 32% in seventy years. Jackson states that "one wag noted that Brooklyn 'sold nature wholesale' to real-estate developers, for sale to homeowners at retail" (Jackson 1985). This sounds quite a bit like today's Sierra Nevada real estate market. Many of the same factors that drew people to Brooklyn in 1830 are now drawing Sacramento commuters to the west-central Sierra Nevada foothills.

These attractions have historically been accessible only to residents of a particular class, however, leading Robert Fishman to call the American suburbs "bourgeois utopias" (Fishman 1987). Here he is referring to the middle-class suburb of privilege, a residential community beyond the core of a large city. The development that he describes is more restrictive than the broader patterns and processes driving today's exurban growth, but it has many of the same roots. What is more important, it accurately describes the subset of exurban Sierra Nevada development that is most like the classic middle-class commuter suburb. Much of what we are now seeing in the Sierra Nevada is similar in intent (if not urban form) to that which first constituted a "suburb" in 1750 in London—having a house "in the country." The need for the exclusion of others from the suburb is important now, as it was two hundred years ago, in part to ensure the preservation of this idyllic setting. Establishment of successful "gated" communities with relatively high suburban densities is therefore not surprising in the context of this historic pattern of suburbanization. Fishman outlines three primary factors driving suburban development: (1) the desire for life in a picturesque space; (2) the protection of the family; and (3) the avoidance of urban problems. All three factors appear to be important considerations in the residential location decisions of recent immigrants to the Sierra Nevada and other exurban areas throughout the rural West. Historical processes of suburbanization are therefore relevant to our understanding of the processes driving exurban growth in the Sierra Nevada.

Like the "crabgrass frontier" of Brooklyn from 1820 to 1890, the west-central Sierra Nevada foothills could gain a similar share of the greater Sacramento metropolitan region's population from 1970 to 2040. And like the "bourgeois utopias" of historic London, the values of many migrants to the Sierra Nevada may reflect basic truisms about human nature and the search for the ideal as much as new technologies and lower housing costs. Suburban development certainly reflects transportation commute times, economic conditions, and land markets, but it also reflects the values, dreams, and lives of the migrants in the places they left for suburbia. Ironically, many of the exurban migrants of the past few decades have come from suburbia. This raises a fundamental question confronting planners and citizens in the Sierra Nevada today: how can we avoid a development process that will destroy the very features that make the region a desirable place to live? The historical record is not encouraging, with the recent exodus to exurbia strong evidence that the suburban ideal has not maintained itself in the face of a wide range of forces that have transformed metropolitan areas throughout the country. Meeting that challenge in the face of significant continuing population growth will not be easy in the Sierra Nevada.

Based upon the DOF forecasts, many other areas are likely to experience similar increases in commuting and

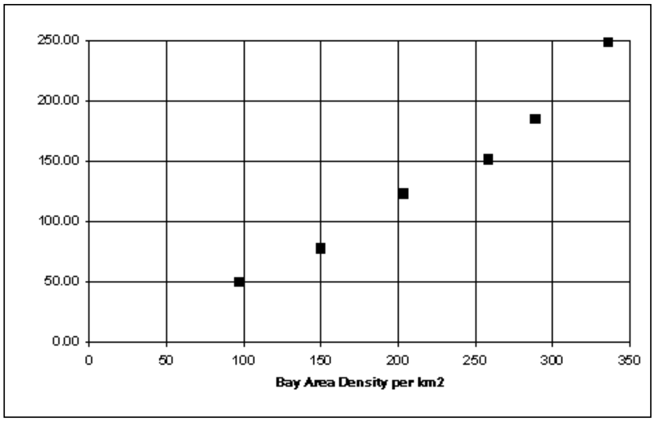


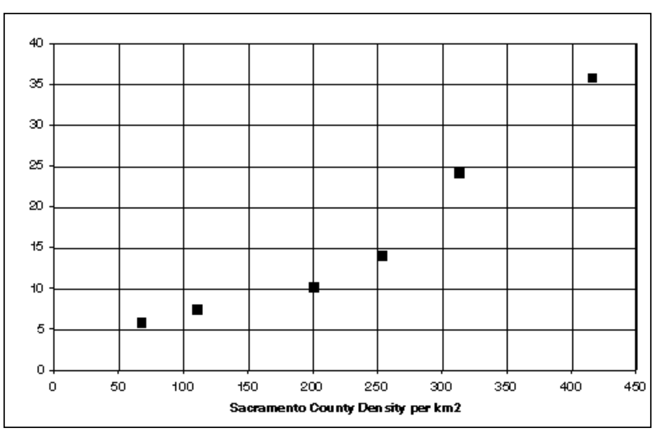
FIGURE 11.22

Density of Sacramento and San Joaquin Counties versus Bay Area, 1940–90.

suburbanization as the metropolitan centers of Stockton, Modesto, Fresno, Visalia, and Bakersfield continue to grow.[36] Fresno and Bakersfield, which are the southernmost communities in the San Joaquin valley, are emerging as significant metropolitan areas in their own right. Nearly 500,000 people lived in the Fresno CCD in 1990, and Fresno County produces more agricultural value than any other county in the United States. Bakersfield, the capital of Kern County, had a population of nearly 300,000 in its immediate CCD in 1990. Kern County produces more oil than any other county in the United States. Agriculture is also very important in Kern County, however, and oil pumps are often working away alongside farm equipment in the fields. Neither Fresno nor Bakersfield is closely tied to the Bay Area through commuting patterns. The more northern communities of Stockton and Modesto have become increasingly linked to the Bay Area economy through the development of Interstates 5, 580, and 205. These highways now link residents in Stockton, Modesto, and the nearby towns of Tracy and Manteca to jobs across Altamont Pass in the Livermore Valley area near the intersection of Interstates 580 and 680. From there, commuters can go north to San Ramon and Walnut Creek; go south to Fremont, San Jose, and the greater Silicon Valley; or continue west to the East Bay employment centers of Oakland and Berkeley. These commutes sometimes total two hours each way, but people are willing to do them in order to have an affordable (or larger) home in a place where they feel safe. They sometimes ride in vanpools, which allows them to sleep or read each way, but they most typically ride in single-occupant automobiles that get stuck in traffic jams on Altamont Pass. The Bay Area Rapid Transit (BART) system is now constructing a feeder line out to Pleasanton and Livermore that will connect potential commuters directly to downtown San Francisco. This in turn is likely to increase commuting to bedroom communities in the Central Valley.

FIGURE 11.23

Gold Country versus Sacramento County density, 1940–90.



These bedroom communities, which were sleepy agricultural towns until recently, are now sprouting commercial centers to provide services to the commuters when they are home. Times have changed since George Lucas grew up in Modesto, which inspired his film American Graffiti. Freeway interchanges along Highway 99 now bustle with neon and traffic jams. Gang violence has also appeared, just as it has in Stockton, Fresno, and Bakersfield. These valley towns are now becoming suburban centers. A large mall in Modesto, growing boat sales in Stockton, and the emergence of dining establishments to feed the weary commuters have all sprung up. These in turn create new employment opportunities both for other residents in the Central Valley and for those willing to commute from the nearby Sierra Nevada foothills. There is probably relatively little commuting at this point from the foothills to these lower-paid service jobs, but the potential is there for new higher-paid employment opportunities. In this way the expansion of the Bay Area directly affects the suburbanization of the Sierra Nevada.

Figure 11.22 shows how increasing population densities in Sacramento and San Joaquin Counties have been closely tied to increasing densities in the Bay Area. A simple bivariate regression analysis of the data has an R-squared of 0.97, which means that 97% of the variation in one variable is explained by variation in the other variable. This is based on only six observations, of course, so we cannot infer much statistical significance to this finding. It nevertheless illustrates that growth in these areas appears to be closely tied.

A similar relationship appears to hold between Sacramento County and the Gold Country counties of Nevada, Placer, and El Dorado. The relationship appears weaker, with an R-squared value of only 0.92, but that appears to be due to a split in the data around 1960. This is also when Interstate 80 was completed, so we have a plausible explanatory variable that is consistent with the general theory of commuting as a primary factor in determining population growth in these counties. Figure 11.23 shows the data for 1940–90, while figure 11.24 shows the stronger relationship from 1960 to 1990.

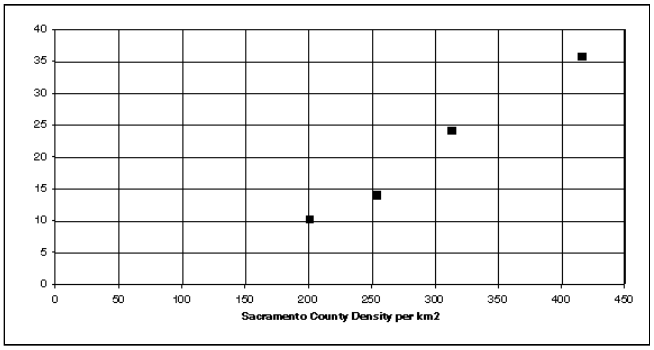


FIGURE 11.24

Gold Country versus Sacramento County density, 1960–90.

The R-squared value for the 1960–90 regression is 0.99, although there are only four data points. Again, this is simple correlation and does not necessarily indicate causation. These figures illustrate merely that the data are consistent with the urban field hypothesis of exurban growth.

Note that the average population densities in the Gold Country counties are considerably lower than the average densities in the metropolitan counties. This is not surprising, but it is exaggerated by the fact that the Gold Country counties have large areas of public land and private industrial timberland, where there is no potential for residences. Due to its relatively small land area, the average density for Sacramento County is also comparable to the average density for the Bay Area (it was lower in 1940 and 1950, almost exactly the same in 1960 and 1970, and has been higher in 1970 and 1980). Average density in San Joaquin County is midway between Sacramento and the Gold Country. Average densities in the Gold Country counties in 1990 (28 to 48 persons per square kilometer) were comparable to average densities in Marin County in 1940, Sonoma County from 1950 to 1970, Solano County until 1950, and Napa County until 1980. The growth patterns and experience in those Bay Area counties from 1940 to 1990 are therefore relevant to the future growth patterns and experience likely for the Sierra region. Even Amador and Calaveras Counties, which are within commuting distance of Sacramento and San Joaquin Counties, had average densities in 1990 (12 to 20 persons per square kilometer) that were comparable to Napa from 1940 to 1950 and Solano or Sonoma in 1940.

Under the April 1993 DOF forecast, individual counties and CCDs in the Sierra region will have widely varying rates of growth . The Sierra region of three of the most remote counties (Plumas, Sierra, and Inyo) will remain less than twice their 1990 population by the year 2040, while eight counties will experience between a doubling and a tripling of their 1990 population by 2040. Seven counties will actually see their Sierra region population more than triple. Two CCDs are forecast to increase by more than tenfold: the Yuba Foothills CCD in Yuba County (2040 population will be 13.5 times the 1990 population) and the Lake Isabella CCD in Kern County (2040 population will be 10.4 times the 1990 population). The population for the Sierra region of Fresno County is forecast to be 9.6 times the 1990 population. Only the Yosemite CCD of Mariposa County, which lost population in 1970–80 due to the relocation of housing for National Park Service employees, is forecast to have a smaller population in 2040 than there was in 1990. Plate 11.1 compares 1990 population density to the maximum forecast population for each CCD in 2040 based upon the county-level DOF forecasts and our simple CCD population allocation methodology.

The DOF population forecasts are highly uncertain, of course, for population forecasting is a risky business. On average, the aggregate absolute population growth per decade for the Sierra Nevada under the DOF forecasts is 50% higher than the absolute population growth during either the 1970–80 or the 1980–90 period. Historic levels of population growth are therefore only about two-thirds of the DOF forecasts. The early 1990s also saw significant domestic emigration from California, taking some growth pressure off the state and the Sierra Nevada. California's net population increase in 1994 was less than half of the peak-year increase of 740,000 people in 1990 (Teitz 1990; Landis 1992). The DOF forecasts may therefore overstate growth in the Sierra region as the greater rural and exurban West absorbs an increasing fraction of the exodus from California's metropolitan areas. Reduced property values in those metropolitan areas have also reduced the opportunities for significant "cash out" by equity refugees, one of the primary factors driving the migration. This change has already reduced the rate of immigration into the Sierra Nevada in the mid-1990s. The DOF forecasts were not completed until April 1993, however, and California was already deeply mired in recession by that time. Net domestic migration is also becoming a less important determinant of overall statewide population growth as the demographic momentum of natural increase becomes more important.

Conversely, the forecasts may overstate the capacity of metropolitan areas to absorb additional growth in the state.[37] If the state-level growth forecasts are accurate (which seems to be reasonable for at least the decade of the 1990s), then this would suggest that nonmetropolitan population forecasts (such as for the Sierra region counties) are understated. Much of the Sierra region growth is also forecast to occur in those counties within commuting distance of the secondary metropolitan centers of the Central Valley. These include Sacramento, Stockton, Fresno, and Bakersfield. Those metropolitan centers may actually carry a greater fraction of their respective county's overall population growth. On the other hand, expansion of those metropolitan centers will also create new employment and service opportunities for the Sierra Nevada foothills. The bottom line is that population growth forecasts are highly uncertain over even short periods of time. Significant population growth is highly likely for most regions of

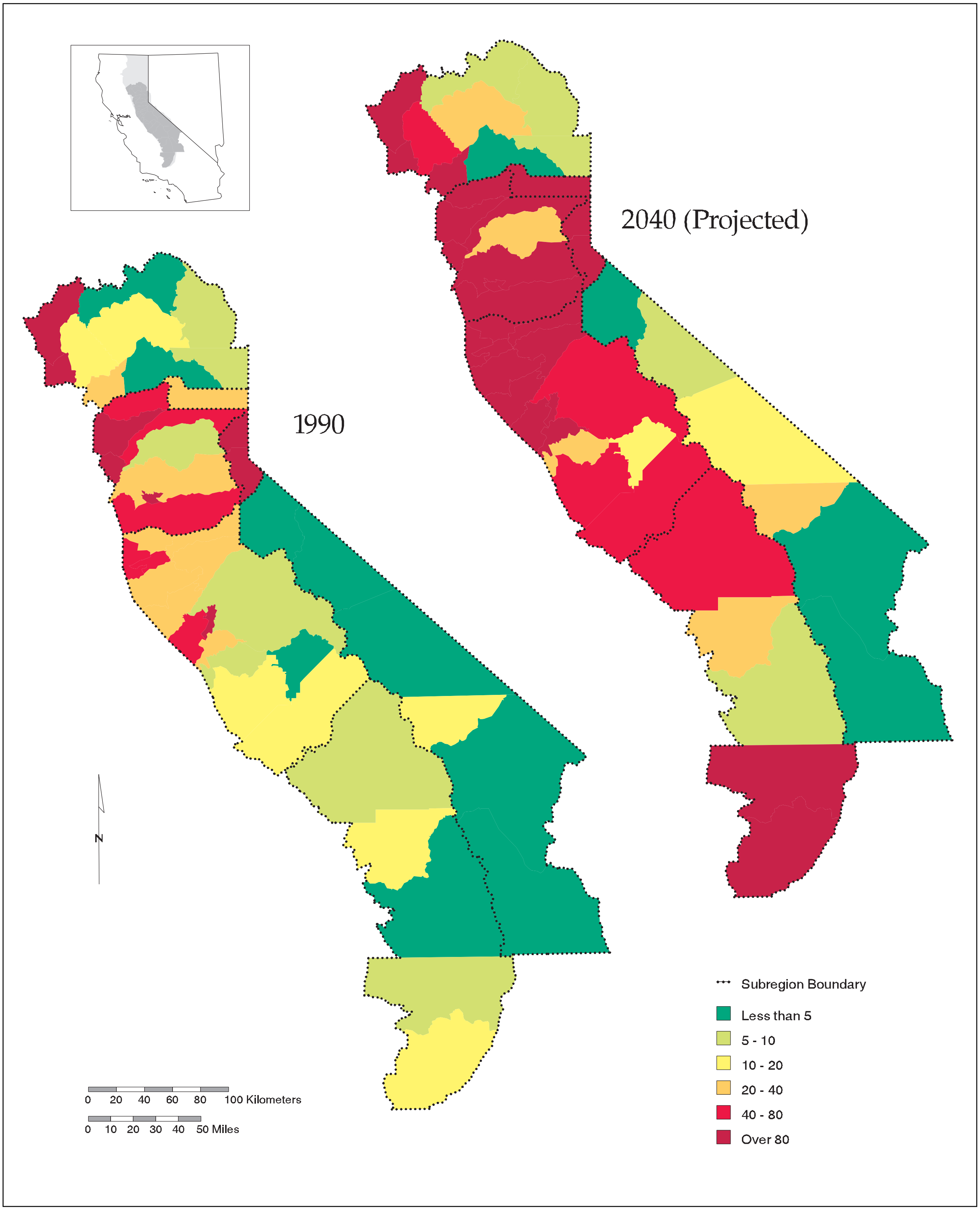


PLATE 11.1

Current and projected population density (persons per square mile) in the Sierra Nevada.

the Sierra Nevada, however, even if the precise levels of such growth are difficult to predict.

Only time will tell if the April 1993 DOF forecasts will accurately predict Sierra region growth for the next fifty years. The DOF made a similarly bold fifty-year forecast in 1971 for Alpine, Amador, Butte, Calaveras, El Dorado, Nevada, Placer, Plumas, Sierra, and Yuba Counties. The 1971 forecast for those ten counties projected a doubling of the population over fifty years from 334,500 in 1970 to 465,200 in 1990 and 695,500 in 2020 (Department of Water Resources 1973). The forecast growth rate was much higher than previous rates of growth for the region, and many observers probably doubted at the time that the region would reach a population of 700,000 by the year 2020. The DOF forecast turned out to be low, however, for the 1990 census showed that those ten counties had already reached a population of 703,856 in just twenty years. We estimate that the Sierra region of those counties had a population of 436,426 in 1990.[38] The population of those counties by the year 2020 will undoubtedly be much higher than the 1971 DOF forecast projected. Continued growth at that absolute rate per decade for those ten counties (i.e., 184,678 persons per decade) would result in a population of 1,257,890 by the year 2020. This would be 81% greater than the original 1971 forecast population of 695,500 in the year 2020.

With a doubling of the Sierra region population from 1970 to 1990, the DOF forecast projection of a tripling of the population from 1990 to 2040 is both plausible and probable. Even if population growth in the Sierra region stayed steady at 175,000 per decade (the same absolute level as 1970–90), the total Sierra region population would increase by 140% to nearly 1.5 million people. The range of plausible population estimates for the Sierra region is therefore from just under 1.5 million people to up to 2.4 million people by the year 2040. Even the low end of the range represents a significant increase.

This growth is likely to make many areas of the Sierra Nevada look more like the Gold Country over the next fifty years. The April 1993 DOF forecast projects that the population of the Gold Country CCDs will grow 179% from 222,837 in 1990 to 621,842 by the year 2040. Due to regulatory constraints that have been imposed by the Tahoe Regional Planning Agency (TRPA) within the Lake Tahoe Basin since the 1970–80 period, however, this probably overstates the level of growth in the Lake Tahoe subregion. The balance of growth that we have forecast for the Lake Tahoe subregion would take place in the Gold Country subregion of Nevada, Placer, and El Dorado Counties. Based upon the original forecast, however, the Gold Country subregion's growth rate is relatively low compared to both the Mother Lode and southern Sierra subregions. The Gold Country subregion's share of overall Sierra region population will therefore decrease from 36% in 1990 to just 30% by the year 2040.

The average population density of more than 30 persons per km^2 in the Lake Tahoe subregion is higher than in any other subregion of the Sierra region. Because a large part of the Donner CCD in Nevada County is actually quite far from Lake Tahoe itself, the population density is actually significantly higher immediately around the lake. Development of the Lake Tahoe Basin proper generally preceded the development of the rest of the Sierra region, and the high rate of population growth in the 1970s decreased dramatically in the 1980s as TRPA regulations took effect. Our allocation model projects that the population of the Lake Tahoe CCDs will grow 147%, from 48,329 in 1990 to 119,453 by the year 2040. Due to regulatory constraints that have been imposed within the Lake Tahoe Basin since the 1970–80 period, however, this probably overstates the level of growth in this subregion (although much of that growth could occur in the spillover "bathtub ring" outside the jurisdiction of the TRPA). The balance of growth would take place in the Gold Country subregion of Nevada, Placer, and El Dorado Counties. If the Lake Tahoe subregion continues to grow according to this forecast, its share of overall Sierra region population will remain steady at 8% through the year 2040.

The Mother Lode subregion is forecast to grow 236%, from 124,795 in 1990 to 418,900 by the year 2040. Despite this rapid growth, the Mother Lode subregion's share of overall Sierra region population will increase only slightly from 20% in 1990 to 21% by the year 2040. This is due to the rapid growth forecast for the southern Sierra subregion, a remarkable 384%, from 92,366 in 1990 to 447,479 by the year 2040. This rapid growth rate means that the southern Sierra subregion's share of overall Sierra region population will increase dramatically, from 15% in 1990 to 25% by the year 2040. No other subregion increases its relative share of overall Sierra Nevada population as much. This primarily reflects the high growth forecast the DOF for the metropolitan areas of the southern San Joaquin valley. It is also slightly distorted by the growth in Kern County population due to prison construction in the Tehachapi CCD from 1970 to 1980. A similar problem exists for the Ione CCD in Amador County and the Stanislaus CCD in Sonora County, the only other CCDs in the Sierra Nevada with a state correctional facility. Both of the latter are located in the Mother Lode subregion, however, where the entire county is located within the Sierra Nevada. Only those errors associated with allocating the county-level DOF forecasts to CCD-level projections in the Tehachapi CCD in Kern County will therefore affect overall Sierra Nevada population projections.

Two of the subregions are likely to experience much slower growth than the rest of the Sierra Nevada. The eastern Sierra subregion is forecast to grow 136% under the DOF forecast, from 28,509 in 1990 to 67,418 by the year 2040. This relatively slow growth rate means that the eastern Sierra subregion's share of overall Sierra region population will decrease from 5% in 1990 to just 3% by the year 2040. The northern Sierra subregion is also forecast to grow relatively little (149%), from 102,110 in 1990 to 254,563 by the year 2040. This relatively slow growth rate means that the northern Sierra subregion's share of overall Sierra region population will decrease slightly, from 16% in 1990 to 13% by the year 2040. In both cases this reflects the relative isolation of these two subregions and their lower levels of direct economic integration with the rapidly growing metropolitan centers outside the Sierra Nevada. These subregional differences therefore highlight and reinforce the importance of metropolitan growth as a primary driver of future population growth throughout the Sierra Nevada.

The subregional summary just presented is based upon the CCD allocation factors for 1970–80, which resulted in the highest overall population forecast from 1990 to 2040 for the entire Sierra Nevada. This set of factors will not result in the highest overall population forecast for individual CCDs or subregions, however, so the spatial pattern of future growth should also be evaluated based upon the 1980–90 and 1970–90 allocation factors. Several differences between the different allocation factors for specific CCDs warrant explicit discussion here. One CCD (Yosemite, in Mariposa County) and one county (Inyo) actually lost population from 1970 to 1980. The reductions in the Yosemite CCD appear to reflect the relocation of housing for some National Park Service employees in Yosemite National Park. All of the population losses in Inyo County occurred in the Death Valley CCD, however, which is outside the Sierra Nevada region. All Sierra Nevada CCDs in Inyo County grew from 1970 to 1980. Three more CCDs (Lone Pine, in Inyo County; Greenville, in Plumas County; and Twain Harte, in Tuolumne County) lost population from 1980 to 1990. Three other CCDs (Ione, in Amador County; Tehachapi, in Kern County; and Stanislaus, in Tuolumne County) had unusually high increases in population from 1980 to 1990 due to construction or expansion of correctional facilities within the CCD. Finally, two CCDs (Yuba Foothills, in Yuba County, and Sierra, in Fresno County) had growth rates that differed by more than 10% across the two periods. Use of the allocation factors for either the low-growth or high-growth periods can therefore result in significantly different shares of overall county growth going to these CCDs during the forecast period. In both cases these CCDs account for only a small share of overall county population, so the error associated with this difference can be quite large. Estimates for all of these CCDs should therefore be viewed cautiously.

The Residential Development Process in the Sierra Nevada

The land use pattern in rural and exurban regions is mixed, and the Sierra Nevada is no exception (Nelson 1992; Yaro et al. 1988; Arendt 1994b; Davis et al. 1994). High-density clusters of structures exist in pockets at critical crossroads and in small villages and towns, but most of the landscape is uninhabited or sparsely settled. The villages and towns often have population and structure densities that are comparable to urban settings in metropolitan regions, but their scale (both in population and area) is significantly smaller. Rural and exurban villages and towns are typically home to 10^2 to 10^4 people, while metropolitan-area towns and cities range from 10^4 to 10^6 residents.[39] This could change if the overall level of population growth in the Sierra Nevada results in significant expansion of existing high-density urbanized areas.

Development in the Sierra Nevada is occurring primarily in the formerly rural, unincorporated areas near gold rush–era communities in the foothills zone. It is not city-centered, although the "urban" centers of the foothills often provide the essential services that the residents now demand. The result is a dominant pattern of low-density, land-intensive, large-lot exurban sprawl. More people in the Sierra Nevada live in high-density settlements than low-density settlements, but much more land area is devoted to the latter than the former. This pattern of settlement is extensive and land-intensive.

The reasons for this pattern of development are manifold. The fundamental force is the desire of new residents to live "in the country" with wooded, open spaces shielding their "homestead" from the view of neighboring homes. Depending on vegetative cover, this can be achieved at densities below approximately one unit per acre. The result is a sense of privacy and a connection with the natural world. Contact with the community comes through regular visits to the nearby town center, where daily employment and/or service needs are met. There is also limited neighborhood contact, although lower densities decrease opportunities for inadvertent interaction with neighbors. Often the center of informal social life in these areas is the post office or the grocery store. These are "sacred spaces" within the community that serve a vital social function (Hester 1990).

Some of these recent migrants are moving from metropolitan areas into "gated" communities, where reproduction of the social, physical, spatial, and market characteristics of the suburban landscapes they left may be desired. They seek the market benefits of that physical and spatial pattern without the costs of scale diseconomies associated with the larger metropolitan pattern they left. Wal-Mart is fine, because a wide variety of goods at a low price is a desirable element for them. What they want to leave behind are the traffic congestion, the crime, the graffiti, and the homelessness they faced in their daily lives in their suburban communities in California's metropolitan areas. The suburban land use pattern of sprawl is therefore only seen as a problem if and when it begins to be associated with those disamenities. Within the tighter and more homogeneous social context of exurbia, however, traffic congestion is the first disamenity they will probably experience. By then, of course, the land use pattern will be very difficult to change.

Development in the Sierra Nevada foothills has generally been through a process dominated to date by incremental construction of individual homes, unlike the "new town" subdivision process common in metropolitan real estate markets. Large parcels are often subdivided without simultaneous development of "model homes" and builder-originated construction. Instead, lots are sold to individuals without any requirement to choose a particular "model home" design or hire the subdivision developer as the home construction contractor. Many of the existing parcels in the Sierra Nevada were created through major subdivisions that were approved by local planners before the Subdivision Map Act of 1973. Many of these were intended for second homes as "recreation residences" but have subsequently been developed for year-round residences. Quarter-acre lots with on-site septic systems are common among these subdivisions from the late 1960s and early 1970s. Just three major developments from this period (Lake Wildwood, Lake of the Pines, and Tahoe Donner) accounted for two-thirds of all new home construction in Nevada County during the 1980s (Nevada County Planning Commission 1993). The land was subdivided and sold off parcel by parcel, but actual development has been incremental over nearly three decades. These rural lots are often purchased by urbanites who will hold them vacant until retirement or another personal (rather than a local real estate market) opportunity finally allows them to move to the Sierra Nevada. Each parcel is then typically developed individually in accordance with the needs of the individual lot owner. The size, style, and impact of each house on the environment therefore varies widely in exurban areas. The overall scale of the development and its eventual impact were therefore difficult to gauge during the early years of the projects. Moreover, most of these large-scale "recreational residential" developments were approved before passage of the California Environmental Quality Act (CEQA) in 1970.

Because individual landowners built their own houses (and because buildout has occurred incrementally over several decades), many of the large-scale subdivisions in the Sierra Nevada have developed without the mass-produced feeling that is more common to the large-scale suburban subdivision developments in California's metropolitan areas. (Homes built by speculators have become more common in the Gold Country since the boom of the late 1980s, although the market appears to have been overbuilt in the early 1990s. Future "spec" home activity is therefore likely to be dampened by the significant losses incurred by speculators in the early 1990s.) Most of the remaining lots have been and continue to be created through "minor" subdivisions of four or fewer parcels that are exempt from the stringent requirements of the Subdivision Map Act of 1973.[40] Concurrent subdivision and infrastructure investments (which are required under the Subdivision Map Act of 1973) have therefore been the exception rather than the rule to date in the exurban development process in the Sierra Nevada. This could change in the future, however, with several large-scale "new town" developments likely to be developed in the future. The implications of such a shift are discussed in our case studies of the General Plans for Nevada and El Dorado Counties.

Minimum lot sizes are usually set by the local government through a General Plan designation and a specific zoning ordinance.[41] The minimum for rural residential lots with on-site septic systems and on-site well water typically varies from one acre to five acres, but there is no standard policy in the Sierra Nevada. As noted earlier, many of the existing parcels were originally approved for on-site septic disposal at densities of up to four units per acre and were "grandfathered" in by the newer General Plans and zoning ordinances in the 1970s and 1980s. Two-fifths of the land in Nevada County was not yet zoned with specific density requirements as late as 1980. The General Plan updates by Nevada and El Dorado Counties now propose a minimum of 3–5 acres for on-site septic disposal systems with an on-site well water source (Nevada County Planning Department 1994a; El Dorado County Planning Department 1994). The 1980 Nevada County General Plan had a 1.5 acre minimum for the same configuration, but that has since been deemed inadequate (Nevada County General Plan 1980; Norman 1982; Boivin 1991–95).

Local government land use policy is usually set by a combination of five factors:

1. Existing parcelization (e.g., current land use designation)
2. Land uses on adjacent properties (e.g., typical densities)
3. Infrastructure availability (e.g., roads, water, sewers)
4. Environmental constraints (e.g., slope, soils, vegetation)
5. Philosophy, values, and ideology (e.g., the role of regulation)

Note that factors 3 and 4 (infrastructure availability and environmental constraints) could lead to land use densities that are often inconsistent with factors 1 and 2 (existing parcelization and land use on adjacent properties). Environmental constraints or a lack of infrastructure may limit the potential development density, for example, but the land may already be zoned for or adjacent to land already developed at higher densities. The final factor (philosophy, values, and ideology) seems to determine the relative weight given to the other factors and the range of alternative policies that elected and appointed officials are willing to consider (Juvinall 1995). Based upon review of the General Plan development processes in Nevada and El Dorado Counties, it appears that local officials often rely upon this existing pattern of parcelization as the primary factor in designating land uses.[42] This is the primary reason that existing General Plans and zoning designations in the Sierra Nevada are often inconsistent with the results of environmental analyses. Decisions have often been made primarily based upon adjacent land uses or existing zoning on adjacent parcels, rather than the availability of infrastructure or the environmental impacts of development. Despite CEQA, the impacts of development are therefore not fully mitigated in the county General Plan and zoning processes. "Overriding considerations" are frequently invoked under CEQA to avoid mitigation for significant effects. This is demonstrated below in our case study of the General Plan updates for Nevada and El Dorado Counties. Planning clearly takes place in a highly politicized context.

The timing, location, and degree of urbanization in metropolitan regions is often determined by major capital investments in infrastructure systems: roads, water supply, sewage collection and treatment facilities, energy supply and related systems (e.g., stormwater drainage). This policy tool—the ability of local governments to control the timing and location of investments in physical infrastructure—has significantly less influence on low-density rural and exurban land development that relies upon on-site infrastructure. It is therefore more difficult to guide development patterns in these areas, where relatively low land costs make site-specific on-site infrastructure investments economic. Indeed, most rural land development occurs without either centralized water supply or sewer systems. On-site wells and septic tanks are common. According to the 1990 census, nearly one in four of all Sierra Nevada Region housing units have private, on-site well water supplies (versus about one in twenty-five for California) and nearly three out of every five housing units have septic tanks or cesspools for waste disposal (versus less than one in ten for California as a whole).

This fact has a direct bearing on the pattern of development that occurs in exurbia. Environmental and health factors dictate that on-site well water systems and on-site septic tank systems should be separated, and therefore zoning regulations require low-density development patterns. This is in part due to the reliance on zoning (which is oriented toward density controls) as the primary means of regulating local land use. Local soil conditions, slopes, and the hydrologic characteristics could all be considered when determining site-specific risks and appropriate standards,[43] but comprehensive analysis of these natural factors has generally been weak in the exurban planning process. Rather than allowing development only where environmental constraints are least limiting, then, local governments have relied on large-lot zoning to increase the likelihood that there will be some buildable site on a given parcel. Undoubtedly, many one-acre parcels have multiple building sites and could support more than one house with an on-site septic system and on-site well water. Conversely, many one-acre parcels have poor soils, steep slopes, proximity to intermittent surface water sources, and very poor ground-water resources. Systematic analysis of environmental constraints would favor shifting development from the latter site to the former site, with less environmental impact at the same level of development. The current reliance on large-lot zoning fails to complete such analysis, however, so it promotes large-lot exurban sprawl and a landscape of fragmentation. Site-specific consideration of natural constraints tends to occur only through the building permit requirements of a percolation test (for septic systems) and minimum well water flow rates. There is rarely any site-specific evaluation of the risk of septic system failures or potential contamination of critical hydrologic resources as a result of failures.[44]

The large lot sizes dominating the prevailing pattern of exurban development are therefore a direct result of the lack of infrastructure to serve the burgeoning exurban population. This lack of infrastructure in turn is a function of both land market economics and the reliance of local land use authorities on low-density, large-lot zoning as the primary means of reducing the potential health risks associated with on-site well water and septic tank systems. These health risks in turn are a function of both on-site infrastructure technology and economics and the environmental constraints of the site. Large lots are not necessarily required to meet the market demand for homes. New residents might be just as satisfied with their "quality of life" on a half-acre lot as on a two-acre lot, for example, if the amenities they seek—privacy, clean water, wildlife habitat, and possible room for a horse—are still available to them in that alternative configuration.[45] A two-acre minimum leads to a development pattern that directly affects up to four times as much land, however, while breaking up ecosystems and habitat, through road networks, building footprints, and the influence of domestic pets, into a pattern of "islands" that are unconnected to larger habitat patches or ecological systems in the landscape. The result may be considerably more environmental damage than would be necessary if the infrastructure allowed higher densities. Higher density does not necessarily mean less environmental impact.

Patterns of Human Settlement in the Sierra Nevada

Much of the literature on rural and exurban land use has failed to distinguish between very different patterns of human settlement in the exurban landscape. Judith Davis and her colleagues made an important distinction in 1994 between "suburban," "exurban," and "small town" residents in their study of exurban counties near the Portland metropolitan area, but that study focused on social, demographic, and economic differences rather than settlement patterns per se (Davis et al. 1994). Further distinctions are necessary to understand land use and the impacts of alternative patterns of human settlement in the Sierra Nevada. Exurban development patterns generally include five distinct types of settlement:

1. Compact small towns of 10^2 to 10^4 population
2. Contiguous exurban subdivisions at suburban densities
3. Stand-alone "gated" communities at suburban densities
4. Large single-family lots with private on-site infrastructure
5. Rural agriculture, natural resource, or open space lands.

These patterns are described in the sections that follow.

Compact Small Towns of 10^2 to 10^4 Population

Communities are the core of exurban areas and the location of most commercial and service activities. In the rural and exurban West their urban form usually dates from the nineteenth century, making them "walkable" and compact in size.[46] These towns were built before the automobile had been invented and long before it had come to dominate urban form. Their architecture is usually a mixed vernacular, offering a variety of styles but relatively standard building scale of between two and four stories. Many of these towns were built around mining or other commodity extractive industries, and their architecture reflects repeated investments and an evolution from tents to shacks to wood-frame buildings to masonry brick structures.[47] Urban designer Peter Owens notes, however, that "most of these places would be illegal under current zoning codes" (Owens 1991–95). Yet they are both intuitively attractive and extremely practical forms of human settlement (Alexander et al. 1977).

Recent "neotraditional" urban designers like Andres Duany and Elizabeth Plater-Zyberk have attempted to reintroduce the spatial patterns and urban form of these traditional patterns in new developments like Seaside, Florida (Duany and Plater-Zyberk 1991). Similar proposals have been made by Peter Calthorpe for the Sierra Nevada foothills (Calthorpe 1993; Local Government Commission 1992). In theory, these neotraditional new towns promise both social and ecological benefits. In practice, the centrally planned neotraditional towns remain socially and economically segregated and lack much of the vitality of the organically developed traditional small towns (Harvey 1993). They are also limited in both population and land area, limiting their potential as a model for handling the dramatic increases in population being experienced in the exurban West. They nevertheless provide a critical social and economic function and offer important lessons for urban design that could yield significant environmental benefits.

Socially and culturally, there is daily interaction among residents in these small towns through shopping, schools, and the rural ritual of picking up mail at the post office box. Social events often revolve around participatory activities (e.g., Little League games, fund-raising pancake breakfasts) rather than professional entertainment. Volunteerism is quite common; in fact, many services that are provided by professionals in urban areas (e.g., fire fighting) are staffed primarily by volunteers in these communities. Reliance on all-volunteer fire departments is changing, however, as the Sierra Nevada grows: commuters and retirees have little interest in volunteer fire fighting, so taxes and fees must be raised to pay for more full-time professional firefighters. Population densities are "urban" within the city limits of these compact small towns—often from 2,000 to 5,000 persons per square mile (plus significant land area dedicated to commercial, industrial, and public uses). In many cases these towns are not incorporated but subject to county oversight for land use planning, regulation, and public services. Truckee was already a bustling town when the Central Pacific railroad was completed in 1869, for example, but it did not incorporate as a municipality with its own city council until 1994.[48] Until then it was "unincorporated Nevada County" and relied upon the county to provide essential public services.

Contiguous Exurban Subdivisions at Suburban Densities

Contiguous subdivisions built in the postwar period are often immediately adjacent to the pre–World War II, compact small towns. These subdivisions are usually connected to the small town's water supply and sewer system, allowing densities comparable to suburban developments in metropolitan areas (anywhere from four to eight houses per acre, or a population density of 5,000 to 10,000 per square mile of residential development after accounting for about 20% dedicated to public roads). Infrastructure access is also necessary to build much higher density multiple-family units. Infrastructure is the key element defining these developments, which have architectural features and a layout that diverge sharply from the patterns in the historic small towns. Residences are typically single-story, while they are often two levels in the historic pattern. Streets are much wider, and the houses are set back from the streets and from each other with ample yard space. The social openness of the traditional front porch has been replaced by the fenced backyard, which isolates the modern family's leisure time and diminishes opportunities for casual interaction (Jackson 1985; Fishman 1987). The garage, a small and hidden addition to the lot in the traditional small town (if it exists at all), has moved from the backyard to the front of the house. The primary means of accessing the residential space is now through the automobile. These subdivisions are designed to maximize vehicle mobility and minimize social interaction. As Michael Southworth, Peter Owens, and Eran Ben-Joseph have demonstrated, the evolution of subdivision design in America reflects a series of systematic changes by nonarchitects that date back to the 1920s and 1930s and continue to constrain urban form (Southworth and Owens 1992; Southworth and Ben-Joseph 1993; Southworth 1995).

Within the development, this settlement pattern is just like that of any other suburban subdivision; within the broader exurban context, however, it is often quite different. Its proximity to the "old town" often allows pedestrian or bicycle access to services, while its overall scale (10^1 to 10^2 acres) is usually much smaller than those developed in metropolitan regions (10^2 to 10^4 acres). This has an important social effect, for the residents retain a familiarity with their neighbors and a connection to the immediately adjacent small town that is often absent in suburbia. These higher density areas are nevertheless very different spaces from the traditional small town itself. They are often the only location in an exurban community where multiple-family housing is located. The poorest members of exurban regions tend to live either in subsidized multiple-family units or in trailers and mobile homes in the most rural (and lowest-cost) settings in the area. Gentrification of the quaint Victorian houses of the historic small towns has increased the need for this kind of housing, but state and federal funding support for affordable housing has diminished recently and is generally concentrated in declining central cities. The rapid growth of the rural and exurban West has created a new affordability crisis (Nevada County Planning

Commission 1993). These contiguous urban subdivisions are therefore becoming more important for their role as pockets of poverty in what is otherwise becoming a more affluent exurban landscape. Examples of this pattern are found in the west-central Sierra Nevada on the outskirts of the historic towns of Grass Valley, Auburn, and Placerville.

Stand-alone "Gated" Communities at Suburban Densities

The opposite condition exists in the many exurban areas that have independent "gated" communities, which are neither physically contiguous to nor socially integrated with the small towns that form the core of the exurban settlement pattern. Unlike the small towns, these "private" communities are usually homogeneous in ethnic (white), social (well-educated exurbanites), demographic (more retirees), economic (wealthy relative to the rest of the region) and political (conservative) characteristics. They are often built around significant recreational amenities (e.g., lakes and golf courses), and they generally have larger lots and more expensive homes. In some cases they have community sewer and water systems, but many older subdivisions continue to depend on private septic systems and on-site wells. This dependence on private infrastructure has not diminished densities, however, for many of these older subdivisions were approved before land use and environmental planning laws required stricter standards. Densities range from one to four houses per acre, or 1,000 to 5,000 persons per square mile. The total population of these private communities is often comparable to the compact small towns at "buildout" (5,000 to 10,000 people). They are usually unincorporated, however, and do not provide many of the service functions of the compact small towns. They are therefore "bedroom communities" that insulate themselves from the rest of the exurban region except as the rest of the region may provide necessary services (e.g., shopping and medical). Because they have assessed themselves to provide infrastructure services (e.g., road maintenance, private community sewer system), their residents often object to tax increases that will benefit the larger exurban community (e.g., for county roads or county schools).

The median assessed values of homes and median family incomes in these communities rival the highly inflated values of metropolitan California. They far exceed typical values for most of the rural and exurban West. Lake of the Pines had a median housing value of $368,500 in 1990, compared with median values of $155,685 in Nevada County, $128,678 for the Sierra region, and $195,500 for California as a whole. The median household income in the core census block group of Lake of the Pines was $55,161 in 1990, compared with medians of $32,464 for all of Nevada County, $29,595 for the Sierra region, and $35,798 for California. Lake Wildwood's median house value was $226,800, and the median household income in Lake Wildwood was $52,359 in the core census block group in 1990. The values are lower in Lake Wildwood than those in Lake of the Pines primarily because Lake of the Pines has a much higher fraction of commuters who work outside Nevada County (53%) than Lake Wildwood (23%). Lake Wildwood also has a higher fraction of retirees, with 66% of its residents at least 55 years of age ("only" 48% of the residents of Lake of the Pines are at least 55 years of age). This compares with 29% of Nevada County residents, 27% of all Sierra region residents, and only 18% of all California residents who are 55 years of age or older (U.S. Bureau of the Census 1990).[49]

These high housing values and household incomes have supported effective privatization of public services without municipal incorporation. Lake of the Pines and Lake Wildwood also rival the incorporated towns of Grass Valley, Nevada City, and Truckee as population centers in Nevada County. Unlike those three incorporated cities, however, the privatized "public" sector of the gated communities is exempt from a wide range of laws guiding public policy in California municipalities. They are exempt from open meeting laws and can structure mechanisms for controlling local land use and infrastructure decisions based upon ownership rather than equal representation. Political jurisdictions are then less relevant to infrastructure and land use decision making in privatized communities. Expansion of this pattern of "gated community" development therefore has implications for the land use planning process itself. It also has a direct bearing on the capacity to provide local infrastructure through general taxation.

Not surprisingly, many of the members of these communities see little reason to tax themselves to provide services for the rest of the county or larger community. The privatization of the public sector through the gated community structure effectively segregates the exurban landscape by class. Gated communities clearly provide a market good with a particular set of characteristics that are highly valued by many consumers in the marketplace. In that sense, they provide room for many of the equity refugees fleeing metropolitan areas for exurbia. The marketing materials for these communities emphasize personal safety and social, demographic, economic, spatial, and architectural homogeneity. Interestingly, the residents of these gated communities appear willing to accept strong restrictions on their (and their neighbor's) "private property rights" through covenants, codes, and restrictions (CC&Rs) in the title to their property. Land use regulation is often strongest in these gated communities, with the homeowners association in charge.

Large Single-Family Lots with Private On-Site Infrastructure

Most exurbanites probably live in one of the three settlement patterns just described. Most of the land area in exurban areas is probably in the fifth settlement pattern described, largely "open space." Most of the land area in exurban regions directly affected by human settlement, however, is probably a result of large single-family lots with private on-site infrastructure.[50] This is an extremely popular form of settlement, for it offers privacy as well as direct contact with the country ideal for the ex-urbanite. Ironically, it can also have significant negative impacts on the environment through habitat fragmentation and potential contamination from septic system operation. As described earlier, the large lot size is primarily a function of the public health need to separate on-site water supplies from on-site sewage disposal through septic tank and leach field systems. This requirement has resulted in minimum lots sizes of from 1 to 5 acres per dwelling unit (300 to 1,500 persons per square mile).[51] Many of the subdivisions were approved under less stringent standards that allowed development at densities up to four units per acre with on-site water and septic disposal, offering a bare minimum of adequate area for leach field drainage. Based upon experience throughout the Sierra Nevada, however, many can therefore be expected to fail under soil, slope, or hydrologic conditions that are less than optimal. In some cases this will preclude further development at the high densities allowable under current land use designations. In other cases, septic or well failures will lead to the establishment of community water supplies and/or public sewer systems, which could then lead to higher-density infill development of these substandard lots. In either case there can still be significant social, economic, and ecological impacts. Unfortunately, these impacts are not analyzed ex ante for most developments.

This pattern of development accounts for a significant fraction of the total land area developed to date in Nevada and El Dorado Counties. Parcels in the size class of 1 to 5 acres per dwelling unit accounted for 11.42% of the land area in improved parcels (6.53% of all land area) in Nevada County and 9.78% of the land area in improved parcels (45.43% of all land area) in El Dorado County in 1992. Proposed county General Plan requirements call for minimum parcel sizes in this range for on-site infrastructure, so this size class is expected to account for at least 11.87% of Nevada County's total land area and 3.03% to 3.43% of El Dorado County's total land area under "buildout" of the draft General Plan updates for each county of 1994. Parcels in the size class of 5 to 10 acres per dwelling unit, 10 to 20 acres per dwelling unit, and 20 to 40 acres per dwelling unit account for a much smaller fraction of the total parcels but a much higher fraction of total private land in 1992 in both Nevada and El Dorado Counties. Each of these size and dwelling unit density classes has different ecological impacts associated with development. Significant variation within each size class also exists due to different management practices and behavior of landowners, however, so it is difficult to generalize ecological impacts by average density or average parcel size class (Duane 1993b; Fortmann and Huntsinger 1989). McBride et al. (1996) highlight some general relationships, however, that suggest the scale of impacts. Unfortunately, we do not yet have a clear understanding of these relationships.

Due to the "grandfathered" substandard lots approved before current standards, however, any analysis based on parcel size classes alone is likely to underestimate the number and land area of parcels with on-site well water and/or septic systems. Conversely, including all smaller parcels (higher densities) is likely to overstate the dominance of this pattern, because many of the new subdivisions with treated water and/or sewage treatment facilities are being built with densities at four units per acre (quarter-acre lots). Parcel size distribution and its implications for "buildout" are discussed in more detail in the sections on the Nevada and El Dorado Counties, General Plans.

Rural Agriculture, Natural Resource, or Open Space Lands

Most residents of exurbia live in one of the four settlement patterns just described, but most of the exurban landscape is still managed primarily for agriculture or natural resources commodity extraction.[52] Its primary economic value, however, appears to be shifting in areas facing rapid population growth from a landscape of production to a landscape of visual consumption (Willis 1994; Alterman 1994). This change is consistent with the historic processes of suburbanization in metropolitan areas. Population densities on these lands are typically no more than one structure per 40–160 acres, or from 10 to 200 persons per square mile. Some exurban ranches have as few as 5 people per 10,000 acres, or less than 1 person per 3 mi^2. Agricultural productivity is often threatened by the encroachment of exurban "ranchette" development, however, as the new exurban residents often impose new restrictions on traditional agricultural practices due to the spillover effects of those productive activities (e.g., noise, pesticides) on the consumptive enjoyment of amenities in the residential regions.[53] In response a number of rural counties have passed "right-to-farm ordinances," which limit new residents' rights to file nuisance complaints against long-standing agricultural practices.[54] The economic viability of many agricultural lands is also threatened by exurban development, however, as increasing land prices make agriculture an increasingly marginal activity when compared to the opportunity costs of subdividing and developing the land (Forero et al. 1992; Hargrave 1993). Moreover, decreasing agricultural activity in exurban regions can reduce the economies of scale in supplying the remaining farmers, increasing the cost and decreasing the availability of farm equipment and related supplies (e.g., feed).[55] A similar phenomenon can occur with natural resource management on private lands (e.g., timber), although public lands management policy is often more important to the viability of local natural resources extraction industries in the Sierra Nevada and in general throughout the West.[56] Public land managers clearly face a new and less supportive sociopolitical context for traditional commodity extraction activities as the private lands adjacent to public lands undergo rapid settlement.[57]

Both agricultural and natural resources lands function effectively as de facto public open space for many of the new exurban residents, offering scenic, aesthetic, recreational, and ecological benefits. The implications of human settlement on recreational opportunities for Sierra Nevada residents is discussed in Duane (1996). Recreational use of these de facto open spaces is probably one of the primary drivers of and values in "agricultural preservation" efforts in suburban and exurban regions. "Countryside preservation" is the real goal of many proponents of regulations maintaining large parcel sizes, while calls for "agricultural preservation" are often simply a rallying cry that invokes the self-sufficient yeoman farmer and images of Jeffersonian democracy (Kemmis 1990). The focus on agricultural production also taps into a deeply held belief in American society: that agriculture is "primary," so it should and must be protected (Powers 1996). Moreover, many environmentalists often argue that the productive soils underlying agricultural lands are a nonrenewable resource that will forever be lost if an area is "paved over" for new subdivisions.[58] This is rarely the case in the Sierra Nevada foothills, however, where the soils are not nearly as rich for agriculture as they are in the Central Valley and the Napa Valley. The rationale for agricultural preservation must therefore go beyond soils.

