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ABSTRACT

This annual meeting site guide is the fourth to be published by the National Council for Geographic Education as part of the "Pathways in Geography" series. The chapters illustrate some of the interactions between people and place that have helped shape the Santa Barbara (California) region over the centuries. The book includes an introduction by the editors and nine chapters written by various authors. The final chapter of the book contains five learning activities which focus on some aspect of California geography. Chapters include: (1) "Santa Barbara, California: An Unauthorized Biography of an Image" (Thomas Herman); (2) "California Missions: The Early Years" (David Hornbeck); (3) "California Population" (William Bowen); (4) "Physical Landscape" (Joel Michaelsen); (5) "The San Andreas Fault" (Antony R. Orme); (6) "Santa Barbara's Water Resources" (Kate Rees, Editor); (7) "Agricultural Patterns in Ventura County's Heartland" (Chris Mainzer); (8) "Wines of Santa Barbara County: A Geographic Perspective" (Vatche P. Tchakerian; Robert S. Bednarz); and (9) "The View from Paradise: Problems and Prospects of the California Central Coast" (William C. Halperin; Lisa Knox Burns). (EH)

A PATHWAYS IN GEOGRAPHY
Resource Publication

The National Council for
Geographic Education

Santa Barbara and California's Central Coast Region:

Images and Encounters

Jeanette Gardner Betts, Susan W. Hardwick and Gail L. Hobbs, Editors

Prepared for the 81st meeting of the National Council for Geographic Education, Santa Barbara, California, November 13-16, 1996

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Introduction

Jeanette Gardner Betts, Susan W. Hardwick, Gail L. Hobbs

> With the dull hues of the swiftly-rising wall of the Santa Ynez Mountains as a backdrop, the richer blue of the Pacific, and the charm of imaginatively landscaped dwellings, [the Santa Barbara coast] has much appeal.
>
> *Lantis, Steiner, and Karinen 1989*

So begins a classic California geography textbook in its section on the Santa Barbara area. What an elegant understatement this brief glimpse provides. Santa Barbara and California's Central Coast are, indeed, dramatic places for living and visiting. A unique human history, weather and climate, setting, and quality of life coalesce here to form one of the most spectacular places in North America.

This annual meeting site guide is the fourth to be published by the National Council for Geographic Education as a part of the PATHWAYS IN GEOGRAPHY series. The chapters that follow illustrate some of the many fascinating interactions between people and place that have helped shape the Santa Barbara region over the past centuries. Using this booklet as a guide, we strongly and wholeheartedly encourage you to find the time to observe the geography of this diverse region firsthand on field trips or on your own before and after the meetings.

Previews

We have assembled a menu of geographic topics in this site guide to inspire and inform you on the local area. We begin with a vivid portrayal of the evolution of Santa Barbara with Thomas Herman's "Unauthorized Biography of an Image." We then offer you one of David Hornbeck's finest with a look at the early establishment of the Santa Barbara mission and its important role in the development of the regional economy and culture. No doubt the earliest padres who settled Santa Barbara would be amazed to read William Bowen's illuminating chapter on population growth in the Golden State during the twentieth century.

Then our discussion of physical patterns in the Santa Barbara-Central Coast region begins. Both Joel Michaelsen and Antony Orme provide excellent overviews of the physical geography of our conference site—including a discussion of the Santa Barbara area's unique climate, landforms, natural vegetation, and earthquake potential. This is followed by a closer look at one of the city's most precious resource—water, edited by Kate Rees. As in much of the state, water has long been a vitally important consideration for both urban and rural settlement in the area. Chris Mainzer in Chapter 7 provides one example in her cogent analysis of agricultural patterns in Ventura County.

Turning water into wine, Chapter 8 then focuses on viticulture in Santa Barbara County. According to authors Vatche Tchakerian and Robert Bednarz, although wine making began as early as mission settlement in the late eighteenth century, the industry did not begin in earnest until the late 1960s. Our final narrative chapter examines geographic issues facing Ventura, Santa Barbara, and San Luis Obispo counties in the new century. William Halperin and Lisa Knox Burns examine past, present, and future patterns and potentials in the region and offer a fitting conclusion to this story of California's "Gold Coast."

California Geographic Alliance—North teachers Terry Williams and Jerry R. Williams, Carol Douglass, and Eunice Gavin present us with a collection of learning activities on the geography of California. Their motivating and instructional examples expand not only our knowledge, skills, and pedagogy for learning and teaching about pressing geographic issues in the state but also offer inspiration for the creation of original activities for use in your own classes when you return home.

Fascinating Facts

We offer the following tantalizing previews of the chapters that follow:

- Santa Barbara was first popularized to the nation in a pamphlet published in 1878 designed to attract health seekers. It described the small village as the "sanitarium of the Pacific Coast."
- A major earthquake in June 1925 leveled almost the entire city of Santa Barbara.
- Cities such as Santa Barbara as Spanish missions now contain more than 60 percent of California's population.
- The Seaside Banana Gardens, located ten miles northwest on the coast from Ventura, raises more than 50 varieties of bananas.
- Ventura County's Port Hueneme currently ships more than 200,000 tons of citrus annually to the Pacific Rim. Its refrigerated warehouse is the largest port facility of this kind in the Western Hemisphere.
- The Santa Barbara area is home to more than 30 wineries, seventy-five percent of which were built after 1982.
- The federal government awarded its first lease for drilling offshore oil in the Santa Barbara Channel in 1966. Three years later, an underwater well off the Carpinteria coast *blew*, spewing thousands of gallons of petroleum into the ocean, killing wildlife and coating beaches from Ventura to Santa Barbara. This event helped launch the nation's environmental movement.

Santa Barbara Attractions

We encourage you to visit some of the following places while you are in the area (see Figure 1.1):

- **Botanical Garden**—1212 Mission Canyon Road, tel. 682-4726. This beautiful 65-acre preserve specializes in plants native to California.
- **Santa Barbara Museum of Natural History**—2559 Puesta del Sol Road, tel. 682-4711. This collection of visual and textual information on the biogeography, geomorphology, migration and settlement, and urban evolution of the area provides useful background for your field observations.
- **Mission Santa Barbara**—corner of East Los Olivos and Laguna streets, tel. 682-4149. Called "Queen of the Missions," this stunning building, constructed in 1786, is one of the best preserved of the missions in California.
- **Stearns Wharf**—on the water at the foot of State Street and Cabrillo Boulevard. Built in 1872, this was a landmark for Santa Barbara. It was used as a port for cargo and passenger ships and, in the 1930s, as a departure point for floating casino gamblers.
- **Alameda Plaza**—bounded by Micheltorena, Sola, Anacapa, and Garden streets downtown. This is a biogeographer's paradise with more than 70 varieties of trees.
- **Historic adobes.** The city's heritage is evident in its colorful cultural landscape of white-washed, tile-roofed buildings and Spanish street names. For a sampling of Santa Barbara's New England and Latino heritage, drive by the Trussell-Winchester Adobe, built in 1854—414 West Montecito Street. You may also wish to visit Spanish-inspired Casa de la Guerra, built in 1828—15 East de la Guerra Street; Casa Covarrubias, built in 1817—715 Santa Barbara Street; and Hill-Carrillo Adobe, built earlier in the city's history in 1826—11-15 East Carillo Street.

One Final Exhortation

We hope the chapters that follow provide you with ample motivation and information to launch into the field on your own while you are in the area. A lush environment awaits you. We encourage you to avoid pressures from family and friends to visit only Disneyland and Knott's Berry Farm (instead of exploring the local area) in an effort to provide you with glimpses of the real (rather than the *surreal*) California. (That is why we have chosen Santa Barbara as the site for these California meetings!) Please, don't forget your camera.

Reference

Lantis, David W., Rodney Steiner, and Arthur E. Karinen 1989. *California: Land of Contrasts*. rev. ed. Dubuque, Ia.: Kendall Hunt.

Santa Barbara, California: An Unauthorized Biography of an Image

Thomas Herman

Turn to the pages marked California in your road atlas and the city of Santa Barbara is not likely to jump out at you as one of the more significant places in the state (Figure 1.1). It merely takes its place with a large collection of moderately-sized coastal cities that offer a great deal more to residents and vacationers than they do to industry. Not only is the Santa Barbara area unique because of the local geography of an east-west running coastline and the coastal ranges (hence the regional label "South Coast") but it is also often of marginal interest on road atlas map pages and mental images because it is in the borderlands between those two squabbling siblings, Northern and Southern California. To the more analytically minded, nevertheless, it may seem no more important to write the biography of Santa Barbara than say Ventura, or maybe Manhattan Beach. It is not a major factor in the material flows that constitute the bulk of the state's economy, nor a dynamic location to observe the changing demographics of the state's population.

Another argument, however, can be made in defense of an analysis of Santa Barbara. Aligned with this position would be the city's historical significance as a village site of the Chumash and other tribes, a mission territory under Spanish rule, and a part of the territory surrendered by Mexico to the United States in 1848. We can offer additional support derived from the beauty and bounty of the natural landscape, including the protected channel waters, enriched by the convergence of warm and cold ocean currents off Point Conception (to the west). The plot that also makes this biography compelling is the continuous interplay between Santa Barbara's aesthetic virtues and envisioning its history. From the time of its earliest settlers, we can attribute a special value to the area that has in turn engendered careful treatment and ambitious designs. The result is a rich and intriguing landscape that expresses historically and culturally dynamic interpretations of and relationship to the natural landscape. These processes have turned Santa Barbara from an important site in historical narratives to a symbol of the ideal Southern California quality and style of life. It is a city in which its citizens have given high priority to image and architecture in a conscious effort to manage and even augment substantial cultural capital. The length of this paper necessitates subordinating much detail while highlighting the continuity of this aesthetic theme and suggesting how history has been reappropriated and reintegrated into the Santa Barbara landscape to maintain selective connections with the events and cultures of the past.

Chumash and Spanish Legacies

In October of 1542, Juan Rodriguez Cabrillo led the first European expedition into this region. Though he was Portuguese, his two ships sailed under the flag of Spain. They entered what is now the Santa Barbara Channel to anchor in the lee of the channel islands and were welcomed by canoes full of the local inhabitants, the Chumash, called the *Canaliños* by the Spanish. Mixing with other hunting peoples in the area as early as A.D. 800, they had evolved a culture reminiscent of Polynesia. They lived together in communal long houses and fed themselves from the ample supply of sea life. They navigated the waters of the channel in canoes of up to 25 feet (7.6 m), carved from fallen redwoods that had drifted down the coast with the currents and washed ashore in the local eddy. At night, they used beacon fires atop the coastal heights for reference. The life the Chumash led reflected a notably higher level of advancement and quality of life than other Native Americans of the region. To European explorers, the *Canaliños* became an asset because of their friendliness and abilities.

Figure 1.1 City of Santa Barbara

For more than 200 years the Spanish made only temporary visits. In 1602, Sebastian Vizcaino was looking for a harbor for the Manila galleons when he entered the channel on 4 December, the feast of an early Christian martyr, Saint Barbara. A Carmelite friar aboard the ship gave that name to the channel and the shore. In 1769, the Spanish returned and in 1782 the Royal Presidio (a military post or fortified settlement) of Santa Barbara was established near a Chumash village. The Father President of the Missions dedicated the Presidio in April of that year, but it was not until four years later (after Junipero Serra's death) that a mission proper was established. Though aged and frail, Father Serra spent months walking the foothills of the area to locate a site suitable for what was planned to be the culmination of Spanish missionary efforts. The site Serra originally chose was several miles to the east in the present town of Montecito, but after his death, concerns over bears and unfriendly natives led his successor to choose its present site, closer to the Presidio. The Mission was established at the mouth of a canyon and from an elevation of 250 feet (76m) commands a sweeping view of the channel three miles away (Figure 1.1).

The Mission itself symbolized the nurturing of the Spanish Catholic royalist presence. Three progressively more ambitious adobe churches were built in 1786, 1789, and 1794. The third was expanded several times and embellished with a Moorish fountain, *lavendaria*, that still stands. On 21 December 1812, an earthquake severely damaged the structure. In planning the fourth mission church, pastor Antonio Ripoll modeled his designs after the Roman architect Vitruvius of the Augustan age. With the future of royal Spanish rule in California in jeopardy, Ripoll sought to make a bold gesture restoring majesty to the mission. Completed in 1820, the neoclassical mission, built not of adobe but sandstone, and surrounded by adjacent monastery, gardens, and orchards, set new architectural and landscaping standards for construction on the California coast. It was heralded as the Queen of the Missions. Just two years after the new mission was dedicated with a fiesta, Mexico broke from Spain, and the impressive structure was suddenly transformed into an ironic icon of an era of imagined grandeur that had never quite been achieved.

Mexican and Yankee Transitions

Before the Mexican revolution of 1822, the *presidio* had become the core of an army town with a social stratification typical of colonies. Religious and military elite of European origin were at the apex of the social pyramid whereas the Mission Indians were at the bottom. About a mile (1.6 km) away at the mission, troubles were brewing for the Franciscans in the form of secularization. The government of the Mexican Republic was eager to demonstrate its control over and its designs for Santa Barbara as a socially and culturally developed episcopal city. The Franciscans were forced to take an oath of allegiance to Mexico, secularization of the missions began in 1833, and finally in 1840, Pope Gregory XVI responding to a request by Mexico's President Bustamente, authorized the upgrading of Upper and Lower California from a missionary territory dependent upon the Franciscan order to an independent diocese with its own bishop. The bishop was originally located in San Diego, but unhappy with his residence there, he relocated to Santa Barbara. The arrival of the bishop was greeted with great fanfare and regalia. After plans were announced for a cathedral, bishop's residence, seminary, and a school for girls, stones were collected in anticipation of construction. A new social order allowed not only for the ascension of Mexican *rancheros* and government officials, an expansion of the middle-class mestizo population but also eliminated the protected status that Native Americans had enjoyed under mission rule.

The promise of episcopal authority and elegance was ultimately short-lived. The bishop's finances collapsed when the new Mexican President Santa Anna seized his allotment of funds for the administration of the government rather than for this grand project in a thinly settled area. The city that he had imagined was never built and the stones that had been collected remained in piles. During this period, the Franciscans of the mission resisted the bishop in many ways and radically decreased their investment in the development of the region. The mission and its grounds fell into disrepair, orchards were neglected, and cattle were slaughtered for hide or tallow. Many of the Chumash who had congregated in a village of adobe huts around the mission began to resume their roving ways, and social problems flourished. For a time, before the United States government took over California, the mission church was rented to Goleta Valley ranchers. Though this was a tumultuous and unproductive period for the development of Santa Barbara, the visions of Bishop Garcia Diego y Moreno of Santa Barbara as a northern outpost of Hispanic civilization spurred the imaginations of future residents and boosters. If only for four short years, the city had taken its place as the religious and cultural capital of California.

During the Mexican period, the military officials of the garrison at Santa Barbara were also prominent traders. None more so than Captain De La Guerra, who was *commandante* under both Spanish and Mexican rule before retiring from active military service. He built a large adobe that became the center of social life for the town. De La Guerra had established contacts with several American traders and investors, some of whom migrated to California, became Hispanicized, and married daughters of De La Guerra. Two Americans who spent periods in Santa Barbara, Alfred Robinson and Richard Henry Dana, Jr., each wrote books that made Americans aware of the character of Hispanic California. Robinson in particular conveyed an empathy for the Hispanic culture and through his accounts developed an archetype of the lifestyle of the region.

Yankee appreciation, or more accurately accommodation, of Hispanic culture helped contribute to amicable relations from the time of occupation in 1846 through the 1860s, when the Spanish-surnamed *Barbareños* comprised 70 percent of the city's 2,500 population. Hispanic leaders represented the city and county in public office and served in the Union army during the Civil War. Even the street names, adopted after the 1851 survey of the city, faithfully recalled the cultures of the past, including Chumash chiefs' names, families of the Spanish and Mexican eras, names from the recent American experience, and Spanish topographical destinations to fill out the map. A drought struck in 1863-64 and weakened the cattle economy. After that, a trend developed of Hispanic land owners losing their holdings to Anglos, and this triggered a widespread migration of the Hispanic and mestizo artisan class. By the 1870s, Hispanics played only a minor role in the import and merchandising sector, which they once dominated.

A new breed of Yankee immigrants were consolidating land holdings in the Santa Barbara region and they remained untouched by Hispanic culture. A handful of owners controlled most of the ranch lands throughout the 2,630 square-mile (6,812 sq-km) county, and American energies began to transform the city of Santa Barbara. Despite the financial success of the large ranches operating in the region, the town did not take on the identity of an agricultural center. The new immigrants from the east saw in the natural and cultural environment of Santa Barbara the possibility for a city that would offer far more than the usual benefits of central place functionality. The next fifty years or so years would be critical for the development of the Santa Barbara that we may now visit and enjoy. The desirability of the region became recognized and then embellished by a local aesthetic that attempted to encapsulate its heritage. Historian Kevin Starr in his book, *Material Dream: Southern California through the 1920s* (New York: Oxford University Press 1990: 258), summed up the period: "...the agricultural realities of Santa Barbara remained socio-economically relevant but conspicuously unpromoted, while another arc of identity—from sanitarium to hotel resort, from hotel resort to Newport on the Pacific to neo-Mediterranean Riviera to, finally, an idealized Spanish city, cream-white and carmine in the sunlight—asserted itself as a dream materialized."