The increased values associated with the amenity benefits of open space lands are not easily captured by landowners, however, creating a conflict between long-term agricultural and natural resource landowners and other community members' values and interests. The real beneficiaries of countryside and agricultural preservation efforts are generally not the farmers or owners of agricultural land but the rest of the community that derives public good benefits associated with the aesthetic, recreational, and ecological goods and services provided by those private lands. Agriculturalists beyond the range of speculative development are also likely to support such efforts, for they yield marginal benefits at very low opportunity cost. Large landowners within the range of speculative development (e.g., their lands are likely to be developed within the next ten to twenty years) are likely to oppose such preservation efforts despite a long family history in agriculture and/or natural resources and a commitment to agricultural preservation. Their children often do not want to continue in this difficult line of work, and they recognize that selling their land to developers is the most effective way to transfer the value of their land to the next generation and relieve themselves of the uncertainties of agriculture. Despite their abstract support for preservation, then, their personal interest in realizing economic gains will often lead them to oppose such efforts. Social conflict is therefore likely to continue between the proponents of such efforts and the supposed beneficiaries of such efforts unless and until the true beneficiaries are willing to structure mechanisms to compensate existing landowners for reduced speculative land values. This is the fundamental challenge of growth management efforts throughout the Sierra Nevada and the rest of exurbia.

Public Land Ownership in the Sierra Nevada

Patterns of public land ownership are an important factor affecting patterns of human settlement. We used a map prepared by the Strategic Planning Program (SPP) of the California Department of Forestry and Fire Protection (CDF) to analyze patterns of land tenure. Various federal, state, and local government agencies administer more than 60% of the total land area of the Sierra Nevada region as public lands. National forests managed by the U.S. Forest Service alone account for two-thirds of publicly owned lands in the region and 40% of all lands in the region. The Bureau of Land Management manages 13% of the region, while the National Park Service administers approximately 6%. City and county governments, the state of California, the U.S. military, and other federal agencies each account for around 1%. These public lands are generally unavailable for human settlement (except for some recreational purposes and for employee housing) under current institutional arrangements. Human settlement is therefore concentrated on private land. We therefore used the land tenure overlay to reduce the error associated with using the census block group (CBG) coverage to estimate patterns of human settlement throughout the Sierra Nevada. The CBG is the next smallest unit of census data aggregation below the CCD. We intersected the two coverages to create a third coverage of "private block group" (PBG) polygons, which then allocated all population and housing units across only the private lands within the CBG. Figure 11.25 shows the distribution of public land by federal land management agency in the Sierra Nevada.

Our map shows that some counties have considerably more public land than others. Amador County is only 22.14% public land, while Inyo County is 98.34% public land. Much of the nonfederal land in Inyo County is owned by the City of Los Angeles Department of Water and Power (LADWP). Table 11.A2 in appendix 11.1 shows the area of each California county in the Sierra Nevada by tenure.

Information on population and housing unit characteristics was derived from the U.S. Census Bureau's Summary Tape File 3A, 1990 Census of Population and Housing. This publication (available in digital form) presents data from the Census Bureau's sample survey of households, including 17% of all households on average (although it may include up to 50% of all households in rural areas). Because data from STF3A are not available at the census block level (the smallest unit of analysis for census data), we used the next largest unit of aggregation, the "split block group" (SBG). The Census Bureau splits block groups that cross city and other political boundaries, providing separate data records for each block group part. This is the smallest geographic unit for which sample census data are readily available. There are 740 split block groups in the five-county central Sierra Nevada counties of Nevada, Placer, El Dorado, Amador, and Calaveras, for example, compared to approximately 17,000 census blocks and eighteen CCDs.

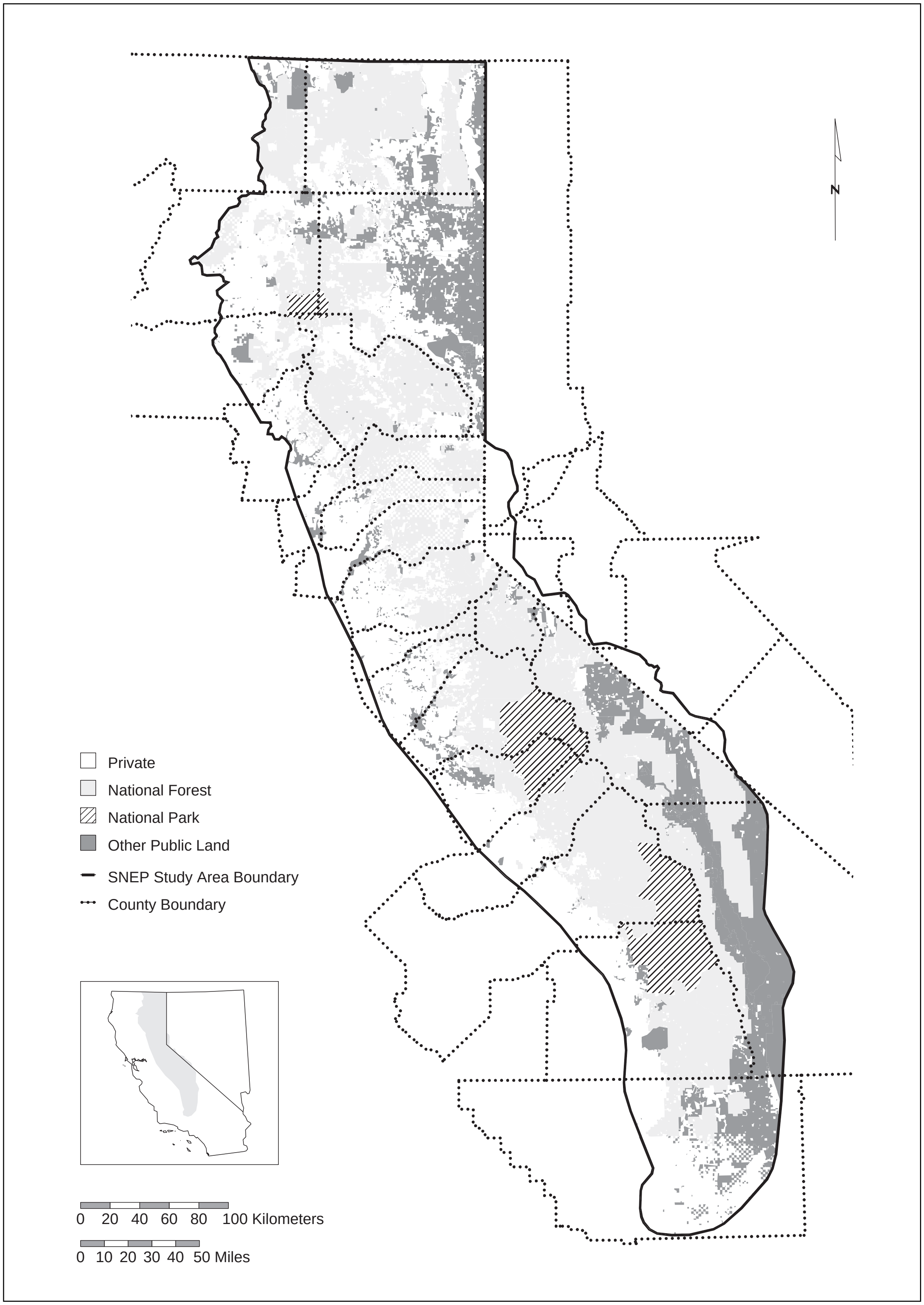


FIGURE 11.25

Public land ownership, Sierra Nevada region.

Private landownership is concentrated at lower elevations, in the foothill areas. Nevertheless, the boundary between public and private lands throughout the region is extremely complex, with numerous pockets and strips of privately owned land extending into higher elevations, particularly in the central and northern portions of the region. This pattern increases the potential for significant impacts on public lands and higher-elevation ecological conditions from development on private lands. The GAP assessment (Davis and Stoms 1996) highlights areas in the Sierra Nevada in which the public-private interface per unit of area is very high. That analysis also highlights vegetation types that are primarily represented on private lands. In particular, the following five vegetation types fall largely on private lands and are subject to settlement: nonnative grassland (88% of mapped distribution on private lands), valley oak woodland (98%), blue oak woodland (89%), interior live oak woodland (71%), and foothill pine-oak woodland (82%). In addition, there is significant human settlement on private lands in the west-side ponderosa pine forest and the lower cismontane mixed conifer–oak forest. This pattern reflects the spatial concentration of human settlement "below the green line" west of national forest boundaries up to around 1,200 m (4,000 ft) in elevation. Based on the Davis and Stoms 1996 analysis, approximately 80% of the land below 1,000 m (3,280 ft) in elevation in the northern Sierra (north of the Stanislaus River) is in private ownership.

Several higher-elevation vegetation types are also being affected by intensive recreational development activity on both public and private lands in the Lake Tahoe and eastern Sierra subregions. These include the Jeffrey pine forest, the east-side pine forest, and some subalpine meadow communities. Both ownership patterns and development patterns are more complex in the higher elevations than in the western foothills, however, so it is difficult to generalize about the relationship between human settlement and vegetation types in these areas. More detailed analysis is necessary at a vegetation-specific level in these areas.

Data limitations constrained our assessment of human settlement at the scale of the entire Sierra Nevada. We therefore focused in greater detail on the five-county central portion of the region where human settlement is already at its densest and growth pressures are high. These five counties of the central Sierra Nevada (Nevada, Placer, El Dorado, Amador, and Calaveras) are characterized by a comparatively high proportion of private land relative to their total areas, however; in all five cases, private lands cover 50% or more of the part of the county within the Sierra Nevada region. They are therefore not necessarily representative of the conditions throughout the Sierra Nevada. They nevertheless offer an interesting case study of the factors affecting human settlement.

More detailed information was available on private lands in these five counties than in any other part of the Sierra Nevada through access to a digital database developed by the Teale Data Center for CDF. The database relates county assessors' parcel records to a georeferenced coverage of the assessors' "map book pages." Each map book page contains multiple parcels, but each individual parcel's assessor's information is available in the database and can be spatially related to the map book page coverage. We assisted CDF in completion of the database through supplementary funding and a contract with Teale to incorporate ownership information into the database. This same ownership information is already publicly available from each county assessor's office, but it had not previously been related to the map book page coverage under the original contract with CDF. We therefore have no more access to parcel information than is available to the general public. Having it in digital form, however, allows us to relate ownership patterns to human settlement and to complete more detailed spatial and statistical analysis of the data than previously possible. Specific findings are discussed in more detail in sections discussing the Nevada County General Plan and the El Dorado County General Plan. All of these data are now available for public access from the California Environmental Resource Evaluation System (CERES) project of the Resources Agency of the State of California (http://ceres.ca.gov/snep), and the Alexandria Project at the University of California, Santa Barbara (http://alexandia.sdc.ucsb.edu/).

Housing Density from 1940 to 1990 in the Sierra Nevada

Social data on well-being is only available at the "census block group" (CBG) level. Census block groups are clusters of several census blocks, containing 650 people on average. We therefore had to rely on the more aggregated CBG data (685 polygons) rather than the more precise Census Blocks (over 50,000 polygons) to assess a number of factors influencing the pattern of human settlement in the Sierra Nevada. There are approximately 800 block groups in the entire SNEP study area, with 685 of those in the eighteen-county Sierra Nevada region covered by the 46 CCDs included in our assessment. Doak and Kusel (1996) used a slightly larger set of 720 census block groups that were then aggregated into the 180 "Community Aggregations" (CAs) reported in their social assessment. Once again, this reflected the different needs of our assessments. We limited our analysis of CBG data to those CBGs within the CCDs analyzed for 1970–90.

We obtained data on a variety of household characteristics from the U.S. Census Bureau's Summary Tape File 3A, 1990 Census of Population and Housing. One question in the 1990 census asked a sample of residents what year their home was built. Based upon these data, we constructed a series of coverages showing the average density of development within each private block group for each decade between 1930 and 1990. This series will tend to understate the degree of development in early years, however, for some structures built in later years may have destroyed older housing on the same site. Older houses that are unoccupied would also not be represented in the Census responses. The resulting maps nevertheless present a fascinating time-series sequence of human settlement in the Sierra Nevada. Plate 11.2 shows this pattern for each decade from 1930 to 1990.

This series of plots shows the steady expansion of human settlement throughout the Sierra Nevada during the 1930–90 period, with a rapid expansion beginning as early as 1960. Because the "private block group" (PBG) polygons are so large, however, these maps will tend to overstate the density in private industrial forest lands and understate the density in other areas within the same PBG. Human settlement was therefore actually more concentrated (and at a higher density) than that suggested by these plots. They nevertheless offer a more accurate picture than that provided by the census block group (CBG) coverage, which allocates density across both public and private land.

Note how the primary areas of increasing density are along U.S. Highway 50 and Interstate 80 between the Sacramento area and the greater Lake Tahoe Basin. It was still possible to connect large areas of low-density or unsettled land along a latitudinal gradient from north to south through the western Sierra Nevada foothills in 1930–50, but development along these highways had effectively isolated the American River drainage from the largely contiguous regions north and south of I-80 and U.S. 50 by 1980–90. Other areas of relatively high density have also appeared to fragment the landscape. The potential implications of such fragmentation are discussed in more detail later.

Access to Infrastructure Services in the Sierra Nevada

We examined a number of additional factors at a variety of spatial scales that could potentially help determine the distribution and rate of residential development in the region. These included descriptive and bivariate analyses of forty census variables for all census block groups in the SNEP study area, for the five-county study area, and for two individual counties (Nevada and El Dorado) for which we had more detailed information.

The availability of physical infrastructure is one of the factors we examined. High-density development depends on proximity to sewer, water, gas, and power lines. At lower densities, development may still be possible through use of septic systems for waste disposal and wells for water. Even low-density development and isolated rural homes almost always depend on public power, however. Unfortunately, we were not able to obtain detailed maps or data that would allow us to incorporate the location of physical infrastructure into our analysis of settlement patterns. Pacific Gas and Electric Company, the only infrastructure entity with regional responsibilities throughout the five-county area, denied our request for infrastructure network information "for competitive reasons." (Pacific Gas and Electric Company staff 1994). We received more support and cooperation from the Nevada Irrigation District (NID), the El Dorado Irrigation District (EID), the Georgetown Divide Public Utility District (GDPUD), the El Dorado County Water Agency (EDCWA), and the El Dorado County Planning Department to convert their infrastructure data into a coverage, but their data were generally not in digital form. Only EID data were digital, and they were based on a CAD system that was not georeferenced in a system compatible with our other coverages (El Dorado Irrigation District staff 1994). NID is hoping to convert its paper-based engineering maps into a geographic information system (GIS) coverage over the next few years (Nevada Irrigation District staff 1994–95). We originally hoped to model the economic costs of infrastructure access and expansion, but we were only able to map the distribution of homes with access to some of these services through use of the private block group data in the census. This is only a proxy measure for patterns of infrastructure access and is not spatially explicit enough to allow development of an economic model of development that is directly linked to infrastructure access.

We analyzed the forty census variables for all 685 census block groups in the Sierra Nevada, but they are difficult to display in graphical form for the entire region. We therefore illustrate the spatial patterns in these variables here with a subset based upon all of the CBGs in the central Sierra Nevada counties of Nevada, Placer, El Dorado, Amador, and Calaveras. The western portion of Placer County, including the cities of Roseville and Rocklin, is outside the area of our analysis but is displayed here for reference purposes. Access to public sewage disposal varies at a county level in the Sierra Nevada from only 21% of Mariposa County residents to 83% of Mono County residents. Figure 11.26 shows the pattern of access to public sewer by CBG in the five central Sierra Nevada counties.

Our bivariate analysis of all forty census variables against one another resulted in very few strong correlations for the 685 census block groups. This result may reflect either poor associations, skewed distributions, or confounding variables not accounted for in our analysis. Population density at the CBG level is positively correlated with the distribution of access to public sewer in the central Sierra Nevada region, for example (R-squared = 0.24; t-statistic value = 14.53), but it is clear from the histogram that all CBGs above an average density of 1,000 to 1,500 persons per square kilometer have nearly 100% sewer coverage. Population density is less strongly correlated with the fraction of the CBG households with access to public water supply (R-squared = 0.157; t-statistic value = 11.09). The lower R-squared value for the public water variable reflects the fact that access to public water is more pervasive in the region. The threshold population density (POPDENS) at which a CBG had nearly complete access to public water is only 500 to 1,000 persons per square kilometer. Figure 11.27 summarizes the fit for both of these variables and shows the histogram for each variable. Note that this analysis used "No Public Sewer" (NOPSEW) and" No Public Water" (NOPWAT) as the independent variables, so there is a negative correlation with POPDENS. Figure 11.27 also shows

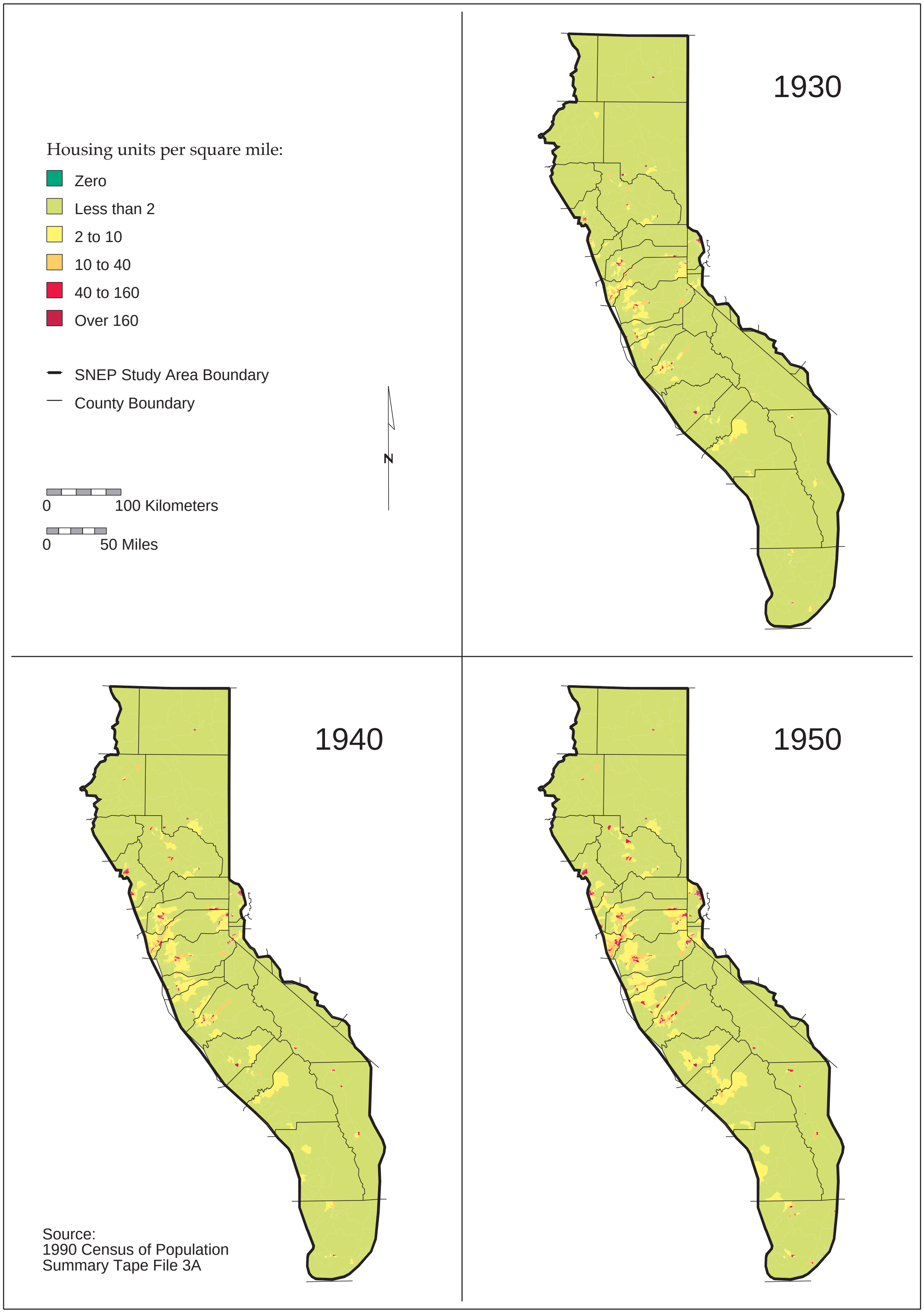


PLATE 11.2

Change in housing density in the Sierra Nevada region, 1940–90 (based on 1990 Census of Population, Summary Tape File 3A).

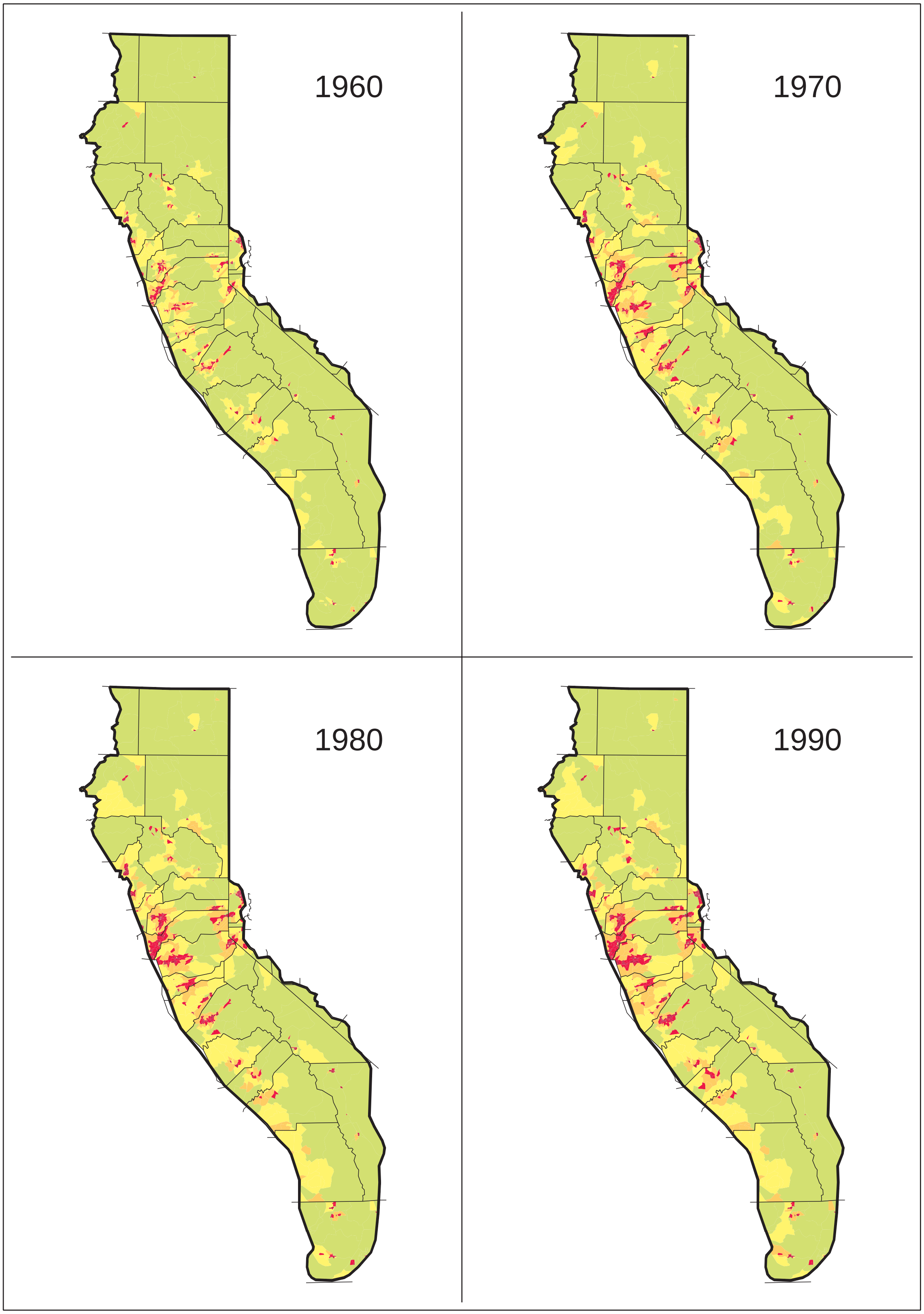


PLATE 11.2 (continued)

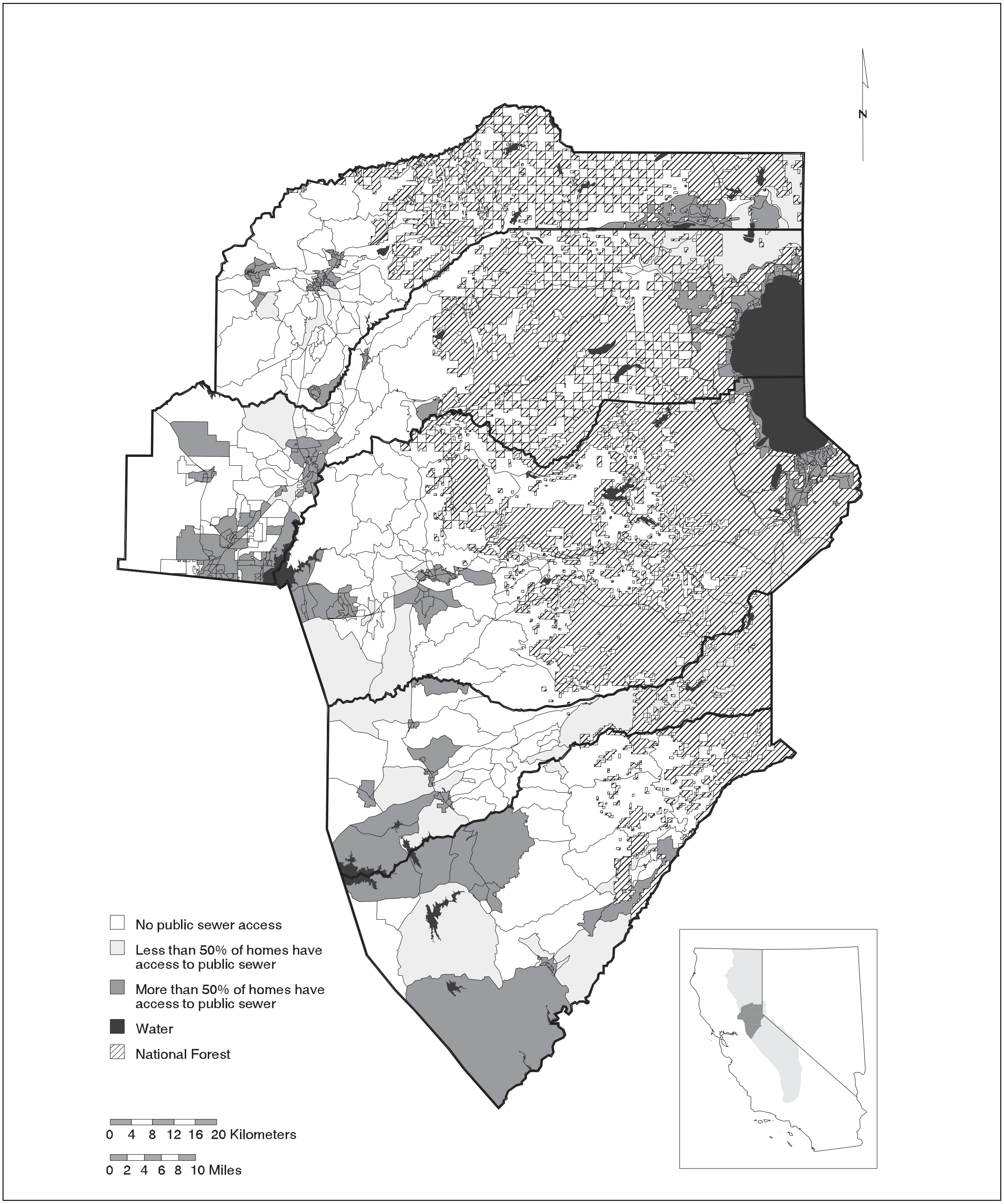
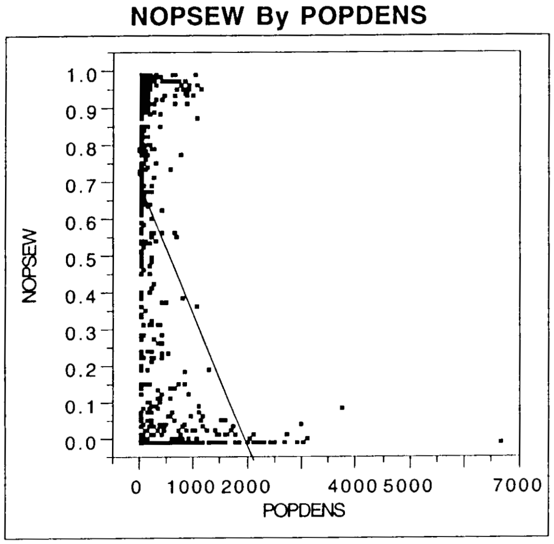


FIGURE 11.26

Access to public sewers, central Sierra Nevada region (based on 1990 Census of Population, Summary Tape File 3A).



Fitting
— Linear Fit

Linear Fit

Summary of Fit

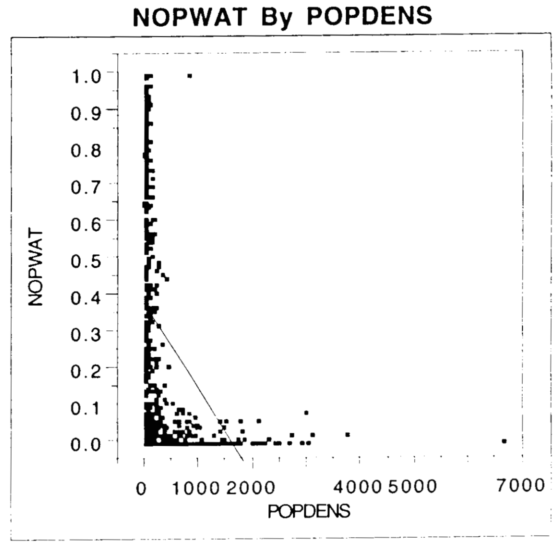
Rsquare	0.242692
Root Mean Square Error	10.73949
Mean of Response	0.58272
Observations (or Sum Wgts)	617460

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	24357.73	24357.7	211.1880
Error	659	76006.90	115.3	Prob>F
C Total	660	100364.64		0.0000

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>It I
Intercept	0.6979085	0.0158	44.17	0.0000
POPDENS	-0.000352	0.00002	-14.53	0.0000



Fitting
— Linear Fit

Linear Fit

Summary of Fit

Rsquare	0.157332
Root Mean Square Error	9.315026
Mean of Response	0.300702
Observations (or Sum Wgts)	617460

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	10676.143	10676.1	123.0400
Error	659	57181.239	86.8	Prob>F
C Total	660	67857.382		0.0000

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>It I
Intercept	0.3769618	0.0137	27.51	0.0000
POPDENS	-0.000233	0.00002	-11.09	0.0000

FIGURE 11.27

Relationship between availability of sewers (NOSEW) and census block group population density (POPDENS) and relationship between availability of public water (NOPWAT) and census block group population density (POPDENS).

POPDENS as the independent variable, although this simply reflects the fact that every bivariate regression was run only once. The display of POPDENS as the independent variable does not change the result.

Figure 11.28 shows that access to public water is much more pervasive in the central Sierra Nevada counties than access to public sewers. County-level access varies from only 41% of Mariposa County residents to 84% of Mono County residents. Once again, the access varies significantly within each county. Figure 11.28 highlights the spatial patterns of access in the five-county central Sierra Nevada. Note in figure 11.28 how the unwieldy census block group boundaries result in the allocation of spatial distribution to all private lands within a census block group, including the "checkerboard" pattern of private industrial forest lands in the mixed conifer zone. This does not mean that there are housing units in those areas with access to public water but simply that the land area with that shading is within a census block group where 50% or more of the homes use public water. The homes themselves are not distributed evenly throughout the census block group polygon but are concentrated within portions of each polygon. This problem led us to use the much smaller census

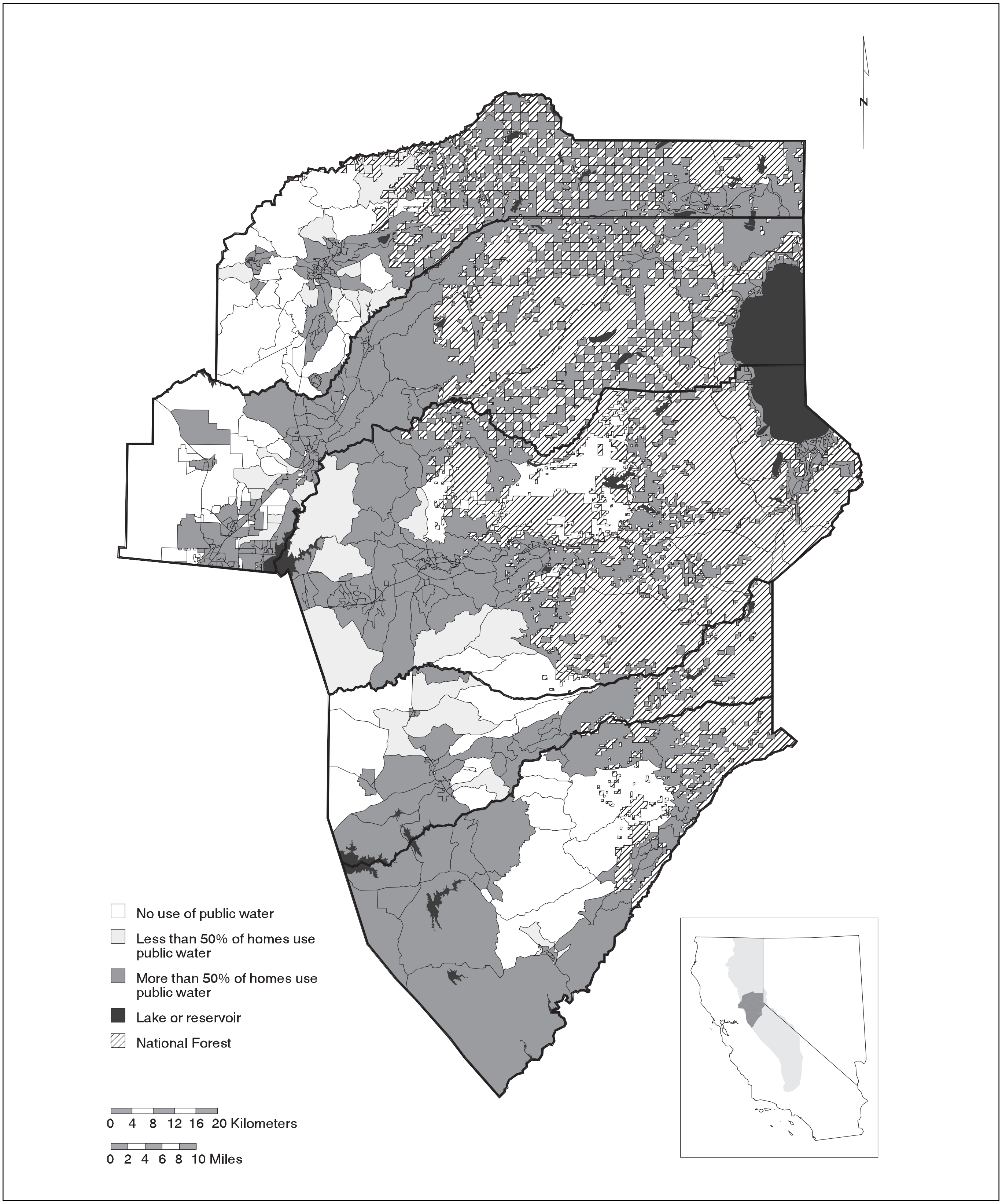


FIGURE 11.28

Source of household water, central Sierra Nevada region (based on 1990 Census of Population, Summary Tape File 3A).

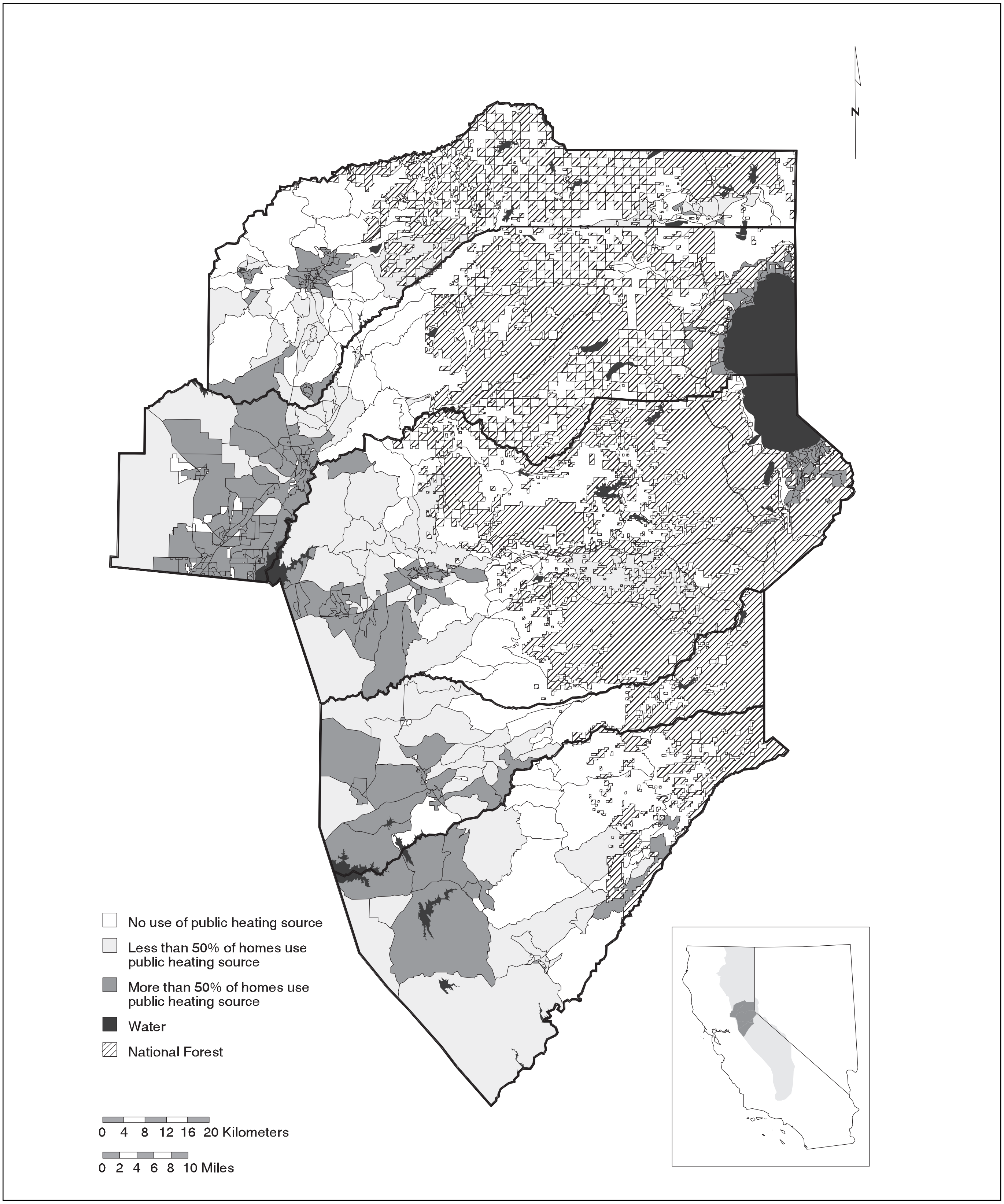


FIGURE 11.29

Source of household heat, central Sierra Nevada region (based on 1990 Census of Population, Summary Tape File 3A).

blocks when we mapped 1990 housing density rather than the less precise census block group or private block group polygons.

Access to natural gas or another public heating source is not a necessary element of development, but public utilities generally do not invest in heating infrastructure unless housing densities are high enough to allow the fixed costs to be recovered across many housing units. Figure 11.29 shows that this occurs only in a few areas: along the I-80 corridor up to Auburn in Placer County, around Grass Valley and Nevada City, along U.S. Highway 50 through El Dorado Hills, and in the area leading to Jackson and Ione in Amador County. The rest of the housing units in this area depend primarily upon a private heating source (generally wood or propane). This has important implications for air quality and market demand for fuel wood as population continues to grow throughout the Sierra Nevada. The trends in air quality discussed in Cahill et al. (1996) should be considered in the context of some reliance on wood heating at low housing densities.

Road access and proximity to major transportation corridors are additional factors influencing settlement patterns. We tested for the relationship between road density (based on the Teale coverage at 1:100,000) and census block group population density and assessor's map book page parcel density. There was no statistically significant relationship between these variables and road density, so roads could not be used as a proxy for density. Access times to employment centers in metropolitan areas outside the Sierra Nevada should be an important variable affecting development patterns, however, and this is apparent from visual inspection of the census block group data for the entire Sierra Nevada. The highest population densities are found in those CBGs proximate to four-lane highways accessing the Sacramento metropolitan area, recreational developments in the Lake Tahoe and eastern Sierra regions, and the historic nineteenth-century towns along Highway 49. We were unable to complete a more systematic analysis that modeled the relationship between commute times and settlement patterns, but we did examine the issue in more detail in our analysis of the Nevada and El Dorado County General Plans. Figure 11.30 shows the fraction of the population working outside the county in each of the census block groups in the central Sierra Nevada. Not surprisingly, these areas are concentrated within commuting distance of the Central Valley. There are also high levels of intercounty commuters at higher elevations, however, including many in eastern Nevada, Placer, and El Dorado Counties.

As the overall picture of density in the Sierra Nevada region makes clear, the spillover effect of proximity to major urban centers such as Sacramento is an important factor affecting both total levels of population and the population densities associated with patterns of human settlement. This proximity has a direct effect on land values in the western foothills of the Sierra Nevada, which in turn increases the viability of making significant investments in infrastructure (e.g., roads, sewers, water, and power) that can then allow much higher development densities. The higher densities are necessary to make such infrastructure investments economic, because they usually involve a high proportion of fixed costs. Increasing land values also make some areas that are marginal for development through on-site infrastructure (e.g., septic systems and well water) attractive for development: the relative costs of those investments declines (and the relative value of making them increases) as land values increase. The cost of drilling a 200-foot well might be a large fraction of total development costs when land is $10,000 per acre, for example, but drilling even an 800-foot well could be economical if land costs $50,000 per acre. These are the types of land value changes we have seen in Nevada, Placer and El Dorado Counties over the past decade.

As a result, many "unbuildable" lots are now being developed. Physically based models of development fail to capture this phenomenon, because the "unbuildable lot" is fundamentally an economic concept. Higher land values can therefore result in significant land development that would not otherwise occur at lower land values. The employment and income characteristics of new Sierra Nevada residents are therefore an important determinant of human settlement patterns in the region. Higher incomes associated with commuters and some retirees puts pressure on land and housing prices, which is likely to lead to development that is both more intensive (i.e., at higher average densities where public infrastructure is provided) and more extensive (i.e., across the landscape into some areas that were previously considered "unbuildable"). Higher land values are therefore unlikely to lead only to either greater density in existing areas of development or greater land area under development at existing densities. Both are likely to occur, and the two types of development have different impacts. The difficulty is predicting when and where each type of development will occur.

The economics of infrastructure in the Sierra Nevada are in part a function of federal, state, and local policies. The federal Safe Drinking Water Act imposes specific requirements for water treatment that have economic consequences for the cost of domestic water supply, for example, while Regional Water Quality Control Board requirements for sewage treatment affect the relative costs of septic versus sewer system waste disposal. Enforcement of the non-point-source (NPS) water pollution provisions of section 319 of the federal Water Quality Act of 1987 (Clean Water Act Amendments) could also lead to greater restrictions (and costs) for the use of septic systems. The California Public Utilities Commission (CPUC) also recently modified its rules and regulations for allocating the cost of power line extensions, which will increase the cost of providing power to more remote rural development sites. These new rules (effective July 1, 1995) will increase the relative attractiveness of developing those parcels that have the easiest access to existing power lines, yet could also increase pressure to develop more remote sites at higher densities (in order to allocate the fixed costs of the line extension across more housing units). Actions by a wide range

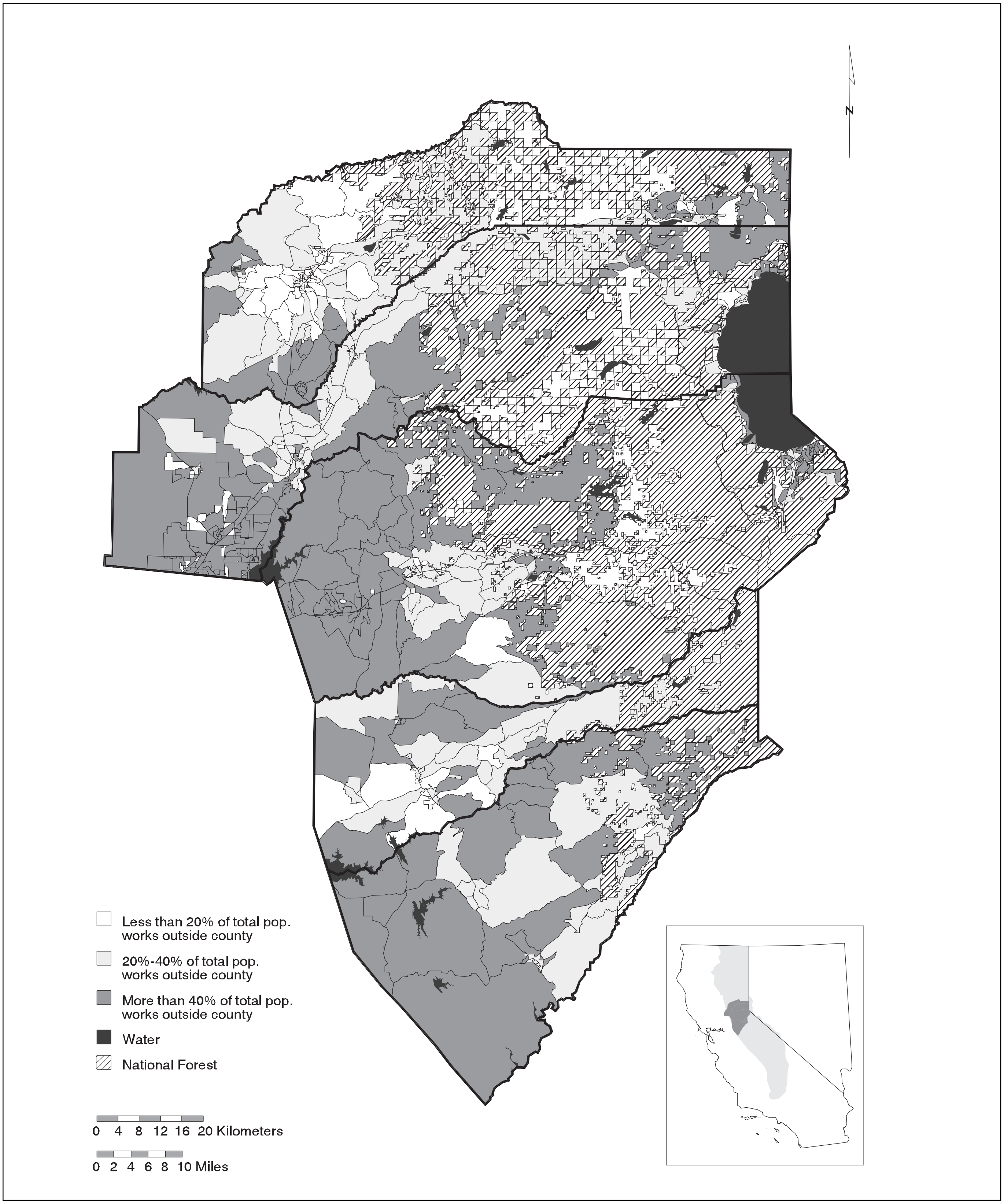


FIGURE 11.30

Place of work, central Sierra Nevada region (based on 1990 Census of Population, Summary Tape File 3A).

of public agencies therefore affect patterns of human settlement. In many cases those actions may be focused primarily on very different issues than those addressed in this assessment, but they can have profound ramifications for the Sierra Nevada.