Dreaming a City on the Sea

American awareness of Santa Barbara grew by leaps and bounds after the 1870s. A New York journalist made a visit to stay with some friends in 1872, and wrote a series of articles for *Harper's Magazine*, also published as a book, *California: For Health, Wealth, and Residence, a Book for Travelers and Settlers*, that informed the nation of a consistently sunny micro-climate and collection of mineral springs ideal for recovering invalids. An 1878

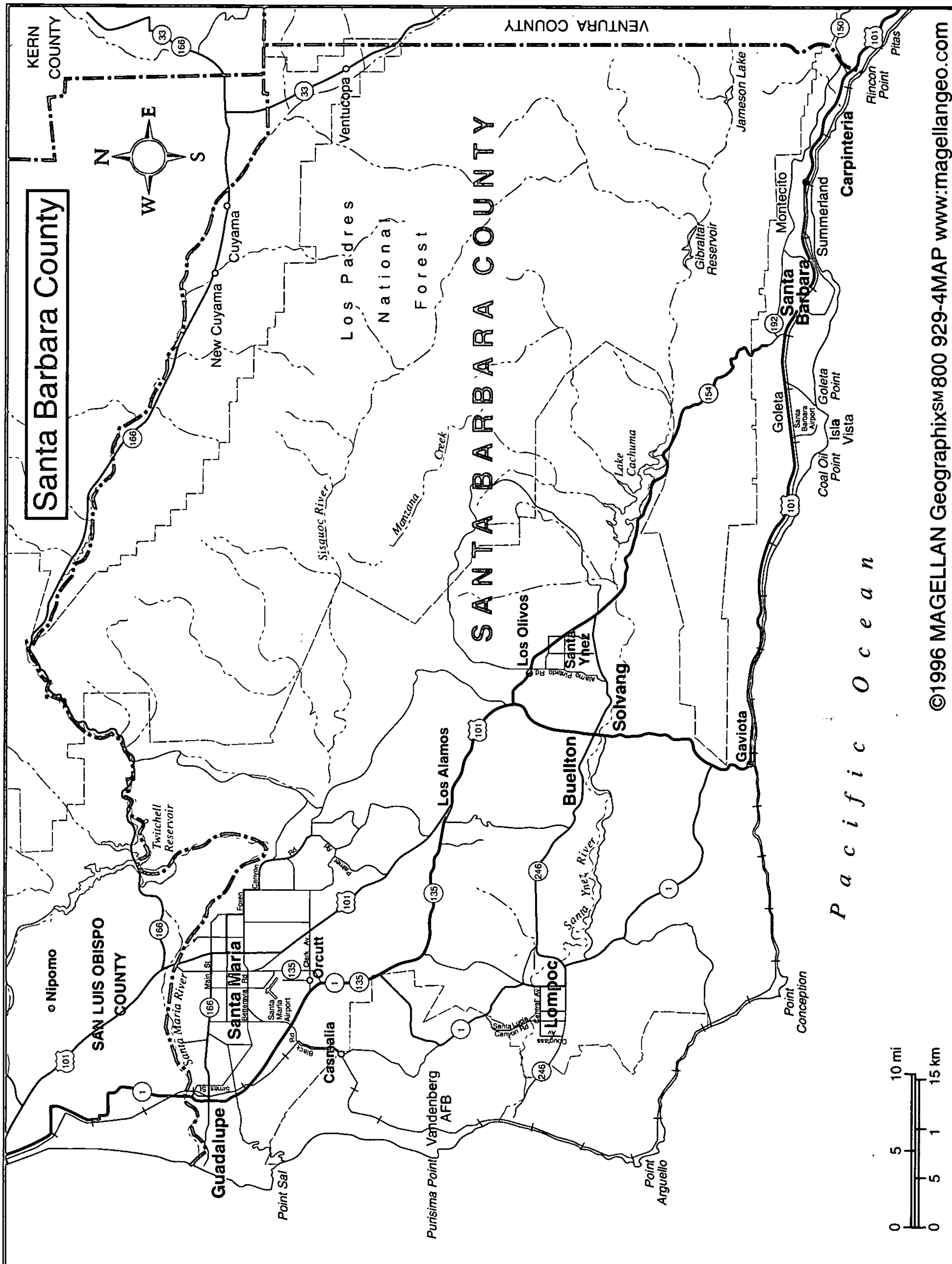


Figure 1.2 Santa Barbara County Reference Map

pamphlet described the city as the "sanitarium of the Pacific coast," and the distribution of bottled mineral water spread that reputation.

To accommodate the interests of visitors, a local landowner and prominent citizen, Colonel William Hollister, spearheaded the construction of a luxurious 90-room hotel, The Arlington, on State Street about a mile from the coast. He also purchased the building that had housed the defunct Santa Barbara College and converted it into a less costly hotel than the Arlington. Hollister himself greeted incoming passenger steamers on Stearns Wharf and escorted visitors either to the Arlington or the less prestigious Elwood depending on their apparent means. Hollister's involvement lent an air of pomp to the new leisure destination, and royalty in the person of Queen Victoria's daughter, Princess Louise, visited during the early years to be received by the colonel.

The steady flow of sick and well visitors to Santa Barbara overwhelmed any momentum that may have accumulated for turning the city into a bustling business location. The construction of two wharves by 1872 and the arrival of the railroad in 1887 had many people predicting a boom as had been seen in Los Angeles. The boom of 1887 never came, however, and modest population growth kept the city's size below 7,000 until the turn of the century. A different type of migration was occurring in the meantime.

A small but steady stream of genteel Americans began to lay claim to the city and to make it an ideal community. A 25-year-old man named Charles Albert Storke was recruited to teach at the newly-formed Santa Barbara College in 1869. He married the daughter of a land baron, and resigning his post at the short-lived school, became active in developing the city. Having celebrated the centennial of the mission in 1886, the city still deeply identified with its Hispanic heritage. The Santa Barbara establishment took seriously the ceremonious revival of its Spanish roots. Storke organized an immigration bureau to promote population growth, served two terms in the state legislature, served as attorney general in 1898, and then as mayor from 1900 to 1902. Storke also acquired the local *Daily News*. He and a group of contemporaries devoted themselves to defining and controlling the Santa Barbara heritage.

The appropriation of Hispanic metaphor was central to the crafting of a modern Santa Barbara that retained the social structures of the past. The novel *Ramona* by Helen Hunt Jackson presented the mission era, now in its twilight, as a mythical ideal. The Mission Santa Barbara, as the last mission in the hands of the Franciscans, was the icon of this depiction. Cultural historicism abounded and the customs kept alive by the minority of Hispanic and Native American residents were again in vogue. Visitors, notably Presidents Harrison, McKinley, and Teddy Roosevelt, appreciated Storke's efforts at recapturing the elegance of the Hispanic era. In the midst of embracing Spanish roots, the main remnants of the past survived in a run-down area of adobes, called Spanishtown, but was home to the Mexican and Chinese communities as well as the saloons and red-light district. Americans saw historic value in the aesthetic preservation of adobe structures, but they considered the majority of Spanishtown an eyesore. They were interested in cultivating Santa Barbara's unique atmosphere, but they feared that shabby conditions in the older areas of town would interfere with plans to create a world-class resort city.

When a direct rail connection to San Francisco was completed in 1901, the Chamber of Commerce approached a prominent hotel developer about building a first-class resort in Santa Barbara. The 600-room Potter Hotel was completed on the waterfront in 1903. To eliminate annoying odors, Potter had the nearby healing spring sealed with concrete, symbolically ending the sanitarium era. The entire hotel, architecture, and interior design, was Mission Revival. When the Arlington Hotel burned a few years later, it also was rebuilt in the Mission Revival style. These top resorts attracted the big names of American capitalism to the area. Many of them enjoyed the surroundings so much they stayed permanently and built estates. Climate and beauty attracted this new class of resident as well as the opportunity to connect with an air of aristocracy. They expressed their ideals in architecture and art, and also in lifestyle, with much yachting, riding, polo, and golf. They constructed grand seasonal mansions in Mediterranean motifs, primarily in the hills of Montecito. The wealthy families that staked an interest in and around Santa Barbara would play important roles in imagining and realizing a city that would fulfill their fanciful dreams and selective history. An echo of a long-dead bishop's grand plans, the construction of St. Anthony's Seminary alongside a restored mission in 1901 also helped to ensure that a once-jeopardized past would remain current.

The final chapter of Santa Barbara's development began in 1909, when the Civic League of Santa Barbara brought in planner Charles Robinson to propose a master plan for the city. Robinson's suggestion was to develop the dramatic, topographically unique site into a cohesively conceived and aesthetically engineered presentation of history. He saw the Mission and the historic Plaza de la Guerra as the symbols for the city, and recommended that the undistinguished public buildings of the civic center be torn down and replaced. The mission and plaza should be framed by a number of landscaped vistas and surrounded by a network of public spaces. Museums to display the city's heritage were also included in the plans. Industrial development was seen as polluting and to be avoided. Robinson's costly and bold recommendations were received and accepted, but nonetheless forgotten. The plan, however, was popular with the local elite who constituted the Civic League. As the years passed and local power shifted into the hands of those elite, Santa Barbara's future would be sculpted to look more and more like Robinson's vision.

On its way to establishing its identity, the city had been presented with many opportunities, which for one reason or another had not worked out. Early in the twentieth century, a Navy presence similar to that which eventually located in San Diego and Long Beach was one possibility. City officials were unenthusiastic about the prospects of a constant sailor population, and the Navy chose other ports for expanding its Pacific operations. The aviation industry also arrived on the local scene. During World War I, three brothers named Loughead (they would later change the spelling to Lockheed) employed eighty-five locals, including one Jack Northrop, to manufacture seaplanes. For a short period the focus of the flying world was on the South Coast, but the brothers eventually moved their operation to Los Angeles in the 1920s. The resorts also opened the door for another industry, filmmaking, which came to town as early as 1910. The world's largest movie studio was built downtown in 1913. Called the "Flying A," the facilities hosted fourteen film companies and produced more than 2,000 major films during the next eight years. By 1921, however, the industry had moved south in search of new filming locations, and the studio was finally destroyed in 1948.

Unperturbed by these transitions in industry, a collection of artists began to colonize Santa Barbara including painters in the *plein air* tradition that valued the quiet and pastoral settings of the region. Horticulturists and wildlife enthusiasts also flowed into Santa Barbara. Another group of painters celebrated the disappearing Old West. The Santa Barbara School of the Arts was opened in the 1920s, and a circle of the artistic elite arose as it did in Santa Fe and Taos, New Mexico. A number of myths, including that of Zorro, were created that invented and capitalized on an image of Santa Barbara life. Citizens of the city were enthralled with the image and sought to embrace and foster it in any way possible. Subdivisions were built to attract wealthy people who wanted to attach themselves to the lifestyle and the lifestyle to themselves. Many celebrities including Mary Pickford and Douglas Fairbanks, Jr. (Zorro himself) made Santa Barbara their home.

The Community Arts Association during the 1920s emerged as the agent responsible for guarding the identity of the city. Under the guidance of prominent citizens, the group began by holding pageants and celebrations to promote Hispanic culture. The group then moved on to the appearance of the city. Money was collected among virtually all of the wealthy residents, and aesthetically inclined leaders directed its expenditure on projects designed to beautify the city and preserve (and in some cases recreate) its Hispanic heritage. At the urging of the committee, the city formed a Planning Commission in 1923. Although the Planning Commission was not able to push through a grand comprehensive plan developed in cooperation with Olmsted and Olmsted of New York, it was able to pass a comprehensive building code for the city. A competition was held for small house designs appropriate for the Santa Barbara image and costing no more than $5,000 to build. The Community Arts Association published the selected designs. In addition, the few remaining historic adobes worthy of restoration were purchased and restored by members of the community.

Built between 1922 and 1924, the El Paseo, a downtown shopping complex, was a significant addition to Santa Barbara architecture. Designed as a street in Spain, the complex attached itself to the authenticity of the Plaza de la Guerra, which had for some time been neglected. It was a form of recycled history that was decidedly popular with local residents. Another project, to provide the city with a theater and opera house, used part of an historic adobe structure in the configuration of a new theater, the Lobero, which also incorporated the essence of Spanish revival.

In the midst of this redecoration of the city along historical, if significantly modified and updated, standards received an unexpected boost when on 29 June 1925, an earthquake leveled much of the city. Though only twelve of 25,000 residents perished, the damage was devastating—unless you had been wanting to tear it all down anyway. The new construction, like the El Paseo complex, the Lobero Theater, the *Daily News* building on the historic plaza, and the homes built according to the new standards, survived the incident, but the older buildings downtown and the mission itself were severely weakened. As far as the Community Arts Association was concerned, the mistakes of the nineteenth and early twentieth centuries had been erased in one fell swoop. The Association's Plans and Plantings Committee was ready for the rebuilding. Just at the time of the earthquake, the committee had pushed through a measure creating a Board of Architectural Review. For the first time in California, and perhaps the United States, preservationists, planners, and aesthetes had gained control of a city and were putting their distinctive mark on it.

The rest of the country noted how quickly and decisively Santa Barbara was being rebuilt. The formerly unsightly spine of State Street was now becoming a downtown strip worthy of one of the world's most beautiful cities. A symbol of Santa Barbara's vision and wealth, the third County Courthouse, completed in 1929, became the centerpiece of the reborn city. Built in the image of a castle in Spain and costing nearly two million dollars, it was touted as the world's most beautiful jail. Details of the building, like 14,000 square feet of floor tile and a mural depicting the history of the area from the first Spanish landing, ensured that the Hispanic metaphor would remain powerful. Throughout the state and among the local elite, money was raised to fund the $400,000 project to restore the mission. At the same time, Major Max Fleischmann (of yeast fame) was single-handedly securing the construction of a breakwater that was necessary to create safe harbor for his 250-foot yacht and other pleasure craft that residents wished to keep. He contributed more than $600,000 to complete the project near Stearns Wharf. Fleischmann also established the Santa Barbara Foundation, which worked devotedly to preserve the buildings and landscapes that projected the much sought after Hispanic aesthetic.

The enthusiastic and able involvement of the private sector in Santa Barbara is what has allowed it to emerge as an extraordinarily endowed smaller city. *Time* magazine would refer to Thomas Storke in the 1930s as the benevolent dictator of Santa Barbara. Individuals like Storke have seen in Santa Barbara something so appealing, even mesmerizing, that they have made it their own. That is why, when you tour around the city, you are left wondering how it, among so many cities of this country, has been able to uphold a dignity and aesthetic beauty that has become so uncommon in our world of temporary landscapes and industrial wastelands. Much has happened in the city since the 1930s, but it can be said with confidence that what has occurred since this time has always been in line with the values of the visionaries who saw the opportunity to make on the west coast of the United States a dazzling Spanish town. It is here for you to see and experience. Unlike other cities, Santa Barbara does not cover up and abandon its past. If anything it seizes the past, takes from it what it desires, and brings that imaginary conception to life in a real city.

This is only a small part of the story of Santa Barbara. It is better for you to discover it for yourself. I have tried to reveal the origin of the image that ties the myth and material of the city together. Mention Santa Barbara and, as travel writer Charles Stephen Brooks observed in 1935, "it is likely that the excited eye of your fancy...will alight on marbled pools and stairways, on Spanish houses that out-castle the palaces of Europe, on Satin apartments larger than a city railway station where a whole company at dinner could be swallowed by lofty walls without the slightest wiggle of their gilded Adam's apples," (quoted in Starr 1990: 302). That is a bit extreme, but it entitles Santa Barbara to be called "The American Riviera."

22

2

California Missions: The Early Years

David Hornbeck

During the past hundred years, missions have increasingly become a symbol of California's past, a romanticized symbol of the halcyon days of Spanish missionaries who supposedly lived an Arcadian existence with their charges. Romantic notions of the missions stem partly from a lack of detailed study and partly because little visual evidence remains today of what the missions were truly like. Many of California's missions have been restored to blend in with their urban surroundings rather than to reflect a sense of their original sites (Figure 2.1). This urbanization of the missions is not surprising when one considers that those cities founded as missions now contain more than 60 percent of the state's population. As a part of the urban scene, missions have become profitable tourist attractions that convey little of their once large, rambling extent or the difficulties associated with early settlement.