Census Variables and Density in the Sierra Nevada

Census data were not available at the CBG level in the Sierra Nevada for 1970, but we considered development of a population forecasting model based upon data for 1980 and 1990. Our exploratory data analysis of the relationships between the forty census variables was designed to help specify such a model. Other exurban modelers have attempted similar LOGIT specifications based on a combination of census data and biophysical variables such as proximity to roads and cities (Sanchez and Nelson 1994). In particular, Ted Bradshaw and Brian Muller at the University of California, Berkeley, have developed a model of exurban growth in California's Central Valley to forecast farmland conversion for the American Farmland Trust (1995).[59] They have also developed a model of exurban development in the forested counties of California for the U.S. Forest Service Pacific Southwest Research Station at Riverside to assist modeling of fire risks (Bradshaw and Muller 1994–95).

In both cases they developed models with only limited explanatory power (Bradshaw and Muller 1994). While they did identify some statistically significant relationships, there was little theoretical basis for the relationships identified. We believe that confounding variables, together with both the inconsistent basis for establishing census block group boundaries and the limited data, make such an approach problematic at this time. We do believe this is a promising direction for future research, however, following completion of the next census in the year 2000. We will then have data for three periods (1980, 1990, and 2000) across the entire country in digital form related to a consistent geospatial reference in the census TIGER files. That data set will then allow systematic analysis of the exurban growth phenomenon throughout both the Sierra Nevada and similar areas throughout the rural western United States. Until then, however, we have chosen to rely upon the simpler modeling strategy described in the section on allocating county-level DOF population forecasts.

Despite the data limitations for forecasting, the descriptive statistical analysis and bivariate analysis were still useful. They helped to establish the distributions of particular variables across the CBG set and then helped us identify outliers (such as those associated with correctional facilities) that could otherwise confuse our analysis. They also allowed identification of potential proxies for particular settlement patterns. Finally, the bivariate analysis confirmed several of the theoretical relationships we suspected based upon the framework established earlier regarding factors driving exurban population growth in the Sierra Nevada. In particular, the bivariate analysis highlighted the relationships between income, housing values, access to water and sewer, and physical proximity to the commuting opportunities in the Central Valley (especially Sacramento). These relationships reinforce the importance of metropolitan expansion and deconcentration as critical factors driving population growth in the Sierra Nevada. They also reinforce the notion that changing land values can radically alter the housing densities that can be supported by the real estate and housing markets. This has important implications for likelihood of alternative future patterns of human settlement in the Sierra Nevada. While we have not been able to develop a more explicit economic model of infrastructure access and development densities, we know it is quite important. Future research in this area should emphasize this important relationship.

Descriptive statistics for each of the forty census variables and the bivariate analyses of relationships between each of those variables are available from the California Environmental Resource Evaluation System (CERES) project of the Resources Agency of the State of California (http://ceres.ca.gov/snep), and the Alexandria Project at the University of California, Santa Barbara (http://alexandria.sdc.ucsb.edu/). Figure 11.27 illustrates these bivariate analyses and those data.

Mapping Housing Density in the Sierra Nevada

The extent of private lands in the region establishes only the most basic template of where human settlement can expand. We decided that a more accurate representation was necessary to assess the spatial patterns of human settlement at various development densities. We therefore relied on the more detailed data from the 1990 Census of Population and Housing on the Summary Tape File 1B publication, which provides basic population and housing characteristics for individual "census blocks" (CBs). A census block is the fundamental geographic unit at which the data are originally recorded by the census following collection at the household level. In urban centers census blocks correspond with actual city blocks; in rural areas census blocks are usually delineated to correspond with logical natural or artificial boundaries, such as roads and rivers. (The relationship between the boundaries of arbitrary units such as census blocks and other geographic features becomes important when several maps are combined for analysis.) Most counties in California, even those with small populations, are divided into thousands of census blocks. They vary in size from about an acre in densely populated urban counties to hundreds of acres in more sparsely populated regions.

We calculated housing density for each census block in the Sierra Nevada by dividing the 100% housing count by the land area of the census block. The latter is reported in the STF1B file with an accuracy of one-thousandth of a square kilometer or 1,000 square meters. Conversion to units per square mile followed this formula:

$$(\text{units}/0.001\,\text{km}^2)(1{,}000)(0.001\,\text{km}^2/1\,\text{km}^2)(1\,\text{km}^2/0.3861\,\text{mi}^2) = (\text{units}/\text{mi}^2)$$

To create a map of census blocks in the Sierra Nevada region, we relied on the TIGER digital line files published by the U.S. Census Bureau.[60] The positional accuracy of boundary segments in these files has a maximum stated error of plus or minus approximately 51 m (167 ft); in other words, census block boundaries in our digital map should be within 51 m of their actual position. This level of accuracy is entirely adequate for a regional study such as ours. We related the polygons in our digital map to the tabular data from the STF1B publication using the census-designated labels that together uniquely identify every block in the nation: State FIPS code (2 characters), County FIPS code (3 characters), Census Tract (6 characters), Census Block (4 characters).

The resulting housing density map of the Sierra Nevada region contained over 50,000 polygons, each with a unique housing density value. For presentation purposes we aggregated individual census blocks into six broad categories based on housing density:

1. Zero housing units per square mile
2. Fewer than two units per square mile
3. Two to ten units per square mile
4. Ten to forty units per square mile
5. Forty to one hundred sixty units per square mile
6. One hundred sixty or more units per square mile

The class with the highest density therefore shows those areas where there is on average at least one housing unit for every 4 acres. In this fashion, census block clusters with relatively high densities show the actual location of communities in the region, regardless of their incorporation status. Plate 11.3 shows 1990 housing density in the Sierra Nevada based on these aggregated clusters.

Our final map of housing density in and around the Sierra Nevada strongly reflects the location of major urban centers in the Central Valley and the transportation corridors connecting the Sierra Nevada to those centers (shown in figure 11.2). Each of these centers is surrounded by areas of relatively high housing density. These areas tend to extend into and are most concentrated in the Sierra Nevada foothills in the counties of Amador, El Dorado, Calaveras, Placer, and Nevada, where the largest area of relatively high housing density in the region is found. Other areas of high-density human settlement are in high-altitude recreational centers, such as the Lake Tahoe Basin and Mammoth Lakes. This census block–based representation of human settlement in the Sierra Nevada for 1990 is more accurate spatially than either the community aggregations used in the social assessment by Doak and Kusel (1996) or the 1930–90 coverage of housing density (based on private block groups) shown in plate 11.2. To our knowledge it is the most accurate representation ever completed for the Sierra Nevada. It is nevertheless limited by the fact that census blocks are not randomly or evenly distributed across the Sierra Nevada. Some errors are therefore likely to exist in the largest and most heterogeneous census blocks. The smallest and most homogeneous census blocks will be the most accurate.

A census block that is only 20 acres within a homogeneous subdivision developed at an average density of four units per acre will accurately show the area of the entire census block as having an average density of four units per acre. Similarly, a large census block of even 1,000 acres within an unsettled national park wilderness will accurately show the average density of zero units per acre throughout the census block. Errors are likely to occur, however, if a census block straddles the two and averages them out. A 100-acre census block that included the high-density 20-acre development and was otherwise undeveloped, for example, would assign an average density of 0.8 units per acre to the entire region. Our analysis would therefore both understate the area in high-density development and overstate the area without any development at all. We have not determined how extensive this type of error may be, but it should be low. The census block boundaries should contain relatively homogeneous units.

Based upon this analysis, we estimate the following distribution of average density of human settlement in the Sierra Nevada by land area (based on the land area within each census block and classified by average census block density). Note that these estimates are for residences only and do not include land conversion due to commercial and industrial uses, which would increase the developed area significantly.[61] These eleven density classes show a finer resolution than shown in plate 11.3, including densities up to one housing unit per acre (640 or more per mi^2). They cover all of the census blocks within the forty-six CCDs we used in the 1970–90 analysis (32,001 mi^2 or 20,481,252 acres). The total population count based on the census blocks (604,644) was slightly lower than the total for the forty-six CCDs, but we have not been able to identify the source of this error.[62] The two estimates are within 3% of each other, and the error is acceptable for an analysis of this scale. We believe the census block estimates of the spatial distribution of land area, housing units, and population density by housing unit density classes is the most accurate estimate for the region, but the CCD data are most useful for landscape-scale analysis. The errors could have come through either the census data tapes, the Arc/Info processing step, or the spreadsheet analysis we completed in Microsoft Excel. Table 11.A3 in appendix 11.1 shows the distribution of these variables by housing unit density class for the region.

Table 11.A3 shows that 1,741 mi^2 (1,114,531 acres) have an average housing density of at least one housing unit per 32

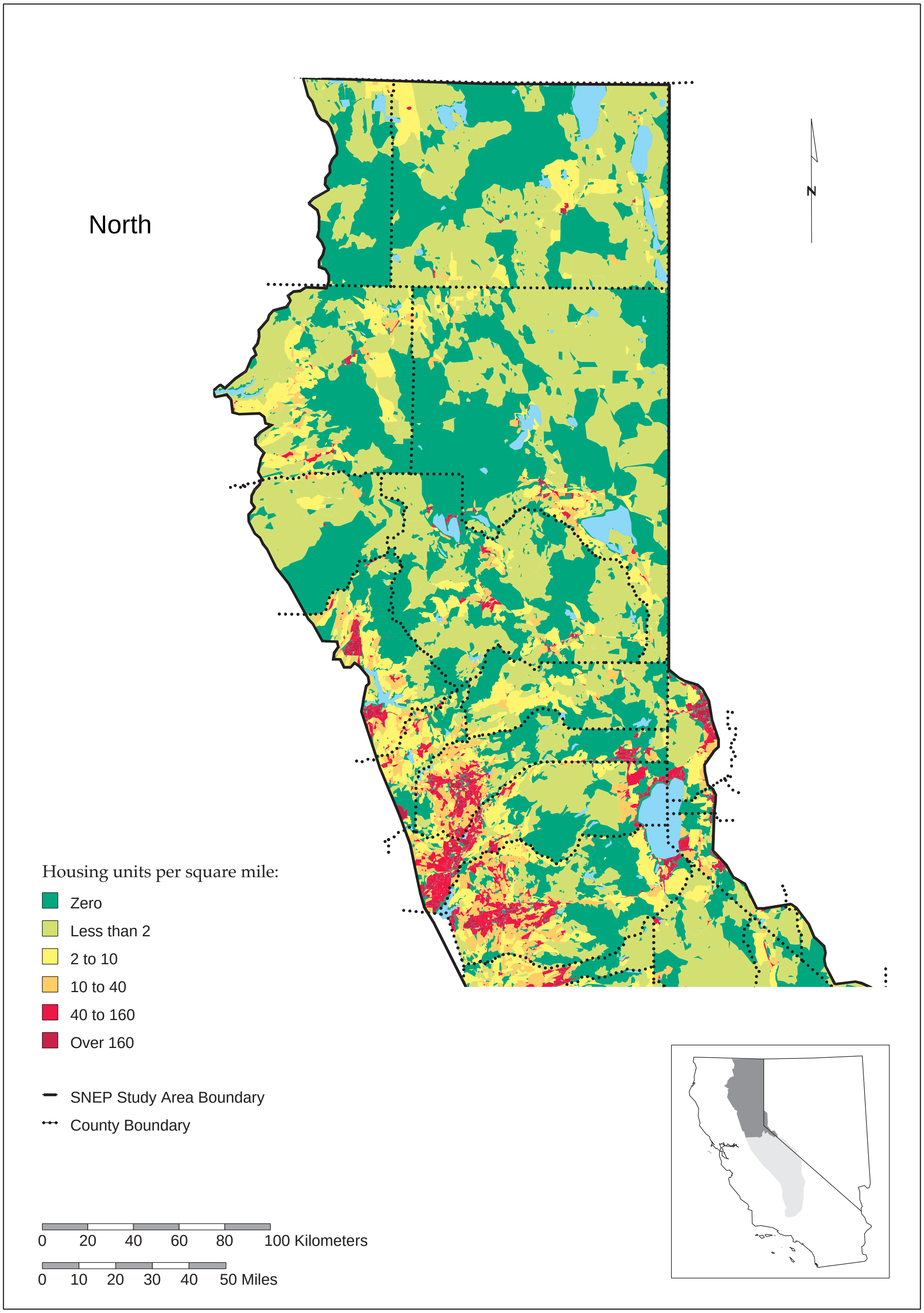


PLATE 11.3

Housing density in the Sierra Nevada region (from 1990 Census of Population, Summary Tape File 1B).

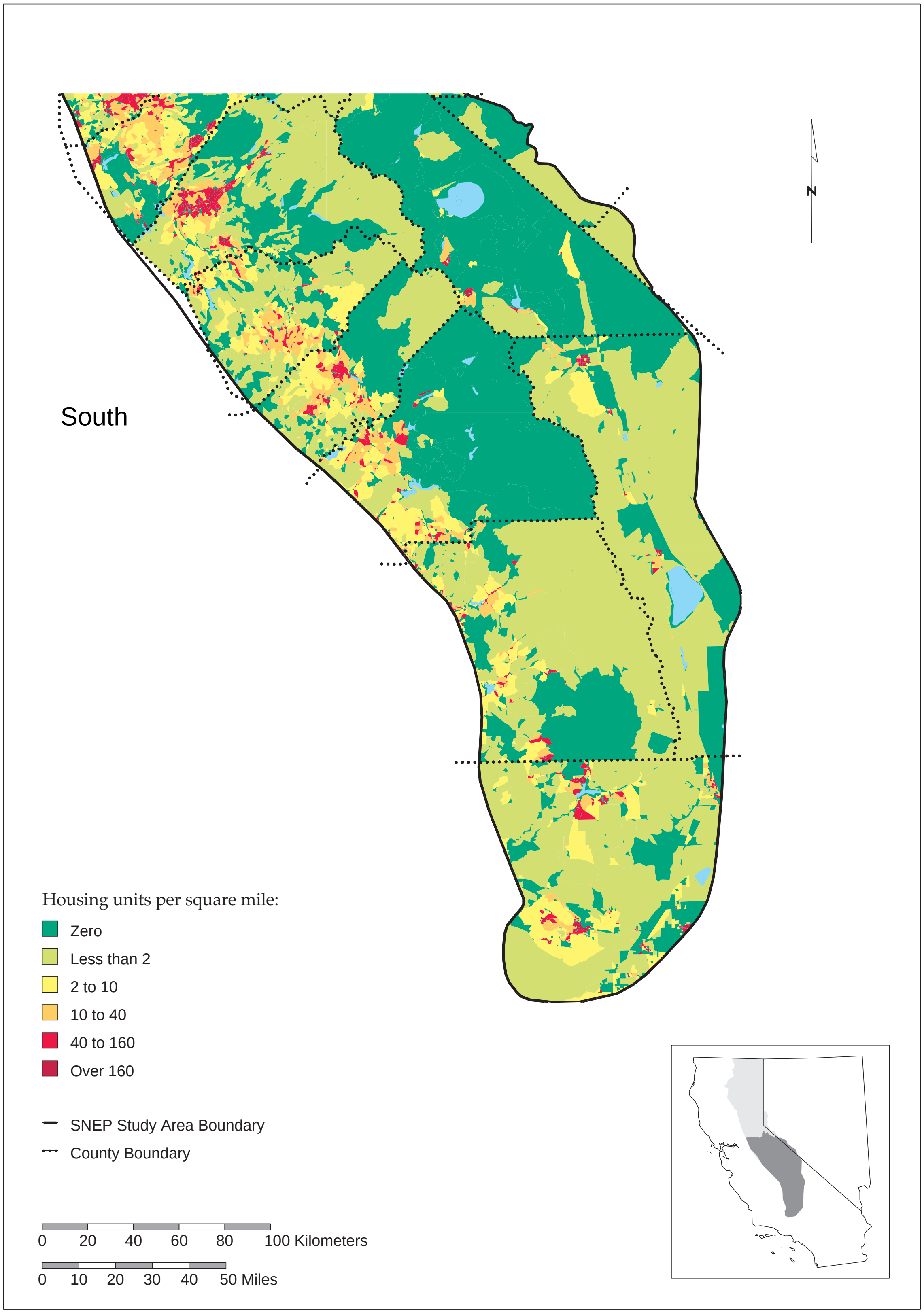


PLATE 11.3 (continued)

acres. This is approximately the same average housing density used by the Strategic Planning Program of the California Department of Forestry and Fire Protection (CDF) as a threshold for indicating that a wildland area has been converted to an "urban" use.[63] It is also considered a threshold below which it is difficult to practice industrial forestry. The California Department of Fish and Game considers critical deer habitat to be adversely affected when parcel sizes are 20 acres or less, while some other species may be significantly affected at higher or lower average densities. Even a threshold average density of one housing unit per 16 acres (forty housing units per square mile) affects 1,009 mi^2 (645,592 acres) of the Sierra region. A lower-density threshold of ten units per square mile (one housing unit per 64 acres) encompassed 2,632 mi^2 (1,684,189 acres) in 1990 in the Sierra Nevada. Nearly 2.5 million acres (3,905 mi^2) were affected at a threshold of five housing units per square mile (an average density of one housing unit per 128 acres). Within this settled area, nearly 300 mi^2 (190,893 acres) are settled at a density 4 acres or less per housing unit, with 89 mi^2 (56,867 acres) at a density of at least one housing unit per acre.

Actual densities can vary considerably within each census block, and the ecological effects of human settlement at higher densities can affect adjacent areas that are settled at relatively low densities. Moreover, the estimates reported here do not include any land area developed for commercial, industrial, or public uses outside the census blocks with these densities. Large commercial shopping centers and many downtown areas have relatively little housing, for example, and will typically be in the lowest-density classes. They are nevertheless the site of significant ecological impacts associated with human settlement. The total land area converted for human settlement includes nonresidential land uses. At least 1,009 mi^2 (645,592 acres) and potentially as much as 3,905 mi^2 (2.5 million acres) of the Sierra Nevada were therefore already converted to human settlement or were directly influenced by adjacent human settlement as of 1990.

It is important to note that the distribution of housing units is not a proxy for the distribution of population by housing density class in the Sierra Nevada. This is a critical factor to consider when allocating future population growth projections to housing density classes in order to estimate the total land area affected by human settlement from 1990 to 2040. Average household sizes are generally smaller in the densest class (640 or more housing units per square mile), which probably reflects the smaller household sizes typically found in multifamily housing units. This distribution could also reflect high seasonal vacancy rates in recreational residences in some of the lower-density classes, where there were vacant housing units when the census was taken in 1990. Surprisingly, some census blocks with no housing units still reported some population in 1990. These could have been temporary residents or seasonal employees. They account for only 1,630 persons, or 0.27% of the total population. Nearly two of every five Sierra Nevada residents (39.49%) lived on just 89 mi^2 (56,867 acres) in the region (0.28% of the land area) in 1990. Another fifth of the population (21.24%) lived on the 209 mi^2 (134,025 acres) settled at an average density of between 1 and 4 acres per housing unit (160–640 housing units per square mile). Three-fifths of the Sierra Nevada population (60.73%) therefore lived on less than 1% (0.93%) of its land base in 1990. This same area accounted for 64.08% of the housing units in the Sierra Nevada in 1990. Fully 80.00% of the Sierra Nevada population lives on the 1,009 mi^2 (645,592 acres) that have an average housing density of 16 acres or less per unit (forty or more housing units per square mile). Figure 11.31 illustrates the distribution of area, housing units, and population by density class.

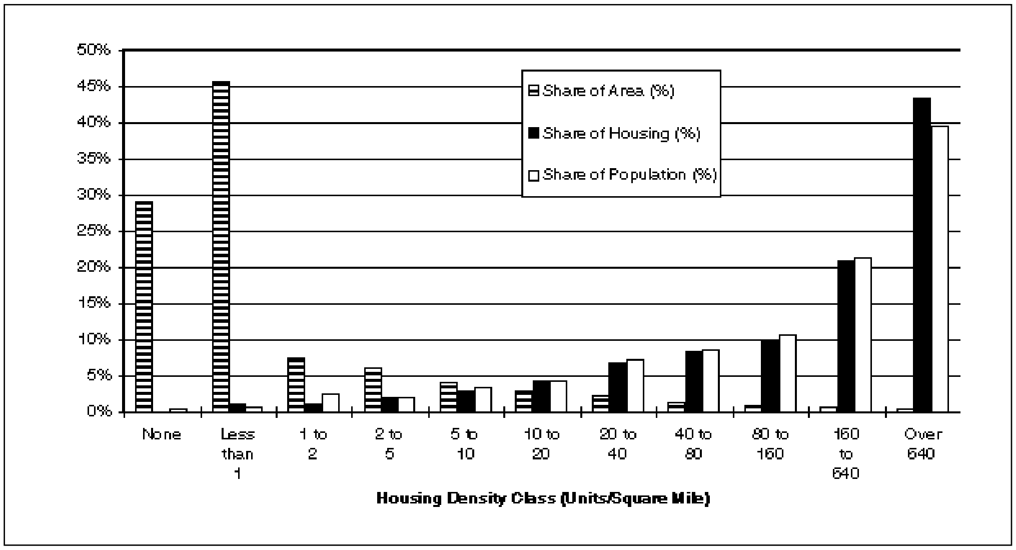
These areas of human settlement are not distributed randomly across the Sierra Nevada landscape. Development in just two counties, Nevada and El Dorado, accounts for 30% of all the land area (791.12 mi^2 [506,317 acres]) in the Sierra Nevada that is settled at an average housing density of ten or more units per square mile (64 acres per housing unit). Those two counties account for 32% of the land area using the 32-acre-per-housing-unit threshold (559 out of 1,741 mi^2) and 35% of the land area using the 16-acre-per-housing-unit threshold (346.5 out of 1,009 mi^2). Nevada and El Dorado Counties also accounted for one-third of the population of the Sierra Nevada in 1990. This is one of the reasons our detailed case study focuses on the General Plans in these counties. Land use patterns and average densities in these more developed counties are likely to be more typical of future conditions in other parts of the Sierra Nevada as they continue to grow. The total land area affected by future population growth and human settlement is therefore likely to be less than the proportional increase expected in population. We discuss expected changes in total area for each of the density classes in our discussion of the General Plans and population forecasts for the Sierra Nevada.

We also determined the distribution of housing units by housing density class by watershed, by county, and by CCD. The twenty-four river basin boundaries in the SNEP study area do not coincide exactly with the forty-six CCDs or the counties, but we were still able to derive useful estimates of human settlement by river basin. Table 11.A4 in appendix 11.1 shows the distribution by river basin. These data, together with the distribution by county and by CCD, are available for more detailed analysis (using either dBase or Excel 5.0 for Windows) from the California Environmental Resource Evaluation System (CERES) project of the Resources Agency of the State of California (http://ceres.ca.gov/snep), and the Alexandria Project at the University of California, Santa Barbara (http://alexandria.sdc.ucsb.edu/).

Table 11.A4 shows that the American River watershed is the most populated, with 42,984 housing units and a population of 99,847 in a total watershed area of 1,887 mi^2. This is not surprising, given its location between I-80 and U.S. 50 in Placer and El Dorado Counties. The Yuba River watershed is nearly as populated, with 40,309 housing units and 90,836

FIGURE 11.31

Percentages of area, housing, and population by housing density class in the Sierra Nevada (based on 1990 census blocks in forty-six CCDs in eighteen California counties).



people in a total watershed area of 1,837 mi^2. The Yuba River watershed includes portions of Sierra, Yuba, Nevada, and Placer Counties (including the Bear River tributary to the Yuba River). The 767 mi^2 Truckee River watershed (including Lake Tahoe) has 42,011 housing units but only 49,767 residents. This reflects the high fraction of housing units that are seasonal. The relatively small Cosumnes River watershed (628 mi^2) has 17,101 housing units and 41,700 residents, while there are 21,213 housing units and 38,681 people in the 1,710 mi^2 Tuolumne River watershed. The latter is largely in Yosemite National Park, however, while the former does not extend far into the higher elevations of the Sierra Nevada.

The Nevada and El Dorado County General Plans

Analysis at the level of the entire Sierra Nevada region is limited by the large size of the region, by the lack of consistent data, and by variation in local environmental conditions, demographic characteristics, and development policies and trends. For this reason, we performed two more detailed case studies at the county level that allowed us to focus on spatial patterns of development at a finer scale. These analyses focused on assessment of the General Plan update process under way for the past five years in Nevada and El Dorado Counties. Both counties adopted new General Plans in late 1995 or early 1996. Our analysis focused on the draft General Plans released in late 1994 and the draft environmental impact reports (EIRs) released in early 1995. These documents represent the most extensive and most current attempts at land use planning in the Sierra Nevada since the early 1980s. Most county General Plans in the region are now at least ten years old, and the experience of Nevada and El Dorado Counties may be useful to other local governments as they attempt to update their General Plans in the coming decade.

We had five objectives in evaluating the General Plan update processes and land use maps in Nevada and El Dorado Counties:

1. To determine the range of spatial patterns for future human settlement and land use that represent the "official future" for Nevada and El Dorado Counties, where one-third of all Sierra Nevada residents lived in 1990.
2. To determine the range of factors considered and their relative importance in the land use planning process and the development of General Plan policies and land use maps.
3. To determine the range of environmental impacts likely to result from development under the General Plans.
4. To determine the type, timing, and costs of infrastructure investments required to achieve the objectives of the General Plans.
5. To determine the degree to which the impacts of buildout under the General Plans will be mitigated through the environmental impact review process under the California Environmental Quality Act (CEQA).

We were therefore interested in both the "product" (e.g., the General Plans, the associated land use maps and ordinances, and the mitigation measures adopted in the final EIR under CEQA) and the "process" ("planning") by which those products ("plans") were developed. Both will have a bearing on future patterns of human settlement in the Sierra Nevada.

County General Plans are important both as indicators and determinants of future development. The process that leads to the creation of a General Plan generally involves consideration of a broad range of ecological, social, and economic factors. Resulting zoning patterns therefore tend to reflect consideration of the opportunities and constraints afforded by these factors. However, a General Plan is not merely a passive document that allocates growth where it seems likely to go anyway. Zoning rules in themselves create a whole new layer of opportunities and constraints affecting an area's potential for development. General Plans are therefore a driving factor themselves.

We determined that the process currently followed by county planning agencies has several critical problems. First, the data relied upon for creating General Plan land use maps can be highly inaccurate. The most basic complication resulting from such inaccuracies is the zoning of areas at densities that have already been exceeded. Our analysis of the draft General Plans for both Nevada and El Dorado Counties indicates that tens of thousands of existing parcels are substandard under the proposed General Plans but are "grandfathered" and exempt from the new General Plan policies. The General Plans themselves therefore grossly understate the potential for new development, for they are based upon a "planimetric" analysis of future buildout under the General Plans' land use designations (rather than the underlying parcelization). The DEIRs for the General Plans therefore underestimate the scope and severity of environmental impacts associated with development under the draft General Plans.

Unfortunately, county planning departments are generally unable to complete the necessary analysis to identify the scale, severity, and spatial pattern of this problem, primarily because land use maps, zoning maps and parcel maps are typically developed on paper and lack the flexibility that would make it possible to experiment with different sets of criteria in the application of zoning. For example, a county may wish to know the effect on total housing counts of stream setbacks of various widths. The development of a series of scenarios would be an expensive, lengthy proposition if carried out exclusively through overlay of physical maps. The use of digital maps in the context of a geographic information system (GIS) allows for this type of flexibility in conducting multiple scenario analyses. Neither Nevada nor El Dorado County had this digital GIS capability during the General Plan update process. Both counties have been developing GIS capabilities, however, and the GIS was used for more limited analysis. The primary use of GIS still appears to be for plotting and presentation purposes, however, rather than geospatial analysis of human settlement and associated land use activities.

Our analysis using GIS answered some questions that were raised in the planning process in late 1994 but were not yet answered as the Nevada County Planning Commission reviewed the DEIR in early and mid-1995. These questions included the effect of existing parcelization on total buildout estimates of future population and housing units. Our results indicate that the DEIR was based upon significant underestimates of total buildout potential due to existing parcelization. This raises questions about the reliability of the assumptions underlying the DEIR and its analysis of the environmental impacts of the draft General Plan. Not surprisingly, those impacts are at the heart of an intense local debate over both the DEIR and the General Plan itself. Consistent and reliable information about the impacts of the General Plan is generally unavailable, however, which exacerbates the conflict through disagreements about basic information. The information before the public at present appears to be erroneous.

For the purpose of this study, we analyzed the land use maps developed for one alternative in Nevada County and two alternatives in El Dorado County. We will begin our discussion of results with a comparison of the El Dorado County General Plan alternatives.

As stated in the draft text of the General Plan, complete buildout in El Dorado County, after which maximum allowable densities will have been reached throughout the county and no new development will be allowed to occur (without changes to the land use designations contained in the General Plan) will happen by the year 2040. The philosophy of the El Dorado County General Plan is also to avoid constraining the land market, however, by not limiting the total amount of land within a given land use designation only to that amount forecast to be required at buildout. The total buildout estimated based on the General Plan land use maps is therefore likely to exceed the actual buildout forecast to occur by the year 2040. Total buildout is nevertheless an accurate representation of how much development could occur without constraints under the General Plan. It is therefore the "official future" of maximum development. (As we will discuss later, however, past experience with General Plans suggests that the actual future will probably differ significantly from the "official future" of the General Plans.)

The General Plan land use maps represent two slightly different visions of how housing will be allocated spatially at buildout. One, the "Project Description," meets anticipated housing needs through a dispersed pattern of development with very limited restrictions based on infrastructure availability or environmental constraints. Plate 11.4 shows the land use map for the El Dorado County General Plan Project Description. The other option, the "General Plan Alternative," concentrates development into a more compact pattern and has greater restrictions based on infrastructure availability or environmental constraints. Plate 11.5 shows the land use map for the El Dorado County General Plan Alternative.

Both options are intended to allow roughly the same amount of total development by the year 2040, and they differ only slightly across all three of the scenarios we considered. Significant modifications have been made to both the Nevada County General Plan and the El Dorado County General Plan since 1994, however, that are not captured in our analysis. The land use maps and associated policies relied on for our analysis were also the basis for the DEIRs released in early 1995, however, so the DEIRs are also inaccurate to the degree that the underlying assumptions in our analysis are inaccurate.

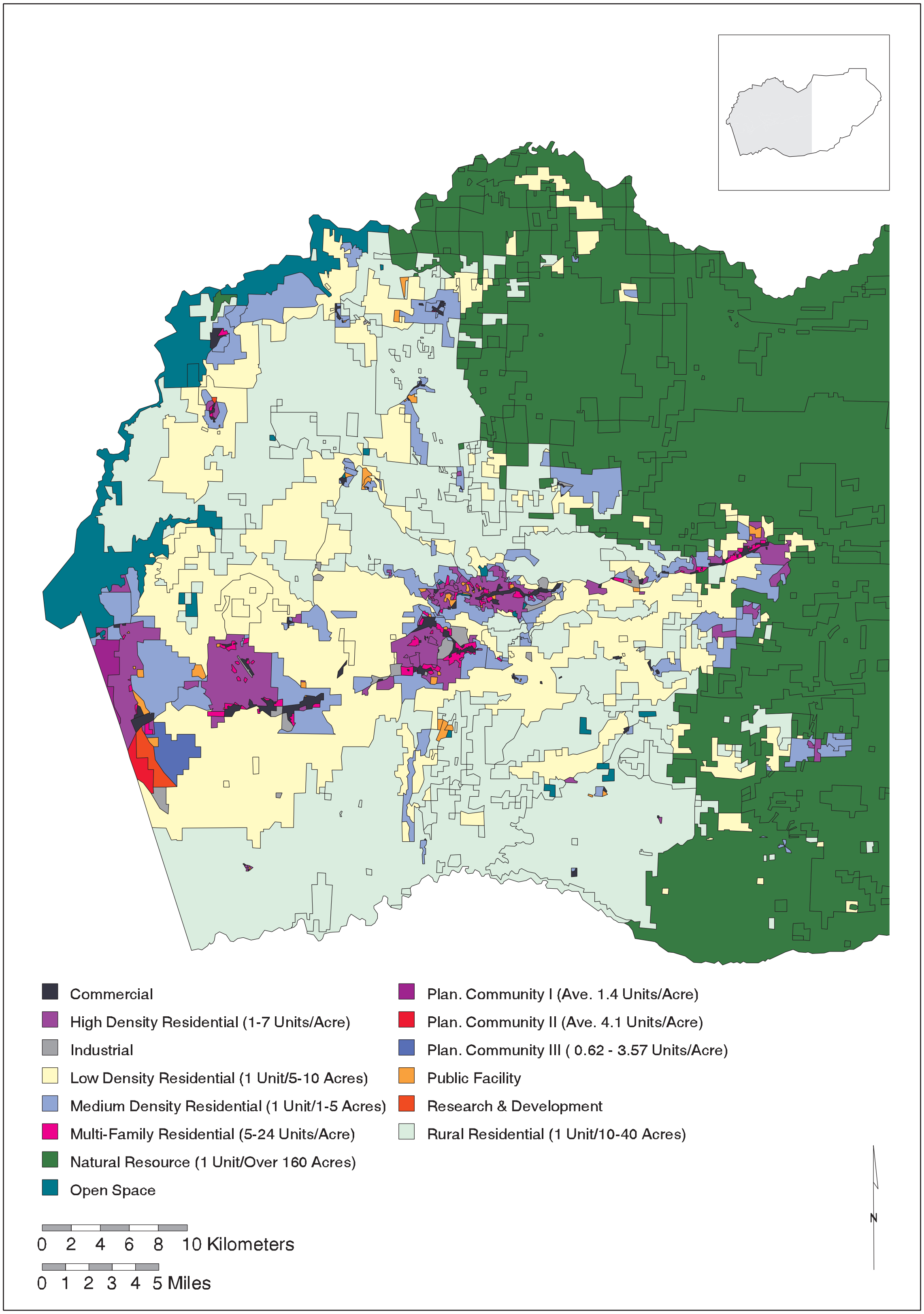


PLATE 11.4

Draft General Plan, Project Description, El Dorado County (western portion) (El Dorado County Planning Department).

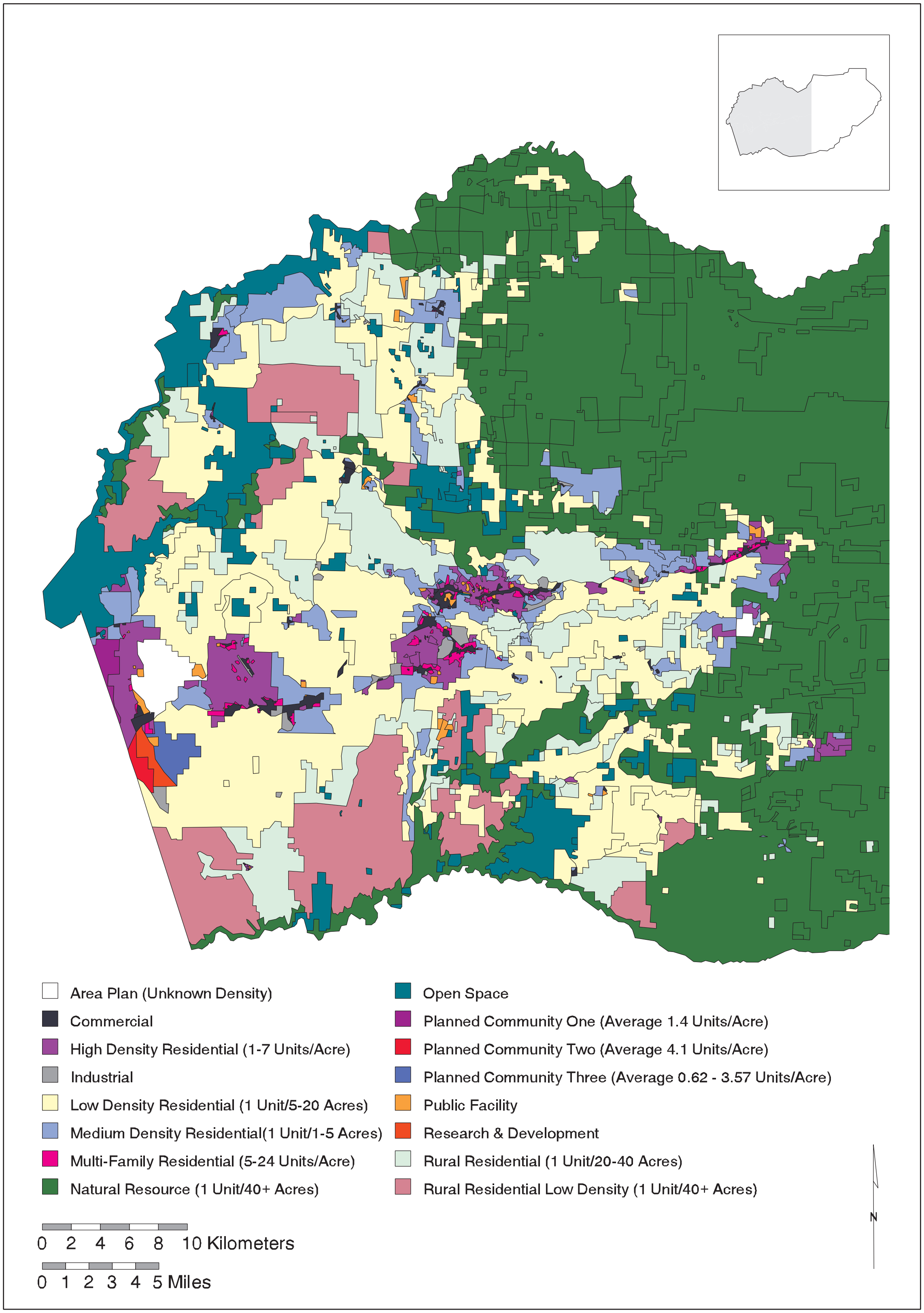


PLATE 11.5

Draft General Plan, Alternative, El Dorado County (western portion) (El Dorado County Planning Department).

The first step in the process was to convert the original land use maps into digital form. The county planning office originally published the maps at a scale of 1:2,000. Using a public land survey township and range section grid supplied by Teale Data Center as our base map, we digitized the zoning boundaries with an average error of 0.005% and a maximum error of 0.01%. This provided a positional accuracy comparable to the census blocks coverage also used in the analysis. Achieving a higher degree of accuracy would have been difficult for several reasons. First, township and range section coordinates may be inaccurate in rural areas, with some measurements dating back to the original land surveys of the nineteenth and early twentieth centuries. Second, some degree of warping inevitably occurs during blueprinting (we did not have access to Mylar originals). Third, and perhaps most important, the planning department itself did not intend for the maps to be used in a context requiring a high degree of accuracy and used thick lines on many of them. These thick lines reduce the accuracy of digitizing and can translate into significant boundary errors in reference to the actual location of the boundaries on the ground. Our land use maps should therefore not be used for finer-scale analysis than we have done here. In particular, they should not be used at the scale of individual parcels. Plate 11.6 shows the land use map for the Nevada County General Plan that was the basis for our analysis.

Once the digital land use maps were completed, we checked them against the originals for labeling and linework errors and assigned density ranges to each zoning area. For the purpose of our study, we used the midpoint of the stated density range for each land use classification. For example, if an area was zoned "Rural Residential" at 10–20 acres per unit, then a buildout density of 15 acres per unit was assumed. We also completed an analysis of total potential housing units at buildout using both a "low" (e.g., 20 acres per unit) and a "high" (e.g., 10 acres per unit) development density. The results of all three buildout scenarios are discussed for all of the alternative General Plans later.

The allocation of land uses by land use classification differs across the three General Plans we reviewed. Table 11.A5 in appendix 11.1 summarizes the amount of land dedicated to each land use classification under each of the land use maps. The implications of these distributions of land use classifications are discussed in more detail later.

An important point to make here is that both counties included land use designations for public lands, although neither county asserts land use jurisdiction over those lands. This stance contrasts with much more militant efforts to assert local jurisdiction in other rural counties in the West (Larson 1995).[64] El Dorado County does zone some Bureau of Land Management (BLM) lands for nonpublic purposes (including potential development) under the General Plan Alternative, however, with the apparent expectation that the BLM will release those lands from public ownership.[65] With the exception of these BLM lands, inclusion of those public lands on the land use maps appears at this point simply to reflect prevailing land use practices under the jurisdiction of the state or federal agencies managing those lands. Some categories of land use, such as "Forest 160" or "Forest 640" in Nevada County and "Natural Resource" in El Dorado County, are dominated by federal and industrial forestlands. These lands are generally expected to continue in these resource uses under their existing ownership arrangements, although General Plan designations for private industrial timberlands can affect both market real estate values and the viability of alternative land uses. Some "checkerboard" areas near Donner Summit, for example, are at present zoned for industrial forestry and would be changed under the draft Nevada County General Plan to accommodate significant recreational, commercial, and residential development. Changing the zoning designation for those lands will change their market value, which will increase the potential cost of land exchanges or acquisition through Land and Water Conservation Act Funds.[66] Because these particular parcels include important trail access to adjacent federal lands, local land use decisions could directly impact management of federal lands.

The two alternatives under consideration by El Dorado County offer an even more dramatic example of how land use designations can affect future use of private industrial forestlands and management of adjacent public lands. The "Natural Resource" land use designation allows only one housing unit per 160 acres under the Project Description, while the same designation under the General Plan Alternative allows one housing unit per 40 acres. The latter land use map has more total area in this designation than the former, but the effective development potential under the same "Natural Resource" designation could allow up to four times as many housing units. More important than the actual density, however, is that 40-acre parcels must be accessed by a road network that would fragment existing industrial forestlands. Social constraints on harvesting could also result, along with increased restrictions on fuels management through prescribed burning. Finally, wildland fire risk could increase in these areas due to increased likelihood of ignition associated with vehicles and the presence of structures. Fire suppression in the urban-wildland intermix zone also tends to emphasize the protection of structures over natural resources. This fact could have enormous implications for fire regimes and costs of wildland resource management if it were adopted more widely in the Sierra Nevada.

This example highlights the important links between local land use planning and state or federal responsibilities for wildfire and natural resources management. Other policies within each of the General Plans have similar implications for water quality, air quality, transportation financing, and the health of local, state, and government finance. These impacts are discussed in more detail when we discuss the DEIR findings for each of the General Plans. Mitigation for these impacts is also discussed later.

Note that the total area classified in the two El Dorado

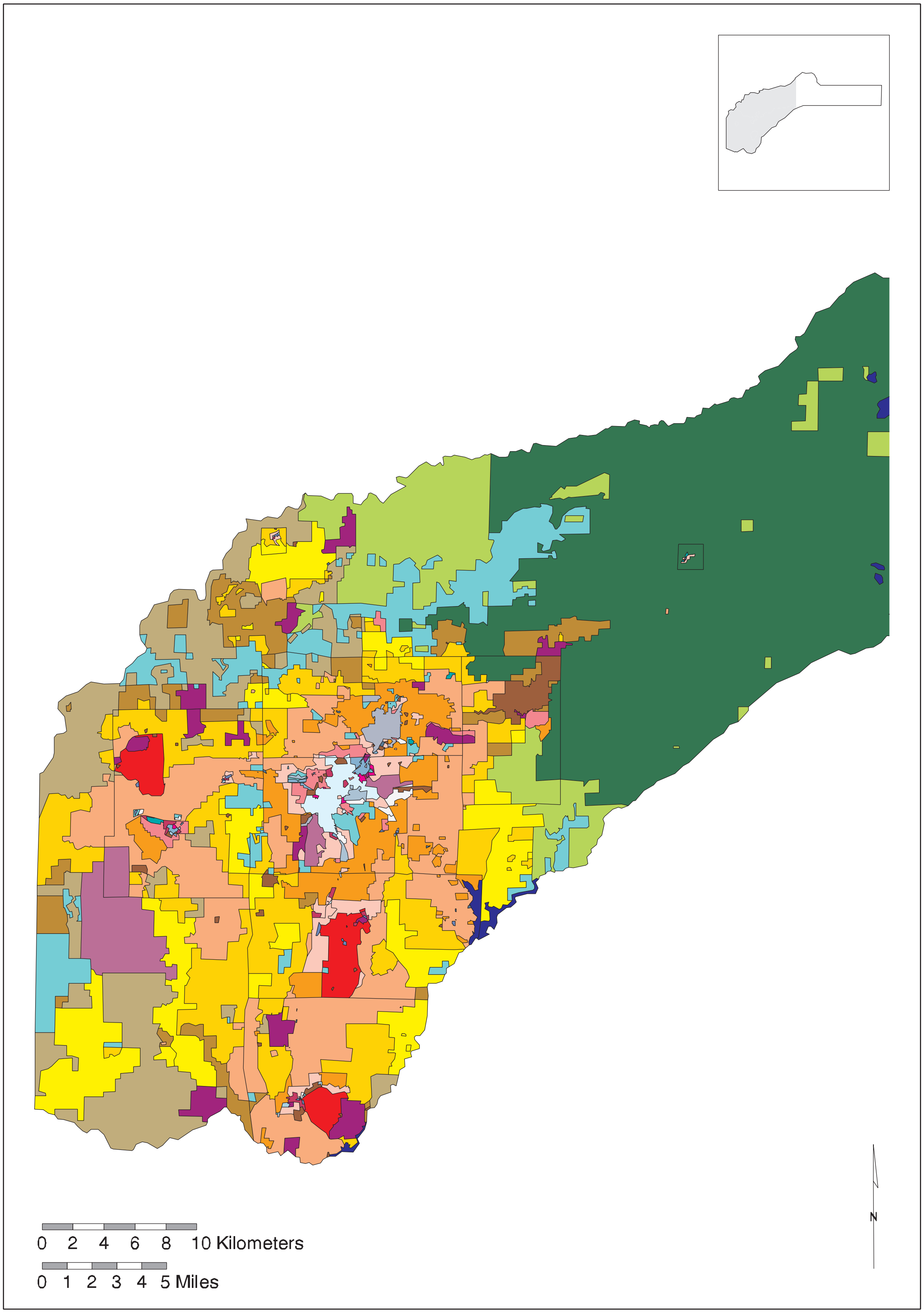


PLATE 11.6

Draft General Plan, Nevada County (western portion) (Nevada County Planning Department).

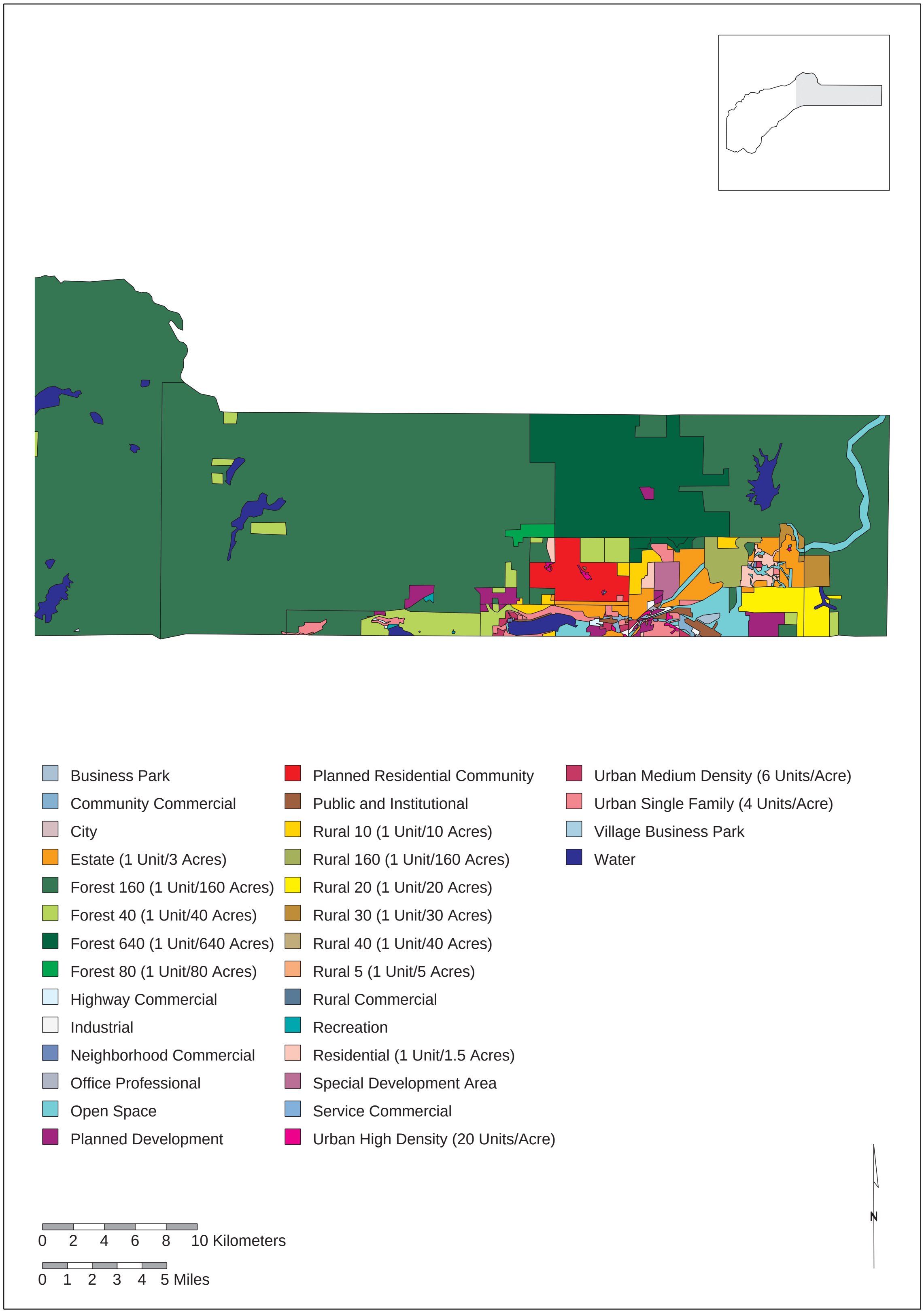


PLATE 11.6 (continued)

Draft General Plan (eastern portion).

County alternatives is only 1,570.6 mi^2, while total area in each county is 1,791.1 mi^2. This reflects the fact that we did not digitize those portions of El Dorado County within the Lake Tahoe Basin, which are subject to the regulations of the Tahoe Regional Planning Agency (TRPA). Our analysis focused on development and land use on the western slope of El Dorado County. Land use within the TRPA jurisdiction must be considered in a regional context, and we did not feel that limited data for El Dorado County only would be useful. Much of this region is also within the incorporated community of South Lake Tahoe. There is a detailed discussion of the TRPA and its regulatory program (together with the associated programs of the California Tahoe Conservancy) in the SNEP case study of the Lake Tahoe subregion prepared by Elliott-Fiske et al. (1996).

We did complete a digitized coverage for all of Nevada County outside the incorporated cities of Grass Valley and Nevada City, but land use patterns in the Truckee-Donner area have been altered by the incorporation of the town of Truckee since the Draft General Plan was released in 1994 . The town of Truckee is now preparing its first General Plan, and it is expected to deviate in several respects from the Nevada County General Plan (generally resulting in lower buildout estimates) (Nevada County Planning Department 1994b). Our focus in the analysis will therefore remain on the western slope, but our county-level statistics for Nevada County do include the eastern part of the county (but do not reflect Truckee's incorporation). This focus reflects the 1994 Final Draft Nevada County General Plan.[67]

Buildout Analysis of the County General Plans

The El Dorado County General Plan land use designations include ranges of allowable density, while the Nevada County General Plan indicates fixed densities for each land use classification. El Dorado County also includes three future sites for a "Planned Community," however, at different average densities. Inclusion of specified densities for these sites allowed us to calculate the range of future housing units allowable under the General Plan maps' buildout directly from table 11.A5. These buildout estimates do not include lands within the Lake Tahoe Basin or the incorporated city of Placerville, so they understate the ultimate number of housing units at buildout in El Dorado County.

The Nevada County General Plan includes three land use classifications that are similar to the "Planned Community" designation used by the El Dorado County General Plan: "Planned Development," "Planned Residential Community," and "Special Development Area." None of these classifications has a specified allowable density of development associated with it. The "Planned Residential Community" designation applies only to four existing subdivisions, however, where we could determine existing parcelization and average buildout densities for the class. Based upon the assessor's 1992 data, Tahoe Donner has 6,094 parcels on 3,809 acres (1.60 housing units per acre), Lake of the Pines has 2,038 parcels on 1,343 acres (1.52 housing units per acre), Lake Wildwood has 3,035 parcels on 2,189 acres (1.39 housing units per acre), and Alta Sierra has 2,855 parcels on 3,100 acres (0.92 housing units per acre). The average density for these 10,441 acres is 1.34 housing units per acre across the 14,022 parcels. We used this total of 14,022 housing units as the buildout estimate for the "Planned Residential Community" land use classification throughout all three of our scenarios.[68]

We had to develop independent estimates of future development density for lands classified as "Planned Development" (which were scattered among many parcels) or "Special Development Area" (which were focused on an area proposed for a "new town"). We analyzed all of the parcel data for any of the assessor's map book pages that intersected with lands designated as "Planned Development" to estimate average development densities. Those parcels totaled 104,802 acres, however, which is more than ten times as much land area as that designated for "Planned Development" under the General Plan. Those parcels have an average designated density of 0.53 units per acre (337 units per square mile), which is very close to the 0.62 housing units per acre (397 units per square mile) used by El Dorado County as the lowest development density for the same designation. We therefore used 0.53 units per acre for our "low" scenario of buildout of those lands designated for "Planned Development" in Nevada County.

The proposed "new town" in the land classified as a "Special Development Area" is expected to have a much higher density, however, so we estimated the future density of the SDA land use classification based on the weighted average density of all areas designated "Urban High Density" (20 units per acre on 3.33% of the land area, accounting for 23.12% of the housing units), "Urban Medium Density" (6 units per acre on 7.44% of the land area, accounting for 15.51% of the housing units), "Urban Single Family" (4 units per acre on 35.11% of the land area, accounting for 48.82% of the housing units), and "Residential" (1 unit per 1.5 acres on 54.13% of the land area, accounting for 12.55% of the housing units) under the Nevada County General Plan. The weighted average density for these areas was 1,841 housing units per square mile, or about 2.88 housing units per acre. We used this density for the "middle" scenario for the SDA designation and the "high" scenario for the "Planned Development" designation. It is within the range of allowable densities for the "Planned Community" designation in the El Dorado County General Plan and is therefore a reasonable proxy for the number of housing units that could be built under the Nevada County General Plan at buildout. We also evaluated a "low" scenario using the lowest allowable density (1.4 units per acre) and a "high" scenario using the highest allowable density (4.1 units per acre) under the "Planned Community" designation in the El Dorado County General Plan. Our "middle" scenario for the "Planned Development" lands was the average of the "low"

(0.53 units per acre) and the "high" (2.88 units per acre). "Planned Development" lands therefore had a lower average density assigned to them than the "Special Development Area" lands for each of the scenarios.

Using these assumptions, total buildout on the 10,127 acres with the "Special Development Area" designation would range from 6,278 housing units to as high as 41,519 housing units. Preliminary proposals for the Gold Country Ranch "new town" estimated only 5,249 housing units on twenty-four adjacent parcels totaling 8,232 acres (0.64 housing units per acre) (Nevada County Planning Department 1994a). Other documents from the Nevada County General Plan suggest that the "new town" site would be only 7,100 acres at an average density of 1.04 housing units per acre. This is based on 920 acres designated "Urban Single Family" (4 housing units per acre), 50 acres in "Urban Medium Density" (6 housing units per acre), 170 acres in "Urban High Density" (20 housing units per acre), and 5,960 acres without residential development. Both of these average density estimates seem very low, however, given the average density of other developments requiring centralized infrastructure. We therefore compared our estimates to densities in other "new town" projects.

The large-scale Stanford Ranch project in nearby Placer County was originally zoned for 11,000 units on 3,500 acres (3.14 units per acre) by the city of Rocklin and is now expected to be built out with around 8,000 units (2.29 units per acre). The decrease in average density is due to new wetlands restrictions and a reduced share of overall units going into multifamily units (due to overbuilding of multifamily units and low occupancy rates elsewhere in Rocklin) (Stanford Ranch Information Center 1994–95). The urban design approach employed by Peter Calthorpe for the Gold Country Ranch project generally calls for compact, "transit-oriented development" (TOD) through a "pedestrian pocket" idea (Calthorpe 1989, 1993). Because of the larger land area designated "Special Development Area,"[69] however, any "new town" projects built under the Nevada County General Plan would probably not maintain such high densities across the entire development. An average density between the "low" scenario (1.4 units per acre) and the "middle" scenario (2.88 units per acre) is therefore likely. These types of areas are very unlikely to be developed at the "high" density of 4.1 units per acre across all of the 10,127 acres in the SDA classification.

We checked these assumptions again by assigning the same average densities to the incorporated cities of Grass Valley and Nevada City, which account for another 3,424 acres that have no densities associated with them in the Nevada County General Plan. This resulted in an estimated 9,849 housing units in the two cities at an average density of 2.88 housing units per acre. This is higher than the current number, which supports a combined population of around 12,000 people. The lower density of 1.4 units per acre results in only 2,123 housing units in the incorporated cities, however, which is well below the current number of housing units. Based upon this comparison with the existing incorporated cities in Nevada County, we believe the range of probable future buildout densities for the Nevada County General Plan is somewhere between our "low" and "middle" scenarios. We used a fixed average density of 1,000 units per square mile (1.56 units per acre) for the incorporated areas in all three scenarios, resulting in 5,350 housing units in the city limits. This allowed us to focus our analysis on the effects of different assumptions about allowable densities in the undesignated areas affected by the Nevada County General Plan. Infill could also increase average densities within the incorporated cities, of course, but that would be subject to the 1982 Grass Valley General Plan and the 1985 Nevada City General Plan. We were unable to digitize those General Plans for this analysis. The average density we assumed for the incorporated areas also reflects a high level of commercial land use within each of the incorporated cities.

Note that all of our buildout estimates are based upon "gross" acreage within a land use designation. A significant fraction of all land is likely to be dedicated to roads, however, resulting in a smaller "net" acreage available for actual development. The fraction assigned to roads and other nonbuildable uses is expected to be from 10% to 20% of all undeveloped land. General Plan policies could still allow development based upon the allowable gross acreage, however, so it is not necessarily appropriate to reduce our buildout estimates by 10–20%. The net land area allowed for development will be a function of specific General Plan policies and specific language in the zoning ordinance.

At this point we were ready to proceed with the first step in our spatial analysis, which was to simply calculate the change in housing density from current levels if complete buildout were to occur. We used the 1990 census blocks coverage as a measure of current housing density. To calculate the change in housing density from 1990 to buildout, we created a new digital map based on the intersection of the two input maps. This intersection was necessary because the boundaries of census blocks and land use designation areas do not coincide; each land use area typically consisted of several blocks, with many blocks straddling the boundary between land use areas. The output map produced by the intersection of the census blocks and land use areas contained a larger number of smaller areas, each belonging to only one census block and one land use area. Figure 11.32 illustrates this intersection for a hypothetical land use and census block.

Each General Plan reported allowable densities in terms of housing units per acre, which could be compared with the existing 1990 housing density. Because we now had a value for the current and future densities, we could calculate two different measures of change:

1. Absolute Change = (Maximum Allowable Density) – (1990 Density)
2. Relative Change = {Absolute Change} / {1990 Density} * 100

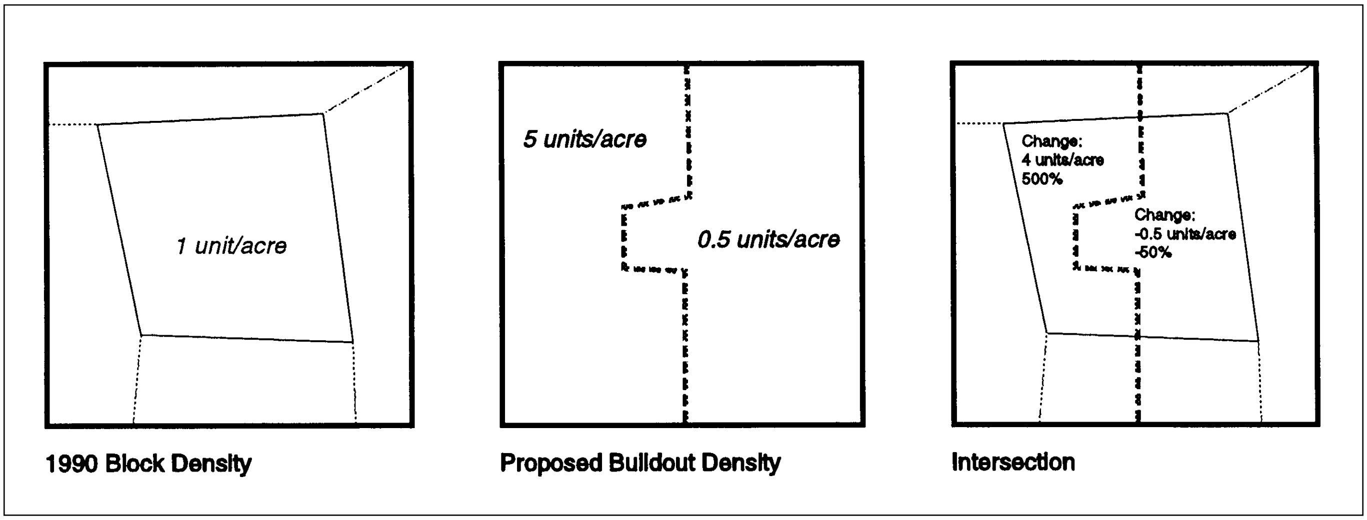


FIGURE 11.32

Illustration of method for calculating change in housing density from 1990 to General Plan buildout using census block data.

Our first analytic step was to calculate these two derived variables and add them to table 11.A5 without any further spatial analysis. The spatial patterns of absolute and relative change are also important determinants of both the ecological and economic effects of development, however. As a result, we can generate new maps illustrating the changes that occur between 1990 and buildout under the General Plan alternatives. Figure 11.33 shows the spatial pattern of the absolute changes that would occur, and figure 11.34 shows the spatial pattern of relative changes for the El Dorado County General Plan Project Description.

Figure 11.35 shows the absolute changes and figure 11.36 shows the relative changes for the El Dorado County General Plan Alternative.

As noted earlier, each of the General Plan alternatives in El Dorado County includes a range of possible densities for each land use classification. We present the "middle" scenario here (based upon the mean density allowed for each land use classification), but there is significant variation between the "low" and "high" range of possible densities. There were approximately 61,000 housing units in El Dorado County in 1990 (without Placerville or the Lake Tahoe Basin), and the "middle" scenario projects a buildout of 156,820–160,919 housing units. Based simply upon allowable density, the "low" scenario would result in only 68,065–70,574 units. These figures are clearly improbable, however, for there are more than 7,065 vacant parcels today. We therefore believe the "low" scenario is highly unlikely and should not be relied upon as the basis for evaluating the impacts of future land use. The "high" scenario would increase the total number of housing units at buildout to 243,083–253,772. This would represent more than a fourfold average increase in the total number of housing units in El Dorado County. The total number of new units above those in 1990 would increase from an average of about 98,000 new units under the "middle" scenario to an average of around 187,000 new units under the "high" scenario. This represents a 91% increase in the absolute growth in housing units under the "high" scenario compared with that estimated under the "middle" scenario. Any estimates of future impacts associated with buildout of the El Dorado County General Plan based upon the "middle" scenario could therefore be underestimating the potential impacts by 50%. Table 11.A6 in appendix 11.1 shows these different buildout estimates for each scenario for both the Project Description and the General Plan Alternative.

We completed a similar analysis for the Nevada County General Plan, using the estimated average housing densities described for those lands designated Planned Development, Planned Residential Development, and Special Development Area. Total buildout under these assumptions results in a total of 128,265 housing units under our "middle" scenario. This compares with 37,352 housing units in 1990. The two estimated land use classifications (Planned Development and Special Development Area) accounted for 35.61% of the total, however, on only 4.17% of the total land area in the county. Our "low" scenario estimated 93,991 housing units, and our "high" scenario could result in up to 152,080 housing units. The two estimated land use designations account for 12.13% of all housing units under the "low" scenario to 45.69% of all housing units under the "high" scenario. The ultimate buildout estimates under the Nevada County General Plan are therefore highly sensitive to the allowable densities for these special land use classifications. Even without them, however, we estimate 82,588 housing units at buildout based only upon the area designated under each of the land use classifications. Table 11.A7 in appendix 11.1 shows these different buildout estimates for each of the scenarios for the Nevada County General Plan.

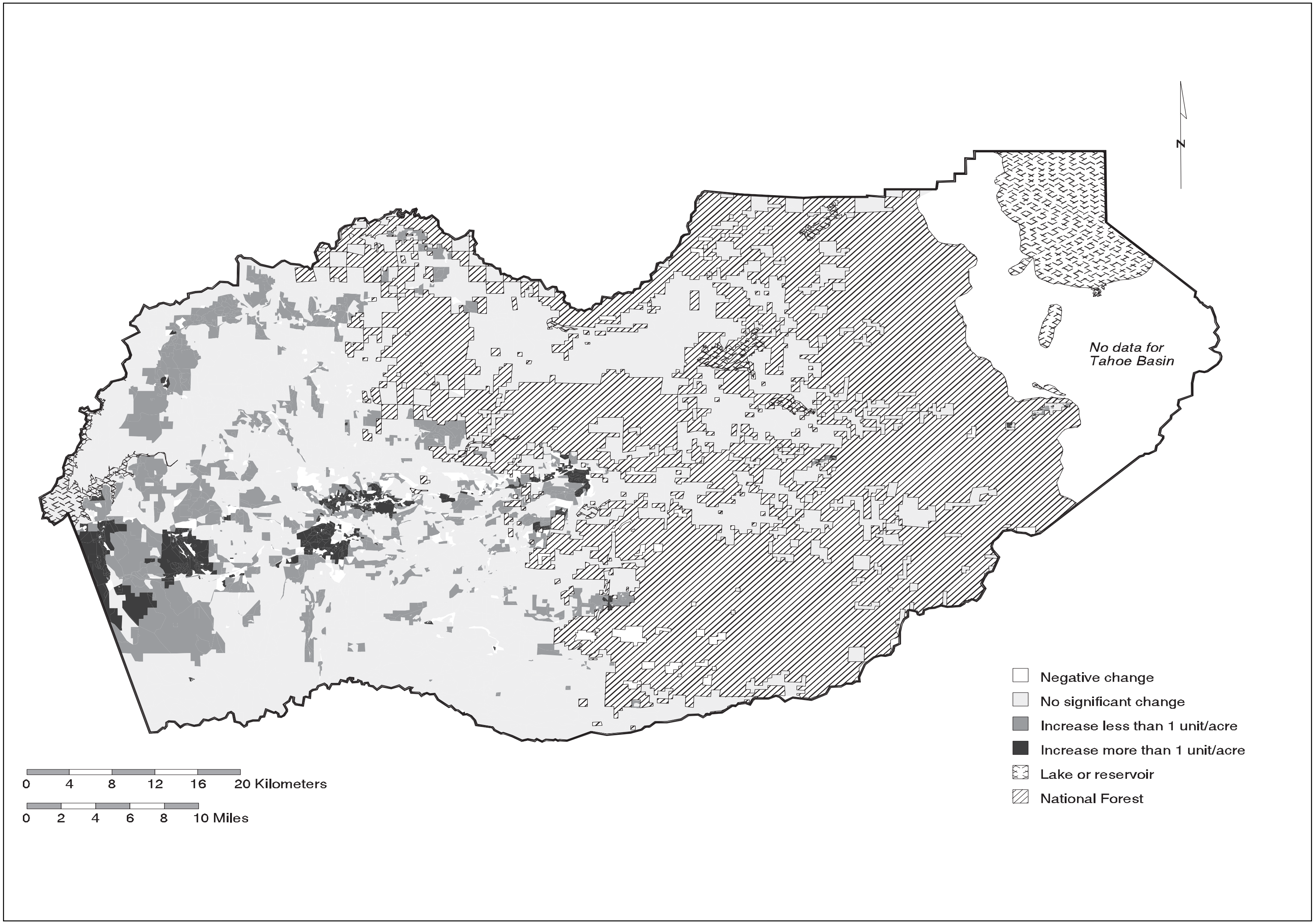


FIGURE 11.33

Absolute change in housing density, El Dorado County, 1990 to buildout (Project Description) (from 1990 Census of Population, Summary Tape File 1B; Draft El Dorado County General Plan).

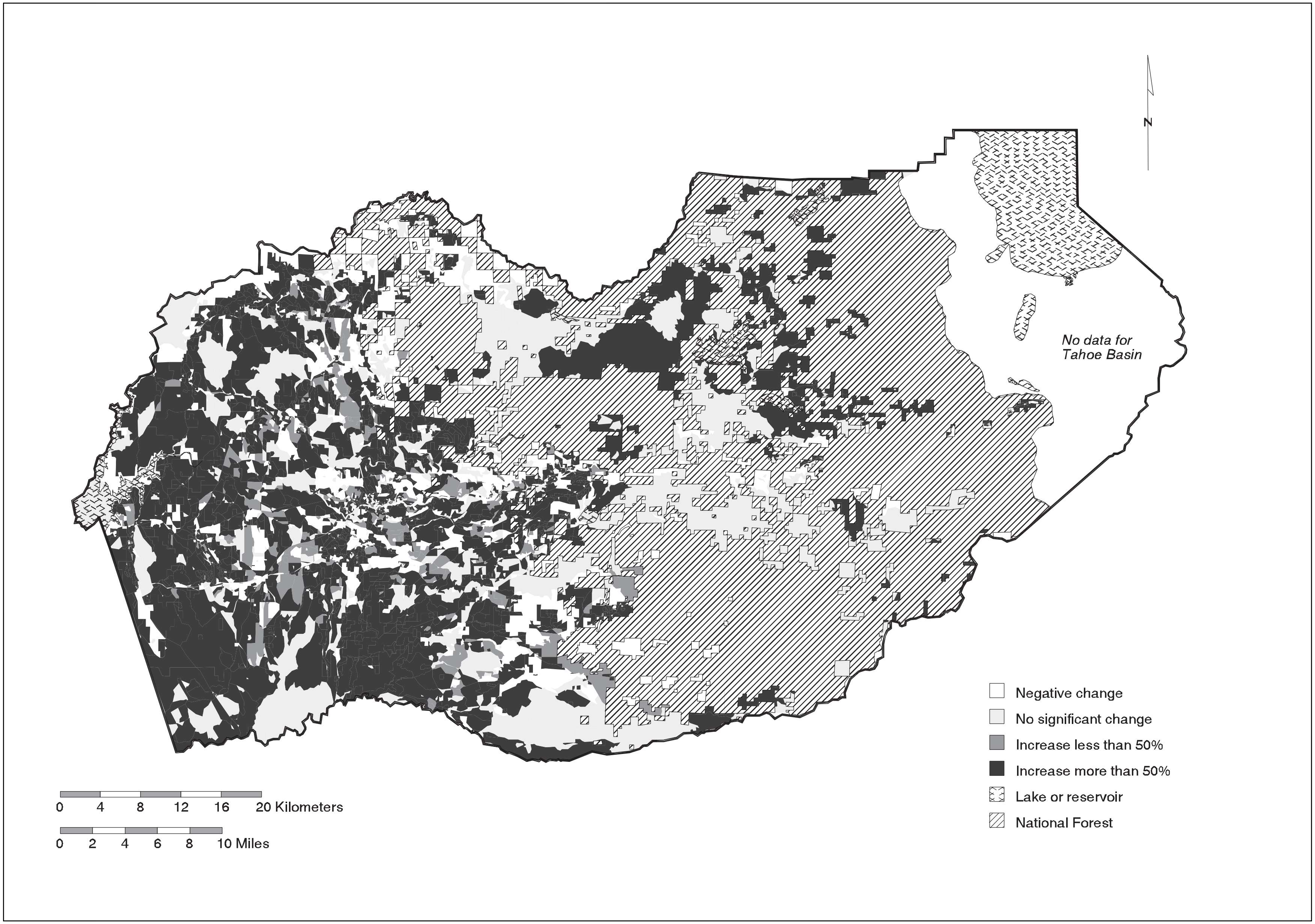


FIGURE 11.34

Relative change in housing density, El Dorado County, 1990 to buildout (Project Description) (from 1990 Census of Population, Summary Tape File 1B; Draft El Dorado County General Plan).

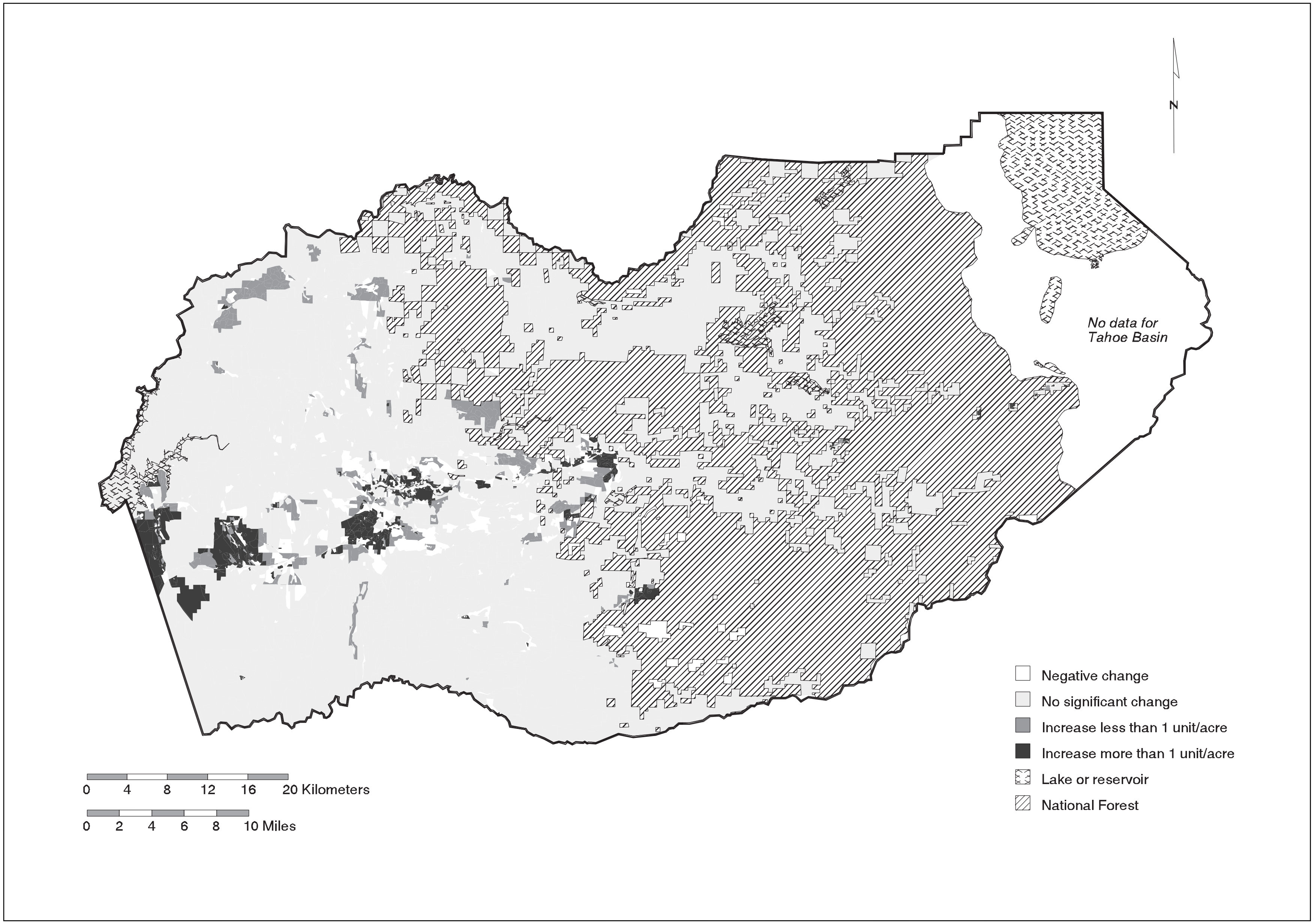


FIGURE 11.35

Absolute change in housing density, El Dorado County, 1990 to buildout (alternative) (from 1990 Census of Population, Summary Tape File 1B; Draft El Dorado County General Plan).

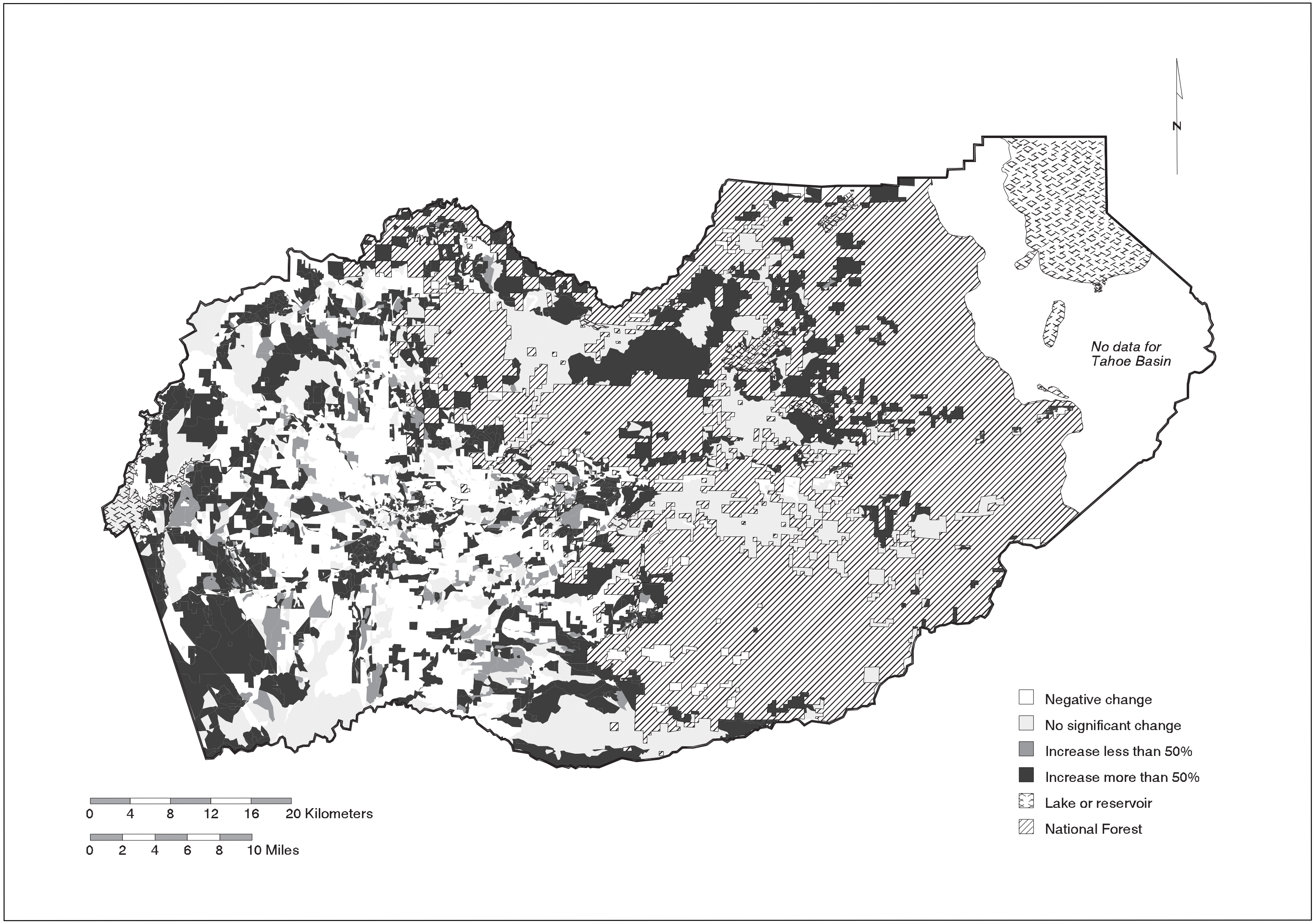


FIGURE 11.36

Relative change in housing density, El Dorado County, 1990 to buildout (alternative) (from 1990 Census of Population, Summary Tape File 1B; Draft El Dorado County General Plan).

Our buildout analysis of the Nevada County General Plan identified a number of problems in the relationship between existing housing density as of 1990 and the buildout housing densities according to the General Plan land use designations. As in the "low" scenario described for the El Dorado County General Plan, any buildout estimates based only on the land use designations and allowable densities contained in the Nevada County General Plan are highly improbable. The Nevada County Planning Department and its General Plan consultants relied upon this simple estimation procedure, however, to estimate future buildout estimates for population, housing units, and additional parcels. Based upon this simplification, those estimates resulted in a total of only 29,769 additional parcels under the General Plan (Nevada County Planning Department 1994a). Figures 11.37 and 11.38 for the Nevada County General Plan buildout analysis show that significant areas would have to experience negative growth compared to actual 1990 densities in order to achieve the buildout densities reflected in the General Plan land use maps. This outcome is highly unlikely, so the General Plan maps probably understate likely future potential "build out." The Nevada County Planning Department has acknowledged that the understatement could be a problem but has not completed a systematic analysis of how existing parcelization affects "build out." (Norman 1994–95; Miller 1994–95). Figures 11.37 and 11.38 show the spatial pattern of absolute and relative changes under the Nevada County General Plan, respectively, compared with actual 1990 population.

This conclusion regarding the failure to account for existing parcelization is consistent with an analysis completed for one subregion of the county by the Lake Vera/Round Mountain Neighborhood Association, which found that there were already 476 parcels in an area designated for 232 parcels under the 1980 General Plan (Lake Vera/Round Mountain Neighborhood Association 1995). Some of those parcels also can be subdivided further, resulting in a future buildout that will vastly exceed the 232 units that would be estimated based upon the simplification relied on in the Nevada County General Plan analysis. Other areas have parcels that are larger than the minimum allowable but cannot be subdivided further (e.g., a seven-acre lot in a five-acre-minimum zone), which means the General Plan land use maps overstate the potential for development in those areas. This problem highlighted the limits to any analysis based upon land use maps and density designations that do not reflect underlying parcelization and existing densities. We therefore completed a more detailed assessment that included the effects of parcelization on the applicability of the General Plan.

Implementing the General Plans with Existing Parcelization

Parcel-specific county assessor's data are a potentially more detailed source of current development information than census data, for they include boundaries and data from the tax rolls that describe existing structures on the property. Such detailed information is not yet widely available, but the process of converting from paper to digital format has begun in many areas. In the absence of specific information for each parcel in Nevada and El Dorado Counties, we performed an analysis using the average parcel densities of each map book page in the assessor's rolls. Based on our preliminary analysis, the accuracy of the underlying data in the Nevada County assessor's database is believed to be less reliable than that for El Dorado County. Before reporting the results, we should describe our method and outline potential problems with the results. This is a preliminary analysis that should be updated as soon as parcel-based map coverages are available with reliable georeferencing.[70] Until then, it should serve as a reasonable basis for identifying the magnitude and spatial pattern of potential conflicts between existing parcelization and land use designations under the General Plans.

First we intersected the General Plan coverage and the map book page coverage. This intersection divided each map book page into one or more land use classifications. We then calculated the average allowable density for each map book page, weighted in proportion to the area under different land use designations. By inverting our estimate for average allowable density, we were able to calculate the average allowable parcel size for that map book page. Any parcel that was smaller than twice the size of the average allowable parcel was deemed unsuitable for further subdivision. We divided all parcels larger than this by the minimum allowable parcel size to arrive at an estimate of the number of additional parcels that could be created by subdivision of existing parcels. Because we relied upon average parcel sizes per map book page, however, these estimates are accurate for only those map book pages where the parcel sizes are closely distributed around the mean. A map book page with one very large parcel and many very small parcels, for example, would overestimate the capacity to subdivide the smaller parcels and underestimate the capacity to subdivide the larger parcel. These types of map book pages should have high coefficients of variation (standard deviation divided by mean), while the most accurately estimated map book pages will have small coefficients of variation. Table 11.A8 in appendix 11.1 shows the results of our coefficient of variation analysis for the assessor's data.

Our results indicate that a remarkably high fraction of the parcels within each county cannot be subdivided under the General Plan land use designations. This reflects (1) land use designations that are consistent with existing parcelization; (2) existing parcelization that is above the allowable density under the land use designation but grandfathered in; (3) existing parcelization that is below the allowable density but not subdividable further; or (4) errors in our methodology due to many map book pages with a high standard deviation in parcel sizes. The results indicate that very few parcels would be subject to the planning reviews and regulations required under the Subdivision Map Act of 1973 (which applies to all subdivisions resulting in 4 or more parcels) under

FIGURE 11.37

Absolute change in housing density, Nevada County, 1990 to buildout (from 1990 Census of Population, Summary Tape File 1B; Draft Nevada County General Plan).

FIGURE 11.38

Relative change in housing density, Nevada County, 1990 to buildout (from 1990 Census of Population, Summary Tape File 1B; Draft Nevada County General Plan).

the new General Plans in either county: only 2,877 parcels (2.95% of the total) in El Dorado County and only 3,153 (5.44% of the total) in Nevada County. The rest of the parcels in each county could either be developed (but not subdivided further) or else be subdivided into 4 or fewer parcels through ministerial actions.[71] This is an important distinction, for ministerial actions do not generally trigger a full environmental impact report (EIR) review process under the California Environmental Quality Act (CEQA). Our estimates for El Dorado County are based upon the Project Description. Because these subdividable parcels are larger than average, however, these parcels accounted for 27.82% of the area in Nevada County that is neither state nor federal land. Fully two-thirds (67.13%) of the land area in El Dorado County that is not in state or federal ownership would be subject to the Subdivision Map Act and therefore require a specific set of requirements for development. The full distribution of parcels and their "subdividability" is summarized for both counties in table 11.A9 in appendix 11.1.

Nevada County had records for 57,963 parcels in the assessor's database in 1992 (53,314 improved and 4,649 unimproved parcels),[72] while El Dorado County had 97,681 parcels (73,780 improved and 23,910 unimproved parcels). Based simply upon existing unimproved parcels, then, there is significant potential to accommodate additional population in each county without additional subdivisions. Many of these existing parcels are within the incorporated communities of Grass Valley, Nevada City, Truckee, Placerville, or South Lake Tahoe. As noted earlier, however, many additional parcels could be created under the draft county General Plans. The primary reason is that large parcels account for a disproportionate share of total potential housing units in both of the counties. Even though only a small fraction of all existing parcels can be subdivided, those parcels tend to be large and could be subdivided into many parcels. Based upon the methodology we employed, there is a potential for the creation of another 144,470 parcels in Nevada County and 71,370 parcels in El Dorado County under the General Plans. Our methodology estimated a range of 107,796 to 181,145 potential total parcels following allowable subdivision under the Nevada County General Plan, which is much higher than the 29,769 additional parcels estimated by the Nevada County Planning Department. Based on the methodological limitations cited above, we believe the actual number lies somewhere between our respective estimates.

Our estimates are based upon the mean number of lots that could be created through subdivision for each subdivision class, with the maximum class (more than 640 parcels) assumed to equal only 640 parcels. We are fairly confident about our estimates for El Dorado County, but very cautious about the estimates for Nevada County for the methodological reasons cited. In particular, land use designations under the Nevada County General Plan are often inconsistent with underlying parcelization. Our methodology is therefore less likely to be accurate in those cases due to the high coefficient of variation in parcel sizes for each map book page and land use designation. Due to parcelization, however, our preliminary analysis nevertheless raises serious questions about the accuracy of any projections of future parcels and housing units based only on the General Plans and their associated land use designations.

We attempted to highlight those areas with a high degree of existing parcelization by developing two related coverages for both El Dorado and Nevada Counties. The first coverage identifies the total acreage in parcels of 160 acres or more for each map book page that has any parcels of that size. All of the other map book pages have already been subdivided into smaller parcels and are represented by blank spaces in each coverage. Note that there are large contiguous areas in the western part of both counties near the historic gold rush towns of Placerville (El Dorado County) and Grass Valley and Nevada City (Nevada County) that have no large parcels. These areas then extend into areas of newer development, such El Dorado Hills and Auburn Lake Trails (El Dorado County) and Lake Wildwood, Lake of the Pines, Cascade Shores, and Chicago Park (Nevada County). There is also a large contiguous area without large parcels in the south-central part of El Dorado County, around Lake Tahoe, and near Truckee in eastern Nevada County. Figures 11.39 and 11.40 illustrate this pattern for El Dorado and Nevada Counties, respectively.

The second coverage focuses more specifically on those map book pages that have a high number of small parcels less than five acres in size. Not surprisingly, many of these areas match the map book pages without large parcels identified in the previous coverage. Figures 11.41 and 11.42 show where these small parcels are concentrated spatially.

This small parcel coverage provides a more detailed spatial representation of the pattern of parcelization, however, which allows a more accurate assessment of the potential to exceed identified buildout forecasts based only upon the General Plan land use maps. Areas with a high level of parcelization, like the Lake Vera / Round Mountain neighborhood in Nevada County, are likely to have much higher rates of both absolute and relative change in average housing densities at General Plan buildout than identified in figures 11.37 and 11.38. Other areas with lower levels of parcelization are less likely to have a problem with substandard lots that have been grandfathered in under the General Plan for higher levels of development density than would otherwise be allowed under their land use classification. Based upon our review, we believe this is a much more serious problem with the Nevada County General Plan than the El Dorado County General Plan. The El Dorado County General Plan more accurately accounts for existing parcelization in its land use designations and is therefore less likely to understate or overstate future development potential. The Nevada County General Plan often fails to recognize high levels of inconsistency between existing parcelization and land use designations for an area, so it tends to understate future development potential. There

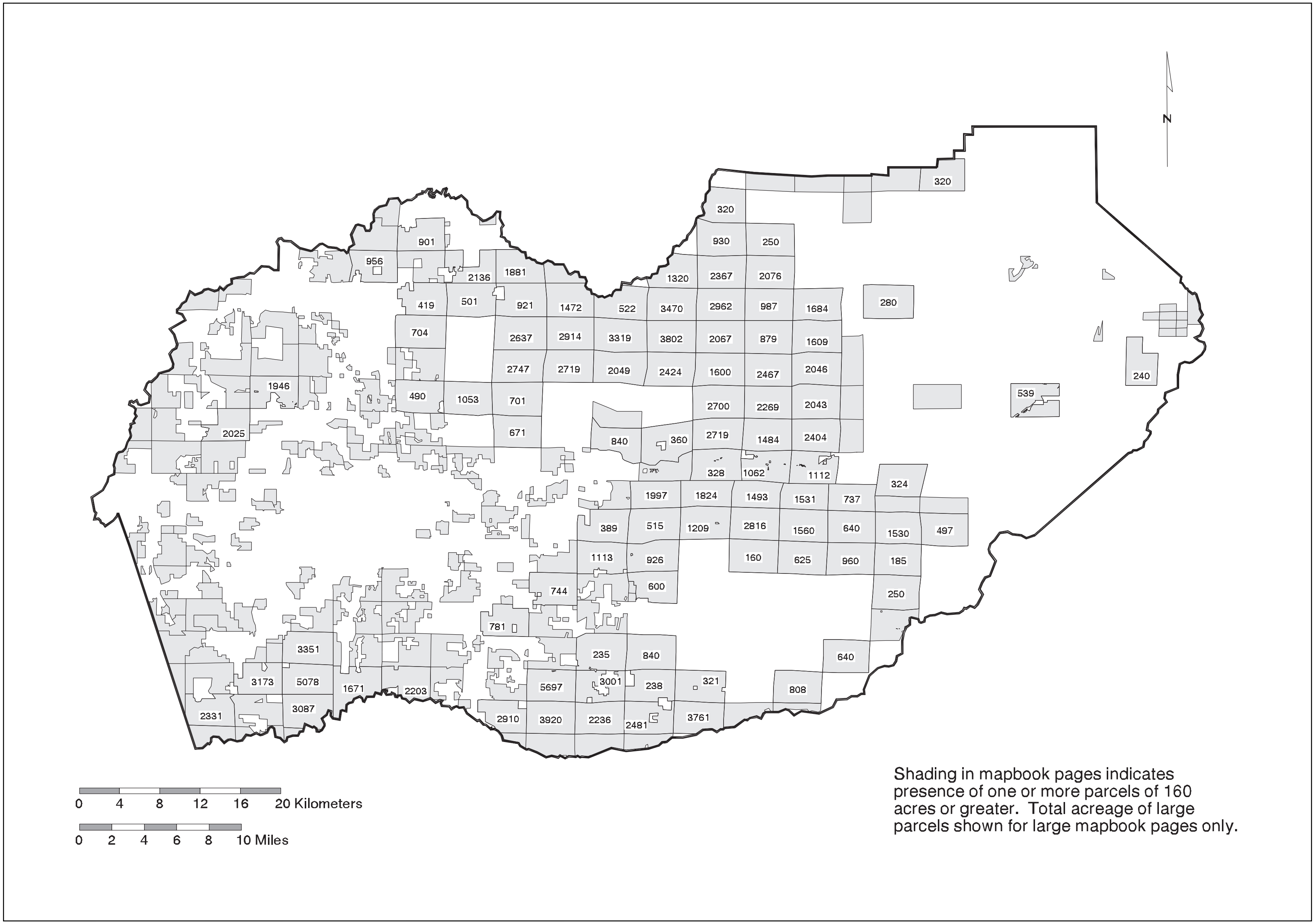


FIGURE 11.39

Acreage in large parcels, El Dorado County, 1992 (from parcel database, El Dorado County Assessor's Office).

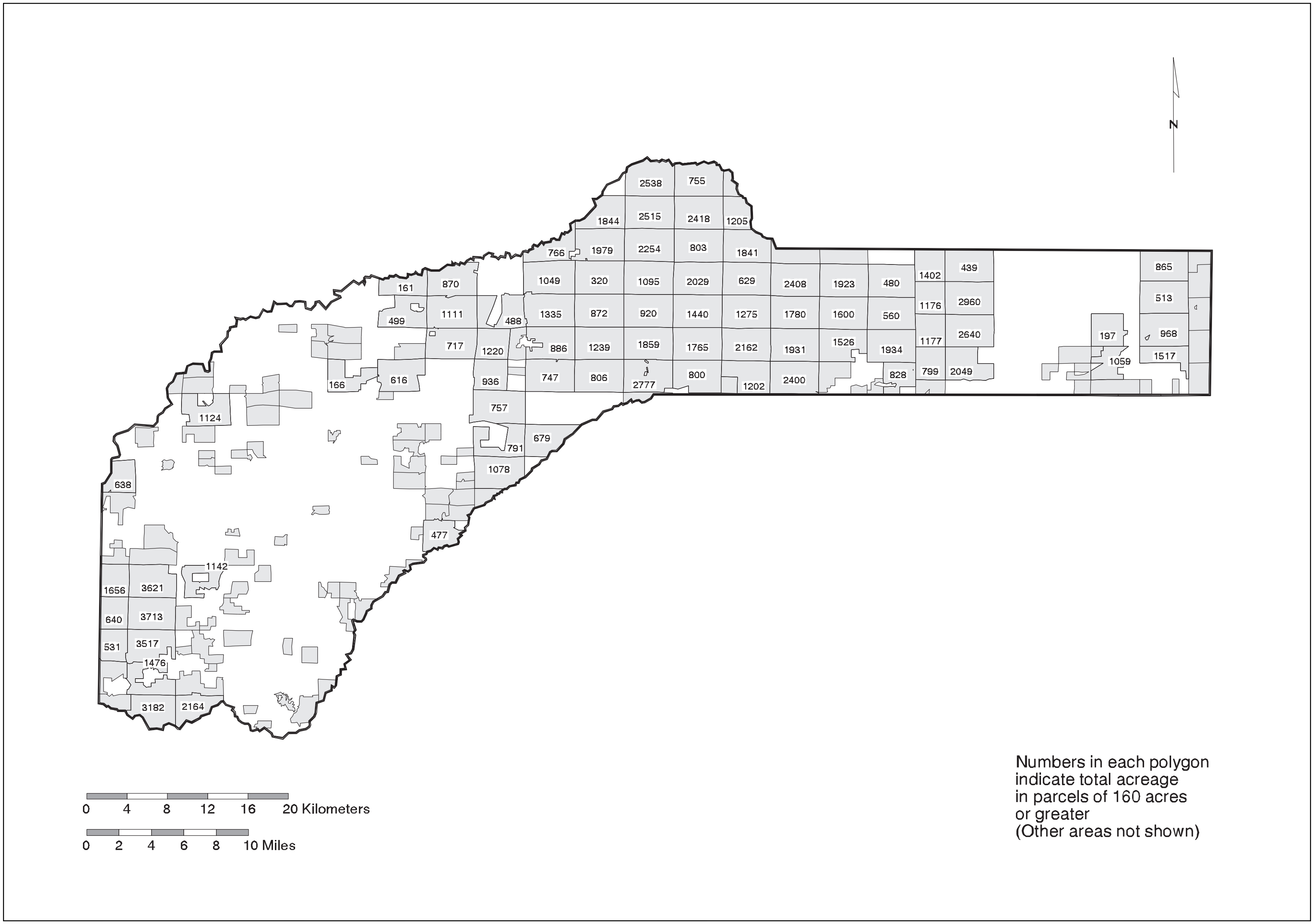


FIGURE 11.40

Acreage in large parcels, Nevada County, 1992 (from parcel database, Nevada County Assessor's Office).