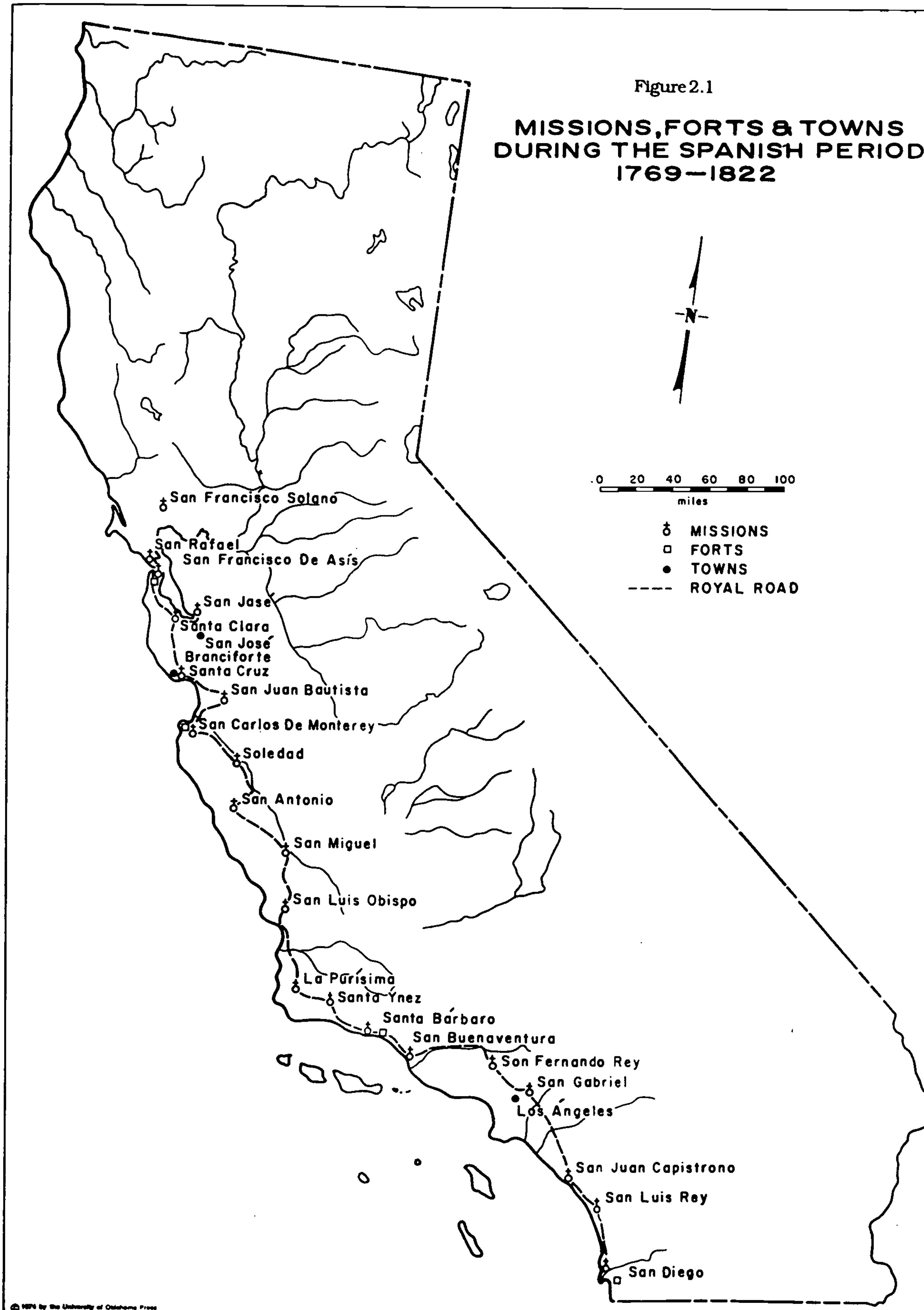
This essay provides a brief glimpse of the founding of the California missions and attempts to convey how the missions appeared and functioned during their early years and what difficulties their founders encountered in establishing the mission system in California. This is a period of mission history and geography not usually associated with a casual stroll through one of the current-day missions. Yet it was during these years that the basic structure and organization of the missions were established. Hardship was commonplace during the first decade or so of mission settlement. It is not easy to visualize these hardships in today's urban settings in which parking lots, restaurants, and condominiums surround the missions.

Fray Junipero Serra was given the task of establishing missions in California, and the ultimate success or failure of Spain's colonizing efforts in California fell upon his shoulders. Much of Serra's practical experience had been obtained from his missionary efforts in the Sierra Gordo area of Mexico. California, however, posed a host of different problems for which his previous experience had not entirely prepared him. Upon Serra's arrival in San Diego in 1769, he was faced with five interrelated problems that had to be solved if missionary efforts in California were to be successful. Serra had to acquire quickly the necessary environmental knowledge about the new land, begin to understand the diversity of the California Indian, try to locate missions effectively, find a labor force to assist mission growth, and finally, minimize the effects of distance between Mexico and California.

Terra Incognita

California was *terra incognita* to Serra and his companions. Nothing was known about California, even the most rudimentary knowledge of its terrain and climate was nonexistent. No maps were available that detailed the twisting California coast, or indicated how the coastal range melted into the long flat Central Valley that in turn, gave way to the towering Sierra Nevada, which blended into the Transverse Range running east-west across California. California's topography must have appeared to Serra and his associates as one continuous maze. The climate also baffled the newcomers, in that there appeared not to be one climate but many. Rainfall varied considerably, with less than ten inches (25 cm) annually around San Diego to more than 28 inches (71 cm) at San Francisco Bay. On the local or regional level it was not uncommon for annual precipitation to vary as much as three to four inches (8 to 10 cm) over short distances, and to complicate the problem there was summer drought. Both topography and climate posed major obstacles in early mission settlement. Exploration quickly provided basic information on the terrain, but it would take time and experience to understand the subtleties of California's rainfall and drought patterns.

Figure 2.1


MISSIONS, FORTS & TOWNS
DURING THE SPANISH PERIOD
1769—1822
N
0 20 40 60 80 100
miles
MISSIONS
FORTS
TOWNS
ROYAL ROAD
San Francisco Solano
San Rafael
San Francisco De Asís
San Jose
Santa Clara
San José
Branciforte
Santa Cruz
San Juan Bautista
San Carlos De Monterey
Soledad
San Antonio
San Miguel
San Luis Obispo
La Purísima
Santa Ynez
Santa Barbara
San Buenaventura
San Fernando Rey
San Gabriel
Los Angeles
San Juan Capistrano
San Luis Rey
San Diego

24

The environment, however, was not the only immediate problem facing Serra. Charged with establishing missions that were to acculturate the Indian, Serra and his companions found the Indians to be as diverse and as bewildering as their environment. In 1769, California contained approximately 310,000 Indians scattered throughout the state, with densities ranging from very high along the coast to very low in the interior. The newcomers were surprised that California Indians did not practice agriculture but instead were hunters and gatherers. The most significant aspect of the California Indian was language. California was a virtual Babel of mutually unintelligible tongues. Throughout California six language stocks existed along with approximately fourteen language families, and about eighty mutually unintelligible tongues, all divided into more than 300 dialects. The human landscape was a mosaic of hundreds of small, autonomous groups, each differing from its neighbor in speech, and quite frequently, in custom.

Both the physical and human landscapes were difficult to understand at first, yet along with the military commander, Serra was charged with the responsibility of founding missions. The problem was that missions were to be founded before the new settlers could obtain much environmental knowledge. Specific site requirements for new missions were large numbers of Indians, available water, flat land for planting and harvesting crops, abundant building materials, and accessibility. The success of mission settlement depended on how well the newcomers could identify and understand these locational factors. At the outset, availability of water proved to be the most crucial factor; San Diego, San Carlos, and San Antonio were moved because their initial sites lacked sufficient water for agriculture. In all, six of the first nine missions had to be moved, illustrating that environmental knowledge was acquired slowly and by painful experiences. (Flooding occurred when 1812 earthquakes caused failure of the dam holding back water in a reservoir in the mountains above the La Purisima mission, and the mission was relocated three miles away from its original site in what is today the city of Lompoc in Santa Barbara County. Scars from that event are still visible from the ruins of the original mission site.)

Once missions were established, a new problem of labor surfaced. An adequate labor supply was an important foundation upon which rested the spiritual and economic success of the mission. Although considerable attention was given to the number of Indians living near a proposed mission site, the local Indians proved inadequate to provide the needed supply of labor. There was a reciprocal relationship between conversion of Indians and labor supply. The introduction of Indians into the mission required a constant food supply, yet food production demanded a constant labor supply. This "catch 22" was a critical problem for the missions because the Indians had to be taught the necessary agricultural or building skills to support the mission. Without an ongoing food supply, Indians could not be attracted to the missions and without Indians, the mission inhabitants could not plant and harvest crops.

Distance and Location

In addition to the difficulties already discussed, distance posed an immediate and serious obstacle to mission settlement. Hundreds of miles of unexplored desert and an unknown number of possible hostile Indians separated California and the nearest Spanish settlements in Sonora, Mexico. The only practical way to maintain the California outpost was by a tenuous sea route that extended well over one thousand miles (1600 km) back to Mexico.

Isolated in a new environment, Serra and his missionaries found themselves groping to solve unfamiliar problems. The handful of missionaries were too few to make more than a feeble effort to occupy the land. Equipment, food, and labor were in short supply or non-existent. The Indian could not be relied upon for food or labor as had been the custom on earlier frontiers. A combination of problems, therefore, made mission settlement problematic, to say the least. By 1774, the missions were scarcely more than tenuous signs of Spanish occupance.

Mission Settlement and Evolution

As the previous discussion suggests, the missions were not easily implanted on the California landscape. Mission settlement finally overcame many of the problems. Slowly during their 65-year tenure in California, missionaries created complicated irrigation systems, constructed new buildings, expanded crops and livestock, and created new land uses that remain a part of California's geographical heritage.

A stroll through the Santa Barbara Mission today would reveal little of the hardships encountered in its establishment. Cultivated fields that once represented the first signs of success in a new land are now covered by condominiums. Irrigation ditches, so vital to the mission's survival, lie buried under parking lots, and office buildings now stand in the place of the Indian villages that housed the mission's hard won labor force. The missions easily fit into this urban milieu because they have not been restored to reflect either the hardships of the past or authentic day-to-day mission life. Missions are clean, almost antiseptic in their appearance and project the image of what we think they should have looked like had they been founded in the twentieth century. Today our missions make few statements about themselves—they blend into the urban scene and tell us more about ourselves than they do about the past.

3

California Population

William Bowen

The last 95 years have witnessed a remarkable transformation of California's landscapes as the plains have been irrigated and great cities have sprung up where only villages formerly existed. In large measure, the remaking of the land has been a direct result of immigration and rapid population growth. At the beginning of the twentieth century, 1,485,053 persons resided in the state and only a quarter of a million people lived in the five counties that make up the Los Angeles Basin.

Transformation of the California Landscape

The expansion of modern irrigated agriculture coupled with the growth of the petroleum, entertainment, aerospace, and electronics industries soon attracted an apparently endless stream of newcomers. During the first three decades, the basin's population doubled every ten years, so that by 1930 almost half of California's 5,677,251 people resided in the south. Neither economic depression nor war would materially slow the flow of people.

The United States Bureau of the Census estimated that by mid-year 1995, the state's population had reached 31,589,153. More than eighteen million of these reside in the vast metropolitan areas stretching southward from Santa Barbara to the Mexican border (Figure 3.1). The people who live here are as numerous as the combined populations of the states of Arizona, Idaho, Nevada, Oregon, Utah, and Washington. They account for roughly one-third of all persons living in the Far West (Figure 3.2).

Comprehending the size and distribution of California's population and the relationships that exist between it, the rest of the nation, and the great Southern California metropolis is difficult. The expansive geography of the state and the immense size of its diverse population make it impossible to grasp this reality easily. Those who live close to the population center of gravity of California easily lose sight of the enormousness of Southern California's population. In 1990, ten of the state's fifty-eight counties had populations smaller than the student enrollment of just one of many college campuses located in the region, California State University, Northridge. One of them, Alpine County (near the bend in the California-Nevada border), had fewer residents (1,113) than the Psychology Department had majors.

Likewise, those who live beyond the limits of the Southern California metropolis often view its immense population with considerable suspicion and even open hostility. Hatred of most things Southern Californian has long been a common sport among certain tribes of the West's intelligentsia, and the issue has hardly been improved by the floodtide of emigrants fleeing northward during recent years. Whether the political debate focuses on water rights, environmental protection, foreign immigration, school desegregation, or other matters pertaining to the future of the state, demographic fault lines separate the northern and southern portions of California and both from the rest of the West.

The Bureau of the Census estimated that by July 1, 1995, some 262,755,270 persons were living in the United States. This figure represents an increase of approximately 14,036,979 individuals during the previous five years, a growth of 5.6 percent. During that same time, California's population grew from 29,758,213 to 31,589,153 people. The additional 1,830,940 persons represent an increase of 6.2 percent (Figure 3.3).