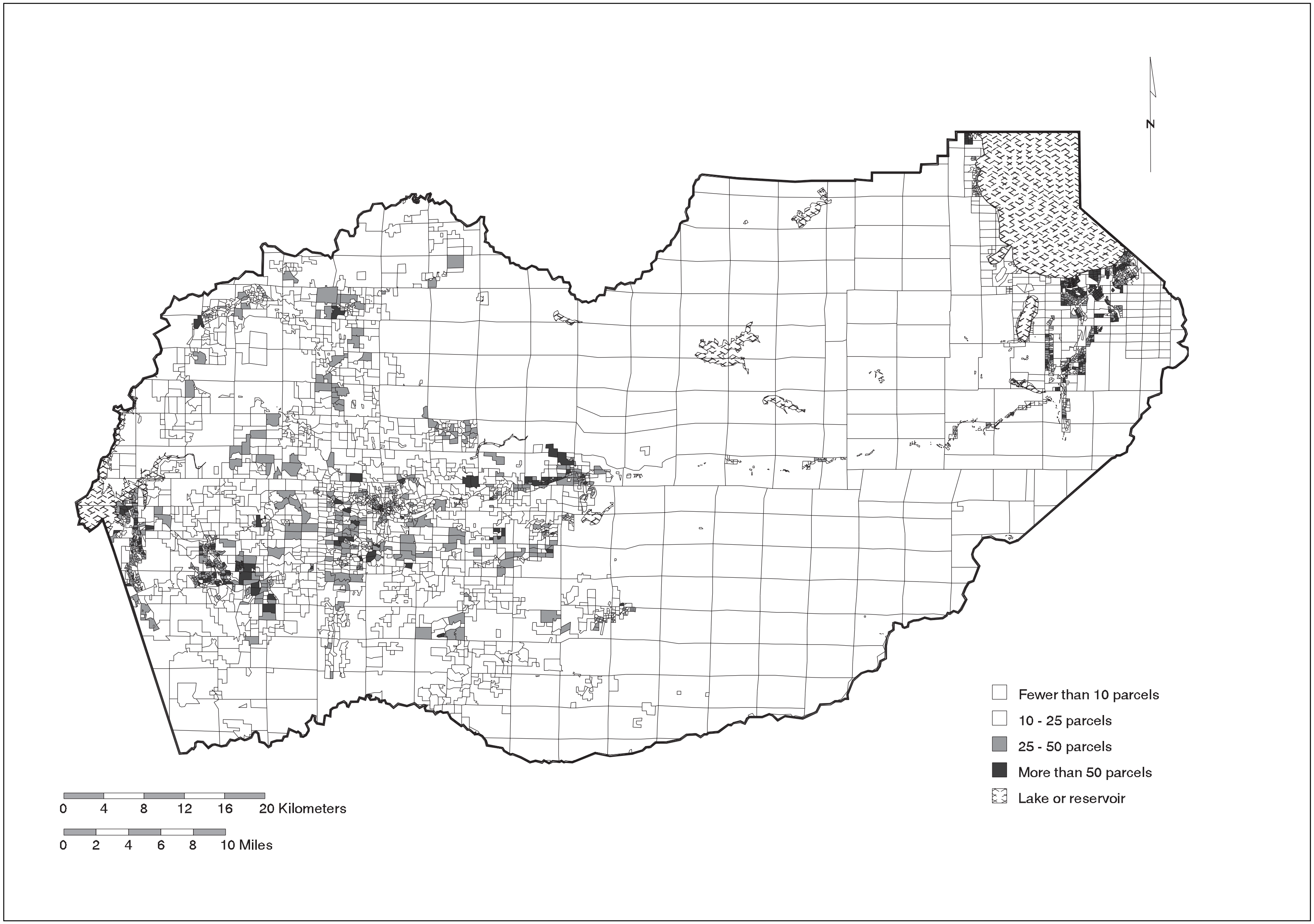


FIGURE 11.41

Concentration of small parcels, El Dorado County, 1992 (from parcel database, El Dorado County Assessor's Office).

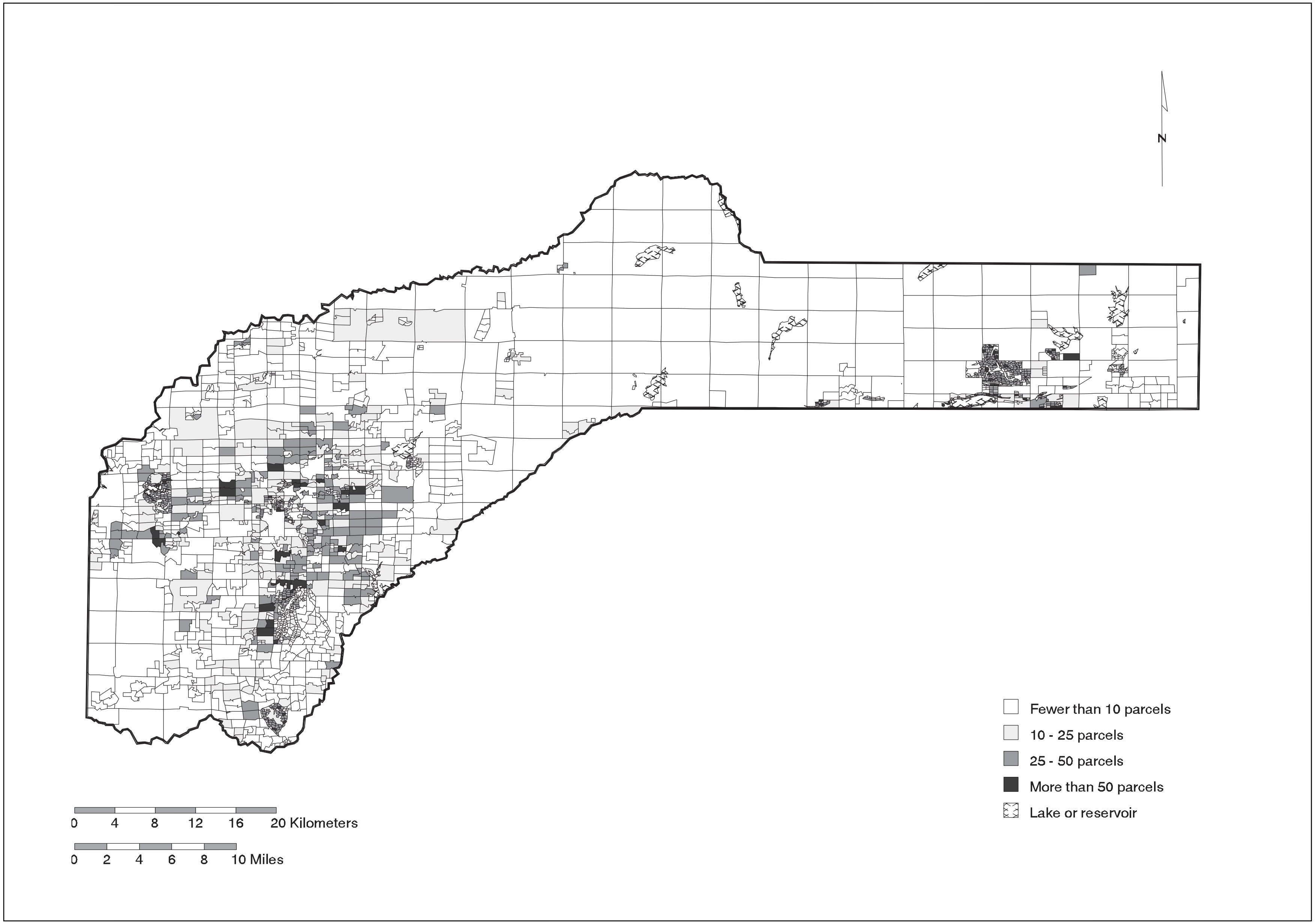


FIGURE 11.42

Concentration of small parcels, Nevada County, 1992 (from parcel database, Nevada County Assessor's Office).

is significant "momentum" for future growth in some areas that has not been addressed in the Nevada County General Plan. We therefore expect ultimate buildout under the Nevada County General Plan to be much higher than forecast based only upon the land use maps and density classifications.

Ownership Concentration and Large-Scale Developments

Our analysis of alternative buildout scenarios demonstrates the importance of large-scale developments on the ultimate number of housing units at buildout. As noted earlier, three special land use designations under the Nevada County General Plan account for anywhere from 21.33% of all housing units under the "low" scenario to 64.20% of the housing units under the "high" scenario. The ultimate buildout estimates under the Nevada County General Plan are therefore highly sensitive to the allowable densities for these special land use classifications. This is true under only one of the scenarios for buildout of the El Dorado County General Plan alternatives, the "low" scenario under the General Plan Alternative. In that scenario, the three "Planned Communities" account for 14.31% of all housing units. They otherwise account for anywhere from 4.68% to 6.71% of total housing units under the other five scenarios under the El Dorado County General Plan. Ownership concentration is nevertheless an important factor affecting human settlement patterns in the region, for a large fraction of El Dorado County's current population resides in large-scale developments (e.g., El Dorado Hills). We therefore examined ownership concentration in detail for both Nevada and El Dorado Counties.

Private land ownership is highly diffused in terms of numbers of parcel owners but highly concentrated in terms of land area in both counties. Many owners have "no reported acreage" associated with their properties because their parcels are smaller than one acre and acreage was recorded only for the subdivision (rather than the indivdual parcels). We consolidated these parcels with the "less than one acre" class for purposes of analysis. The 300 landowners who own 160 acres or more control 55.89% of the private land in El Dorado County, while just 290 landowners in the same class control 53.00% of the private land in Nevada County. In contrast, there are 66,159 landowners with less than 5 acres in El Dorado County. They account for 84.26% of the owners but hold only 6.06% of the private land. There are 35,121 landowners with less than 5 acres in Nevada County, constituting 79.13% of the owners but controlling just 8.04% of the private land. The figures for Nevada County require more complex calculations due to the inclusion of state and federal land in the assessor's database. Most of these parcels are in the size class of "owners of over 640 acres." We have adjusted the total area used in the denominator of the spreadsheet to exclude state and federal lands.

Much of this land is owned by industrial timber companies or public utilities. We therefore analyzed the records for all landowners with 160 acres or more for each county in order to identify areas of potential large-scale development in the future. At least 130,500 acres (42.48%) of the 307,218 acres owned by this group are owned by private industrial forestry concerns in El Dorado County. Five of the six top landowners were in this category, led by Michigan-California Lumber Company (73,254 acres in 276 parcels).[73] Georgia-Pacific Corporation held 32,038 acres in 157 parcels, Wetsel-Oviatt Lumber Company had 10,054 acres in 82 parcels, Sierra Pacific Industries had 9,081 acres in 55 parcels, and Fibreboard Corporation owned 6,073 acres in 35 parcels. The Sacramento Municipal Utility District (SMUD) also owned 3,384 acres in 105 parcels.

Private industrial forestlands account for 59,773 acres (26.85%) of the 222,580 acres in Nevada County owned by the top 290 owners (each with at least 160 acres). Sierra Pacific Industries is the largest private landowner, with 55,054 acres on 219 parcels, followed by Pacific Gas and Electric Company with 11,926 acres on 91 parcels and the Nevada Irrigation District (NID) with 8,098 acres on 149 parcels. Several local timber owners control large properties of several thousand acres each, while Fibreboard Corporation owns 1,035 acres on 10 parcels. Together these large landowners (including PG&E and NID) account for 35.85% of the land in this class. The state of California is also a very large landowner, with 10,835 acres on 279 parcels in Nevada County. These are not included in the totals reported here for large private landowners.

The large landowners described generally own land in the mixed conifer zone and above, where industrial forestry is the primary land use. Many of these lands are adjacent to or surrounded by federal lands managed by the U.S. Forest Service. Changes in land use on these lands could therefore have significant ramifications for ecosystem management efforts on the public lands. Neither wildlife, water, nor fire recognize ownership boundaries in the checkerboard pattern of Nevada and El Dorado Counties. Recreational activities also sometimes cross between public and private lands without recreational users even recognizing the boundary. Access to many public trails is through private land, and some major trails even cross private land. Private timber companies have also converted their forestlands into recreational uses in the past (e.g., Tahoe Donner, Incline Village, and Northstar-at-Tahoe) and could do so again in the future. Any of these actions would be subject to the regulatory jurisdiction of the county General Plans. Land use designations for these lands are therefore important in terms of how they may affect future uses of adjacent public lands and how those future changes in land use may affect the social, economic, and ecological health and sustainability of the Sierra Nevada.

The Nevada County General Plan, for example, proposes designation of some private forestlands for high-density development near Donner Summit and Castle Peak along Interstate 80. Such development could affect recreational access and recreational demand if developed to the allowable density requested by the landowner in the update process. Many other forestlands could be classified to allow one housing unit on every 40 acres, which could lead to subdivision of industrial forestlands and conversion to recreational or residential uses. The presence of recreational residences on these lands could in turn affect industrial forestry operations on adjacent private and public lands. Local government action to allow increased development under the General Plan also tends to increase the market value of land, which could create a windfall for some private landowners if public acquisition of those lands is pursued later by the state or federal government (even if such efforts have been ongoing before the new land use classification). This could significantly increase the cost of land trades and land acquisition by public agencies attempting to rationalize land ownership in order to improve land and resource management in the Sierra Nevada. These efforts usually do not involve condemnation, and there are sometimes specific restrictions against the use of condemnation by public agencies (e.g., to acquire public land in a wild and scenic river corridor if more than 50% of the corridor is already owned by public agencies) (South Yuba River Citizens League 1993). The new land use designations under the General Plan would still increase the costs of land for the public agencies.

Despite these possible consequences from General Plan designations for large owners in the mixed conifer zone, however, development activity for human settlement is most likely to be concentrated "below the green line" on private lands in the west-side ponderosa pine and below in the foothills. Figure 11.43 shows a summary of the distribution of land ownership by parcel frequency and area for both counties for those areas west of the "green line" or national forest boundary in each of the counties.

Parcel size alone does not capture the potential size of future developments, however, for clustered ownerships of adjacent parcels can result in large-scale development opportunities. We therefore used the assessor's data to identify clusters of adjacent parcels with a single owner that were likely to become the site of large-scale human settlement. These sites cannot be identified based on parcel size alone, for they often involve many smaller parcels that have been aggregated to accommodate a larger development. The largest private landowner in El Dorado County that is not from the timber industry is Cook Ranch Partners of Rancho Cordova, for example, developers of the Cinnabar Ranch site south of Placerville (7,771 acres on 27 parcels). The owners of this project are primarily foreign investors who have proposed 569 housing units on 4,975 acres of the site. This represents a significant reduction in density from previous proposals, but the site design involves extensive land conversion to accommodate human settlement on a network of 5-acre parcels. There is no higher-density development on the site, but the cumulative effects of the project are still likely to be significant (Fugro-McClelland [West] 1994; McKuen 1994). Lower densities do not necessarily result in lower impacts—an important point to consider when evaluating future patterns of human settlement for the Sierra Nevada. The project averages only 46.86 housing units per square mile for the entire site and 73.20 housing units per square mile for the 4,975 acres of developed land. In contrast, the "Planned Community" designations under the two El Dorado County General Plan alternatives would have average densities of 397 to 2,624 units per square mile. They would therefore be able to accommodate the same population as the Cinnabar Ranch project on a range of 139 to 917 acres. This would take only 3–18% of the land area that will be developed by the Cinnabar design.

In Nevada County, the largest private landowner not from the timber industry is Gold Country Ranch, Inc. The land-

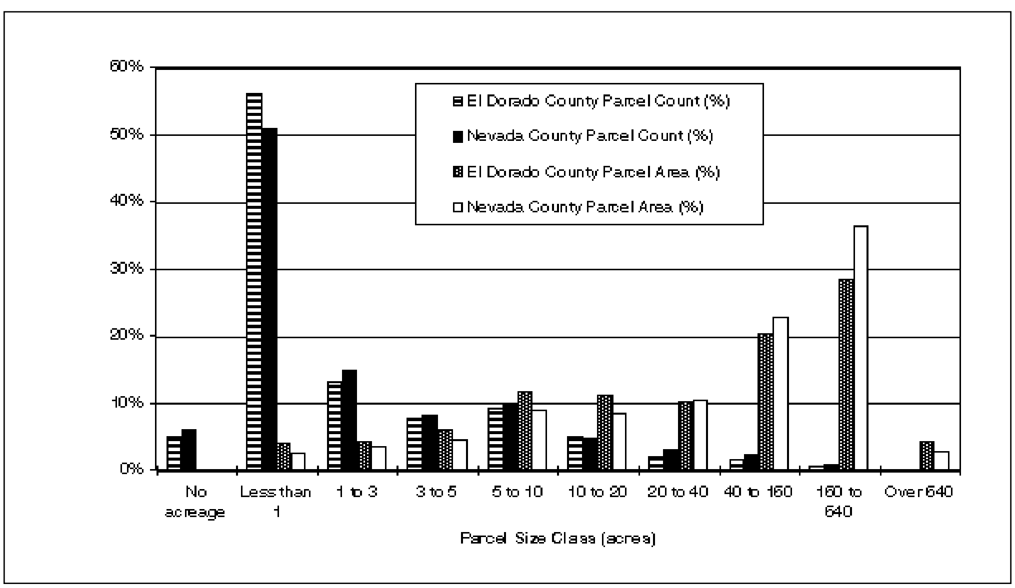


FIGURE 11.43

Number of parcels versus area by parcel size class for Nevada and El Dorado Counties "below the green line" (west of the national forests).

holdings of Gold Country Ranch cover 8,232 acres in 24 adjacent parcels. The corporation is based in Rocklin and includes several large local landowners with adjacent parcels. This project proposes a more compact development and a much higher level of total housing units and population than the Cinnabar Ranch project. Unlike the Cinnabar Ranch, however, the Gold Country Ranch project has not yet prepared an environmental impact report (EIR). It is therefore difficult to evaluate the potential impacts of the project in the absence of more specific information on the design. We therefore considered a range of future buildout scenarios for this site in our estimation of potential future housing units under the Nevada County General Plan. These buildout scenarios assume average development densities of anywhere from 397 to 2,624 units per square mile, consistent with those used for the "Planned Community" designation in the El Dorado County General Plan alternatives. Our "middle" scenario assumes an average density of 1,841 units per square mile (2.88 units per acre). These densities are considerably higher than those now expected for the Cinnabar Ranch project. Given recent changes in real estate markets, the Gold Country Ranch project proposal is likely to lie dormant for the next few years before coming forward under the new Nevada County General Plan with a more detailed site-specific proposal.[74]

This has also happened with several other "new town" proposals in nearby Yuba, Sutter, Placer, and El Dorado Counties. Only the Stanford Ranch, which broke ground in 1987, is continuing to develop at the rate and on the scale of these proposed "new town" developments. Those projects that have not yet started actual development are now delaying the significant up-front investments in infrastructure required to develop such large-scale projects. Stanford Ranch has already made those investments, so it has a strong incentive to continue the development process in order to allocate those costs to as many homeowners as possible. There are now over 2,000 homes at Stanford Ranch, with about 8,000 homes forecast to be developed on the 3,500-acre site at buildout (Stanford Ranch Information Center 1994–95). Most of those residents are expected to commute to work in the greater Sacramento metropolitan area, which now includes Roseville in western Placer County and Folsom at the edge of El Dorado County. Expansion of employment opportunities in the electronics industry and in state government are primary drivers of the growing demand for housing in this area.

Retirees are also moving to the western Sierra Nevada foothills and this portion of the greater Sacramento metropolitan area. The Del Webb corporation, which has built several "Sun City" retirement communities from scratch, recently decided to locate its first Sun City in northern California in the community of Roseville. Sun City Roseville will have 3,500 homes for an estimated 6,000 residents age 55 and older at buildout. The project was first formerly proposed in January 1993, broke ground in February 1994, and sold 629 homes in the first seven months. Unlike at Stanford Ranch, where a dozen individual developers are building homes with different price ranges and styles within the overall development, the Del Webb corporation handles every aspect of its development. Its first Sun City, near Phoenix, was started in 1960 and now has 26,000 homes. The company is now starting construction on 4 new homes every day at the Roseville site (Grass Valley Union 1995c). The residents are expected to come primarily from elsewhere in California.

Each of these developments in western Placer County represents a very different pattern of development than that which has dominated human settlement in the Sierra Nevada to date. The higher incomes of their target population represent the same sociodemographic group that has emerged as the driving force in the real estate markets of Nevada and El Dorado Counties, however, and the higher housing costs they can afford have allowed high levels of investment in centralized infrastructure. This in turn has allowed development at higher densities than those typically found in the Sierra Nevada. These developments therefore represent one important model for human settlement in the future for a significant fraction of the Sierra Nevada population. As in the private, unincorporated communities of Lake Wildwood, Lake of the Pines, and El Dorado Hills, each home owner's land use is controlled more by codes, covenants, and restrictions (CC&Rs) in the deed than by local land use regulations. Infrastructure has also been privatized, with special assessment districts that tap the development site for special property taxes that go only toward infrastructure that serves that site. The result is the effective privatization of many functions that would normally be handled by local governments. This privatization has enormous implications for the future of land use planning and infrastructure investment throughout the Sierra Nevada where these types of developments take place (Egan 1995).

The emergence of large-scale development proposals in Nevada and El Dorado Counties suggests that the land development process could be entering a new phase in the Sierra Nevada foothills within the commute orbit of the Sacramento metropolitan area (Hoge 1995). One aspect of these large-scale projects is that they involve significant ownership by landowners from outside the area. We used the ZIP code data from the 1992 assessor's parcel database to identify counties in California where residents or corporations with primary addresses in those counties owned a large amount of land within either county. Figure 11.44 shows the distribution for Nevada County, with clear ties to nearby Placer County and Shasta County (where Sierra Pacific Industries is located). There is also a pattern of nonlocal landowners with significant holdings in Nevada County from Sacramento, San Francisco, Contra Costa, Santa Clara, and Los Angeles Counties. Landowners in the Sacramento area and the San Francisco Bay Area could include recreational second-home owners who spend time in the Truckee-Donner area, but Los Angeles–area landowners are probably holding land for future development. This conclusion is suggested by both the size of the landholdings by Los Angeles–area landowners and the relative distance between Los Angeles and the land in Nevada County.

El Dorado County records show a similar pattern, although there is a higher concentration of ownership in adjacent Placer, Amador, and Sacramento Counties. There are also large landholdings among residents and corporations based in Solano, Contra Costa, Alameda, Santa Clara, San Mateo, and Los Angeles Counties. These include both second-home owners in the Lake Tahoe region and potential land developers. Timber industry ownership shows up for Shasta (SPI), Amador (Georgia-Pacific), and Tuolumne (Fibreboard) Counties. Figure 11.45 shows the coverage for El Dorado County.

Similar analysis for the five-county central Sierra Nevada region (the only counties for which we have ownership records) show high levels of ownership by residents of the state of Nevada. Ownership by foreign interests and owners in other states was not significant. These data represent county locations for only the recorded address ZIP code in the assessor's database, however, and do not record the location of owners of partnerships or corporations with a single address. These could include significant foreign investors, such as those in the Cinnabar Ranch project. These data are therefore only a first-order measure of the spatial pattern of landownership in each of the counties. They do highlight large ownership in both the San Francisco Bay Area and the Los Angeles area, however, which suggests that there are significant "communities of interest" in those areas that may not be represented among the residents of each of the counties.

Incremental Development and Minor Subdivisions

The potential for large-scale developments is certainly concentrated among those landowners with large amounts of contiguous land, but the most significant effects of development under the proposed General Plans could come through the incremental development of existing parcels and minor subdivision of those existing parcels. These activities do not trigger significant environmental review under CEQA and are in most cases ministerial actions that do not require approval from the local land use authority. The existing pattern of parcelization among parcels smaller than 160 acres may therefore dominate future patterns of human settlement under the General Plans without any systematic opportunities in the future to mitigate the impacts of that development.

The existing parcels in both Nevada and El Dorado Counties are overwhelmingly small "below the green line" west of the national forest boundary. Our analysis indicates that nearly all of the parcels in the database that do not have a specific acreage associated with them are less than 1 acre and are within higher-density subdivisions. Parcels less than 1 acre in size therefore account for 61.21% of the parcels but only 4.10% of the land area in western El Dorado County below the green line. This smallest parcel class accounts for 56.75% of the parcels but only 2.59% of the land area in western Nevada County outside the national forest boundary. Parcels 1–10 acres in size constitute about one-third of the total parcels in both counties (30.05% in El Dorado County and 32.51% in Nevada County), but only 21.71% of the land area in El Dorado County and 16.73% of the land area in Nevada County. These parcels are all generally on septic systems and typically get their domestic water supply from an on-site well, but many of them (especially those greater than 5 acres) could be subdivided further into several parcels that still meet the local health department's minimum lot size requirements for on-site well water with a septic system. There were 23,991 parcels in El Dorado County and 18,383 parcels in Nevada County 1–10 acres in size in 1992. In area, they accounted for 97,663 acres in El Dorado County and 74,909 acres in Nevada County.

Slightly larger parcels of 10 to 40 acres account for nearly a comparable amount of total land area (21.17% in El Dorado County and 18.77% in Nevada County) but are far fewer in number (only 6.75% of the total parcels in El Dorado County and 7.65% in Nevada County). These larger parcels could be subdivided once into two or three parcels (a "minor" subdivision), sold to several buyers while the original owner retains a home on one of the lots, then subsequently subdivided again by the purchasers of the smaller lots. In this way a 40 acre parcel may become four 10 acre parcels before each of these is ultimately split again into several parcels of 3–5 acres. What may be a single housing unit today on 40 acres could therefore easily turn into eight to thirteen housing units on septic systems and on-site well water. Multiplied across the landscape, this pattern of incremental development and minor subdivisions can increase human settlement considerably. There were 5,389 parcels in El Dorado County and 4,328 parcels in Nevada County in the 10–40 acre size class in 1992. In area, they accounted for 95,203 acres in El Dorado County and 84,018 acres in Nevada County. Combined with the totals in the 1–10 acre size class, there are therefore 192,866 acres in El Dorado County and 158,927 acres in Nevada County in parcels that are between 1 and 40 acres. All but the smallest of these parcels could potentially be subdivided through minor subdivisions and result in significant cumulative increases in housing units without the extension of sewer and/or public water infrastructure.

The final size class, which we have not yet discussed, is between 40 and 160 acres. This size class accounts for only 1,188 parcels in El Dorado County (1.49%) and 1,287 parcels in Nevada County (2.28%), but these parcels cover 91,293 acres in El Dorado County (20.30%) and 101,860 acres in Nevada County (22.75%). The mean size of these parcels was 76.8 acres in El Dorado County and 79.1 acres in Nevada County. These larger parcels could also be subdivided into four or fewer parcels without either approval from the land use authority or environmental reviews, with the same ultimate sequence of subsequent subdivisions. These larger parcels are generally more rural and remote from services, however, and they are less likely to face conversion pressures in the near term.

Specific land use designations in the General Plans could

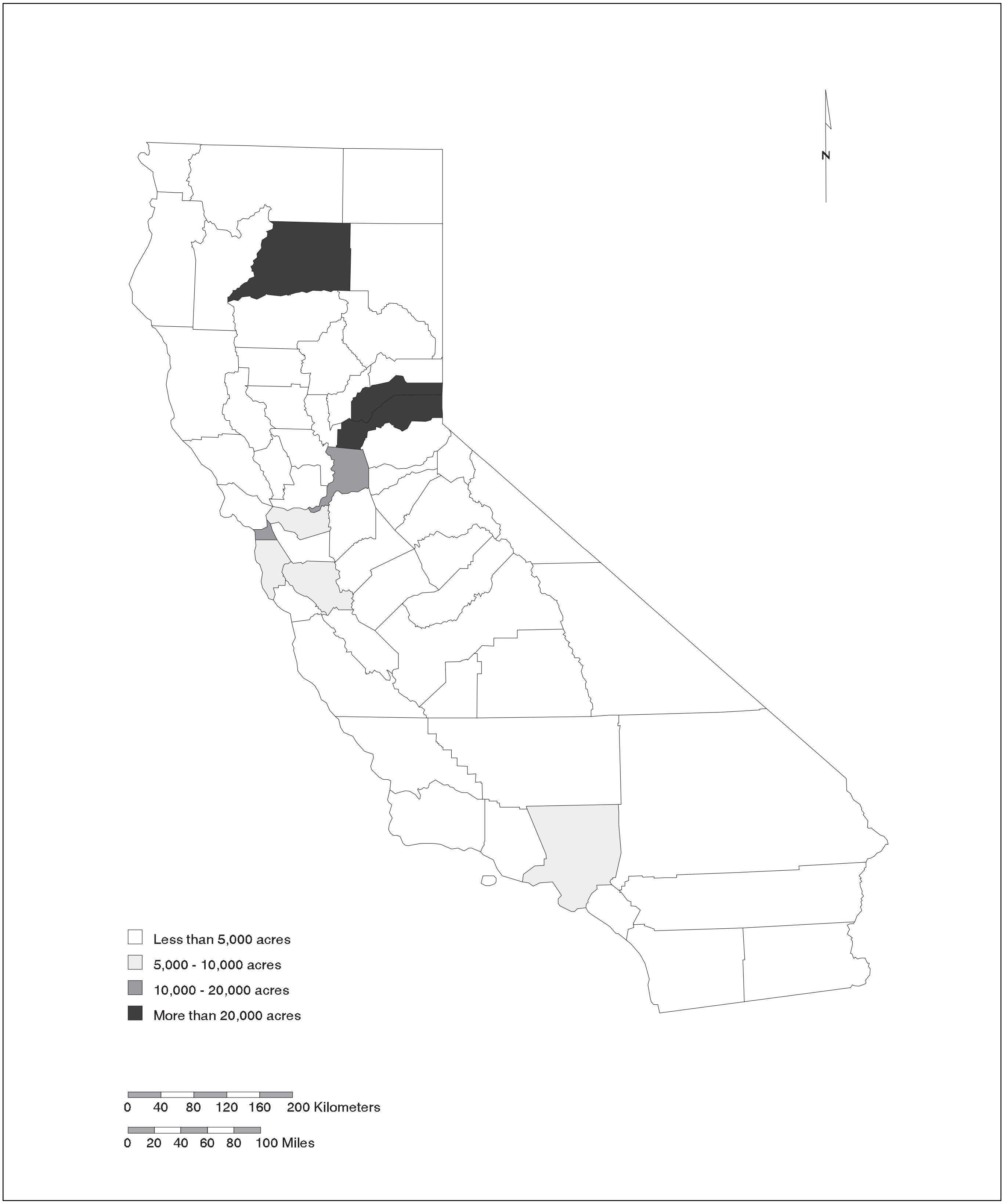


FIGURE 11.44

Distribution by county of residence for owners of land in Nevada County (from parcel database, Nevada County Assessor's Office).

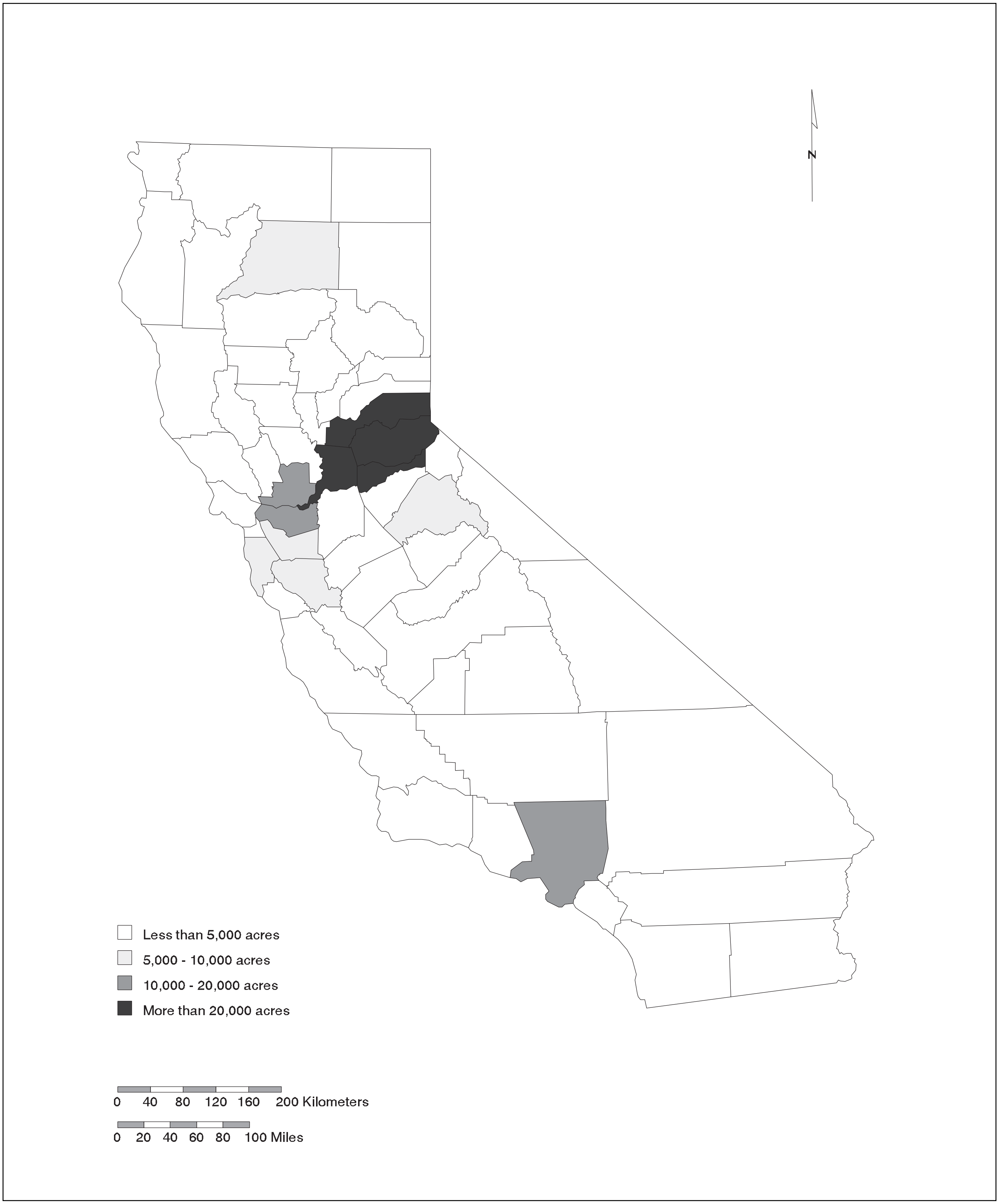


FIGURE 11.45

Distribution by county of residence for owners of land in El Dorado County (from parcel database, El Dorado County Assessor's Office).

directly affect the feasibility of significant parcelization of these larger parcels through sequential minor subdivisions. The Project Description version of the El Dorado County General Plan has a minimum parcel size requirement of 160 acres for lands in the "Natural Resource" classification, for example, while the General Plan Alternative has only a 40 acre minimum for the same classification. Subdividing a 160-acre parcel under the "Natural Resource" classification would therefore be much more difficult under the Project Description, for it would require a General Plan amendment. The landowner could easily complete a minor subdivision of a 160 acre parcel into four 40 acre parcels without needing approval under the General Plan alternative. Nevada County has designations for "Rural 40" and "Rural 160" under its proposed General Plan, with additional land use classifications of "Forest 40," "Forest 80," Forest 160," and "Forest 640." The same 160 acre parcel could be split into four 40 acre parcels without any additional approvals if it were classified as either "Rural 40" or "Forest 40," but such a subdivision would require a General Plan amendment if it were classified "Rural 160," "Forest 160," or "Forest 640." The parcel could be split into two 80 acre parcels without additional approvals if it were classified as "Forest 80." The draft Nevada County General Plan proposed classification of 36,958 acres as "Rural 40" and 34,914 acres as "Forest 40," and much of this land is probably already subdivided into 40 acre parcels. Most of the land designated in the overall "Forest" classification is either "Forest 160" (279,583 acres) or "Forest 640" (20,481 acres), but most of that land is "above the green line"—already in public ownership.

Table 11.A10 in appendix 11.1 shows the complete distribution of parcels by parcel size class (rather than total acreage owned by individual owners) for each of these parcel size classes.

Remember that table 11.A10 is only for those parcels that are "below the green line" (west of the national forest boundary) and are therefore most likely to face development pressure. Federal lands under the jurisdiction of the U.S. Forest Service are therefore excluded, but the Nevada County assessor's database includes some public lands managed by the U.S. Bureau of Land Management or the California Department of Parks and Recreation. Most of these lands are in the South Yuba River region with relatively steep slopes and would not generally face significant development pressure.

Draft Environmental Impact Reviews of the General Plans

The California Environmental Quality Act (CEQA) requires that a draft environmental impact report (DEIR) be prepared and circulated for review for the Final Draft General Plans for both Nevada County and El Dorado County. These DEIRs were circulated in early 1995, and each county held public hearings to take comment on the DEIRs, which are intended to describe the potential environmental impacts of the General Plans and to mitigate those impacts where feasible. Comments on the DEIRs were then incorporated into the final EIRs (FEIRs) by either the EIR consultants (in Nevada County's case) or county staff (in El Dorado County's case). The local planning commission and board of supervisors then evaluated the final EIRs and modified them to reflect their own independent findings regarding the impacts of the General Plan on the environment. CEQA requires that "significant" environmental effects be reduced to "less-than-significant" through mitigation measures. Significance has been established through either statute, CEQA guidelines issued by the Governor's Office of Planning and Research (OPR), or case law. Local authorities may also make findings that some impacts are "significant but unavoidable" due to "overriding considerations" that make mitigation measures infeasible. Both counties made these kinds of findings when reviewing their respective final EIRs, but those findings have been challenged and litigation has been threatened by local groups.[75]

These are large and complex documents, so we are not able to describe them in detail here. For papers on the two General Plan draft EIRs, describing the critical points found in the longer documents, see Thomas and Duane (1995a, 1995b). We will summarize the primary findings briefly here to highlight the types of environmental impacts that can be anticipated under the General Plans.

The DEIRs identified some common themes across the two General Plans, although the El Dorado County General Plan DEIR is more comprehensive and more thoroughly documented than the Nevada County General Plan DEIR. This appears to be primarily a result of both inadequate information supporting the Nevada County General Plan analysis and its greater degree of generality. It is therefore difficult to evaluate the potential environmental impacts of the Nevada County General Plan with reliability or specificity. Even with that limitation, however, it is clear that development under both of the General Plans will result in "significant and unavoidable" impacts on the environment. The critical question is the degree to which those impacts will be mitigated under CEQA. Because both counties' final EIRs were under appeal at the time of our analysis, we cannot describe the final EIR here with any certainty. Our discussion therefore focuses on the impacts associated with implementing the 1994 draft General Plans that were identified in the draft EIRs.

The draft EIRs are dominated by five general impacts associated with development:

1. Decreased wildlife habitat and recreational open space due to the conversion of land to residential, commercial, industrial, and public uses
2. Increased traffic congestion and air emissions due to development, with increased traffic delays and decreased traffic safety
3. Increased water quality problems associated with both point-source wastewater treatment facilities and nonpoint-source septic systems

4. Increased fire risk and safety hazards associated with settlement in the urban-wildland intermix, including emergency escape on substandard roads
5. Increased shortfalls in the capacity of local governments to provide services, including education, public safety, and parks and recreation

In addition, El Dorado County could face serious limitations in domestic water supply due to increased demand associated with development under the General Plan. Anticipation of this problem led the El Dorado County Water Agency to initiate a study of water supply and demand in 1994 that identified potential sources of future supply. This study analyzed supply and demand for all of the water suppliers in the county, which are dominated by the El Dorado Irrigation District (EID). In contrast, the Nevada Irrigation District (NID) is one of the few water districts in the state that has ample supply capacity to handle the significant growth anticipated under the Nevada County General Plan, in part due to a large fraction of agricultural users who pay relatively low prices for their water. NID therefore has the potential for significant shifts between agricultural and domestic uses. EID is more restricted in this regard, and it is negotiating to acquire water rights for the Silver Fork of the South Fork of the American River from Pacific Gas and Electric Company (PG&E) (El Dorado County Water Agency 1994; Doolittle 1994–95). Alpine and Amador Counties have opposed the water rights request, however, unless it includes guarantees to maintain lake levels at Caples and Silver Lakes. Resolution of the water supply issue is therefore dependent on resolution of that water rights controversy (Doolittle 1994–95; Brissenden 1993–1994; Center 1991–95).

Many parcels currently rely on ground water for domestic water supply, which is inconsistent and highly variable in the fractured bedrock geology of the Sierra Nevada (Swain 1994). There are very few true aquifers in Nevada and El Dorado Counties, so water supply is difficult to predict without site-specific well drilling and analysis. Limitations in groundwater availability could therefore limit future development at buildout under the General Plans. Development under the General Plans could also potentially affect existing supplies, necessitating significant expansion of the treated water supply distribution system to more remote locations currently served by wells. Due to the need to complete site-specific analysis, however, neither of the General Plans has analyzed the availability of ground water to supply the water necessary to accommodate growth. It is therefore unclear how much of the buildout population's demand could be met through on-site well water.

Land Conversion

The scale of land conversion anticipated under the General Plans is astounding. When compared with the land area in each of the density classes reported at the census block level for the 1990 census, we estimate that the Nevada County General Plan would increase the area dedicated to human settlement at an average density of one unit per acre or greater from 12 mi^2 in 1990 to 30.37 mi^2 at buildout (146%). The land area settled at an average density of 1–4 acres per unit would nearly double from 30 mi^2 in 1990 to 59 mi^2, while the 4–8 acre class would increase 76%, from 40 mi^2 to 71 mi^2. Using our most conservative estimate of 16 acres per housing unit as a threshold (forty housing units per square mile), the total land area subject to human settlement will increase from 143.43 mi^2 in 1990 to 228.37 mi^2 (a 59% increase). Another 11.0 mi^2 are dedicated to commercial, industrial, and public uses. The total land area with less than ten housing units per square mile will drop only from 662 to 528 mi^2, but more than half of that land area will move from being unsettled to being lightly settled.

El Dorado County's General Plan is similar. Once again, the density class of just two to five housing units per square mile increases the most (396%) under the General Plan Alternative. The density class of ten to twenty housing units per square mile increases the most (608%) under the Project Description. The highest-density class (one or more units per acre) roughly doubles under each alternative, with an overall increase of land settled with at least four housing units per square mile from 203.1 mi^2 in 1990 to 563.7 mi^2 (278%) under the General Plan Alternative. The area affected by at least this level of human settlement would increase to only 294.2 mi^2 (45%) under the Project Description, however, for it has greater increases in lower-density classes. The land area settled at an average density of ten to twenty housing units per square mile increases by 933% under the Project Description, from 153.4 mi^2 to 1,086.5 mi^2. The El Dorado County General Plan Alternative also has 8.6 mi^2 dedicated to commercial, industrial, and public uses, while the Project Description commits 13.4 mi^2 of land to those designations. There are also some lands with unknown densities. Tables 11.A11–11.A13 in appendix 11.1 summarize the changes in land area under each of the General Plans compared with 1990 settlement densities.

Transportation

Accommodating this level of land use change requires significant investments in new infrastructure, and the transportation sector is the one that will experience some of the greatest impacts. The El Dorado County General Plan anticipates a need for transportation improvements that would cost between $800 million and $1 billion over the twenty years (Thomas 1995, 1994). U.S. Highway 50 and local Highway E16 would need to be widened to six lanes each to handle increased traffic associated with development under the General Plan (Thomas 1994). This analysis of the El Dorado County General Plan reflects consistent and comprehensive consideration of land use changes within transportation analysis zones (TAZs) that comprise census block groups for consistent social, demographic, and economic information (Rivas 1994). Though we have not evaluated the modeling efforts used to derive the estimates, we believe they are a reasonable projection of future transportation impacts and the need for additional facilities.[76] The funding needs under the General Plan are well beyond current revenue projections, however, making many of these infrastructure investments unlikely. Further degradation of level of service (LOS) standards and significant air-quality impacts associated with a highly congested transportation system can therefore be expected in the absence of those investments.[77]

Nearby Placer County's General Plan EIR, which was released in late 1993 for a General Plan that was then adopted in August 1994, anticipated similar problems along Interstate 80. "By its own analysis," noted one newspaper article on the EIR, development under the General Plan would "induce a 20-mile-long traffic jam on Interstate 80 each weekday rush hour between Citrus Heights and Auburn" (Bowman 1994). The article also noted that "as it is now, I-80 during weekday commuting hours is generally jammed for about a two-mile stretch" (Bowman 1994). Development under the Placer County General Plan would therefore increase the highway mileage of congestion tenfold, since vehicle trips and vehicle miles traveled (VMT) were both projected to increase at a much higher rate than population. That increased congestion could in turn affect commuters from Nevada County to the greater Sacramento metropolitan area. Following the historic pattern of metropolitan deconcentration, continuing traffic congestion could then accelerate the relocation of employment opportunities to the metropolitan fringe (in order to avoid the congestion costs associated with commuting to Sacramento itself). This process of metropolitan expansion and deconcentration could then put portions of western Nevada County within commuting distance of jobs in Placer County. A similar phenomenon has already had some effect on the shift of employment to Roseville and Folsom, which are both beyond the areas of I-80 and U.S. 50 that experience daily congestion now.

Congestion within Nevada County is much more difficult to ascertain from the draft EIR. The 1994 Regional Transportation Plan (RTP) was not released until May 1995, well after the draft EIR and final EIR had been reviewed and debated by the planning commission. Transportation modeling for the Nevada County General Plan was also based upon buildout densities derived from the General Plan land use classifications, failing to account for existing parcelization and the potential for much higher buildout in some areas. Transportation modeling depends upon spatially explicit analysis of origin and destination linkages through assumed trip patterns, so it is nearly impossible to complete a reliable model of the transportation system under buildout without spatially explicit estimates of trip generation and travel patterns under buildout. Even without reliable spatially explicit data, however, the 1994 RTP anticipates significant funding shortfalls over the next twenty years. Short-term needs of $72 million, intermediate-term" needs of $84 million, and long-term needs of $54 million total $209.2 million (Nevada County Transportation Commission 1995a). As the RTP notes, however, "The regional travel demand model is not designed to analyze improvements for intersections" (Nevada County Transportation Commission 1995b). The impact of development upon intersections—which are a primary determinant of LOS and congestion—have therefore not been fully considered in the needs identification process. The $209.2 million estimate cited is therefore probably low, and only $72.5 million in likely revenues have been identified to cover those costs. The $136.7 million shortfall is nearly two-thirds the anticipated need even without additional costs for intersection improvements.

Future development under the Nevada County General Plan is therefore likely to result in significant degradation of LOS for most of the roads in the county. The 1994 RTP analyzes daily LOS standards for all of the major highways and arterials in the county both "with" and "without" identified improvements, and many of the roads have LOS ratings of F (the lowest possible) without the improvements (Nevada County Transportation Commission 1995c). Even with the improvements, however, many roads retain LOS ratings of C or D. These improvements often involve expansion of two-lane roads to four lanes, which increases road capacity and speeds. Highway 49 from Alta Sierra Drive to McKnight Way does not rise above an F rating even with improvements and expansion to four lanes.

Due to the uncertainty about funding for improvements, the air quality impacts associated with buildout under both the Nevada and El Dorado County General Plans is likely to be greater than that anticipated in the DEIRs. Increased congestion, particularly following "cold starts" by commuters, is likely to result in significant increases in hydrocarbons, nitrogen oxides, and carbon monoxide (especially at intersections). El Dorado County is part of the Sacramento Metropolitan Air Quality District, which is a nonattainment area and therefore subject to greater regulatory oversight. Nevada County is part of the Northern Sierra Air Quality District, however, and receives less scrutiny under both the federal Clean Air Act of 1990 and the state Clean Air Act of 1988. Modifications to air-quality regulations and/or the boundaries of the districts (especially since a significant part of Nevada County's locally generated emissions appears to be due to commuting) could result in future constraints on land use due to "indirect source" air-quality impacts.

Water Quality

Development under the General Plans must address disposal of liquid wastes through either centralized sewage treatment or on-site septic systems. As discussed earlier, the economics of infrastructure investment have led to reliance on sewage treatment only when settlement densities are high enough to allocate the high fixed costs across many users. Some of the existing sewage collection systems in Nevada and El Dorado Counties date from the nineteenth century, and most of the wastewater treatment plants (WWTPs) in the area were constructed since passage of the federal Clean Water Act in 1972. Federal and state grants financed the first round of projects throughout the 1970s, then federal and state funding sources shifted to low-interest loans rather than grants in the 1980s. Even these loan funds are now diminishing in the face of significant state and federal budgetary contractions, which could force future WWTP investments (and maintenance of depreciating existing systems) to be sustained by WWTP users. All wastewater dischargers must acquire a permit from the Regional Water Quality Control Board (RWQB) of the state of California under the National Pollution Discharge Elimination System (NPDES), which was established under the Clean Water Act in 1972 and is technically administered by the federal Environmental Protection Agency (EPA). California's Porter-Cologne Act of 1970 also establishes receiving water standards, an approach that was adopted in part by the federal Water Quality Act of 1987 (Richardson 1992–94). Section 319 of the 1987 act also establishes stricter requirements for the use of "best management practices" (BMPs) for the control of non-point-source (NPS) pollution (Thompson 1989). Possible NPS sources associated with the General Plan include erosion and sedimentation from construction activity and surface water contamination from septic systems.

El Dorado County has three major NPDES permits and four minor permits outside the Lake Tahoe Basin: Deer Creek (2.0–2.5 million gallons per day [mgd]), El Dorado Hills (1.0–1.6 mgd), and Hang Town in the city of Placerville (1.0–1.6 mgd) are major dischargers, while the Dunlap Ranch, Sierra Pacific Lumber Company, Wetzel-Oviatt Lumber Company, and the El Dorado Hills Community facilities operate under minor NPDES permits. The major permits require more frequent monitoring and are subject to somewhat greater scrutiny by the RWQCB. Nevada County has five major permits and five minor permits: Donner Summit (0.5–1.0 mgd; capacity to be upgraded to 2.0 mgd), Lake of the Pines (0.7–1.1 mgd), Lake Wildwood (1.1 mgd), Grass Valley (1.7 mgd), and Nevada City (1.3 mgd) are major dischargers, while Penn Valley (0.1 mgd), Cascade Shores (0.025 mgd), North San Juan (0.025 mgd), Mountain Lake (0.015 mgd), and Gold Creek Park (0.015 mgd) operate under minor permits. The last two cases are particularly interesting, because they service private subdivisions that are quite distant from major WWTP facilities. This highlights the potential for higher-density development in areas with limited capacity to handle septic systems even when not contiguous to existing urban areas. Higher land values will probably make this more common in the future.

The allowable flows noted for each of the NPDES permits are for "average" conditions, which are difficult to define and relatively rare in the hydrologic regime of the Sierra Nevada. In particular, many of the older systems suffer from significant "inflow and infiltration" (I & I) problems due to stormwater flows into the WWTP in the winter and spring. These flows often overflow the WWTP and result in raw sewage spills into surface waters. The California Department of Fish and Game (CDFG) is especially concerned about the impacts of WWTP operation on aquatic biota, but enforcement under the Fish and Game Code has been difficult in the absence of adequate monitoring (Lehr 1995). The RWQCB has attempted to deal with the problem through new permit requirements and selected application of "cease and desist" orders limiting additional sewer hookups (CVRWQCB 1989, 1992). In some cases, however, improvements to existing WWTPs have only occurred with state or federal financing. As noted earlier, such financing may be less likely in the future. This could become a serious problem for existing facilities as they become older and less reliable, for the fee increases necessary to renovate facilities could be extremely high. Recent funding for improvements to the Cascade Shores facility (east of Nevada City) are costing over $18,333 per parcel and over $30,000 per existing home. The state is paying $1.7 million of the costs and offering a 20-year loan of $225,000 to get the plant operating. Users will only have to repay the loan. The improvements are unlikely to have occurred without the state grant, and water-quality problems would have continued (Lauer 1995c, 1995b).

Development under the General Plans will probably be associated with some septic system failures on substandard existing parcels, which will lead to increased demands on existing WWTP capacity. These increased demands, together with discharges from new WWTPs designed and built to serve higher-density developments, could have dramatic impacts on hydrologic regimes. Dilution associated with existing natural surface-water flows could be reduced as effluent becomes a larger fraction of overall flows (EIP Associates 1995). This could result in impacts on ecological processes, recreational access, and public health in existing surface waters. Wastewater flows could significantly increase in-stream flows during drought periods of summer and autumn, while sewering existing septic systems could reduce ground-water and surface-water flows in other areas. Potential septic system failures could also result in ground-water contamination and increased demands for potable water supplies for domestic use.[78] Diversions associated with meeting that demand for domestic supply could in turn result in impacts in other watersheds.

Septic system failures have been documented in Nevada and El Dorado Counties since at least 1970 due to the poor site quality of many soils (Davis 1994; Cranmer Engineering and Halatyn 1971). Almost all classified soils in Nevada, El Dorado, and other Sierra Nevada counties have been rated with a "severe" soil limitation rating for standard conventional deep trench septic systems due to shallow depth to bedrock (less than 4 ft), steep slopes (more than 9%), slow soil permeability, rock outcroppings, and/or high shrink-swell potential (Nevada County Planning Department 1994b). The Sierra Nevada also has tremendous soil and topographic variability, however, so septic suitability is not well characterized by the large-scale (1:20,000 or 1:24,000) soil surveys prepared by the Soil Conservation Service (SCS). A more careful overlay of topography and soil types indicates that certain regions are suitable for septic tank systems, particularly if proper maintenance standards and ongoing monitoring are enforced. Higher land values also make alternative systems more feasible, making some "unbuildable lots" suitable for building with alternative systems. Standard systems cost $3,000 to $4,000, but typical installation costs range from $6,000 to $8,000 in Nevada County. Advanced sand filter systems run between $12,000 and $20,000 (Sage 1995). The failure of existing septic systems could therefore necessitate significant additional investment in on-site infrastructure if significant water quality impacts are to be avoided. Unfortunately, the potential for widespread septic system failures has not been well studied in the DEIRs for the General Plans. It is therefore difficult to estimate either the environmental or economic impact of potential septic system failures under the General Plans at buildout. The DEIR for the Nevada County General Plan called for a detailed study of this issue as a mitigation measure, but it was not used to formulate the land use designations in the General Plan itself. The background assessment work simply has not been completed.

This is only a brief overview of the ecological, technical, and economic constraints associated with water quality, water supply, and wastewater disposal issues associated with development in Nevada and El Dorado Counties. These issues are described in more detail in Megatelli and Duane (1995), which summarizes the results of our assessment of these issues.

Fire Safety

One of the most serious but least understood impacts of buildout under the General Plans is the impact on fire safety. Human settlement is associated with fire ignitions and modifies the suppression strategies for wildfire fighting in the urban-wildland intermix zone (Irwin 1987, 1989). Higher-density developments that are dominated by the built environment are less threatened by this impact, but their proximity to wildlands in an "edge" environment could still increase ignition risks (e.g., due to children playing with matches, sparks from motorcycles, etc.). Lower-density developments are both difficult to protect and difficult to evacuate. The presence of structures in the urban-wildland intermix zone alters suppression strategies and complicates sharing of fire-management responsibilities among local, state, and federal agencies. In particular, resources (e.g., firefighters, water, and equipment) are often allocated to the protection of individual structures and public safety rather than protection of wildland resources. This could result in both greater wildland resource damage and significantly greater fire-suppression costs. Finally, the presence of human settlement affects the viability of many presuppression fuel-management options. The specific patterns of human settlement that are likely to occur under the General Plans are therefore likely to have a significant impact on fire regimes in the Sierra Nevada.

The greatest risk, due to the many substandard lots and roads that have been grandfathered under the General Plans, is to public safety. Evacuation difficulties along the steep, narrow streets of Nevada and El Dorado Counties are likely to be similar to those experienced in the tragic Oakland and Berkeley hills fire of October 1991. New state standards adopted after that fire in 1992 apply only to new subdivisions, yet much of the development expected to occur under the General Plans will occur either on existing parcels or through "minor" subdivisions that are exempt from the Subdivision Map Act. The fire risk is an area that needs considerably more analysis than that in either of the DEIRs. In particular, the DEIR for the Nevada County General Plan incorrectly relies upon the General Plan land use designations to evaluate the fire risks associated with the General Plan. As noted earlier, existing parcelization makes that a dangerous assumption. El Dorado County has adopted a more stringent set of fire safety standards for new developments, but our analysis of their application in the Cinnabar Ranch project suggests that considerably more work is necessary in order to mitigate fire safety risks associated with human settlement. Alternative settlement patterns could reduce some of those risks.

Government Services

In addition to the specific funding needs identified in the DEIRs for physical infrastructure (e.g., roads, sewers, and water), development under the General Plans will affect local government revenues and local governments' capacity to provide ongoing services. These include police and fire protection, general administration, public health, planning, libraries, and the other costs of local government. The relationship between land use patterns and future revenues and costs is difficult to forecast, however, due to the instability of state and federal budget mechanisms in recent years. This has been true at least since the passage of Proposition 13 in 1978, which reduced property tax rates in California and limited the rate of increase in assessed property values. The problem has been exacerbated in the 1990s by a severe statewide recession that has resulted in greater claims by the state on local revenues. Finally, the slowdown in construction activity within the Sierra Nevada has dampened the "boost" that new construction brings to average assessed values and property taxes. General fund revenues have consequently fluctuated wildly.

Together, these conditions have made local governments increasingly reliant on growth and fees to pay for basic services. Unfortunately, growth in the cost of providing these basic services appears to have been greater than growth in local revenues. Development fees do not generally cover the full cost of providing even physical infrastructure, let alone libraries and sheriff's deputies. This situation is symbolized by the Nevada County Library, a spacious new building (built largely with state funds) that has many empty shelves. The old Nevada City library, now the county historical branch, is open only nine hours each week. Buildout under the General

Plans is not anticipated to alleviate this situation, although demand for local government services is expected to grow. Continuing degradation in the levels of service (LOS) for many of these government services is therefore a likely outcome under the General Plans.[79]

The level of these impacts has resulted in challenges to the final EIRs that were adopted by both counties in 1995. Appellants claimed that the EIRs were inadequate under CEQA due to a failure both to consider alternatives that could reduce the level of impacts and a failure to adopt specific mitigation measures that include changes to the land use maps. El Dorado County has since modified both the language and land use designations of the 1994 Final Draft General Plan and released a supplemental EIR that will include consideration of a lower-growth alternative that has less environmental impact. Most of the changes appear to increase allowable development densities and decrease requirements for comprehensive consideration of the environmental effects of development under the General Plan. In particular, the LOS standards for many of the roads in the county were reduced to a lower level. References to regional coordination for air-quality and transportation planning have also been deleted, along with many requirements for development of an integrated recreational trail system and public parks. The new board of supervisors also fired the director of the El Dorado County Planning Department following its rejection of an internally prepared “low growth alternative” to the existing General Plan. Legal counsel has been retained by the board in order to prepare for litigation on the General Plan and the final EIR, which is likely soon after the General Plan is adopted (Rivas 1995; Griffiths 1995).

The Nevada County Board of Supervisors recently rejected an appeal of its final EIR after the Nevada County Planning Commission eliminated many of the draft EIR mitigation measures in its deliberations. The board of supervisors then adopted some of those same mitigation measures as changes to the General Plan itself on October 13, 1995 (Mooers 1995). Final adoption of the El Dorado County General Plan was not expected until late 1995 or early 1996, so we have had to limit our analysis and discussion to the Final Draft General Plans released in 1994 and the DEIRs circulated for review in early 1995. Our findings would certainly be modified by the subsequent action on both of the General Plans in 1995, but we were unable to revise our analysis to incorporate those changes. In general, however, the changes made by both counties since release of the DEIRs are likely to increase the unmitigated environmental impacts of the revised General Plans. Infrastructure funding shortfalls are also likely to be exacerbated by the changes. The exception to this generalization is the decision by Nevada County supervisors to eliminate the “new town” site and to reduce average densities in some areas. They made no changes to the land use map, however, to account for existing parcelization and underestimation of future growth.

Modeling the Spatial Patterns of Future Human Settlement

Our assessment of historic population growth, projected population growth, land use planning, and the development process associated with human settlement is intended to provide the basis for estimating the ecological, social, and economic consequences of human settlement in the Sierra Nevada. The spatial pattern of future human settlement is one important determinant of these ecological, social, and economic consequences. We therefore attempted to model the spatial patterns of future human settlement for the entire Sierra Nevada through a series of relatively simple models for allocating the CCD-specific population growth forecasts for 1990–2040.

For our simplest spatial model of density-dependent population growth, we developed a series of future population counts for census blocks based upon a “contagion” model of contiguous development that was estimated as a function of two density-dependent growth factors: (1) a measure of the density of census blocks adjacent to each census block; and (2) the housing density of each census block. The first factor was calculated as a function of the area-weighted density of each adjacent census block and the fraction of the total perimeter of each census block adjacent to each adjoining census block. Larger, denser adjacent census blocks with a greater fraction of adjoining perimeter were therefore assumed to exert a greater influence on future development pressure than smaller, less dense adjacent census blocks with a smaller fraction of adjoining perimeter. The second factor, census block density-dependent growth, was then calculated based upon the positive half-period interval of a sine curve.

The general formula for a sine curve is

$$f(x) = A \sin [(2 * pi / B)(x - C)] + D$$

where

f is the height of the curve (growth rate)

A is the amplitude of the curve (maximum growth rate)

B is the period of the curve (0.5 * B is the positive interval of the sine curve)

C is the horizontal shift from the origin (minimum density threshold)

D is the vertical shift from the origin (minimum growth rate)

x is the horizontal distance from the origin (density) where

$\{ x$ if $x <=$ threshold;

$x = \{$ threshold if $x >$ threshold and threshold $< [(0.5 * B) - C]$

In each county there were a few blocks with extremely high housing densities, usually corresponding to prisons or other institutions. To ensure that they did not skew the distribution along the interval, an additional maximum threshold was applied to the density values prior to calculation. This allowed us to use a smaller period and therefore obtain a wider spread for most of the densities.

Our use of a sine function rests on the implicit assumption that maximum growth will occur at intermediate levels of existing density. This assumption allows for noncontiguous growth to occur through "metastasis" as well as direct "contagion" through density proximity. By varying the portion of the positive half-period interval that we used, we were able to vary the density at which maximum growth would occur. We also tested alternative models that had increasing and decreasing rates of growth as a function of density. Neither linear nor nonlinear formulations of these model specifications yielded satisfactory results, however, that allowed any useful spatial differentation across the landscape for further assessment of ecological impacts. We therefore focused on the sine function model to derive results that demonstrated differential landscape changes.

To implement the sine model, we wrote a program (in the PERL computer language) in which B, C, and D were fixed for the entire region for each run and A was determined through an iterative process for each CCD such that the calculated population increment when summing across all blocks in a CCD was within 1% of the population increment determined from our analysis of the DOF forecasts. The following steps describe the process we developed for each CCD:

1. For the first iteration, an arbitrary amplitude of three times the average growth rate for the CCD was used.
2. The formula was then applied to all populated blocks in the CCD, on the empirically reasonable assumption that nonpopulated blocks are in the public domain and not likely to experience population growth.
3. A running total of the population increment of all blocks was maintained.
4. Once all blocks had been processed, the total resulting population increment was compared to the estimated population increment for the CCD from the DOF forecasts.
5. If the calculated increment was greater than the DOF estimate, the amplitude was lowered by an amount proportional to the difference between the two, or vice versa if the calculated increment was less than the DOF estimate.
6. This process was repeated until the calculated increment and estimated increment were within 1% of each other.
7. Population increments for each block were then converted to housing density increments based on the mean household size for each housing density class across the entire Sierra Nevada region.

Unfortunately, our attempts at spatial allocation of population growth based on this sine function model did not generate empirically satisfying results at the spatial scale of census block polygons. It proved impossible to generate a growth rate curve that allocated the population in a reasonable fashion such that no set of census blocks received unreasonably large shares of the growth. We were therefore unable to develop a reasonable spatial allocation of the 1990–2040 forecasts at the census block scale.

There are two characteristics of the census block polygons that help explain our difficulties. The first is the relatively nonuniform distribution of existing housing densities in the census blocks. Most clusters of housing units are contained in small, dense polgyons, with surrounding areas represented as large, sparsely settled polgyons. This situation is not apparent in our reported distribution of population by density class due to the exponential fashion in which we defined our density classes. (We suspect we would have achieved better results with an exponential scaling of housing density as the dependent variable rather than the linear scaling that we used in the sine function modeling, but we did not have adequate time to test this alternative specification.)

The degree of correlation between size and density in the census block polygons themselves represents a second complication for forecasting. Already densely settled areas are apportioned into small polygons, while less densely settled areas are apportioned into relatively large polygons. Census block polygons are therefore not randomly distributed across the landscape but are already correlated with density by size. As we added population to the polygons, the overall picture of growth would become increasingly unrealistic because additional population would appear spread throughout these polygons, while due to their large size they would register relatively minor changes in density.

These complications led us to develop an alternative conceptual model for spatial allocation of the 1990–2040 CCD growth forecasts in future modeling. Our next attempts will be based on a raster model, in which the landscape is divided into small cells of fixed size. The raster model offers several advantages over a vector model:

- Processing of raster-based models is much quicker than processing of vector-based ones, due to the simplicity of the raster data model as represented in digital form. This speed advantage will allow us to repeat a greater number of more complex permutations of our analysis scheme.
- Incorporation of natural factors such as slope, soil type, and vegetation, which tend to be highly heterogeneous over a landscape and best represented in raster form, is facilitated by the use of the raster model for the analysis itself.
- The small, fixed cell size of the raster representation eliminates the problems we experienced using the census block polygons and will allow us to allocate population and settlement growth more precisely in response to both local and adjacent factors.

The first step in implementing the raster model was to convert the vector-based census block coverage to raster form.

We chose a cell size of 30 m (98 ft) to be consistent with the elevation and slope data we will also use in the future. Figure 11.46 shows an area near Grass Valley and Nevada City in census block converted from census block polygon (vector) densities to raster-based densities using the 30 m grid size.

Part of our new allocation model stipulates that new development is dependent on existing adjacent densities (i.e., low-density areas in proximity to high-densities areas will be subjected to highest growth pressure). This assumption reflects an implicit economic model of the costs of extending infrastructure, which we will also be testing explicitly in the future. To develop a measure of adjacent density, we calculated a "focal mean" for each cell in the map. The focal mean represents an average density value for all cells within a 300 m or 10-cell radius of any particular cell. The choice of 300 m is arbitrary. We can and will also test alternative radii for derivation of focal mean density values in the future. Figure 11.47 shows the focal mean density representation (based upon the 300 m radius) for the same area near Grass Valley and Nevada City.

The simplest analysis that we can then perform is to select a threshold value for the focal mean density as defining a high degree of settlement, which yields a set of smoothly shaped areas on the map. Figure 11.48 shows the difference in density values between existing 1990 housing densities and the focal mean density value for each grid cell.

To identify preliminary areas for infill, the existing density is merely subtracted from the focal mean density. Figure 11.49 shows areas likely to experience infill using this model of proximate density as the basis for determining likely development patterns.

We were unable to apply this modeling approach to the entire Sierra Nevada, but our preliminary exploration of its specification offers promise for future application. We must therefore rely upon coarser estimates of land conversion for 1990–2040 in this assessment. Spatially explicit characterizations of future patterns of human settlement are possible at this time only for Nevada and El Dorado Counties, where General Plan land use maps have been digitized. We have therefore had to limit our estimates of land conversion for human settlement from 1990 to 2040 to the CCD-specific analysis described in the next section.

Land Conversion Estimates for Human Settlement from 1990 to 2040

The total land area converted to human settlement to accommodate 1990–2040 growth will depend upon the spatial pattern and average density of settlement, which will in turn depend upon the complex interaction of public policy, infrastructure, and land economics. Strict development controls, significant expansion of water and sewer systems, and higher land prices would likely lead to a more intensive pattern of development with less land conversion than would occur in the absence of those conditions. Continuing existing patterns of development would consume more land than could be achieved under those conditions. The ecological implications of continuing existing patterns of development and a range of alternative potential growth management policy mechanisms for mitigating those impacts are discussed in outline later.

Without assuming any specific linkages to specific policies or market conditions, we considered six alternative distributions of future population by housing density class. These were based upon our GIS analysis of the distribution of population by housing density class under the following:

1. 1990 Sierra Nevada census blocks
2. 1990 Nevada County census blocks
3. 1990 El Dorado County census blocks
4. Nevada County General Plan
5. El Dorado County General Plan Project Description (EDCGPPD)
6. El Dorado County General Plan Alternative (EDCGPA)

The three General Plan distributions were based on the planimetric estimates of area designated for buildout at specific density classes in the General Plan land use maps but did not account for the higher levels of density that are likely due to existing parcelization. Table 11.A14 in appendix 11.1 shows the distribution of population by housing density class for each alternative.

We then considered four alternative future growth projections from 1990 to 2040 for each of the fourty-six CCDs in our analysis:

1. Based on each CCD's 1970–90 share of overall county growth (DOF7090)
2. Based on each CCD's 1970–80 share of overall county growth (DOF7080)
3. Based on each CCD's 1980–90 share of overall county growth (DOF8090)
4. A lower projection at two-thirds the DOF7090 projection, which was the approximate absolute growth rate historically 1970–90 for the entire Sierra Nevada (HISTORIC).

Combined with the six alternative population distributions by density class, these four alternative population projections for 1990–2040 result in twenty-four possible 2040 land-conversion estimates for each of the forty-six CCDs in our analysis.

The resulting 1,104 cells of land-conversion estimates are a bit overwhelming for presentation, however, and many of the population distributions by housing density class are similar to one another. We therefore simplified the set to four scenarios:

FIGURE 11.46

Housing density, Grass Valley–Nevada City area, 1990.

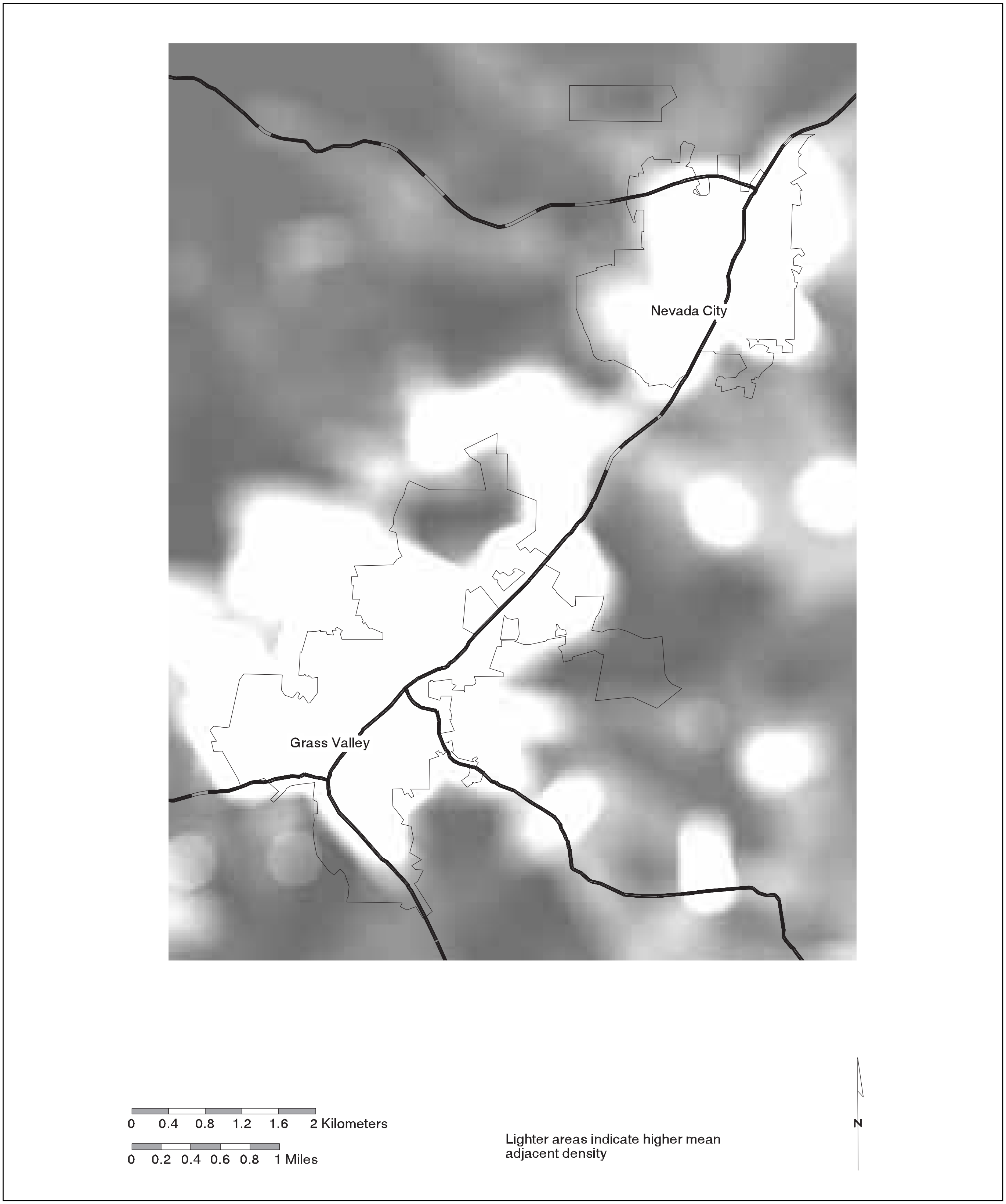


FIGURE 11.47

Focal mean housing density, Grass Valley–Nevada City area, 1990.

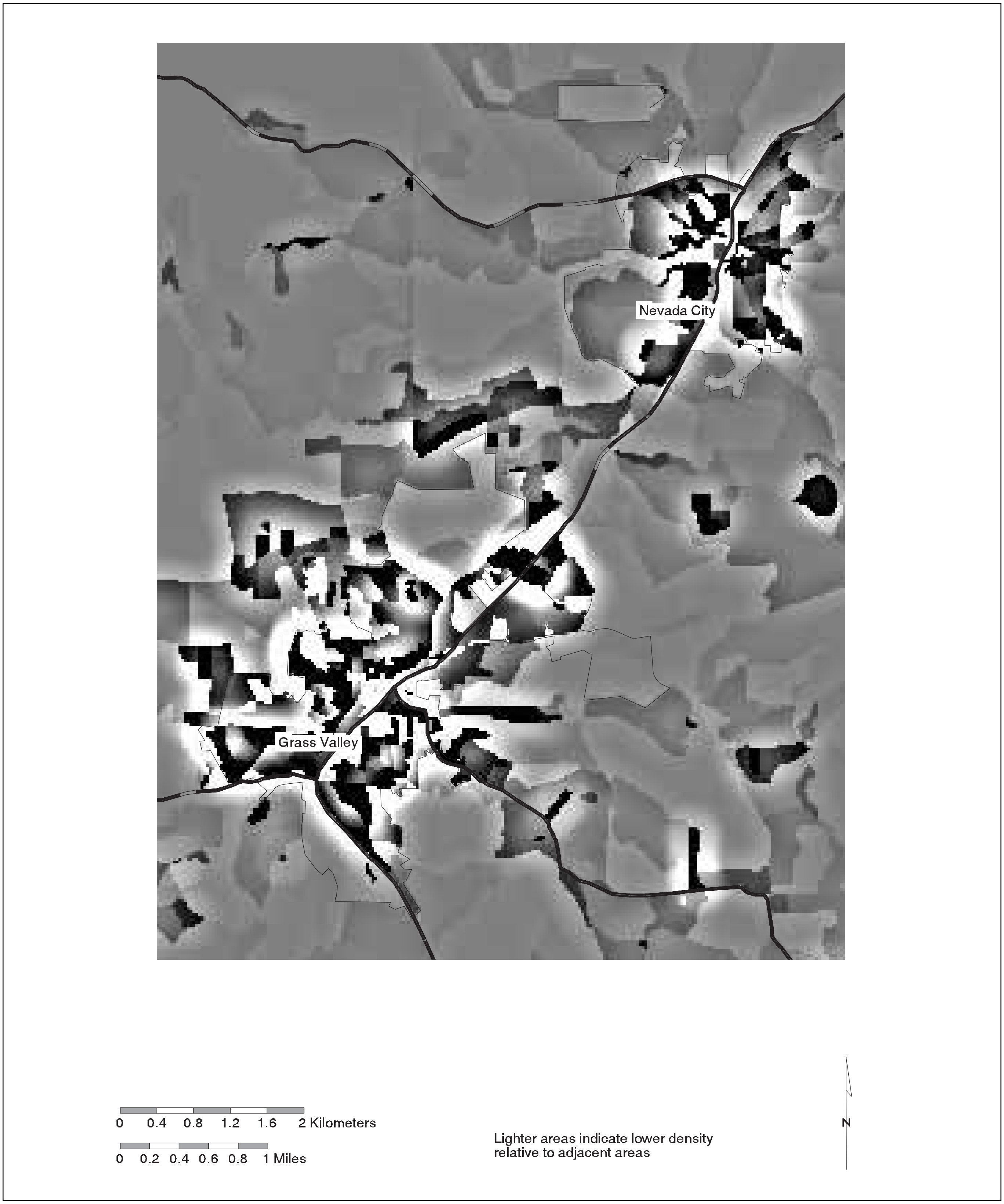


FIGURE 11.48

Difference between point and adjacent housing density, Grass Valley–Nevada City area, 1990.

FIGURE 11.49

Opportunities for infill development, Grass Valley–Nevada City area, 1990.

Scenario A: low population growth with compact human settlement patterns (Low-Compact)

Scenario B: high population growth with compact human settlement patterns (High-Compact)

Scenario C: low population growth with sprawling human settlement patterns (Low-Sprawl)

Scenario D: high population growth with sprawling human settlement patterns (High-Sprawl)

The most compact population distribution was the Nevada County General Plan, in which 71.34% of the population is accommodated in the highest housing density class (640 or more dwelling units per square mile). Note that this is a significantly higher fraction of the population than there was living in this class in 1990, when Nevada County's distribution was not significantly different than that for the entire Sierra Nevada. The much more compact distribution assumed in the Nevada County General Plan still consumes roughly a quarter-acre per person in the highest housing density class, moreover, in an average of roughly two dwelling units per acre. This "compact" pattern is therefore considerably less dense than most suburban subdivisions in metropolitan areas. We believe this reflects a bimodal distribution within this density class, where there are clusters of parcels close to one acre in size (with on-site domestic well water and on-site wastewater disposal through septic systems) and around a quarter-acre in size (with public water and sewer). Unfortunately, we were not able to disaggregate housing density below this level for our analysis. Doubling the average density for this class (through an infrastructure-directed development strategy) could reduce the land-conversion estimates for the compact scenarios by 50% in the highest-density class. It would have little effect, however, on the total land area converted by human settlement at any of the lower thresholds for human settlement. As noted in our more detailed analysis, the Nevada County General Plan also underestimates the amount of land that is likely to be developed at lower densities due to existing parcelization. Our quarter-acre-per-person estimate for the highest housing density class is therefore a reasonable basis for estimating the land-conversion effects of compact human settlement patterns across the entire Sierra Nevada.

The most dispersed (sprawling) population distribution was the 1990 Sierra Nevada census block distribution, in which 39.49% of the population resided in the highest housing density class. We therefore assumed continuation of this existing distribution across all CCDs in the Sierra Nevada for our sprawl scenarios of human settlement. This allowed us to estimate the total land area required in each CCD to accommodate 1990–2040 population growth if existing patterns of human settlement were to continue. Land tenure relationships constrain the potential to expand the land area converted to lower housing density classes, however, so the lower housing density classes generally increase their average densities within their density ranges rather than expand in area (e.g., land in the class of ten to twenty dwelling units per square mile might move from twelve dwelling units to eighteen dwelling units). We have therefore estimated land converted to human settlement only above the density threshold of twenty dwelling units per square mile (32 acres per dwelling unit).

Based upon these four scenarios, the range of additional land-conversion required to accommodate population growth from 1990 to 2040 (beyond the land area already converted for human settlement in 1990 that was reported earlier) is estimated to be

- 106–579 mi^2 at an average density of at least 640 units per square mile
- 299–875 mi^2 at an average density of at least 160 units per square mile
- 480–1,655 mi^2 at an average density of at least 80 units per square mile
- 477–2,957 mi^2 at an average density of at least 40 units per square mile
- 134–5,105 mi^2 at an average density of at least 20 units per square mile

The Low-Compact scenario (A) always represented the lower bound of our range and the High-Sprawl scenario (D) always represented the higher bound of our range, with the exception of the 640 or more dwelling units per square mile threshold. These two extreme scenarios resulted in approximately the same land area conversion in the latter case, while the Low-Sprawl scenario (C) resulted in the least land-conversion and the High-Compact scenario (B) resulted in the most land-conversion. This primarily reflects the fact that the compact scenarios concentrate 71.34% of the total population into the highest housing density class. The compact scenarios therefore result in more land area converted to human settlement in the highest housing density class, but they still result in less land area converted to human settlement in all of the other housing density classes. This is made clear at all of the other density thresholds. Figure 11.50 shows the total land area converted to human settlement in the Sierra Nevada in the year 2040 (including land already converted in 1990) for each of the four scenarios at each of the density thresholds.

These estimates of land conversion associated with human settlement 1990–2040 are not uniform throughout the Sierra Nevada. They reflect the distribution of population forecast by the DOF for each county and the allocation of that population by our allocation models to each of the CCDs in our analysis. In general, the land most likely to be converted to human settlement is primarily in the western foothills and within commuting distance of rapidly growing cities in the Central Valley. Some specific vegetation (Holland) types and Wildlife Habitat Relationship model (WHR) types are therefore more

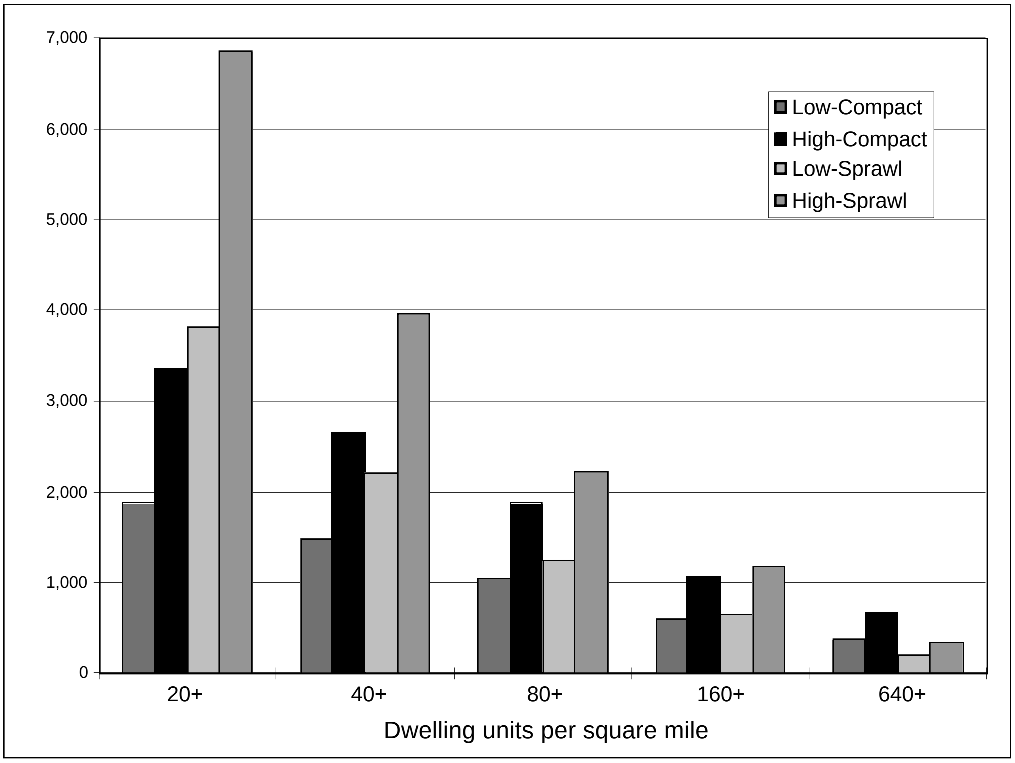


FIGURE 11.50

Land area converted to human settlement in 2040 by housing density class thresholds (square miles).

threatened by human settlement than others, reflecting the nonrandom spatial distribution of growth, private ownership, and vegetation. More spatially explicit analysis is necessary to determine the effect of specific patterns of human settlement on specific vegetation (Holland) types and WHR types. As noted earlier, we were unsuccessful in our attempt to develop a general model for spatially explicit allocation of 1990–2040 population growth.

We disaggregated vegetation (Holland) type and WHR type data by CCD in order to complete more detailed analysis of the relationship between projected land conversion and specific ecological features. Unfortunately, similar disaggregation by river basin or watershed was not possible, because the CCD boundaries often cut across watersheds. The CCDs are large analytic units, so it is impossible to infer land-conversion estimates for specific vegetation (Holland) and WHR types or watersheds without a spatially explicit model of human settlement that allocates the 1990–2040 population forecasts. We can nevertheless identify those vegetation (Holland) or WHR types that could be converted by human settlement on the private lands within each CCD with the CCD-level data. We were unable to complete such an analysis for all of the CCDs and vegetation (Holland) or WHR types for the forty-six CCDs in the Sierra Nevada, but all of our disaggregated data are available in dBase and Excel format from the California Environmental Resource Evaluation System (CERES) project of the Resources Agency of the State of California (http://ceres.ca.gov/snep), and the Alexandria Project at the University of California, Santa Barbara (http://alexandria.sdc.ucsb.edu/), for further analysis in the future.

Ecological Implications of Land Conversion for Human Settlement

The ecological implications of land conversion expected for human settlement from 1990 to 2040 in the Sierra Nevada will depend upon the spatial patterns of human settlement and the distribution of land conversion by vegetation type, wildlife habitat, watershed, slope, elevation, and a wide range of other natural factors. The specific effects of alternative patterns of human settlement are still poorly understood, although preliminary estimates of the relationship between settlement density and vegetation change have been characterized in McBride et al. (1996). Significant additional empirical work is still necessary to project the ecological impacts of future landconversion, but we can outline the range of possible impacts based upon the literature (Peck 1993). Here we offer a partial summary of the ecological implications of land conversion for human settlement.

Land conversion causes at least five direct effects on vegetation and wildlife:

1. Reduced total habitat area through direct habitat conversion
2. Reduced habitat patch size and increased habitat fragmentation

3. Isolation of habitat patches by roads, structures, and fences
4. Harassment of wildlife by domestic dogs and cats
5. Biological pollution from non-native vegetation alleles

Reduced Total Habitat Area through Direct Habitat Conversion

Reduction of habitat is the most apparent effect of development, but low-density development may not actually result in significant reduction in total habitat area. The actual building site and associated construction impacts may cover only one-fourth of an acre, for example, plus up to another quarter acre for access roads, septic system leach lines, and a domestic water well. This density level could indeed result in denaturation of up to 25%–50% of a 1 acre parcel but only 5%–10% of a 5 acre parcel. We estimate that the direct effect of low-density exurban development is probably a reduction in total habitat area by around 20% (10%–30%). Some specific habitats are disproportionately threatened with reductions in area, however, for they lie in the path of most exurban development. This fact reflects the underrepresentation of many vegetation types on land in public ownership (e.g., blue oak woodland in the Sierra Nevada foothills) and the overrepresentation of a limited number of ecosystems (e.g., “rocks and ice” of alpine wilderness preserves in the Sierra Nevada high country). The gap analysis (Scott et al. 1991) completed for SNEP (Davis and Stoms 1996) highlights specific vegetation types that are most likely to be affected by human settlement on private lands in the Sierra Nevada (most notably in the western foothills). Direct reductions in total habitat area can be significant for many rarer habitat types or those that have already suffered significant reductions in total area.

Reduced Habitat Patch Size and Increased Habitat Fragmentation

Even when reductions in total habitat area are limited, the average patch size of remaining habitat is reduced significantly with low-density exurban sprawl. Depending upon how edge effects are evaluated (e.g., distance from roads and structures), average patch size can drop from thousands of acres to less than an acre (e.g., if the entire area is fragmented into 1 acre building lots). The negative consequences of habitat fragmentation are well known theoretically and documented in a number of specific cases for both tropical and temperate regions (Harris 1984; Adams and Dove 1989; Gilpin and Soule 1986; Wilcove et al. 1986; Lovejoy et al. 1986; Soule 1991b). The distribution of patch sizes also typically shifts from a few large-sized patches to a pattern in which only a small fraction of the total number of patches for any given habitat remain large enough to support viable populations of many species. Those may be the only patches that remain “effective habitat,” despite both the continued existence of many patches with similar vegetation and a relatively small reduction in total habitat area. Total area may decrease only 20%, but effective area may decline by more than 90% at buildout. Roads are probably the single biggest source of habitat fragmentation in exurban areas.[80]

Isolation of Habitat Patches by Roads, Structures, and Fences

Neither total habitat area nor the distribution of habitat among patches of various sizes is an adequate description of the changes that may occur in the landscape matrix as a result of exurban sprawl. The way patches connect with one another is an important factor determining the effective habitat available for wildlife use and gene transport (Defenders of Wildlife 1989; Hudson 1991; Noss 1991; Soule 1991a), which is a critical determinant of population viability (Soule 1986; Gilpin and Soule 1986; Pimm 1986). One of the most significant impacts of low-density exurban sprawl is therefore the isolation of habitat patches by roads, structures, and fences. Of course the effect of each depends upon the specific life histories of each species affected. Structures can usually be avoided by most wildlife at densities of less than one unit per acre, and they do not constitute significant barriers if dispersed among adjacent parcels. Fences can serve as significant barriers for many mammals and reptiles, but they appear to constitute a relatively low barrier to the migration of birds and invertebrates or the transport of genetic material from most vegetation. Roads are probably the single most important barrier to both wildlife and genetic movement between habitat patches, just as they are the most important source of habitat fragmentation and edge effects. Unfortunately, transportation planners rarely consider the effects of transportation network design upon native biological diversity. Further research and education (of both the public and transportation planners and engineers) are necessary to develop transportation network designs that minimize these impacts.

Harassment of Wildlife by Domestic Dogs and Cats

Even if wildlife can avoid residential structures, they are often unable to avoid harassment by domestic dogs and cats. These pets extend the effective area of human settlements to a degree that development could form a significant barrier between and/or reduce the effective habitat of adjacent habitat patches. It is difficult to estimate the “dog-shed” or “cat-shed” associated with this effect, but it can be quite large. Many exurban properties have limited lawns and limited fencing, and leash laws are usually only loosely enforced. The result is that both dogs and cats are able to roam freely throughout the exurban matrix as long as they avoid conflict with humans. The range of dogs can easily be several miles in a single day, making most of the settled portion of the exurban matrix subject to the effect of dogs. Michael Soule has documented the apparent effect of cat predation on birds in the urbanizing areas of northern San Diego County (Soule 1991b), and harassment from dogs is known to affect many species that are common in areas facing rapid exurban growth.

Dogs and cats can also be a source of seed dispersal of non-native plants (discussed later) and can be a source of disease for native wildlife. Other pets or domesticated animals (e.g., cattle or sheep) can also be disease sources that can decimate native wildlife populations (e.g., ungulates). This effect could be important when seasonal migrations occur (Yuba County Community Services Department 1985; Peck 1993).

Biological Pollution from Non-native Vegetation Alleles

The risk of "biological pollution," or genetic contamination, is a concern both for non-native invasives (e.g., Scotch broom) and for nonlocal stock of species that are native to an area (e.g., Douglas fir). In the first case, the invasive species can outcompete and displace some native species, modifying the vegetative structure to a degree that affects other species and the entire landscape matrix. A sun-tolerant species may invade a recently opened forest area, for example, displacing an entire succession of species that would normally have occurred in the absence of that species. The specific species being displaced is therefore not the only one directly affected. The second instance is more subtle and much more difficult to evaluate: genetic hybridization may occur or the population with the nonlocal alleles may outcompete the local alleles. The apparent structure of the landscape matrix may not change as a result, but the genetic information contained in the resulting matrix will be different than the information in the native matrix. This change may then diminish the capacity of the entire system to respond to some significant disruption (e.g., global climate change) in the future. To the degree populations are determinants of the long-term viability of Sierra Nevada ecosystems, it may be just as important to protect against nonlocal genetic contamination as it is to minimize the risk of invasive non-natives. Considerably more research must be completed before we can confidently determine the relative importance of particular populations (Medbury 1993).

In addition to these direct effects upon vegetative composition, structure, and function (which in turn affects wildlife habitat and wildlife viability), land conversion for human settlement has several direct effects on hydrologic regimes that could be important:

6. Increased impervious surfaces and increased peak runoff
7. Increased heavy metal and oil runoff from impervious surfaces
8. Increased risk of ground-water and/or surface-water contamination through septic effluent disposal
9. Decreased ground-water flow to surface-water system due to ground-water pumping
10. Modified surface water flow due to irrigation, septic system effluent disposal, and treated wastewater discharges

Increased Impervious Surfaces and Increased Peak Runoff

Conversion of wildlands for human settlement includes the construction of roads, parking, and structures as well as soil compaction and vegetation modification. In general, these changes are likely to increase impervious surface, decrease leaf canopy and its capacity to intercept precipitation, and decrease evapotranspiration on the site. A change in the local hydrograph often results, although intervening factors may dampen the effect of these changes on sedimentation and downstream hydrological characteristics. On-site water retention timing and volume can also be affected, so it is difficult to generalize the effects of land conversion for human settlement. Changes in vegetation can also increase evapotranspiration over time as planted vegetation matures.

Increased Heavy Metal and Oil Runoff from Impervious Surfaces

Many of the impervious surfaces associated with human settlement accumulate heavy metals and oils due to the presence of transportation technologies (e.g., cars, trucks, motorcycles) and other human activities (e.g., chain saws). These substances are then likely to be removed from the site or transported from points of concentration on the site through heavy precipitation during peak runoff periods. The degree to which these materials then enter surface water systems and affect hydroecological systems depends on the characteristics of both the intervening watershed and the aquatic ecological system. It is therefore difficult to generalize these effects from human settlement, and the impact of nonresidential land uses (e.g., commercial, industrial) is likely to be greater on a per-acre basis than all but the highest density pattern of human settlement.

Increased Risk of Ground-Water and/or Surface-Water Contamination through Septic Effluent Disposal

As noted in our discussion of census data for the Sierra Nevada, the use of septic systems is significantly higher in the exurban landscape of the Sierra Nevada than it is for California as a whole. The potential risk of septic system contamination of ground-water is a function of system operation, leach field characteristics, and ground-water characteristics (Davis 1994). These are highly site-specific features in the Sierra Nevada, where both soils and ground-water characteristics are highly variable. Historic failures of septic systems have led to building restrictions, ground-water contamination, and surface-water contamination (Cranmer Engineering and Halatyn 1971; Davis 1994; Lauer 1995a, 1995c; 1995b; Lenahan 1995). All of these outcomes are possible through the failure of existing or newly developed septic systems. They may also occur even if septic systems are operating normally, however, as densities increase to the point at which soils are unable to "treat" the septic effluent to an acceptable standard (Thompson 1989; Hanson and Jacobs 1989).

Decreased Ground-Water Flow to Surface-Water System Due to Ground-Water Pumping

On-site ground-water is a primary source of domestic potable water and irrigation water for many low-density exurban households in the Sierra Nevada (Turner 1973; U.S. Bureau of the Census 1990). The ground-water system in the region is characterized by highly variable and unpredictable storage in fractured bedrock, however, rather than a clearly delineated set of ground-water aquifers (Swain 1994). This system is therefore interconnected with the surface-water system in complex and unpredictable ways. Dependence on ground-water pumping for water supply therefore has the potential to affect surface-water flows. It is unclear how significantly this may affect surface-water systems, but any effect is likely to be site-specific.

Modified Surface-Water Flow Due to Irrigation, Septic System Effluent Disposal, and Treated Wastewater Discharges

Human settlement requires access to water supplies, and the provision of water supplies usually involves either importing water through interbasin transfers or significant in-basin storage to accommodate seasonal differences between natural flow regimes and human uses (Turner 1973). Those human uses of water then result in either irrigation for outdoor uses (which can either recharge ground-water or enter the evapotranspiration cycle) or internal domestic use. Most water used internally is then discharged through either septic system disposal or sewered wastewater treatment. Septic system disposal can then affect ground-water and/or surface-water hydrology within the local watershed (Hanson and Jacobs 1989), while sewered wastewater treatment can lead to either in-basin discharges or interbasin transfer to another watershed. Wastewater can then account for a significant fraction of surface-water flow, altering both the seasonal timing and overall level of flows downstream of the point of discharge (CVRWQCB 1989, 1992).

Finally, land conversion due to human settlement can have a wide range of indirect effects on ecological structure and function. The most important of these in the Sierra Nevada is associated with impacts on the fire regime in both settled areas and adjacent wildlands. Human settlement affects the structure and level of fuel loads, the viability of presuppression fuel-management strategies, the likelihood of ignition risk, the availability of suppression resources, and the allocation of those resources through suppression efforts (Irwin 1987, 1989). Each of these will in turn affect the future risk and characteristics of fire in the Sierra Nevada. Vegetation management in the "urban forest" of areas converted to human settlement can either decrease or increase fuels in the urban-wildland intermix zone (Doyle 1995). Further research is necessary to establish empirical relationships between alternative patterns of human settlement and each of these indirect effects on the Sierra Nevada.

CONCLUSIONS

Land use in the Sierra Nevada has changed dramatically during the past fifty years (Weeks et al. 1943), beginning when California's population boomed and standards of living rose during the first two decades following World War II. The population of the Sierra Nevada has more than doubled since then, resulting in a 1990 population that is approximately four times the peak population during the gold rush. Most of the new residents have settled near the historic centers of the gold rush, but their patterns of settlement have resulted in much more extensive land conversion. Three out of five Sierra Nevada residents lived on less than 300 mi^2 (less than 1%) in 1990, but human settlement was spread across nearly 1,741 mi^2 at an average density of at least one housing unit per 32 acres to accommodate seven out of every eight Sierra Nevada residents. This constituted 5.44% of the entire Sierra Nevada, or nearly 14% of all private land (including industrial timberlands). Up to one-eighth of the entire Sierra Nevada (3,905 mi^2) may have been affected by human settlement in 1990 at an average density of at least one housing unit per 128 acres.