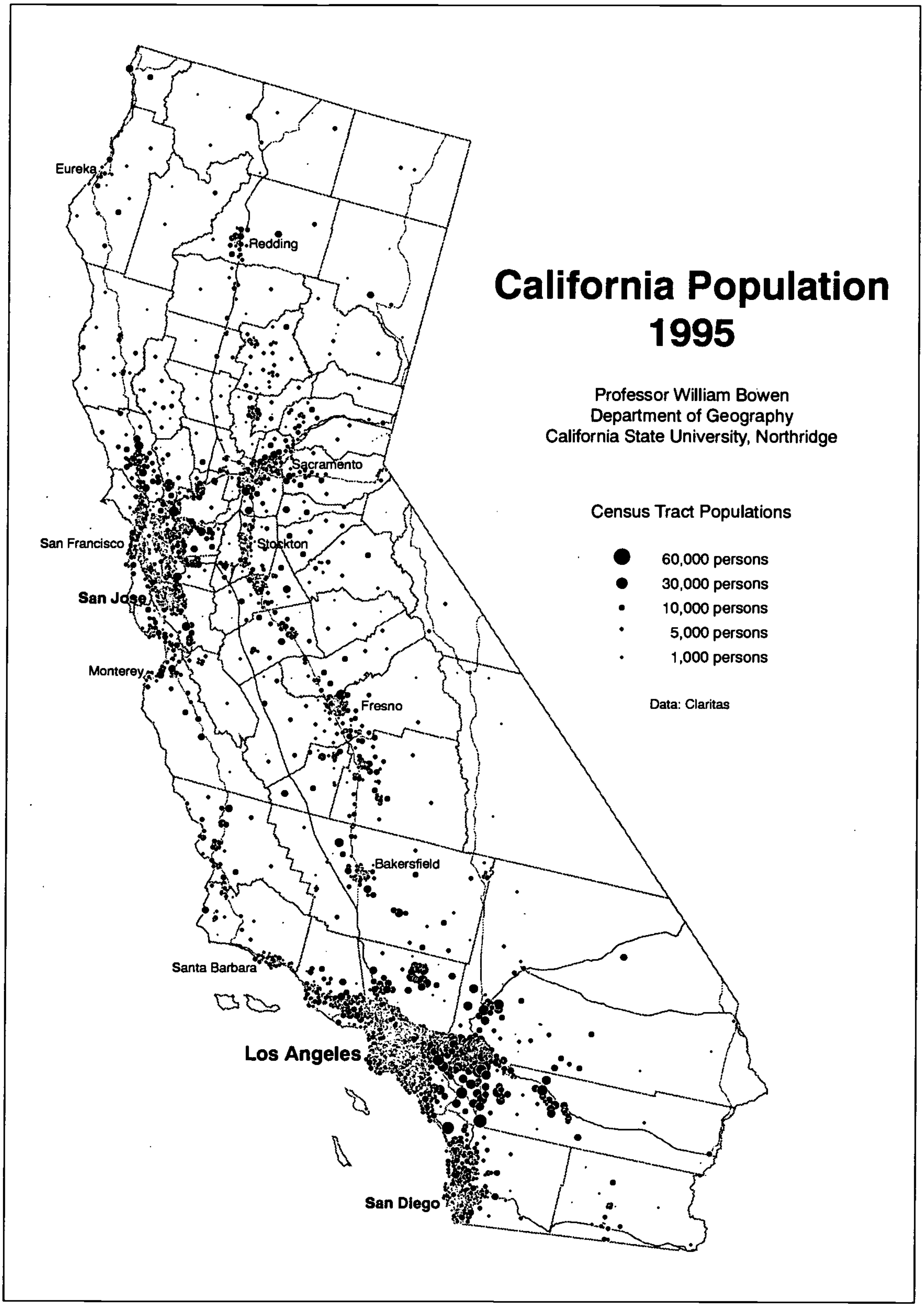


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Figure 3.1

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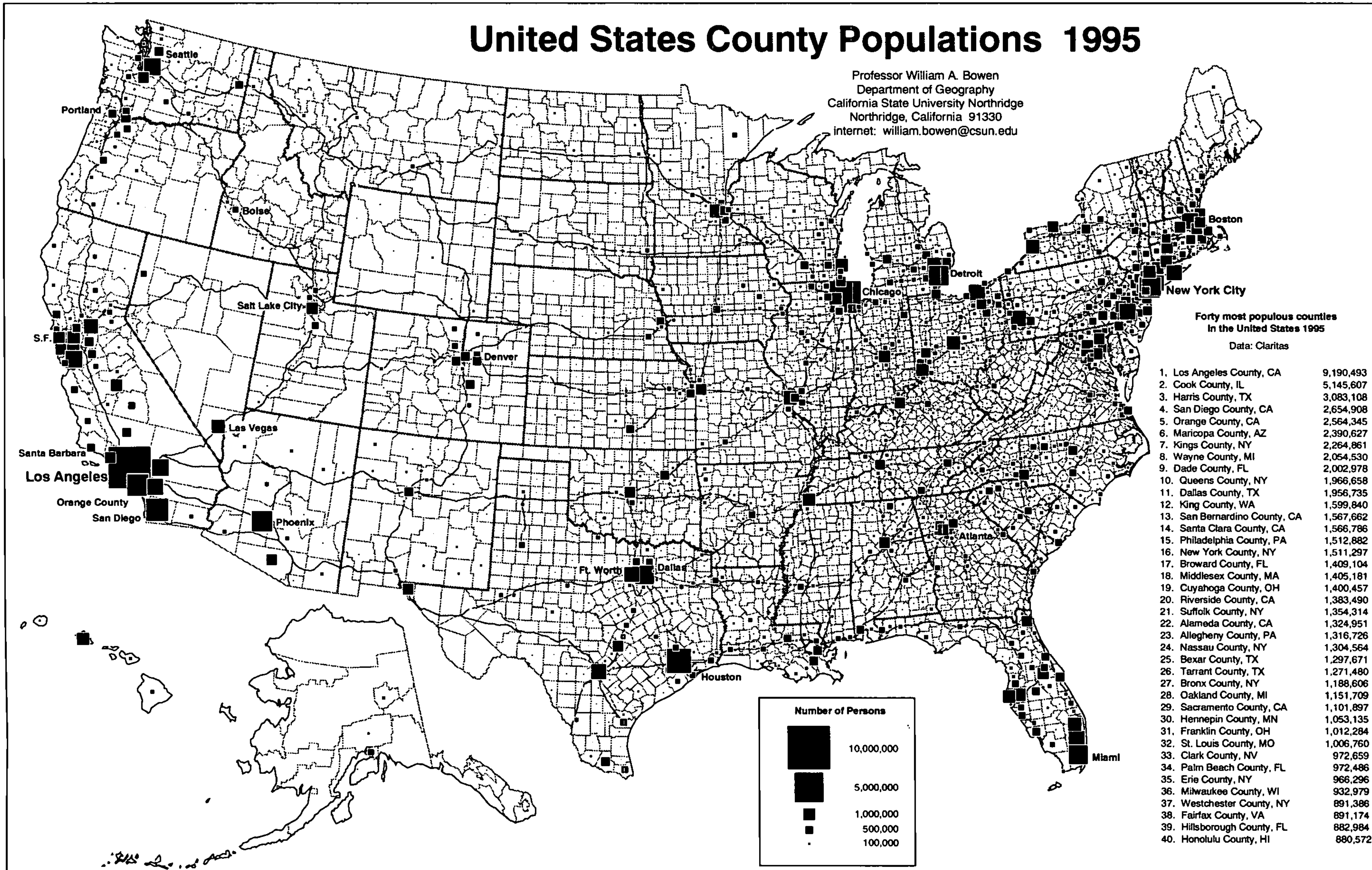

Figure 3.2

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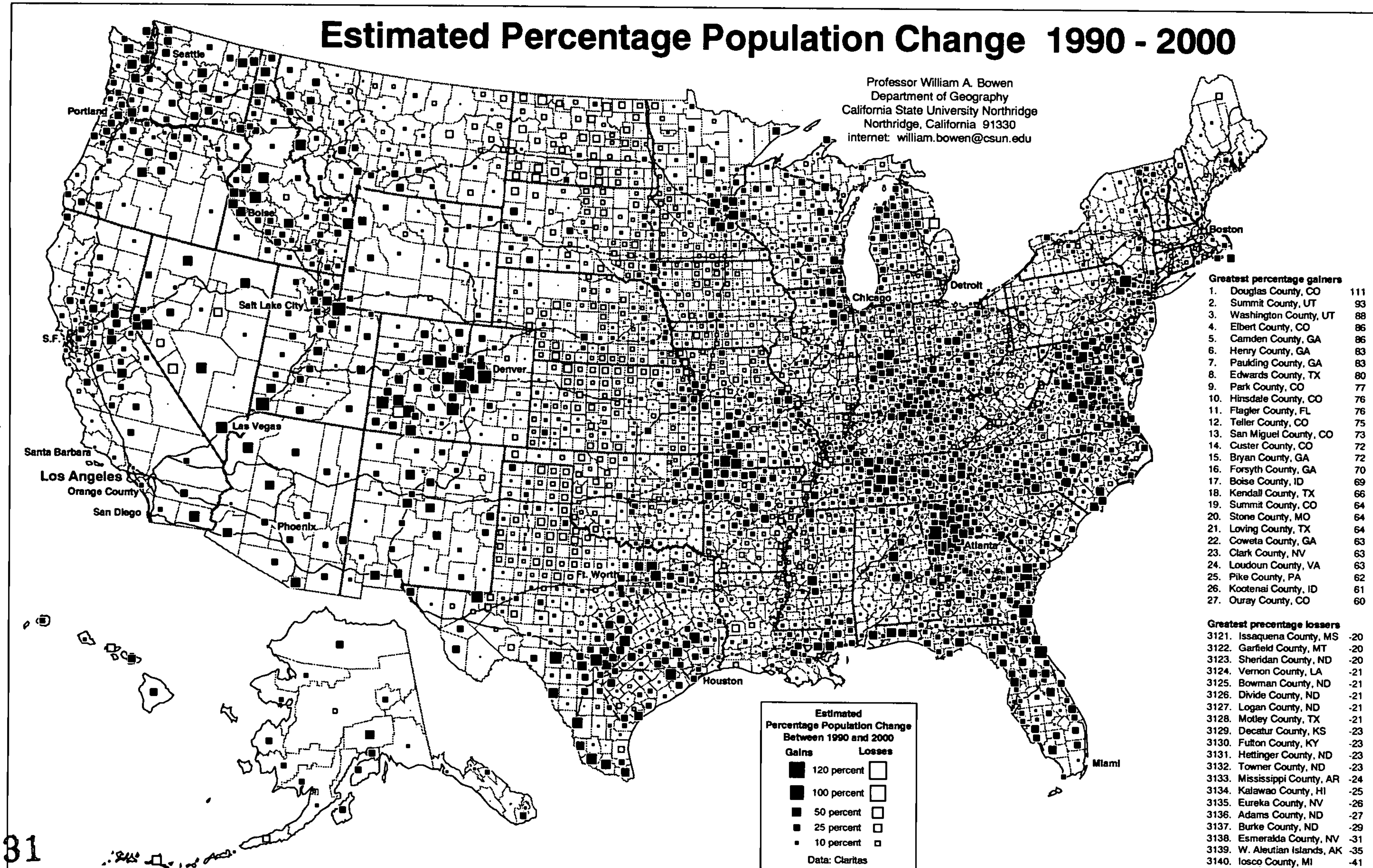

Estimated Percentage Population Change 1990 - 2000
Professor William A. Bowen
Department of Geography
California State University Northridge
Northridge, California 91330
internet: william.bowen@csun.edu
Seattle
Portland
Boise
Salt Lake City
S.F.
Denver
Las Vegas
Santa Barbara
Los Angeles
Orange County
San Diego
Phoenix
Ft. Worth
Houston
Chicago
Detroit
Atlanta
Boston
Miami
Estimated
Percentage Population Change
Between 1990 and 2000
Gains
Losses
120 percent
100 percent
50 percent
25 percent
10 percent
Data: Claritas
Greatest percentage gainers
1. Douglas County, CO 111
2. Summit County, UT 93
3. Washington County, UT 88
4. Elbert County, CO 86
5. Camden County, GA 86
6. Henry County, GA 83
7. Paulding County, GA 83
8. Edwards County, TX 80
9. Park County, CO 77
10. Hinsdale County, CO 76
11. Flagler County, FL 76
12. Teller County, CO 75
13. San Miguel County, CO 73
14. Custer County, CO 72
15. Bryan County, GA 72
16. Forsyth County, GA 70
17. Boise County, ID 69
18. Kendall County, TX 66
19. Summit County, CO 64
20. Stone County, MO 64
21. Loving County, TX 64
22. Coweta County, GA 63
23. Clark County, NV 63
24. Loudoun County, VA 63
25. Pike County, PA 62
26. Kootenai County, ID 61
27. Ouray County, CO 60
Greatest precentage lossers
3121. Issaquena County, MS -20
3122. Garfield County, MT -20
3123. Sheridan County, ND -20
3124. Vernon County, LA -21
3125. Bowman County, ND -21
3126. Divide County, ND -21
3127. Logan County, ND -21
3128. Motley County, TX -21
3129. Decatur County, KS -23
3130. Fulton County, KY -23
3131. Hettinger County, ND -23
3132. Towner County, ND -23
3133. Mississippi County, AR -24
3134. Kalawao County, HI -25
3135. Eureka County, NV -26
3136. Adams County, ND -27
3137. Burke County, ND -29
3138. Esmeralda County, NV -31
3139. W. Aleutian Islands, AK -35
3140. Iosco County, MI -41
3141. San Juan County, CO -47
31

32

Figure 3.3

Population Growth

Although not matching the levels of growth witnessed in previous decades, the increase is altogether remarkable given the fact that California has begun experiencing the greatest exodus of residents from any state in our nation's history. Its 1993 to 1994 net domestic out-migration rate reached 1.4 percent, the highest of any state, and represented a net loss of 426,000 migrants to other states. The Census Bureau estimates that between 1990 and 2020, California will sustain a net loss of four million internal migrants to other states. This tremendous loss, however, is expected to be more than offset by the arrival of ten million new international migrants (39 percent of the nation's total) and more than twice as many births as deaths (20 million versus 8 million).