The Sierra Nevada is likely to undergo significant land conversion through continuing population growth over the next half-century. Population growth in the metropolitan centers of California is forecast to result in a doubling of the state's population between 1990 and 2040, leading to expansion of the emerging metropolitan centers of the Central Valley that are within commuting distance of the Sierra Nevada foothills (Teitz 1990). Metropolitan areas near the Sierra Nevada are also forecast to continue growing in the state of Nevada. This growth would create new employment opportunities on the urban edge and extend the reach of reasonable commute times into areas that have not yet faced significant residential location by commuters. The result is likely to be continuing immigration by commuters, retirees, and former metropolitan-area residents who are seeking a rural or exurban lifestyle offering significant natural and social amenities. Many of these latter immigrants are likely to accept lower incomes in exchange for these amenities, but they also generally bring human and financial capital with them. They therefore have the potential to generate new employment in the Sierra Nevada.

These new residents are likely to have higher incomes than most existing residents and will put pressure on land and housing prices. The factors driving the exodus to exurbia over the past three decades are likely to continue, resulting in an increasingly homogeneous population of affluent, white, well-educated residents in the commuter and retiree communities proximate to the Central Valley and the Lake Tahoe region. More isolated communities in the northern and eastern Sierra are likely to experience relatively slow growth, however, with less pressure on land and housing prices. Existing patterns of human settlement are more stable in these areas, where lower land prices will make significant investments in centralized infrastructure uneconomic. Large higher-density developments are likely in the Gold Country, however, where proximity to the Sacramento metropolitan area has already increased land and housing prices significantly. Nonlocal landowners have already consolidated parcels in these areas and have proposed development of several planned communities in the region.

The social, economic, and ecological ramifications of future development will depend upon specific spatial patterns of human settlement in relation to existing communities, infrastructure services, vegetation and habitat types, and watershed boundaries. As discussed earlier, our understanding of those relationships is still poor at this time. It is therefore impossible for us to characterize the specific impacts that population growth and human settlement will have in the Sierra Nevada. The range of impacts could be quite significant, however, if existing development patterns continue. Continuing the existing pattern of sprawl development with a high-growth scenario could result in human settlement on nearly half the private land in the Sierra Nevada (6,846 mi^2) at an average density of at least one housing unit per 32 acres. A low-growth scenario with the existing pattern of sprawl would reduce that figure by 44%, to just 3,817 mi^2. This area is still significantly greater than the 1,741 mi^2 affected by human settlement at that average housing density in 1990.

Even modified settlement patterns are forecast to result in significant land conversion from 1990 to 2040, suggesting that the scale of population growth alone could lead to significant impacts. A high-growth scenario with a more compact form of settlement would result in nearly a doubling of land converted to human settlement, from 1,741 mi^2 to 3,363 mi^2 at an average density of at least one housing unit per 32 acres. A low-growth scenario with a more compact form of settlement, on the other hand, could nearly be accommodated within the land area already converted to human settlement at an average density of at least one housing unit per 32 acres in 1990. Through infill and carefully targeted density transfers, the low population forecast for 1990–2040 would require only 1,875 mi^2 (only 8% more than in 1990). Both the scale and pattern of human settlement will therefore affect—and must therefore be considered by—local, state, and federal land and resource management agencies with responsibilities for the health and sustainability of Sierra Nevada ecosystems.

This suggests that any factor influencing future patterns of human settlement has the potential to affect the future impacts of continuing population growth on the health and sustainability of Sierra Nevada ecosystems. One of the most important factors determining patterns of human settlement is land use policy embodied within local General Plans. These documents and associated land use maps are the legal framework within which local land use planning, infrastructure investment, and land development occur. The ecological, social, and economic effects of subsequent development under the General Plans is required to be evaluated in an environmental impact report (EIR) prepared under the California Environmental Quality Act (CEQA). Local jurisdictions are then required to mitigate environmental effects unless "overriding considerations" warrant accepting those effects. Based upon our review of the Nevada and El Dorado County General Plans and their associated EIRs, however, it appears that the current planning process fails adequately to (1) determine the scale and location of future land conversion accurately; (2) systematically determine the effects of such land conversion on a wide range of ecological, social, and economic systems; and (3) mitigate those impacts that are determined to be significant. The current General Plan and EIR process therefore appears inadequate to the task of mitigating the effects of future land conversion for human settlement in the Sierra Nevada (Johnston and Madison 1991; Bank of America et al. 1994; Governor's Interagency Council on Growth Management 1993).

MANAGEMENT IMPLICATIONS

The importance of future population growth to the future of health and sustainability of the Sierra Nevada cannot be overstated. Management implications will vary for local, state, and federal agencies, but nearly all aspects of land and resource management in the Sierra Nevada will be affected. Local agencies will be affected as specific patterns of human settlement result in specific patterns of demand for services and as that demand in turn affects the fiscal capacity of local government to provide those services. The privatization of some services through high-density, large-scale "gated" communities has very different implications than the privatization of services through low-density, large-lot exurban sprawl development relying on well water and septic systems. State agencies with responsibility for fire protection, wildlife, water quality, transportation, and air quality will also be affected directly by these different patterns of development. Federal land and resource managers are likely to be impacted by modified fire regimes, increasing social constraints on industrial timber operations, and increasing demand for local recreation and open space benefits provided by federal lands to local communities.

Alternative patterns of human settlement will affect each of these issues differently. Our evaluation of management implications must therefore address both the different patterns of human settlement that are possible and the management strategies associated with them. We will focus here on the range of growth management policies available to mitigate the impacts we have identified and the institutional setting for implementation of those policies. We are not recommending policies here, but merely outlining the potential suitability of alternative policies to mitigate the specific impacts identified in this assessment. We also believe there are significant constraints to adoption of many of those policies, however, so we discuss the ecological, economic, and social factors (including institutional factors) that influence both applicability and adoption of specific policies in the Sierra Nevada. It is clear that alternative patterns of human settlement and their implications for ecological, economic, and social systems in the Sierra Nevada are too heterogeneous to warrant a "one size fits all" policy for human settlement, so there is no "silver bullet" policy option that will mitigate the impacts of human settlement.

Growth Management Policies to Mitigate Human Settlement Impacts

There is a wide range of policies available to manage population growth and to mitigate the impacts of human settlement. The appropriateness of specific policies depends upon the impact of concern, however, as well as its specific relationship to human settlement. A particular settlement pattern might have a significant effect upon native nesting songbirds, for example, that can primarily be traced to the presence of domestic dogs and cats. Alternative settlement patterns might all have a similar impact, therefore, while alternative pet management regimes could mitigate the impact. In contrast, the effects of human settlement on hydrologic regimes may be either a linear or nonlinear function of housing density. Perhaps there is an effect that is proportional to housing density only up to (or down to) a threshold density, above (or below) which higher (or lower) density does not have an effect. The specific form of these relationships is likely to vary across impacts, so we can not make a general statement about either impacts or policies. Proper evaluation of alternative policies requires a better understanding of the relationships between alternative patterns of human settlement and a wide range of impacts.

Despite this caveat, it is still possible to hypothesize likely relationships and to evaluate the capacity of alternative policies to mitigate the likely impacts of human settlement. Growth management tools have been in use since the first case of informal urban design, when incompatible uses were separated in order to reduce the likelihood that "nuisance" uses would impact other uses (Kostof 1991). This approach has generally been formalized and institutionalized through zoning ordinances and land use planning approaches that emphasize the spatial separation of incompatible uses. Zoning has been widely used in urban areas since the landmark Supreme Court case Euclid in 1926,[81] but was adopted and applied to all land uses only in the 1970s and 1980s for many parts of the Sierra Nevada. Planning techniques have evolved more recently to include a complex suite of both broad and specific tools for managing growth and mitigating its impacts (Stein 1993; DeGrove 1992). We therefore have an extensive literature to draw on when discussing growth management alternatives (Innes et al. 1993; Stein 1993; DeGrove 1992). Because it is extensive, we will offer only a brief introduction here to some of the techniques that may have specific application to the rural and exurban context of the Sierra Nevada. A more systematic consideration of growth management techniques and their capacity to mitigate the effects of human settlement in the Sierra Nevada requires a better understanding of the relationship between alternative patterns of human settlement and likely impacts. Carefully targeted growth management tools can then be evaluated accordingly.

In general, growth management tools can be characterized as one of three types:

1. Spatial, in which the location of specific land uses is designated and constrained
2. Temporal, in which the timing of development is controlled by local authorities
3. Outcome, in which the activities allowed on a particular site are controlled in their timing, duration, frequency, or intensity to maintain particular outcomes or conditions

Any of these broad classes of tools might be proposed and/or adopted to address similar impacts. Conversely, different approaches are likely to be appropriate and necessary to mitigate different types of impacts. General public concern about the traffic impacts of new development, for example, could result in the following new policies:

- Limitations on new commercial development near substandard intersections
- Requirements that new commercial development can go forward only after intersections have been upgraded sufficiently to accommodate all forecast traffic flow
- Requirements that new commercial developments could be open only during certain hours in order to avoid exacerbating traffic problems at substandard intersections

These examples are simply illustrative, but they highlight how the term growth management can mean very different things to different people. Irving Schiffman outlines twenty-six different growth management tools in Alternative Techniques for Managing Growth (1989), and there are many variations on each of his themes. State-level growth management regimes have taken a variety of forms (Innes 1991), from Oregon's land use (spatial) emphasis (Knapp and Nelson 1992) to Florida's infrastructure concurrency (timing) requirements (DeGrove 1992). Local jurisdictions have also adopted a wide range of growth management approaches within California (Governor's Interagency Council on Growth Management 1993; Landis 1992; Glickfeld and Levine 1992). The effectiveness of those measures is still subject to considerable debate, for it is difficult to control study data for the specific growth management policy alone (de Neufville 1981; Landis 1988, 1992; Innes et al. 1993). Moreover, growth management policies may have the effect of increasing land prices and decreasing housing affordability (Dowall and Landis 1981; Dowall 1984, 1991). Spillover effects into adjacent jurisdictions are also difficult to capture, and many of the growth management systems have been in place only a short time or have been modified following legal challenges (Landis 1988, 1992; Glickfeld and Levine 1992). It is therefore impossible to generalize about the likely effects of growth management tools on ecological, social, or economic conditions in the Sierra Nevada.

The specific effects of human settlement in the Sierra Nevada will dictate which types of growth management tools, if any, are appropriate for impact mitigation. Urban limit lines, for example, are unlikely to make a significant contribution as long as centralized infrastructure is not a significant determinant of settlement patterns. Moreover, concerns about maintaining "rural character" and the "quality of life" in the Sierra Nevada may make a highly concentrated pattern of human settlement undesirable for many residents. Specific impacts on vegetation and wildlife, on the other hand, could call for innovative growth management approaches that have not been applied yet in other jurisdictions. These could include seasonal limitations on specific activities that could negatively affect rare and endangered or endemic native plants, for example, but would not necessarily limit the opportunities to develop adjacent areas for human settlement. The potential scope of such limitations could be identified through an overlay of local land use plans with the U.S. Geological Survey 7.5-minute quadrangle GIS database prepared by Shevock (1996). Similar analyses need to be completed in relationship to other ecosystem resources.

Other rural areas (outside the Sierra Nevada) facing rapid population growth have pursued an innovative set of policies to maintain the "rural character" and "quality of life" amenities that dominate public debate about land use planning in the Sierra Nevada. These approaches draw upon a long tradition in landscape architecture and site design that was popularized by Ian McHarg in Design with Nature in 1969 (McHarg 1992). A comprehensive guide to these techniques was first published regionally by the Center for Rural Massachusetts in 1988 (Yaro et al. 1988), then subsequently updated with additional examples from other locations by Randall Arendt in Rural by Design (1994b). Other useful guides to these techniques have been published separately both by researchers (Arendt 1994a; Pivo 1990, 1988; Wolfe 1990) and by local jurisdictions that have adopted these policies (Redman 1992; Montgomery County 1992b, 1991, 1992a; Livingston County Planning Department 1991). High-altitude mountain environments also have special design problems due to their harsh conditions (Dorward 1990), which are important considerations for many parts of the Sierra Nevada.

The basic approach to "open space development design" (Arendt 1994a) is quite simple: instead of creating a landscape of large-lot parcels, subdivision development should be clustered to protect important aesthetic, economic, and ecological resources in the community and the landscape. Protection can be achieved without restricting total development through a redistribution of the overall site development density to the most suitable locations (determined by analysis of natural factors, viewsheds, and social factors that could constitute constraints on or opportunities for development). The result is many smaller parcels for human settlement and a few larger parcels for protection of amenity values. The overall development level is not changed, however, avoiding the charge that landowners' private property rights have been violated. The pattern has simply been altered to mitigate the effects of human settlement on ecological, social, and economic concerns. (Further reductions may still be necessary in order to mitigate some impacts, however, such as transportation and air-quality impacts associated with peak levels of transportation demand. Design changes alone may therefore not be sufficient to mitigate all significant impacts.)

This approach can best be illustrated visually. Figure 11.51 shows an existing site that has a high level of potential development associated with its existing zoning designation. Figure 11.52 shows how this site would be developed under standard large-lot zoning.

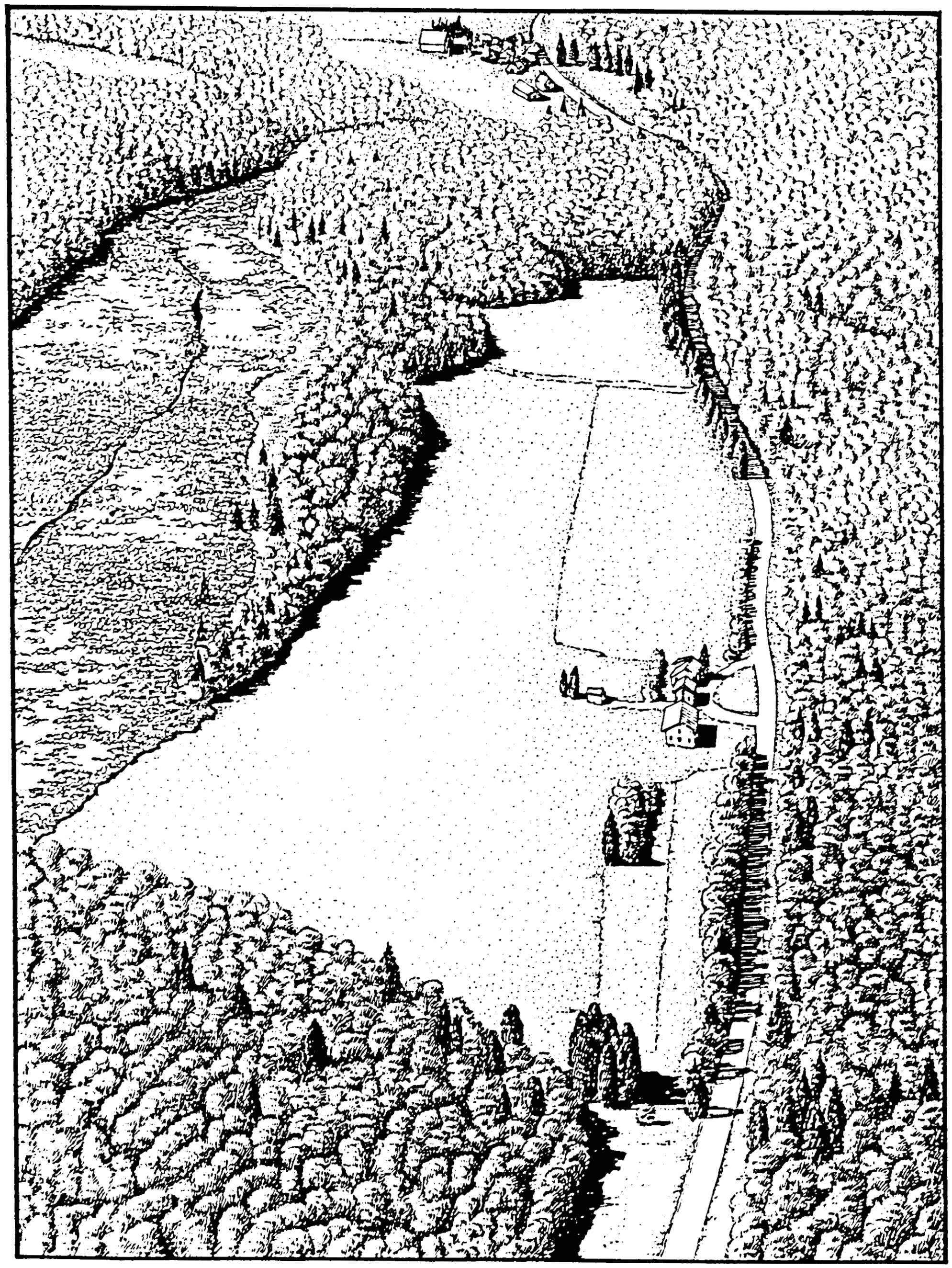
This large-lot pattern has the effect of fragmenting the landscape visually, socially, ecologically, and economically. The scale, texture, and design characteristics of the landscape that brought the new residents have now been altered forever. This outcome may be acceptable, but it is not necessarily inevitable. Figure 11.53 shows how the same number of housing units can be developed through a creative open space development design that clusters the housing units at a scale appropriate to the landscape.

Most of the primary visual features of the landscape have been preserved under this design alternative. Most of the housing units also have access to more open space than they would under the conventional development pattern, and they each generally retain a sense of privacy despite being located on smaller individual parcels. Small, multiple-household septic systems have been sited under this arrangement to improve septic system operation despite the higher density of development in each of the cluster areas. The ecological and hydrological effects of this development pattern have not been analyzed systematically, but explicit design around natural features should result in lessened impacts. The scale of both the open space and clusters, however, would affect whether or not significant benefits accrue. The literature on this issue is still very weak, because most analyses of the relationships between human settlement and ecological impacts in exurban landscapes have been at a coarser scale that fails to capture subtleties of site design. This is the most significant limitation of our assessment for the Sierra Nevada: we have been unable to determine the relationships between finer-scale settlement patterns and ecological, social and economic impacts on Sierra Nevada ecosystems.

This approach was nevertheless proposed as a central mitigation strategy in the draft EIR (DEIR) for the Nevada County General Plan (Harland Bartholomew and Associates 1994). The Nevada County Planning Commission subsequently rejected a mandatory clustering requirement for all new developments, however, and the Nevada County Board of

FIGURE 11.51

Existing land use in a typical rural and exurban landscape.



Supervisors did not override that decision on appeal. The Nevada County General Plan instead relies primarily upon poorly defined "flexible" site development standards (SDSs) to mitigate some of the impacts of future development. No mechanisms were adopted to address existing parcelization, such as transfer of development rights (TDR) arrangements, and concurrent provision of infrastructure or timing limitations as a function of infrastructure capacity were also rejected. In general, the General Plan and its associated EIR were adopted despite projections of significant ecological, social, and economic effects on the grounds of "overriding considerations." Those impacts are therefore still likely to occur as described earlier and in the EIR.[82]

Clustered development was also a key design feature in earlier versions of the El Dorado County General Plan, although it was not proposed as a prominent feature in either the General Plan Project Description or the General Plan Alternative released by El Dorado County in 1994. Recent changes to both the language in the General Plan and the land use designations on the General Plan land use maps will generally increase the impacts identified in the DEIR. Once again, the El Dorado County Planning Commission and El Dorado

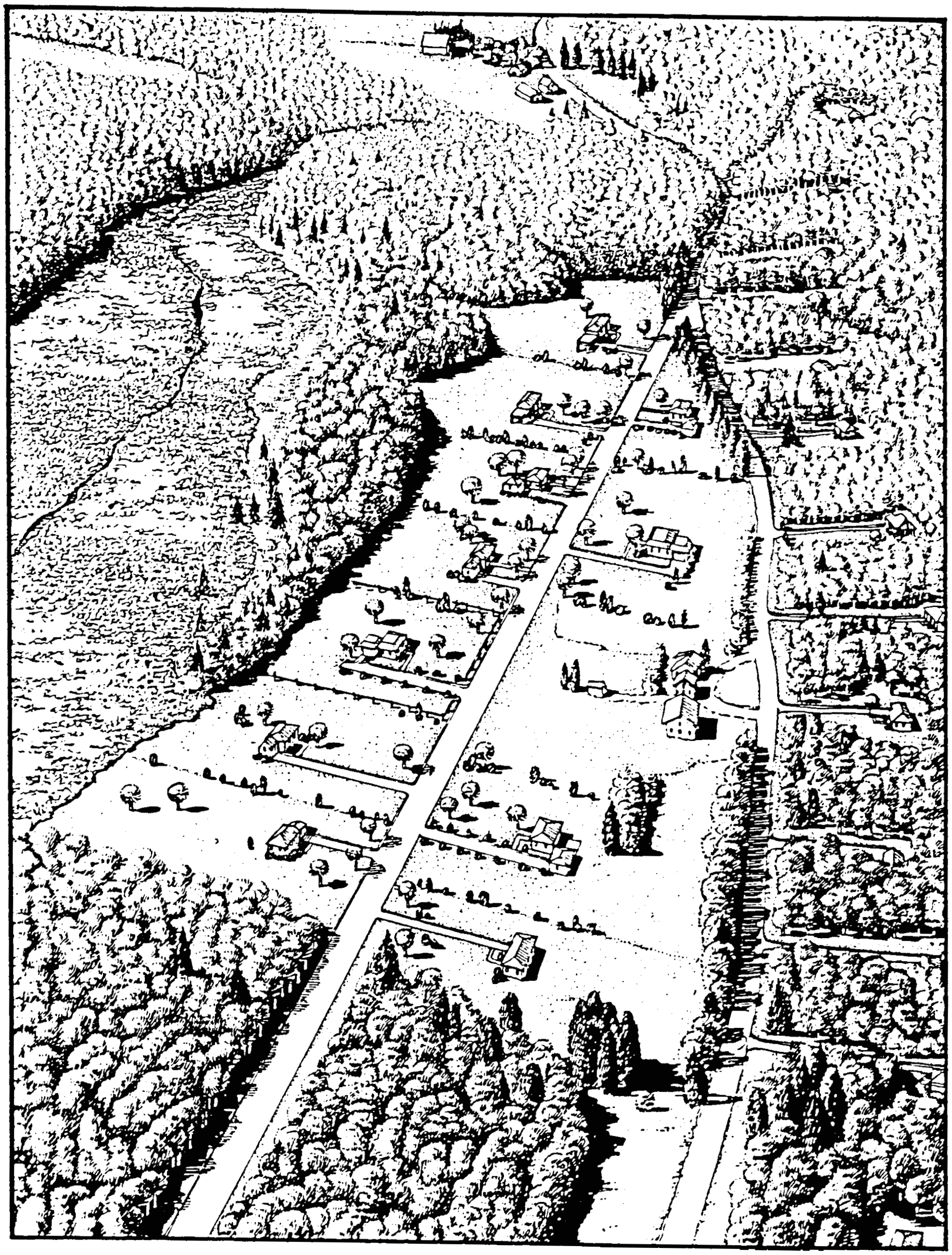


FIGURE 11.52

Development under conventional design and land use plan.

County Board of Supervisors are expected to adopt a final General Plan despite these impacts on the grounds of "overriding considerations." These include regional effects associated with air quality in the greater Sacramento metropolitan area, although the new version of the General Plan text strikes out most references to regional responsibilities.[83] Although many of those regional impacts were identified in the DEIR, the county is required only to accommodate regional housing needs under state law. The impacts of local land use policies on other resources of regional, state, or federal concern (e.g., water quality or biodiversity) must only be disclosed under CEQA. Unless other institutional mechanisms require modifications (e.g., for "listed" species under the federal Endangered Species Act of 1973 or air-quality regulations affecting transportation improvements), local agencies are not required to mitigate the impacts of their decisions.

It should be clear that the availability of appropriate growth management tools is therefore not enough to ensure their adoption and implementation. A variety of social factors have generally limited their adoption by local governments in the Sierra Nevada and other rural areas (Popper 1984). With few exceptions, those aspects of the planning process that do re-

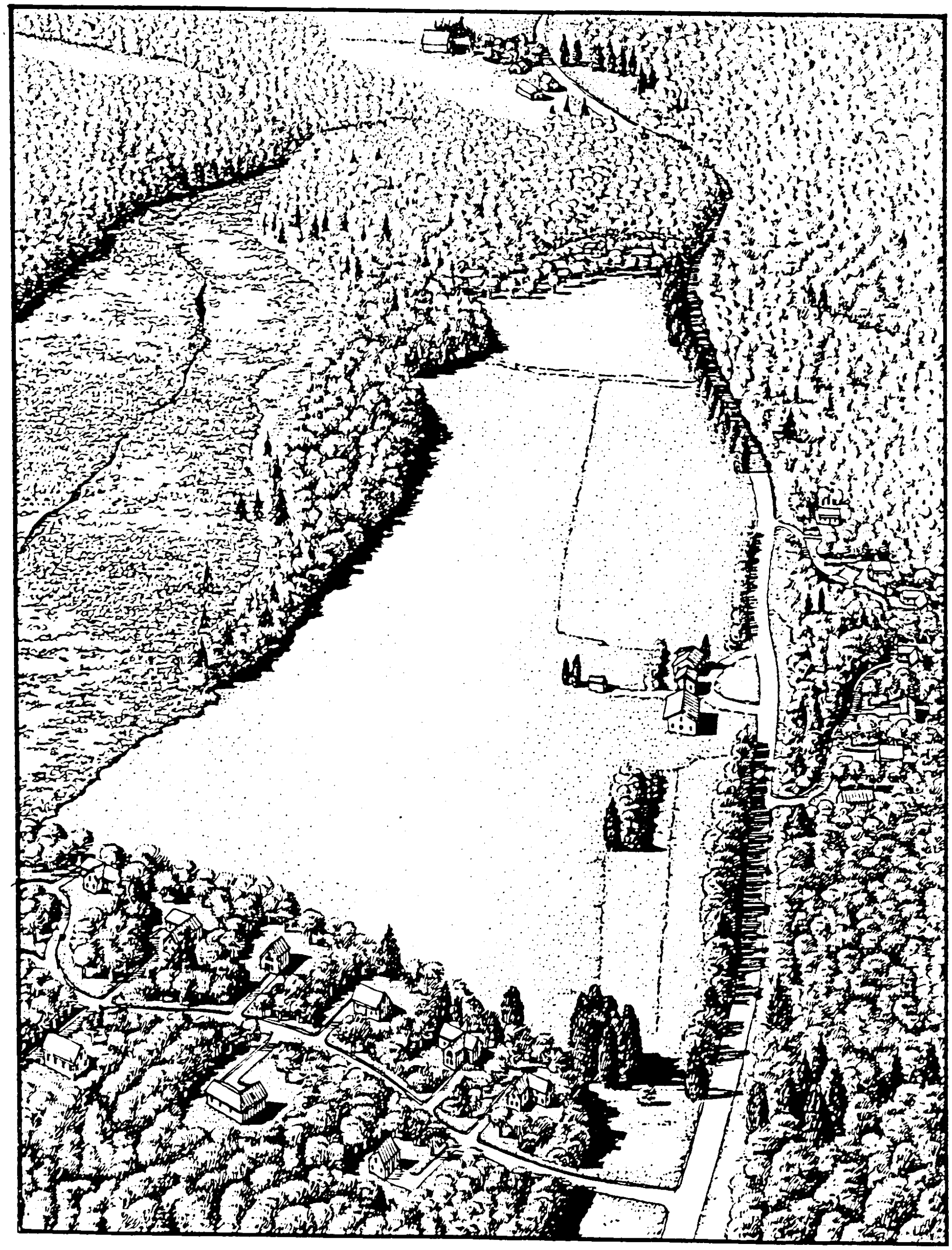


FIGURE 11.53

Development under open space development design alternative.

sult in disclosure and mitiation of impacts are generally required under state law. The politics of growth management and planning are therefore critical to the success of planning and policy. It is also important to note that policy makers often lack adequate information about both the costs and the benefits of alternative patterns of human settlement and alternative policies. Establishment of basic information about these relationships may therefore be a necessary prerequisite to the adoption of more targeted policies. In some cases this information is collected through the CEQA process (Yuba County Community Services Department 1985), while some jurisdictions have established policies as part of the general planning process (Granholm 1987). Better integration of these two processes has also been advocated widely, but it may require changes in state law (Johnston 1991; Duane 1993a). State and federal land and resource managers are generally dependent upon local planning agencies for information on future human settlement patterns, but that information is generally not well integrated with state and federal land and resource management and planning efforts (Forest and Rangeland Resources Assessment Program 1988). In response, some state agencies (e.g., the Strategic Planning Program of the California Department of Forestry and Fire Protection) have initiated efforts to improve local planning agencies' knowledge of and incorporation of regional-scale ecological concerns (Peck 1993; Giusti and Tinnin 1993).

Institutional Setting and Constraints on Effective Growth Management

Implementation of growth management policies is constrained in part by institutional considerations. One institutional issue that arises immediately for the "open space development design" approaches is who will have responsibility for management of and liability for open space. This issue has generally been dealt with through either a homeowners association or public management, although ownership in the open space lands is usually retained by the individual home owners. In either case, however, it clearly requires a greater degree of institutional coordination than that required under the large-lot conventional development model. Local residents are also often concerned that the "open space" lands could possibly be developed later, resulting in much higher levels of overall development. Complex and detailed codes, covenants, and restrictions (CC&Rs) are therefore necessary on titles and deeds to ensure maintenance of design integrity. In the case of public management, it may be necessary to establish a new entity (such as an open space district) or to empower an existing agency (such as the parks and recreation department of the local resource conservation district) with new powers. Getting the new system in place also has institutional and economic costs. Due to economies of scale, moreover, it may be more costly to accomplish this jurisdiction by jurisdiction. Many open space districts in metropolitan areas are consequently regional in nature, with responsibility for acquisition and management of lands in multiple jurisdictions (e.g., East Bay Regional Parks District, covering all of Alameda and Contra Costa Counties).

A second institutional problem emerges for application of these design concepts to areas that have already been parcelized. Coordinated planning is difficult and faces high transactions costs in these situations in the absence of other mechanisms to consolidate ownership and development rights (e.g., through TDRs). This is a common problem in the Sierra Nevada, where many parcels were created in the late 1960s and early 1970s that were later grandfathered in under stricter state land use and environmental planning requirements. Sometimes these parcels have multiple owners, and each of those owners may have purchased his or her parcel with an expectation of building a single-family home on the lot, making it extremely difficult politically to propose non-development of specific lots, even if other areas might be allowed to develop at higher densities. Some mechanism must simultaneously be established to transfer development potential either from one parcel owner to another or from one parcel to another in order to rationalize land use to protect ecological, social, or economic concerns (e.g. the value of surrounding properties, which could be negatively affected by the elimination of adjacent open space and views). This problem is less intractable when a single owner has retained control over multiple adjacent parcels, but that owner is still not generally under any legal obligation to modify the subdivision map and associated lot lines. In fact, the prospect of significant public opposition to a project could lead to development of a project with greater impacts simply because the existing subdivision design can avoid potential delays associated with discretionary review. This is also true for many large-acreage sites where a developer faces a choice between easy approval of a conventional development or great uncertainty associated with a more innovative open space development design. Not surprisingly, the landowner usually pursues the less risky conventional development (Arendt 1994).

Institutional considerations also affect the degree to which matters of regional, state, or federal concern are addressed in land use planning. California has a long tradition of "home rule" on matters of local land use, for example, with fierce local resistance to the imposition of state or regional controls on land use decision-making authority. Ironically, however, many of the problems associated with existing parcelization and substandard infrastructure in the Sierra Nevada reflect local land use decisions that predate stricter state requirements from the early 1970s (Grass Valley Union 1970a, 1970b). These state requirements include the California Environmental Quality Act (CEQA) of 1970, the Subdivision Map Act (SMA) of 1973, and General Plan consistency requirements dating from legislation in 1971. In all three cases, the state imposed new land use planning or environmental analysis requirements on the local land use planning process. Some of these requirements were substantive, such as the SMA requirement that subdivisions of more than four parcels have developed infrastructure before parcels could be sold. General Plans and zoning ordinances are also now required to be consistent under state law, and local authorities are required to have a specific set of elements in their General Plans. Many of the state-imposed requirements, however, are largely procedural. Significant impacts must be mitigated under CEQA, for example (a substantive requirement), but local authorities can avoid this substantive requirement by making findings of "overriding considerations," effectively translating the substantive requirement into a procedural requirement. The result is that many significant environmental impacts of human settlement are not mitigated.

Examples of regional or state land use control are limited and have usually involved resources of state, federal, or international significance. These have included filling restrictions in the San Francisco Bay, where the San Francisco Bay Conservation and Development Commission (BCDC) was established by state legislation in 1965; Lake Tahoe, where the bi-state Tahoe Regional Planning Agency (TRPA) was established by congressional action and the bi-state Tahoe Compact in 1970; and the California coastal zone, where the

California Coastal Commission was established through a vote of the California electorate in 1971 and subsequent legislation in 1976. Subsequent efforts to establish regional land use authorities have been rejected by the legislature in the face of strong opposition from elected local officials in the jurisdictions whose authority would be reduced. Regional institutions have been successfully established in California for the management of resources that have traditionally been managed by the state, however, such as the Bay-Delta Oversight Commission (BDOC), or where local jurisdictions have not traditionally exercised authority (e.g., ground-water management). Several regional planning efforts have also been pursued to address endangered species concerns in California. Many state and federal functions are also administered through regional offices, many of which are organized along ecological boundaries (e.g., air-quality management districts). Voluntary associations of government also act as a clearinghouse for state and federal grants administration, information generation, and coordinated planning. These "councils of government" (COGs) include the Association of Bay Area Governments (ABAG). Similar organizations in the Sierra Nevada include the Sierra Planning Organization (SPO) and the Sierra Economic Development District (SEDD). Neither plays a strong role in land use planning for the Sierra Nevada.

The California Department of Fish and Game has commented on General Plans in terms of their impacts on wildlife; the California Department of Forestry and Fire Protection has raised fire safety issues related to density, vegetation management, and access; the regional water-quality control boards have identified potential water-quality issues and the California Department of Parks and Recreation has addressed the impact of some policies on recreational activities. Despite this participation, however—which has been quite limited due to staff and budgetary limitations—local land use planners and decision makers are not required to modify General Plans to reflect the state's resource concerns. State agencies also participated in the local planning process in the late 1960s and early 1970s, sometimes raising concerns that have been realized a quarter-century later (Gerstung 1970, 1973). The linkage between state resource management concerns and local land use planning still remains weak. Local land use planning decisions continue to affect state resource management interests in a very direct way, however. State agencies have primary responsibility for wildlife, fire suppression, and water quality, for example, but the local authorities retain all control over many of the factors affecting the exercise of those state responsibilities. The state, in turn, retains some discretionary control over some resources (e.g., transportation and wastewater treatment plant funding) that directly affect local land use planning and patterns of human settlement. That discretionary control, however, has generally not been used to encourage alternative growth management policies, based on the potential impacts of settlement patterns on another state agency's area of responsibility. Coordination among state agencies on these issues appears to be relatively weak.

Finally, the linkage between the local land use planning process and federal agencies—who control roughly three-fifths of the land base in the Sierra Nevada—is also weak. Local officials have often commented on federal land management plans, but federal agencies rarely comment on or attempt to influence local land use plans. The exceptions are those cases in which local land use policies could clearly affect the capacity of the federal agencies to manage their own lands. Examples include proposed land use designations that could facilitate high-density development projects that could impede public access to recreational resources or could be critical to public use of those recreational resources (e.g., ski resorts on federal lands, where the "base" facilities are on adjacent private lands). Local land use planning and development policies can clearly have a wide range of more diffuse indirect effects, however, that could potentially constrain a wide range of management practices. Increased local settlement could increase recreational demands, alter wildlife habitat for species that travel seasonally up- and downslope, or even increase local opposition to timber harvest and fuel-management practices on federal lands.

This set of management implications is merely illustrative of the effects of human settlement on the health and sustainability of Sierra Nevada ecosystems. Considerably more research is necessary to determine the precise nature of the impacts of alternative patterns of human settlement on the system and the capacity of alternative growth management policies to mitigate those effects. Even in the absence of such definitive research, it should nevertheless be clear that human settlement in the Sierra Nevada has had and will continue to have a profound effect upon the ecological, social, and economic characteristics of the Sierra Nevada. Land and resource managers at the local, regional, state, and federal levels must now address those effects in future planning. The challenge of managing the impacts of human settlement raises a number of complex issues about the relationship between different levels of government and the relationship between private property rights and community and ecological well-being, but those conflicts are likely to be compounded in the future if institutions fail to address them proactively today (Niebanck 1984; Dubbink 1984).

ACKNOWLEDGMENTS

This research would not have been possible without the assistance of a number of graduate students, consultants, and colleagues from the University of California, Berkeley, and the Sierra Nevada Ecosystem Project. Karl Goldstein provided critical and consistent GIS analytic support throughout the project and prepared most of the maps in the report. He was clearly the most important resource I had while completing this research project. Karl worked closely with me on both the GIS analysis and the conceptual development of spatial modeling approaches described in the text. He also prepared all of the final maps.

Karl built on previous work by Phil Griffiths, who did the GIS analysis of 1970–90 population growth trends by CCD for me in 1992–93 (before SNEP). Phil was assisted during that early GIS effort by David Paradise, who volunteered his time to the research while on a brief sabbatical from Silicon Graphics, Inc. (SGI). Chris Thomas completed the analysis of the draft environmental impact reports for the Nevada and El Dorado County General Plans and the analysis of the implications of General Plan buildout for the transportation system in El Dorado County. He also prepared the initial population growth allocation spreadsheet by CCD for 1990–2040. Melody Tannam collected and input the 1850–1990 census data by county, city, and ethnicity and prepared several related charts. Dan Barry completed a literature review and annotated bibliography on the phenomena of exurban growth, demographic change, and rural communities in transition. Nabiha Megateli prepared an overview of septic systems and wastewater treatment in Nevada and El Dorado Counties. Craig Mayer completed the descriptive statistical analysis and bivariate analysis of 1990 census variables with the assistance of Karl Goldstein. Karl Goldstein, Craig Mayer, and Nabiha Megateli digitized the Nevada and El Dorado County General Plan land use maps. Miho Rahm, Jenna Lloyd, Barbara Hadenfeldt, and Carey Pelton provided administrative support through the Institute for Urban and Regional Development. Bill Mallgren assisted with the spatial analysis of the assessor's database and ownership consolidations, and Malcolm McDaniel organized the bibliography and in-text citations using EndNote. Carrie Salazar prepared final charts and graphs from my preliminary figures in Excel.

SNEP Science Team members and special consultants Greg Greenwood, Rowan Rowntree, Joe McBride, Bill Stewart, Jonathan Kusel, Dennis Machida, and Doug Leisz provided important insights on the forces driving human settlement in the Sierra Nevada. My colleagues Ted Bradshaw and Bob Twiss at the University of California, Berkeley, offered similar insights, while my colleague John Radke provided critical GIS support. Brian Muller shared his work with Ted Bradshaw on modeling exurban development in the Central Valley for the American Farmland Trust, while Bob Johnston from the University of California, Davis, shared his efforts to model transportation and land use for the Sacramento Area Council of Governments (including Placer and El Dorado Counties). Sharon Boivin and Pat Norman of the Nevada County Planning Department and Pierre Rivas of the El Dorado County Planning Department were very helpful with materials for the case studies, as was Nevada County GIS coordinator Diana Carolan. Information on water supplies and hydroelectric development issues in Nevada and El Dorado Counties was provided by Les Nicholson of the Nevada Irrigation District, Marie Davis of the Georgetown Divide Public Utility District, Rob Alcott of the El Dorado Irrigation District, and El Dorado County water resources consultant Jim Doolittle.

Participants at our September 1994 workshop on our assessment included Betty Riley, Michael Reeves, and Lynne Purvis from the Sierra Planning Organization/Sierra Economic Development District; Bob Roan of the High Sierra Resource Conservation and Development Council; Placer County Planning Director Fred Yeager; Amador County Supervisor Stephanie D'Agostini; Amador County Planning Director Susan Grijalva; Steve Chilton and Kelly Berger from the Tahoe Regional Planning Agency; Greg Greenwood, Cathy Bleier, and Sheila Peck from the Strategic Planning Program at the California Department of Forestry and Fire Protection; and Susan Kocher of Forest Community Research (working with Jonathan Kusel on the SNEP social assessment chapters [Kusel, 1996; Doak and Kusel, 1996]). CDF ranger Jim Smith and California Department of Fish and Game employees Stafford Lehr, Daniel Hinz, and Bob Mapes also attended another workshop near Placerville in May 1995. All of their comments helped us frame the assessment and focus on the key questions.

Former El Dorado County supervisor Bill Center and former El Dorado County planning commissioner Ray Griffiths also provided insight on the development of the El Dorado County General Plan from 1991 to 1994. Dozens of participants in the Nevada County General Plan update process provided additional information on the Nevada County General Plan. These included members of the Resolution Committee (Dale Creighton, Sam Dardick, Peter Van Zant, and Laurie Oberholtzer), representatives from the Rural Quality Coalition (Peter Van Zant and Laurie Oberholtzer), and representatives from the California Association of Business, Property, and Resource Owners (Maskey Heath, Todd Juvinall, and Margaret Urke). All of these individuals and others involved in planning and land use issues in both counties provided information that assisted development of this assessment. None of them is responsible for the subsequent analysis or conclusions we have reached.

Graduate students in the Environmental Planning Studio at the University of California, Berkeley, reviewed specific aspects of the Nevada County General Plan in May 1993 (Cecilia Collados, Philip Griffiths, Scot Medbury, Andrew Partos, Leora Elazar, Steven Lewis, Perl Perlmutter, Karl Goldstein, Jeff Wutzke, Sarah Marvin, Juliet Lamont, Sheila Peck, Jennifer Knauer, Kallie Marie Kull, Trang Ngan Le, Norrie Cooper, Rebecca Coffman, Robert Faulstich, and Ming Zhao) and the El Dorado County General Plan in May 1994 (Nelia Badilla Forest, Malcolm McDaniel, Lori Tsung, Tim Hargrave, John Deck, Craig Mayer, Chris Thomas, Andrew Delaney, Rachel Arthur, Jennifer Vick, Andrea Lucas, Maria Wiseman, and Gretchen Hayes). Their individual papers and classroom discussion were invaluable, as were conversations with other graduate students and colleagues. Three anonymous peer reviewers and several members of the public also provided important comments on an earlier draft of the assessment.

Harry L. Dodson generously provided permission to use the perspective drawings in figures 11.51–11.53, which were illustrated by Kevin Wilson based on plans by Dodson Associates, Landscape Architecture and Planning, in Ashfield, Massachusetts.

My wife, Teresa McGlashan, provided patient and critical support as a “SNEP widow” during many months of late-night and weekend analysis and writing. My son, Cody Kenneth Duane-McGlashan, provided inspiration for the future of the Range of Light as the seventh generation to spend time in the Sierra Nevada. He entered the world on September 23, 1995, and he will be able to check on the validity of our analyses in the year 2040 at the early age of 45. His existence now makes our abstract, future projections of population growth and land conversion from 1990 to 2040 seem much less distant and much more concrete. Ultimately, he and his children will judge the value of the Sierra Nevada Ecosystem Project and assessments like this one.

This assessment built on work that was previously funded in part by the Committee on Research, the Beatrix Farrand Fund of the Department of Landscape Architecture, and the Townsend Humanities Center at the University of California, Berkeley. The Strategic Planning Program of the California Department of Forestry and Fire Protection also provided additional funding for the development of digital databases that were critical to the assessment. The author alone remains responsible for the contents of the assessment.

NOTES

1. We do not include some counties that border the northern boundary of the Sierra Nevada, such as Lassen.
2. Portions of other counties (e.g., Lassen in California and Washoe, Carson, and Douglas in Nevada) are in the Sierra Nevada, but the CCD boundaries for those counties extend into areas that include significant populations of non-Sierra residents. We have therefore limited our analysis to the forty-six CCDs in the eighteen California counties. The total population for the Sierra Nevada is therefore slightly larger than this.
3. Historical plaque beneath “Chinese Wall” and railroad tracks at Donner Summit and old Highway 40.
4. Based on pamphlets 25 (1) and 25 (2) of the Nevada County Historical Society, written by Patrick Tinloy.
5. Based on the Sierra Nevada portion of the population of the eighteen California counties included here.
6. An estimated 818,000 Californians moved from California to the interior West between 1985 and 1991, and many of these moved to rural or exurban regions of those states. The Sierra Nevada has also experienced continuing growth, and rural areas throughout California are growing despite net domestic emigration from California from 1990 to 1992. By comparison, only 250,000 Americans migrated westward on the Oregon Trail to California from 1843 to 1865 (others arrived by clipper ship or via other routes).
7. Plumas, Sierra, Nevada, El Dorado, Amador, Calaveras, Alpine, Mariposa, and Mono Counties.
8. Data for the state of Nevada were unavailable at the time of the analysis, so the results presented here refer only to those portions of the Sierra Nevada within California. Because the state of Nevada was not a signatory to the Biodiversity MOU, however, the focus of the policy recommendations is on California.
9. All figures cited are from our analysis of the 1990 census and cited in detail in Griffiths (1993). Note that these data are only for those persons 5 years of age and older, since younger ones were not alive in 1985!
10. This analysis is based on table 3.1 of Griffiths (1993).
11. Although the standard retirement age is 65 for many people, we have highlighted the age cohort of 55 years of age or older due both to the data on immigration and to the significant equity capital that has allowed many Sierra Nevada immigrants to “semi-retire” at an earlier age. The American Association of Retired Persons also uses 55 years of age as the basis for eligibility in the AARP, regardless of employment status.
12. The impact of these prisons on these communities is described in the social assessment by Doak and Kusel (1996). We have not calculated community-specific social and demographic characteristics.
13. This correction is most important for Amador and Tuolumne Counties’ overall ethnicity estimates.
14. These characterizations of changes since 1990 are based upon personal observation and conversations with residents of the Lake Tahoe subregion (including Truckee, in Nevada County) and the eastern Sierra subregion. Employers in the tourism and construction industries commented on the increase in their utilization of a Latino workforce since 1990. This appears true for both large and small businesses. Based upon these conversations, it appears that there is very little employment of illegal aliens in the formal sector. Stricter penalties against employees and Proposition 187, together with tighter federal border controls, appear to have minimized the role of illegal aliens in the economy of the Sierra region. Bilingual education data are presented in Elliott-Fisk et al. (1996) and community poverty data are presented in Doak and Kusel (1996).
15. Nelson (1992) offers a detailed discussion of the literature on exurban development and suggests criteria for defining exurban regions within the constraints of U.S. Census Bureau data collected at the county level. His definition emphasizes the role of the central city in metropolitan regions as an employment center for exurban households. We argue that the conception of exurban development should be construed more broadly to include patterns of economic activity that are dependent upon and integrated with urban centers but not physically proximate. This means that some exurban households can be located well beyond commuting distance to cities, in areas that would otherwise be considered “rural” based on their overall appearance or their apparent physical relationship to the nearest metropolitan region.
16. Note that our definition of exurbia is broader than Nelson’s (1992) and would include many areas that may be classified as “rural” by his criteria or could be classified as “metropolitan” by the census. An example of the former would be Calaveras County; an example of the latter would be Placer County.
17. The Sierra Nevada experienced its first significant population increase during this same decade.
18. Some recent data suggest that rural areas have again experienced

a small net in-migration from 1990 to 1991. Surprisingly, nonmetropolitan areas had a lower unemployment rate than metropolitan areas in fiscal year 1992 (for the first time in thirteen years, since the "rural renaissance" of the 1970s supposedly ended). The factors driving this shift are discussed in detail later.

19. The basis for this conclusion is described in our discussion of census block group data later.
20. These results are for the entire sample of 748 respondents. More detailed cross-tabs are also available by supervisorial district, age, housing status, income, school children, education, occupation, political ideology, length of residence, Sacramento commuters, area, acreage of parcel, June 1990 voter status, political party, and sex. These cross-tabs reveal some significant differences among subgroups, which highlight some of the differences in values between newcomers and oldtimers.
21. It is extremely difficult to get this information, for race is a highly charged issue in American society. Anecdotal evidence strongly supports this hypothesis, but more systematic research is needed on the issue.
22. Some writers have challenged the idyllic representation of small-town life and "the demonization of city life" (Zukin 1993) as unrealistic, and the "latent preference" cited by Nelson (1992) and Blackwood and Carpenter (1978) may indeed reflect a romantic vision of nonmetropolitan living. It is nevertheless a genuine preference for many (but certainly not all) Americans, however, and they are now able to pursue it.
23. Forthcoming in 1996. The author reviewed a final draft manuscript for Island Press in January 1995.
24. Assuming an 8%–10% interest rate and typical insurance and taxes in California, the monthly (before tax) cost of a mortgage is approximately 1% of a thirty-year, fixed-rate mortgage. Annual costs of $10,000–$20,000 for private schools equal $833–$1,667 per month. Avoiding those costs therefore frees a comparable amount for a mortgage, allowing one to acquire a mortgage of approximately $83,300–$166,700 (average = $125,000) without a reduction in net cash flow. The median owner-occupied household housing value in the Sierra Nevada was $128,678 in 1990. Lower current interest rates for mortgages translate into even greater home purchasing power for each dollar of savings from education.
25. This is a key selling feature for real estate advertisements for Lake Wildwood in Nevada County.
26. This appears to be true with Lake of the Pines in Nevada County, where local law enforcement personnel attribute a higher crime rate to high levels of "latchkey" children in two-income, commuter families. The high level of commuters in the community has reduced the daytime adult presence.
27. According to a survey conducted by the U.S. Fish and Wildlife Service, Americans spent some $14 billion on "primary nonconsumptive wildlife recreational pursuits" in 1985. The actual value of those recreational experiences was probably much higher, because there is only a limited "market" for these activities. In the jargon of economics, in other words, there was a large uncaptured consumer surplus.
28. Detailed statistics on the relative affordability of housing in Nevada County are presented in the draft 1994 Nevada County General Plan Housing Element. The comparison to costs in Sacramento is based upon materials prepared by Common Ground Communities for a Community Development Block Grant application in 1995. The author is on the board of directors of Common Ground Communities.
29. Home buyers in the late 1980s and early 1990s purchased their homes at high prices and have seen slow or negative growth in their equity since then. This reduces the future potential for significant equity gains that could then free another wave of equity refugees to migrate to exurbia.
30. The final version of the Nevada County General Plan and the latest draft El Dorado County General Plan state that maintaining rural quality and environmental quality are essential goals for each county.
31. Assuming that the lower-bound DOF forecast is 6% greater than the CCSCE forecast and that the higher-bound DOF forecast is 8% greater than the lower-bound DOF forecast (1.08 * 1.06 =1.14).
32. The DOF estimates for 1990 differ slightly from the 1990 census figures, which are from April 1990.
33. The San Francisco Bay Area referred to here includes the nine counties, Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma, that are members of the Association of Bay Area Governments. Population figures are taken directly from census data summarized in published tabular form for 1940, 1950, 1960, 1970, 1980, and 1990. No digital sources were available.
34. These amenities include the Bureau of Reclamation's Folsom Lake, on the edge of the foothills.
35. Two of the three homes listed for sale in the May-June 1994 issue of the internal "Intel Folsom News" classified ads section were in El Dorado County, while the third was in nearby Placer County. We do not have any statistically valid data on the residential location of high-technology employees in Folsom.
36. The San Joaquin valley town of Merced may also have significant growth if it becomes the site for the tenth campus of the University of California. Closure of the nearby Castle Air Force Base is at present threatening to stall economic development in the area, but a new UC campus would be likely to serve as an incubator for a wide range of employment opportunities both in research and in the private sector.
37. This has been suggested as a likely problem by Ted Bradshaw at the University of California, Davis.
38. This estimate is based upon the sum of all Sierra region CCDs within the ten-county study area.
39. These values indicate the order of magnitude of the population, rather than the absolute number. Villages are usually in the 100s and up to maybe 1,000s of people, for example, while towns are in the 1,000s and possibly into the 10,000s. Rural and exurban regions usually do not have communities larger than maybe 10,000–20,000 people, but there may be some centers up to 20,000–50,000. Note that the U.S. Census would treat any county with a community larger than 50,000 in population as "metropolitan."
40. A "minor" subdivision typically involves a parcel split that results in four or fewer lots, thereby avoiding detailed planning and environmental review under the state Subdivision Map Act of 1973.
41. This has been required by California law only since the early 1970s, however, and most Sierra Nevada counties did not have zoning ordinances that were consistent with their General Plans until at least 1970.
42. This conclusion is supported by review of the 1980 Nevada County General Plan, 1982 Grass Valley General Plan, 1994–95

Nevada County General Plan update, and 1994–95 El Dorado County General Plan update. Local officials are consistently unwilling to "downzone" below existing parcelization.

43. Analysis of these environmental characteristics follows the basic framework established by Ian McHarg in his book Design with Nature (McHarg, 1992).
44. Based upon a detailed review of General Plan documents for Nevada County and the city of Grass Valley and preliminary review of General Plan documents for Placer, El Dorado, Tuolumne, Inyo, and Mono Counties and the cities of Nevada City and Mammoth Lakes. The Lake Tahoe region is an exception due to the detailed environmental thresholds established by the Tahoe Regional Planning Agency (TRPA).
45. Existing market data on consumer preferences are limited by the lack of suitable alternatives for comparison, however, so it is difficult to ascertain how consumers would respond to the alternatives.
46. Many similar villages that dot the New England countryside date from the eighteenth century.
47. Fires often destroyed these small towns in their earliest days, with subsequent rebuilding using brick to ensure greater resistance. The current appeal of these small towns in part reflects this evolution over time.
48. There were multiple attempts to incorporate Truckee before final incorporation as a municipality.
49. All data are from the U.S. Bureau of the Census STF 3A, Population and Housing, 1990 Census. Based upon an independent analysis of Locally Adjusted Personal Income (LAPI) data for 1989, however, Stewart (1996) has determined that the 1990 census data underestimate transfer payments by a factor of 2 to 3. This error is concentrated in both the lower-income households (due to a failure to report AFDC and related social welfare payments) and the higher-income groups (due to a failure to report interest, investment, and dividend income). These estimates of median total income are therefore lower than actual median incomes.
50. The data available for this assessment did not offer a clear conclusion regarding this question.
51. Minimum lot size requirements vary widely with jurisdictions, reflecting both the high uncertainty and lack of detailed analysis of septic or well system risk associated with various soils, slopes, and other natural factors. Higher minimum parcel sizes of 10 or 20 acres per dwelling unit are often required to maintain the rural character of a place or to protect some sensitive area (e.g., steep slopes or an adjacent wetland), but those larger parcel sizes are not usually required to meet public health concerns. It is important to note that the general application of a minimum lot size requirement means that the site-specific capability to accommodate water and septic is usually not evaluated.
52. Parcel size distribution and land uses are discussed in detail later for Nevada and El Dorado Counties.
53. This has been a more significant problem to date in the Central Valley than in the Sierra Nevada.
54. Several Sierra Nevada counties have adopted these "right-to-farm" ordinances over the past decade.
55. Note that a shift in the mix of agricultural supplies may also occur rather than an overall reduction in the total value of such supplies. Many "ranchette" activities require significant supply expenditures that may actually increase the overall level of total economic activity in the agricultural supply sector.
56. Nearly half (48%) of the eleven western states and three-fifths of the Sierra Nevada is owned by the federal government, with much higher proportions of some rural counties in the Sierra Nevada.
57. For example, there were significant public protests against land trades by the Bureau of Land Management in Nevada County in 1988 due to concerns about herbicides for industrial forestry activities.
58. Materials for the People for Open Space and the Greenbelt Alliance emphasize this in the Bay Area.
59. Ted Bradshaw is now at the University of California, Davis.
60. We used the 1992 TIGER files; the 1994 files were still not available at the end of June 1995.
61. We considered use of LANDSAT Thematic Mapper satellite imagery from 1972, 1986, and 1992 for a more comprehensive analysis of land conversion, but we determined that we could not reliably differentiate changes in the TM measurements based on land conversion alone in the areas for which we had TM data. The census data is the only reliable source for human settlement for the entire Sierra Nevada region.
62. We suspect that it reflects the failure to include some blocks that are outside the SNEP core region that were otherwise included in the CCDs, because the SNEP core region does not coincide with the CCDs.
63. SPP was established following the Forest and Rangeland Resources Assessment Program (FRRAP). This threshold was used in previous studies by CDF to indicate an "urban" land conversion classification.
64. There has been a movement by some counties (notably Catron County, New Mexico, and Nye County, Nevada) to establish local land use controls over federal lands. The U.S. Justice Department filed suit in federal court in 1995 to establish exemption of federal lands from local land use regulation, and there has never been a successful case establishing local government jurisdiction over federal lands. The case was still pending as we prepared this assessment report (Larson 1995).
65. We identified this pattern through our analysis of the El Dorado County General Plan, and it was confirmed by Pierre Rivas, principal long-range planner, El Dorado County Planning Department, at our workshop with local planners from the five-county central Sierra Nevada region in September 1994.
66. Nearby private lands have been acquired through this funding source for recreational purposes.
67. The Final Draft Nevada County General Plan was adopted in March 1994 just as Truckee incorporated.
68. The Nevada County General Plan map shows only 10,141 acres in this classification (when calculated by Arc/Info), but we estimated ultimate buildout of these subdivisions at 14,022 total housing units.
69. A total of 10,127 acres are designated SDA, but Gold Country Ranch is only 8,232 acres.
70. El Dorado County had developed a parcel-based digital coverage by October 1994, but the county surveyor would not make it available for our use until the board of supervisors authorized a fee schedule for its release. Despite repeated requests, we were unable to trade our working data for use of the parcel-based coverage. We also believe there are serious errors associated with georeferencing of that coverage. Nevada County is developing a similar coverage based upon scanned images of zoning designa-

tion maps (ZDMs) and digitized centroids of each parcel, but that coverage will not allow direct calculation of area.

71. We estimated that two-thirds of the parcels in the class "Can be subdivided into 3–5 parcels" were in this class, while one-third could be subdivided into 5 parcels and were therefore subject to the Subdivision Map Act as "major" subdivisions. Note potential methodological problems cited in the text, however.
72. This statement conflicts with other reports from the Nevada County Planning Department during the General Plan process that there are over 17,000 unimproved parcels in Nevada County out of a total of only 51,000 (Boivin 1991–95).
73. These data are from 1992, before Sierra Pacific Industries acquired most of Michigan-California's assets.
74. The area designated for this "new town" on the 1994 draft Nevada County General Plan will now be designated as a development reserve zone, to be studied when a specific project is proposed.
75. The Rural Quality Coalition of Nevada County and the Federation of Neighborhood Associations have led the challenge to the Nevada County General Plan, while the El Dorado County Taxpayers for Quality Growth have led the challenge to the El Dorado County General Plan. No case has yet been filed, but it is likely that the final El Dorado County General Plan will be litigated in part on the grounds of CEQA violations.
76. Robert Johnston at the University of California, Davis, is currently modeling the impact of transportation system on land use in El Dorado and Placer Counties for the Sacramento Area Council of Governments. The results of his analysis were not available in time for inclusion or review here.
77. The most recent draft of the El Dorado County General Plan, dated August 17, 1995, establishes much lower LOS standards for many roads in comparison with the 1994 draft El Dorado County General Plan.
78. Threats to potable water supplies have been one of the primary drivers of sewering since the 1970s.
79. Both counties completed separate fiscal analyses of their respective Final Draft General Plans, but they came to very different conclusions. El Dorado County determined that development under its General Plan would not improve the fiscal condition of the county and that LOS standards would continue to decline. Nevada County determined that its General Plan would be fiscally sound for the county, but that analysis failed to consider many of the costs discussed here. It also suffered from the same inadequacy of the DEIR: reliance upon General Plan buildout estimates that fail to account for existing parcelization.
80. Their effect on the distribution of patch size (and total patch area) is a function of both their geographic distribution and the "edge effect" attributed to them from the roadway into the interior of adjoining patches. A four-lane freeway and a two-track dirt road probably have significantly different effects, and they should be considered accordingly. Much more research needs to be done on the effective edge effect of different road types and uses.
81. Euclid v. Ambler Realty Co., 272 U.S. 365 (1926).
82. There are two major exceptions to this generalization in the final Nevada County General Plan adopted on October 13, 1995: (1) temporary elimination of the "new town" or special development area in western Nevada County (until further studies are completed) and (2) reductions in allowable densities in several areas that had high-density or medium-density designations. The overall buildout population estimates appear to have been reduced more significantly, to around 140,000 people, through other changes in assumptions about household size, net versus gross development densities, and several other more minor changes in assumptions. As noted in our analysis, however, these reductions are overwhelmed by more significant buildout underestimation errors due to failure to account for existing parcelization.
83. Compare the 1994 Draft El Dorado County General Plan to the revision released on August 17, 1995.

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APPENDIX 11.1

Human Settlement Data

TABLE 11.A1

Sierra Nevada population and population growth by county, 1970–90.

County	1970	1980	1990	1970–80	70–80%	1980–90	80–90%	1970–90	70–90%
Alpine	484	1,097	1,113	613	127%	16	1%	629	130%
Amador	11,821	19,314	30,039	7,493	63%	10,725	56%	18,218	154%
Butte	101,969	143,851	182,120	41,882	41%	38,269	27%	80,151	79%
Calaveras	13,585	20,710	31,998	7,125	52%	11,288	55%	18,413	136%
El Dorado	43,833	85,812	125,995	41,979	96%	40,183	47%	82,162	187%
Fresno	413,329	514,621	667,490	101,292	25%	152,869	30%	254,161	61%
Inyo	15,571	17,895	18,281	2,324	15%	386	2%	2,710	17%
Kern	330,234	403,089	543,477	72,855	22%	140,388	35%	213,243	65%
Madera	41,519	63,116	88,090	21,597	52%	24,974	40%	46,571	112%
Mariposa	6,015	11,108	14,302	5,093	85%	3,194	29%	8,287	138%
Mono	4,016	8,577	9,956	4,561	114%	1,379	16%	5,940	148%
Nevada	26,346	51,645	78,510	25,299	96%	26,865	52%	52,164	198%
Placer	77,632	117,247	172,796	39,615	51%	55,549	47%	95,164	123%
Plumas	11,707	17,340	19,739	5,633	48%	2,399	14%	8,032	69%
Sierra	2,365	3,073	3,318	708	30%	245	8%	953	40%
Tulare	188,322	245,738	311,921	57,416	30%	66,183	27%	123,599	66%
Tuolumne	22,169	33,928	48,456	11,759	53%	14,528	43%	26,287	119%
Yuba	44,736	49,733	58,228	4,997	11%	8,495	17%	13,492	30%
Total	1,355,653	1,807,894	2,405,829	452,241	33%	597,935	33%	1,050,176	77%

TABLE 11.A2

Total area and private area in Sierra Nevada by county.

County	Total Area in Sierra Nevada (square km)	Percent of Total Area	Total Private Area in Sierra Nevada (square km)	Percent of Total Private Area	Percent of County in Public Land
Alpine	1,925	1.67%	155	0.36%	91.95%
Amador	1,432	1.25%	1,074	2.51%	25.00%
Butte	2,429	2.11%	1,720	4.01%	29.17%
Calaveras	2,493	2.17%	1,941	4.53%	22.14%
El Dorado	4,639	4.04%	2,416	5.64%	47.91%
Fresno	7,135	6.21%	1,673	3.90%	76.55%
Inyo	8,677	7.55%	144	0.34%	98.34%
Kern	8,924	7.76%	5,515	12.87%	38.20%
Lassen	12,219	10.63%	4,765	11.12%	61.00%
Madera	3,439	2.99%	1,389	3.24%	59.60%
Mariposa	3,722	3.24%	1,749	4.08%	53.00%
Modoc	10,820	9.41%	3,888	9.07%	64.07%
Mono	8,074	7.02%	671	1.56%	91.69%
Nevada	2,524	2.20%	1,711	3.99%	32.20%
Placer	3,371	2.93%	1,885	4.40%	44.09%
Plumas	6,769	5.89%	2,007	4.68%	70.35%
Shasta	5,629	4.90%	3,216	7.50%	42.88%
Sierra	2,491	2.17%	743	1.73%	70.19%
Tehama	2,742	2.38%	1,738	4.06%	36.61%
Tulare	8,626	7.50%	2,285	5.33%	73.51%
Tuolumne	5,891	5.12%	1,445	3.37%	75.46%
Yuba	999	0.87%	722	1.69%	27.68%
TOTAL	114,969		42,854		62.73%

TABLE 11.A3

Area versus housing units versus population by density class for 46 CCDs based on 1990 census blocks by housing unit density class (units/sq. mi.).

Housing Density (per sq. mi.)	Area (sq. mi.)	Area (acres)	Area % (of total)	Housing Units (in class)	Housing % (of total)	Population (in class)	Population % (of total)
None	9,238	5,912,437	28.87%	0	0.00%	1,630	0.27%
Less than 1	14,547	9,309,919	45.46%	3,264	1.07%	4,298	0.71%
1 to 2	2,361	1,510,985	7.38%	3,200	1.05%	14,160	2.34%
2 to 5	1,951	1,248,638	6.10%	6,298	2.06%	11,864	1.96%
5 to 10	1,274	815,084	3.98%	8,859	2.90%	20,022	3.31%
10 to 20	890	569,659	2.78%	12,690	4.15%	25,948	4.29%
20 to 40	733	468,938	2.29%	20,317	6.64%	43,015	7.11%
40 to 80	444	284,245	1.39%	25,298	8.27%	52,369	8.66%
80 to 160	266	170,454	0.83%	29,951	9.79%	64,139	10.61%
160 to 640	209	134,025	0.65%	63,427	20.73%	128,449	21.24%
Over 640	89	56,867	0.28%	132,616	43.35%	238,750	39.49%
Grand Total	32,002	20,481,252	100.00%	305,920	100.00%	604,644	100.00%
Cumulative Totals	**Area (sq. mi.)**	**Area (acres)**	**% of total**	**% of 80+**	**% of 40+**	**% of 20+**	**% of 10+**
640+ (< acre/unit)	88.86	56,867	0.28%	15.74%	8.81%	5.10%	3.38%
160+ (4 acres/unit)	298.27	190,893	0.93%	52.83%	29.57%	17.13%	11.33%
80+ (8 acres/unit)	564.60	361,347	1.76%	100.00%	55.97%	32.42%	21.46%
40+ (16 acres/unit)	1,008.74	645,592	3.15%		100.00%	57.93%	38.33%
20+ (32 acres/unit)	1,741.45	1,114,531	5.44%			100.00%	66.18%
10+ (64 acres/unit)	2,631.55	1,684,189	8.22%				100.00%

TABLE 11.A4

Area by housing density class by river basin (see key to CalWaterID codes and HUD classes below).

cawatid	Data	hudclass 1	2	3	4	5	6	7	8	9	10	11	Grand Total
514	Sum of sq_mile	545	492	192	177	89	108	97	88	55	33	10	1,887
	Sum of hu100	0	112	212	573	642	1,587	2,881	4,810	6,307	10,356	15,504	42,984
	Sum of pop100	609	90	116	785	1,052	3,109	7,051	12,544	15,719	24,726	34,046	99,847
518	Sum of sq_mile	1,557	1,251	247	186	142	84	49	12	15	12	5	3,561
	Sum of hu100	0	466	347	587	1,043	1,163	1,278	739	1,676	3,863	6,892	18,054
	Sum of pop100	48	635	335	1,112	1,728	2,097	2,482	1,409	3,446	6,361	12,635	32,288
532.2	Sum of sq_mile	201	43	62	66	69	79	45	27	18	14	5	628
	Sum of hu100	0	18	92	201	487	1,146	1,339	1,453	1,934	4,199	6,232	17,101
	Sum of pop100	0	48	125	379	1,124	2,729	3,238	3,606	4,984	10,233	15,234	41,700
533	Sum of sq_mile	32	8	16	113	109	66	24	7	3	4	1	382
	Sum of hu100	0	3	24	327	689	925	622	402	313	980	1,020	5,305
	Sum of pop100	0	6	44	695	1,437	1,699	1,288	818	770	1,421	1,612	9,790
534	Sum of sq_mile	272	165	111	96	29	31	51	8	14	11	4	793
	Sum of hu100	0	60	193	327	207	505	1,283	469	1,561	4,001	4,368	12,974
	Sum of pop100	108	45	3,965	605	368	741	2,480	670	2,153	5,147	4,833	21,115
536	Sum of sq_mile	459	981	31	67	25	38	33	28	22	19	7	1,710
	Sum of hu100	0	161	46	238	198	542	940	1,661	2,576	5,960	8,891	21,213
	Sum of pop100	34	215	68	450	260	1,099	1,870	3,843	4,721	11,167	14,954	38,681
537	Sum of sq_mile	171	0	0	0	0	0	0	0	0	0	0	171
	Sum of hu100	0	0	0	0	0	0	0	0	0	1	0	1
	Sum of pop100	0	0	0	0	0	0	0	0	0	1	0	1
552	Sum of sq_mile	339	774	93	79	41	44	18	14	1	1	0	1,403
	Sum of hu100	0	138	125	281	255	594	501	876	69	250	307	3,396
	Sum of pop100	0	146	229	656	502	1,437	916	1,093	115	267	218	5,579
553	Sum of sq_mile	206	367	110	46	27	27	12	9	1	1	0	808
	Sum of hu100	0	140	163	154	201	379	298	487	132	292	189	2,435
	Sum of pop100	85	352	440	322	383	766	649	945	249	506	392	5,089
554	Sum of sq_mile	601	1,265	277	28	63	12	16	21	5	7	4	2,297
	Sum of hu100	0	233	349	95	404	149	418	1,253	474	1,878	4,919	10,172
	Sum of pop100	0	148	324	163	706	144	657	1,887	798	2,855	7,072	14,754
601	Sum of sq_mile	263	428	6	0	4	12	0	0	1	1	0	717
	Sum of hu100	0	163	7	1	39	185	0	21	162	165	252	995
	Sum of pop100	0	185	13	0	77	144	0	9	150	117	301	996
637.3	Sum of sq_mile	327	11	2	15	4	0	6	0	0	1	0	365
	Sum of hu100	0	3	2	39	41	2	151	15	7	288	106	654
	Sum of pop100	0	4	0	46	0	0	50	13	4	120	33	270
509521	Sum of sq_mile	520	458	30	45	25	21	18	7	6	4	4	1,139
	Sum of hu100	0	189	33	200	188	286	549	396	659	1,403	5,195	9,098
	Sum of pop100	0	235	21	466	471	637	1,210	991	1,318	3,049	10,719	19,117

cawatid	River Basin	cawatid	River Basin	cawatid	River Basin
509,521	Sacramento	536	Tuolumne	601	Mono Basin
514	American	537	Merced	603,552	Owens
516,517	Yuba	538-540	San Joaquin	623-625	Mojave
518	Feather	552	Kings	630,631	Walker
532.2	Cosumnes	553	Kaweah	632,633	Carson
532.4,532.6	Mokelumne	554	Kern	634-636	Truckee
533	Calaveras	555	Tule	637	Eagle Lake
534	Stanislaus	556	Caliente		

Housing Density Classes correspond to table 11.A3 (1 = 0 units per sq. mi.).

continued

TABLE 11.A4 (continued)

cawatid	Data	hudclass 1	2	3	4	5	6	7	8	9	10	11	Grand Total
516517	Sum of sq_mile	579	212	166	301	158	122	128	82	47	33	10	1,837
	Sum of hu100	0	109	206	992	1,115	1,723	3,707	4,611	5,223	9,059	13,564	40,309
	Sum of pop100	157	69	165	1,668	2,472	4,306	8,753	11,064	12,736	21,227	28,219	90,836
603552.33	Sum of sq_mile	845	1,670	206	134	9	14	24	4	5	7	5	2,923
	Sum of hu100	0	327	280	372	61	160	583	223	536	2,077	11,441	16,060
	Sum of pop100	76	365	481	815	106	441	887	467	967	4,421	14,594	23,620
630631	Sum of sq_mile	172	540	112	25	24	4	7	1	1	0	0	886
	Sum of hu100	0	355	131	79	139	78	191	50	76	170	95	1,364
	Sum of pop100	72	132	309	174	385	136	261	72	126	322	165	2,154
632633	Sum of sq_mile	94	385	59	23	1	4	0	0	1	0	0	567
	Sum of hu100	0	34	101	67	4	58	10	15	77	46	80	492
	Sum of pop100	0	23	112	131	7	119	12	34	109	120	168	835
538539540	Sum of sq_mile	516	1,549	137	105	121	79	87	33	13	9	2	2,651
	Sum of hu100	0	144	183	352	832	1,193	2,340	1,809	1,516	2,424	2,208	13,001
	Sum of pop100	71	247	423	812	1,990	2,365	5,340	4,361	3,562	4,220	2,657	26,048
634635636	Sum of sq_mile	397	65	24	56	77	27	36	31	20	16	18	767
	Sum of hu100	0	10	29	193	574	320	964	1,958	2,295	5,769	29,899	42,011
	Sum of pop100	1	11	55	260	311	277	1,094	971	2,645	6,383	37,759	49,767
532.4,532.6	Sum of sq_mile	259	100	141	73	51	65	41	34	19	10	2	795
	Sum of hu100	0	17	229	247	357	902	1,164	1,986	2,140	2,639	2,678	12,359
	Sum of pop100	4	15	127	499	446	1,888	2,228	3,916	3,971	5,169	5,407	23,670
555.(1,2,4,5)	Sum of sq_mile	222	409	104	93	48	15	12	16	3	2	1	924
	Sum of hu100	0	202	160	303	378	223	373	912	332	510	770	4,163
	Sum of pop100	100	337	496	492	685	305	525	732	525	681	738	5,616
556.1,625.3	Sum of sq_mile	63	112	69	16	67	2	4	0	0	0	0	334
	Sum of hu100	0	40	98	49	384	34	88	25	31	1	12	762
	Sum of pop100	0	118	131	86	601	46	151	39	61	2	22	1,257
623,624(1,2),	Sum of sq_mile	187	627	44	12	1	1	1	0	0	0	0	873
625(1,2,4)	Sum of hu100	0	227	49	43	6	21	23	2	32	14	0	417
	Sum of pop100	0	402	44	71	13	76	61	7	72	36	0	782
637.(1,2,4)	Sum of sq_mile	907	582	75	110	47	45	19	11	4	3	2	1,804
	Sum of hu100	0	131	107	424	333	619	494	621	423	889	3,669	7,710
	Sum of pop100	509	200	279	921	785	1,539	1,224	5,691	1,080	2,187	8,748	23,163
(blank)	Sum of sq_mile	11,541	14,435	1,994	2,521	1,382	994	802	416	277	237	261	34,861
	Sum of hu100	0	3,475	2,889	8,020	9,768	14,322	22,635	23,422	31,096	74,994	558,320	748,941
	Sum of pop100	9,246	7,880	14,142	21,955	33,945	41,168	63,933	67,306	89,957	207,460	1,531,369	2,088,361
Total Sum of sq_mile		21,275	26,928	4,306	4,388	2,613	1,896	1,530	852	531	426	340	65,083
Total Sum of hu100		0	6,757	6,055	14,164	18,345	27,116	42,832	48,216	59,647	132,228	676,611	1,031,971
Total Sum of pop100		11,120	11,908	22,444	33,563	49,854	67,268	106,360	122,488	150,238	318,198	1,731,895	2,625,336
SNEP Sum of sq_mile		9,734	12,493	2,312	1,867	1,230	902	728	436	253	189	78	30,222
SNEP Sum of hu100		0	3,282	3,166	6,144	8,577	12,794	20,197	24,794	28,551	57,234	118,291	283,030
SNEP Sum of pop100		1,874	4,028	8,302	11,608	15,909	26,100	42,427	55,182	60,281	110,738	200,526	536,975

cawatid	River Basin	cawatid	River Basin	cawatid	River Basin
509,521	Sacramento	536	Tuolumne	601	Mono Basin
514	American	537	Merced	603,552	Owens
516,517	Yuba	538-540	San Joaquin	623-625	Mojave
518	Feather	552	Kings	630,631	Walker
532.2	Cosumnes	553	Kaweah	632,633	Carson
532.4,532.6	Mokelumne	554	Kern	634-636	Truckee
533	Calaveras	555	Tule	637	Eagle Lake
534	Stanislaus	556	Caliente		

Housing Density Classes correspond to table 11.A3 (1 = 0 units per sq. mi.).

TABLE 11.A5

Land-use designations in draft general plans (1994).

Zoning Classification	Allowable Density	Area (sq. miles)	Area (acres)	Share (%)
El Dorado County "Alternative"				
Multi-Family Residential	5-24 Units/Acre	3.1	1,972	0.20%
High Density Residential	1-7 Units/Acre	26.0	16,641	1.66%
Medium Density Residential	1 Unit/1-5 Acres	47.6	30,433	3.03%
Low Density Residential	1 Unit/5-20 Acres	211.8	135,580	13.49%
Rural Residential	1 Unit/20-40 Acres	98.3	62,900	6.26%
Natural Resource	1 Unit/40+ Acres	1010.9	646,960	64.36%
Rural Residential Low Density	1 Unit/40+ Acres	75.6	48,411	4.82%
Planned Community Three	Average 0.62 - 3.57 Units/Acre	1.1	722	0.07%
Planned Community One	Average 1.4 Units/Acre	1.6	1,028	0.10%
Planned Community Two	Average 4.1 Units/Acre	3.0	1,915	0.19%
Commercial	N.A.	6.1	3,888	0.39%
Industrial	N.A.	3.5	2,222	0.22%
Open Space	N.A.	71.9	46,045	4.58%
Public Facility	N.A.	2.5	1,577	0.16%
Research & Development	N.A.	1.4	908	0.09%
Area Plan	Unknown Density	5.5	3,545	0.35%
Unlabeled on Plan Map	Unknown Density	0.7	434	0.04%
TOTAL		1,571	1,005,183	100%
Planned Communities		6	3,665	0.36%
Total w/o PCs		1,565	1,001,518	99.64%
El Dorado County "Project"				
Multi-Family Residential	5-24 Units/Acre	3.1	2,000	0.20%
High Density Residential	1-7 Units/Acre	25.7	16,447	1.64%
Medium Density Residential	1 Unit/1-5 Acres	53.8	34,448	3.43%
Low Density Residential	1 Unit/5-10 Acres	180.3	115,390	11.48%
Rural Residential	1 Unit/10-40 Acres	295.0	188,801	18.78%
Natural Resource	1 Unit/Over 160 Acres	963.1	616,415	61.32%
Planned Community Three	Average 0.62 - 3.57 Units/Acre	3.0	1,915	0.19%
Planned Community One	Average 1.4 Units/Acre	1.6	1,028	0.10%
Planned Community Two	Average 4.1 Units/Acre	1.1	722	0.07%
Commercial	N.A.	5.2	3,345	0.33%
Industrial	N.A.	3.4	2,171	0.22%
Open Space	N.A.	31.0	19,863	1.98%
Public Facility	N.A.	2.7	1,702	0.17%
Research & Development	N.A.	1.5	932	0.09%
TOTAL		1,571	1,005,180	100%
Planned Communities		6	3,665	0.36%
Total w/o PCs		1,565	1,001,514	99.64%
Nevada County General Plan				
Urban High Density	20 Units/Acre	0.7	427	0.07%
Urban Medium Density	6 Units/Acre	1.5	955	0.15%
Urban Single Family	4 Units/Acre	7.0	4,507	0.73%
Residential	1 Unit/1.5 Acres	10.9	6,950	1.13%
Estate	1 Unit/3 Acres	32.9	21,046	3.41%
Rural 5	1 Unit/5 Acres	70.7	45,258	7.33%
Rural 10	1 Unit/10 Acres	68.3	43,703	7.08%
Rural 20	1 Unit/20 Acres	53.5	34,227	5.55%
Rural 30	1 Unit/30 Acres	25.3	16,214	2.63%
Rural 40	1 Unit/40 Acres	57.7	36,958	5.99%
Rural 160	1 Unit/160 Acres	2.8	1,786	0.29%
Forest 40	1 Unit/40 Acres	54.6	34,914	5.66%
Forest 80	1 Unit/80 Acres	1.0	665	0.11%
Forest 160	1 Unit/160 Acres	436.8	279,583	45.30%
Forest 640	1 Unit/640 Acres	32.0	20,481	3.32%
Business Park	n.a.	0.9	562	0.09%
Community Commercial	n.a.	1.2	737	0.12%
City	n.a.	3.4	2,200	0.36%
Highway Commercial	n.a.	0.2	149	0.02%
Industrial	n.a.	1.3	843	0.14%
Neighborhood Commercial	n.a.	0.4	247	0.04%
City	n.a.	1.9	1,224	0.20%
Office Professional	n.a.	0.2	138	0.02%
Open Space	n.a.	44.7	28,606	4.63%
Planned Development	n.a.	15.2	9,725	1.58%
Planned Residential Community	n.a.	15.8	10,141	1.64%
Public and Institutional	n.a.	6.6	4,252	0.69%
Rural Commercial	n.a.	0.1	60	0.01%

continued

TABLE 11.A5 (continued)

Zoning Classification	Allowable Density	Area (sq. miles)	Area (acres)	Share (%)
Recreation	n.a.	0.4	258	0.04%
Special Development Area	n.a.	15.8	10,127	1.64%
Service Commercial	n.a.	0.0	2	0.00%
Unknown	n.a.	0.3	185	0.03%
Village Business Park	n.a.	0.1	72	0.01%
Water	n.a.	10.0	6,432	(Not Included)
TOTAL		974	623,634	100%
Total in PD and SDA		31	19,852	3.22%
Total w/o PD or SDA		943	603,783	96.78%
Total in GV and NC		5	3,424	0.55%
Total w/o GV and NC		969	620,210	99.45%
Total w/o either above		938	600,358	96.23%

TABLE 11.A6

Housing units forecast under El Dorado County General Plan "buildout" scenarios.

Zoning Classification	Middle Density	Middle Housing	Middle Share (%)	Low Density	Low Housing	Low Share (%)	High Density	High Housing	High Share (%)
El Dorado County General Plan Project Description (densities are per sq. mi.)									
Multi-Family Residential	9,280	29,000	18%	3,200	10,000	11%	15,360	47,999	32%
High Density Residential	2,560	65,787	42%	640	16,447	17%	4,480	115,127	76%
Medium Density Residential	384	20,669	13%	128	6,890	7%	640	34,448	23%
Low Density Residential	96	17,309	11%	128	23,078	25%	64	11,539	8%
Rural Residential	40	11,800	8%	16	4,720	5%	64	18,880	12%
Natural Resource	4	3,853	2%	4	3,853	4%	4	3,853	3%
Planned Community Three	1,341	4,012	3%	397	1,187	1%	2,285	6,837	4%
Planned Community One	896	1,439	1%	896	1,439	2%	896	1,439	1%
Planned Community Two	2,624	2,960	2%	2,624	2,960	3%	2,624	2,960	2%
TOTAL		156,829	100%		70,574	100%		243,083	100%
Planned Communities		8,412	5%		5,587	6%		11,237	7%
Total w/o PCs		148,417	95%		64,987	94%		231,847	93%
El Dorado County General Plan Alternative (densities are per sq. mi.)									
Multi-Family Residential	9,280	28,601	18%	3,200	9,862	14%	15,360	47,340	19%
High Density Residential	2,560	66,563	41%	640	16,641	24%	4,480	116,485	46%
Medium Density Residential	384	18,260	11%	128	6,087	9%	640	30,433	12%
Low Density Residential	80	16,948	11%	32	6,779	10%	128	27,116	11%
Rural Residential	24	2,359	1%	16	1,573	2%	32	3,145	1%
Natural Resource	16	16,174	10%	16	16,174	24%	16	16,174	6%
Rural Residential Low Density	16	1,210	1%	16	1,210	2%	16	1,210	0%
Planned Community Three	1,341	1,512	1%	397	448	1%	2,285	2,577	1%
Planned Community One	896	1,439	1%	896	1,439	2%	896	1,439	1%
Planned Community Two	2,624	7,852	5%	2,624	7,852	12%	2,624	7,852	3%
TOTAL		160,919	100%		68,065	100%		253,772	100%
Planned Communities		10,804	7%		9,739	14%		11,869	5%
Total w/o PCs		150,114	93%		58,326	86%		241,903	95%

TABLE 11.A7

Housing units forecast under Nevada County General Plan "buildout" scenarios.*

Zoning Classification	Middle Density	Middle Housing	Middle Share (%)	Low Density	Low Housing	Low Share (%)	High Density	High Housing	High Share (%)
Nevada County General Plan (densities are per sq. mi.)									
Urban High Density	12,800	8,539	7%	12,800	8,539	9%	12,800	8,539	6%
Urban Medium Density	3,840	5,729	4%	3,840	5,729	6%	3,840	5,729	4%
Urban Single Family	2,560	18,030	14%	2,560	18,030	19%	2,560	18,030	12%
Residential	427	4,634	4%	427	4,634	5%	427	4,634	3%
Estate	213	7,015	5%	213	7,015	7%	213	7,015	5%
Rural 5	128	9,052	7%	128	9,052	10%	128	9,052	6%
Rural 10	64	4,370	3%	64	4,370	5%	64	4,370	3%
Rural 20	32	1,711	1%	32	1,711	2%	32	1,711	1%
Rural 30	21	540		21	540	1%	21	540	
Rural 40	16	924	1%	16	924	1%	16	924	1%
Rural 160	4	11		4	11		4	11	
Forest 40	16	873	1%	16	873	1%	16	873	1%
Forest 80	8	8		8	8		8	8	
Forest 160	4	1,747	1%	4	1,747	2%	4	1,747	1%
Forest 640	1	32		1	32		1	32	
City**	1,000	3,438	3%	1,000	3,438	4%	1,000	3,438	2%
City**	1,000	1,912	1%	1,000	1,912	2%	1,000	1,912	1%
Planned Development**	1,089	16,549	13%	337	5,125	5%	1,841	27,973	18%
Planned Residential Community**	860	14,022	11%	860	14,022	15%	860	14,022	9%
Special Development Area**	1,841	29,128	23%	397	6,278	7%	2,624	41,519	27%
TOTAL		128,265	100%		93,991	100%		152,080	100%
Total in PD and SDA		45,677	36%		11,403	12%		69,492	46%
Total w/o PD or SDA		82,588	64%		82,588	88%		82,588	54%
Total in GV and NC		5,350	4%		5,350	6%		5,350	4%
Total w/o GV and NC		122,915	96%		88,641	94%		146,730	96%
Total w/o either above		77,238	60%		77,238	82%		77,238	51%

*Note text explanation of likely errors in Nevada County General Plan forecasts due to existing parcelization at higher than densities allowable under the Plan.
**See text explanation of methods used to estimate high, middle and low average "build out" densities for these unspecified density land use classifications.

TABLE 11.A8

Coefficient of variation (C.V.) analysis of map book page data from 1992 El Dorado and Nevada County assessor's records.

	Nevada County						El Dorado County					
C.V.	Parcels	Area	Pages	%Parcels	%Area	%Pages	Parcels	Area	Pages	%Parcels	%Area	%Pages
0	959	1,654	140	2%	4%	7%	24,959	14,247	1,069	60%	41%	57%
0-0.499	21,967	27,994	1,028	51%	61%	52%	4,454	4,651	154	11%	13%	8%
0.5-0.99	11,459	12,515	517	27%	27%	26%	9,609	13,735	526	23%	40%	28%
1.0-1.99	6,705	3,022	211	16%	7%	11%	1,923	1,793	108	5%	5%	6%
2.0-2.99	918	336	29	2%	1%	1%	126	24	8			
3.0-3.99	351	96	17	1%		1%	289	262	12	1%	1%	1%
4.0-4.99	179	80	6				48	9	3			
5.0-9.99	336	65	9	1%			64	36	4			
10.0+	102	21	5				178	11	5			
Sum	42,976	45,784	1,962	100%	100%	100%	41,650	34,768	1,889	100%	100%	100%
0-0.5	22,926	29,648	1,168	53%	65%	60%	29,413	18,898	1,223	71%	54%	65%
0-0.99	34,385	42,163	1,685	80%	92%	86%	39,022	32,633	1,749	94%	94%	93%
0-1.99	41,090	45,185	1,896	96%	99%	97%	40,945	34,427	1,857	98%	99%	98%
0.5+	20,050	16,136	794	47%	35%	40%	12,237	15,870	666	29%	46%	35%
1.0+	8,591	3,621	277	20%	8%	14%	2,628	2,135	140	6%	6%	7%
2.0+	1,886	599	66	4%	1%	3%	705	342	32	2%	1%	2%
3.0+	968	263	37	2%	1%	2%	579	318	24	1%	1%	1%
4.0+	617	167	20	1%	0%	1%	290	56	12	1%	0%	1%
5.0+	438	86	14	1%	0%	1%	242	47	9	1%	0%	0%

Nevada County has 138 Map Book Pages where the C.V. is 1.0+ and the Area exceeds 10.00; El Dorado County has only 64 MBPs in this class. Nevada County has 17 Map Book Pages where the C.V. is 0.5+ and the Area exceeds 80.00; El Dorado County has 22 MBPs in this class.

TABLE 11.A9

Subdividability of existing parcels under Nevada and El Dorado County General Plans.*

Subdividability	Frequency	Area	Mean	Minimum	Maximum	Std Dev	Parcel %	Area %	Middle
El Dorado County									
At or above allowable density	78,062	0	0.00	0.00	0.00	0.00	80%		0
Lower than allowable density but cannot be subdivided further (e.g., a 7-acre parcel in a 5-acre zone)	12,462	12,462	1.00	1.00	1.00	0.00	13%	17%	0
2-3 smaller parcels possible	4,280	9,702	2.27	2.00	3.00	0.44	4%	13%	10,700
4-5 smaller parcels possible	1,079	4,776	4.43	4.00	5.00	0.49	1%	6%	4,856
6-10 smaller parcels possible	896	6,769	7.55	6.00	10.00	1.36	1%	9%	7,168
11-20 smaller parcels possible	514	7,334	14.27	11.00	20.00	2.68	1%	10%	7,967
21-40 smaller parcels possible	183	5,071	27.71	21.00	40.00	5.51		7%	5,582
40-160 smaller parcels possible	162	12,712	78.47	41.00	158.00	32.11		17%	16,200
161-640 smaller parcels possible	36	9,434	262.06	161.00	575.00	110.48		13%	14,418
640 or more smaller parcels possible	7	6,845	977.86	716.00	1,544.00	273.54		9%	4,480
TOTAL	97,681	75,105	1,375.61	963.00	2,356.00	426.61	100%	100%	71,370
Subdivision Map Act Restrictions	2,338	50,553					2%	67%	
Nevada County									
At or above allowable density	29,620	93,659	3.16	0.00	628.76	59.87	51%	16%	29,620
Lower than allowable density but cannot be subdivided further (e.g., a 7-acre parcel in a 5-acre zone)	16,934	101,723	6.01	0.09	662.76	28.14	29%	18%	16,934
2-3 smaller parcels possible	7,163	163,508	22.83	0.12	671.05	91.66	12%	29%	14,326
4-5 smaller parcels possible	1,639	80,391	49.05	0.26	760.77	142.91	3%	14%	6,556
6-10 smaller parcels possible	1,317	42,969	32.63	0.37	883.74	85.70	2%	8%	10,536
11-20 smaller parcels possible	665	32,097	48.27	0.61	638.64	111.19	1%	6%	10,308
21-40 smaller parcels possible	332	18,374	55.34	1.12	1280.00	125.65	1%	3%	10,126
40-160 smaller parcels possible	240	25,260	105.25	4.25	2081.20	200.81		4%	24,120
161-640 smaller parcels possible	50	12,113	242.27	31.00	955.00	234.13		2%	20,025
640 or more smaller parcels possible	3	1,333	444.43	219.88	560.00	194.49			1,920
TOTAL	57,963	571,429					100%	100%	144,471
Subdivision Map Act Restrictions	3,153	158,945					5%	28%	

*note text for methodological problems in analysis and likely source of errors in estimating subdividability of parcels under each of the General Plans. Higher estimate for the Nevada County General Plan than the El Dorado County General Plan reflects failure by Nevada County to address existing parcelization in land use designations.

TABLE 11.A10

Distribution of parcel sizes for Nevada and El Dorado Counties.*

Parcel Size Class	El Dorado Frequency	Nevada Frequency	El Dorado Area	Nevada Area	El Dorado Frequency %	Nevada Frequency%	El Dorado Area%	Nevada Area%
No acreage**	4,031	3,335			5%	6%		
Less than 1 acre	44,834	28,753	18,431	11,616	56%	51%	4%	3%
1 to 3 acres	10,441	8,381	18,904	15,714	13%	15%	4%	4%
3 to 5 acres	6,210	4,548	26,880	19,559	8%	8%	6%	4%
5 to 10 acres	7,340	5,454	51,880	39,636	9%	10%	12%	9%
10 to 20 acres	3,866	2,671	49,920	37,613	5%	5%	11%	8%
20 to 40 acres	1,523	1,657	45,282	46,405	2%	3%	10%	10%
40 to 160 acres	1,188	1,287	91,293	101,860	1%	2%	20%	23%
160 to 640 acres	385	451	128,046	162,647	0%	1%	28%	36%
Over 640 acres	16	14	19,116	12,597	0%	0%	4%	3%
TOTAL	79,834	56,551	449,752	447,647	100%	100%	100%	100%

*Note that these data are only for those private lands in areas within each county that are “below the green line” west of the national forest boundary.
**These parcels include parcels less than one acre in size within subdivisions for which the subdivision’s area is listed in the assessor’s records. They also include condominiums or time-share units, which are also generally less than one acre in size. This size class is generally < 1 acre.

TABLE 11.A11

El Dorado County General Plan Project Description at “buildout” versus 1990 census densities.

Housing Density Class	1990 Area	Project	Abs. Change	Rel. Change	Housing Units	% of Housing	Population	% of Pop
None	510.6	71.9	–438.68	–86%				
Less than 1	223.4		–223.43	–100%				
1 to 2	231.5		–231.47	–100%				
2 to 5	194.1		–194.12	–100%				
5 to 10	152.5		–152.54	–100%				
10 to 20	153.4	1,086.5	933.14	608%	17,384	11%	36,709	12%
20 to 40	122.5	98.3	–24.20	–20%	98		233	
40 to 80	84.2		–84.21	–100%				
80 to 160	62.4	211.8	149.46	240%	16,948	11%	40,833	13%
160 to 640	38.6	47.6	8.98	23%	18,260	12%	40,237	13%
Over 640	17.9	34.8	16.87	94%	105,968	67%	195,020	62%
TOTAL	1,791.1	1,551.0	–240.19	–13%	158,658	100%	313,032	100%
Commercial/Industrial/Other		13.4	11.00					

Housing Density Class is given in units per square mile and all areas are given in square miles.

TABLE 11.A12

El Dorado County General Plan Alternative at “buildout” versus 1990 census densities.

Housing Density Class	1990 Area	Alternative	Abs. Change	Rel. Change	Housing Units	% of Housing	Population	% of Pop
None	510.6	31.0	–479.6	–94%				
Less than 1	223.4		–223.4	–100%				
1 to 2	231.5		–231.5	–100%				
2 to 5	194.1	963.1	769.0	396%	3,853	2%	5,891	2%
5 to 10	152.5		–152.5	–100%				
10 to 20	153.4		–153.4	–100%				
20 to 40	122.5		–122.5	–100%				
40 to 80	84.2	295.0	210.8	250%	11,800	8%	29,293	9%
80 to 160	62.4	180.3	117.9	189%	17,309	11%	41,703	13%
160 to 640	38.6	53.8	15.3	40%	20,669	13%	45,545	15%
Over 640	17.9	34.6	16.6	93%	103,198	66%	189,923	61%
TOTAL	1,791.1	1,557.9	–233.3	–13%	156,829	100%	312,356	100%
Commercial/Industrial/Other		8.6	8.6					

Housing Density Class is given in units per square mile and all areas are given in square miles.

TABLE 11.A13

Nevada County General Plan density distribution at “buildout” versus 1990 census densities.*

Housing Density Class	1990 Area	General Plan	Abs. Change	Rel. Change	Housing Units	% of Housing	Population	% of Pop
None	365	55	–310	–85%				
Less than 1	87							
1 to 2	97	32	–65	–67%	32		28	
2 to 5	59	440	381	644%	1,759	1%	3,507	1%
5 to 10	54	1	–53	–98%	8		19	
10 to 20	79	112	34	43%	1,797	1%	4,768	2%
20 to 40	90	79	–11	–12%	2,252	2%	5,337	2%
40 to 80	61	68	7	12%	4,370	3%	10,849	4%
80 to 160	40	71	30	76%	9,052	7%	21,809	9%
160 to 640	30	59	29	97%	11,649	9%	25,669	10%
Over 640	12	9.20	–3	–25%	97,346	76%	179,153	71%
TOTAL	974	926	–48	–5%	128,265	100%	251,139	100%
Commercial/Industrial		11	11					

*Note text explanation of likely errors in Nevada County General Plan due to failure to address existing parcelization at higher than allowable densities.
Housing Density Class is given in units per square mile and all areas are given in square miles.

TABLE 11.A14

Distribution of population by housing density class.*

Housing Density Class (per sq. mi.)	1990 Census 46 Sierra CCDs	1990 Census Nevada County	1990 Census El Dorado County	Nevada County General Plan	El Dorado County General Plan Project Description	El Dorado County General Plan Alternative
None						
Less than 1	1%					
1 to 2	2%					
2 to 5	2%		1%	1%		
5 to 10	3%	1%	1%			
10 to 20	4%	4%	4%	2%	12%	
20 to 40	7%	8%	7%	2%		
40 to 80	9%	10%	9%	4%		9%
80 to 160	11%	13%	14%	9%	13%	13%
160 to 640	21%	23%	21%	10%	13%	15%
Over 640	39%	40%	44%	71%	62%	61%
TOTAL	100%	100%	100%	100%	100%	100%

*Note that General Plan estimates assume that land use designations will be accurate at “buildout” and will be unaffected by inconsistent existing parcelization.

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