Most of the newcomers have not yet sought a lasting political affiliation with the new land. Recent estimates reveal that in the entire state approximately 5,960,000 were non-citizens in 1994, 3,852,000 from Latin America and 1,253,000 from nations bordering the western rim of the Pacific Ocean. More than 98 percent of these new arrivals have settled in the metropolitan areas of the state, 2,706,000 (45.4 percent) in large central cities and 3,150,000 (52.8 percent) in the more suburban areas and smaller cities. By far the greater number of these people have chosen to make their new homes in the Los Angeles Basin. Their numbers simply dwarf those measured elsewhere in the United States.

Influence of Immigrants

By 1994, approximately 25 percent of the state's population were foreign immigrants. Among the adult population the percentage was considerably higher. One effect of these two migration streams was the creation of a multi-national metropolis in Southern California almost overnight. By 1990, more than 38 percent of all adults in Los Angeles County were foreign-born (Figures 3.4 and 3.5). In broad areas of the Los Angeles Basin encompassing many scores of square miles, the majority of adults are no longer Americans by birth or naturalization. In some neighborhoods immediately west of downtown Los Angeles the percentages exceed 90 percent! More than 100 foreign languages are spoken by children attending Los Angeles City schools. The America known to politicians from Arkansas and Kansas is remote, unknown, and hardly even relevant.

By the end of this century, the Claritas Corporation estimates that 275,392,233 persons will reside in the United States, a gain of 26,682,360 individuals during the 1990s. This increase will be distributed unevenly across the nation. All 25 of the counties gaining the largest number of new inhabitants will be located in the West or South. Those counties suffering the greatest losses will be, with a few exceptions, the locations of aging nineteenth century cities such as Philadelphia, Detroit, Washington, D.C., and Baltimore. Smaller, but often desperately significant, declines are occurring in approximately 21 percent of counties in the United States. Most of these are located in the rural lands of the Great Plains and Upper Middle West.

Five of the nation's top ten counties witnessing the greatest population increases will be located in Southern California. Two others will be located nearby in Nevada (Clark County–Las Vegas) and Arizona (Maricopa County–Phoenix). The only California county to experience a significant decline in population will be Monterey (central coast of California), where major economic dislocations have occurred already as a result of the closure of Fort Ord.

Although metropolitan Southern California exceeds all other areas of the nation in the sheer size, scope, and visibility of its population growth, the percentages at which its counties are growing today are relatively small. It is extraordinarily difficult to sustain high percentages of growth in already large populations. How much simpler it is to double the size of a rural county's population with the development of several large, new subdivisions across the line from a neighboring city. Douglas County, Colorado is a case in point. It lies immediately to the southwest of Denver and has recently been invaded by suburbanites.

Foreign-Born in Metropolitan Los Angeles County

Persons not born in United States or possessions

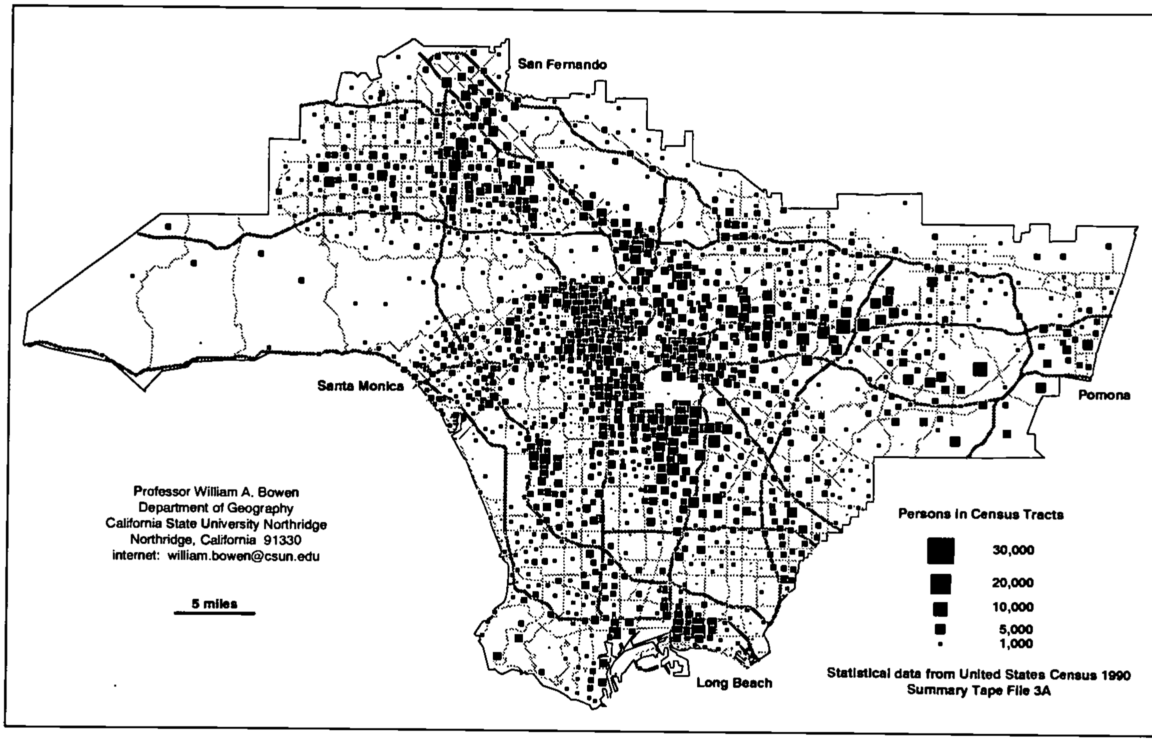


Figure 3.4

Foreign-Born in Metropolitan Los Angeles County

Percentage of persons not born in United States or possessions

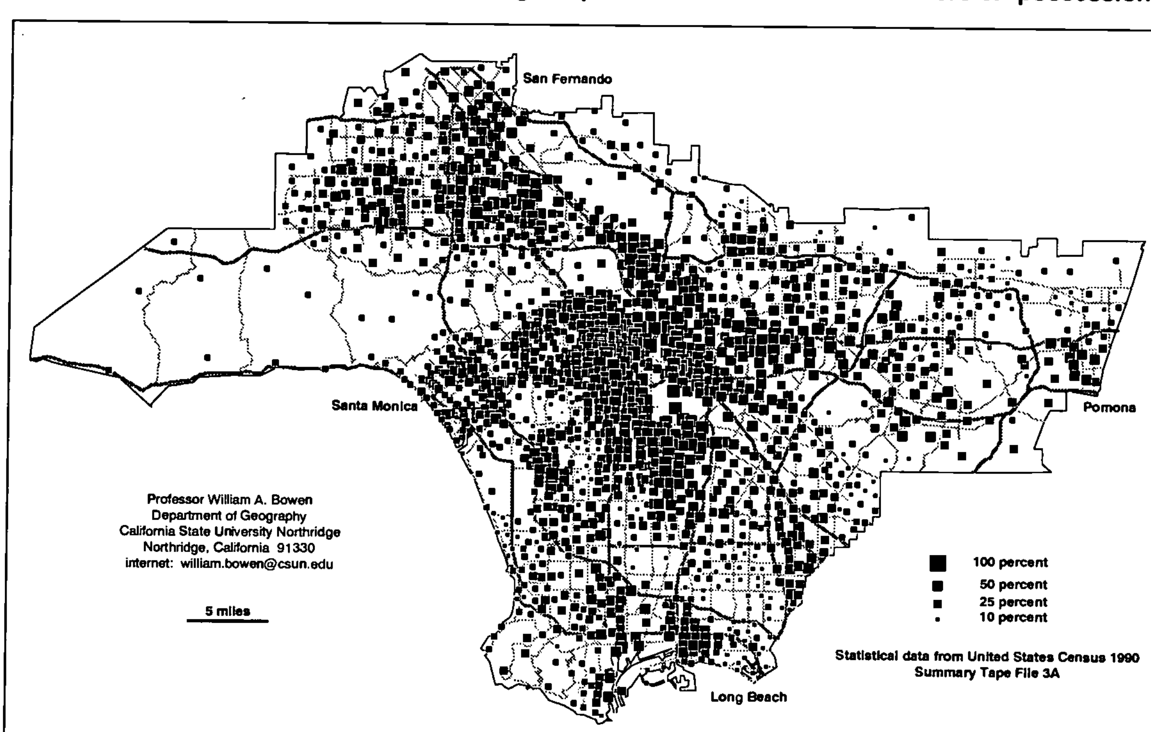
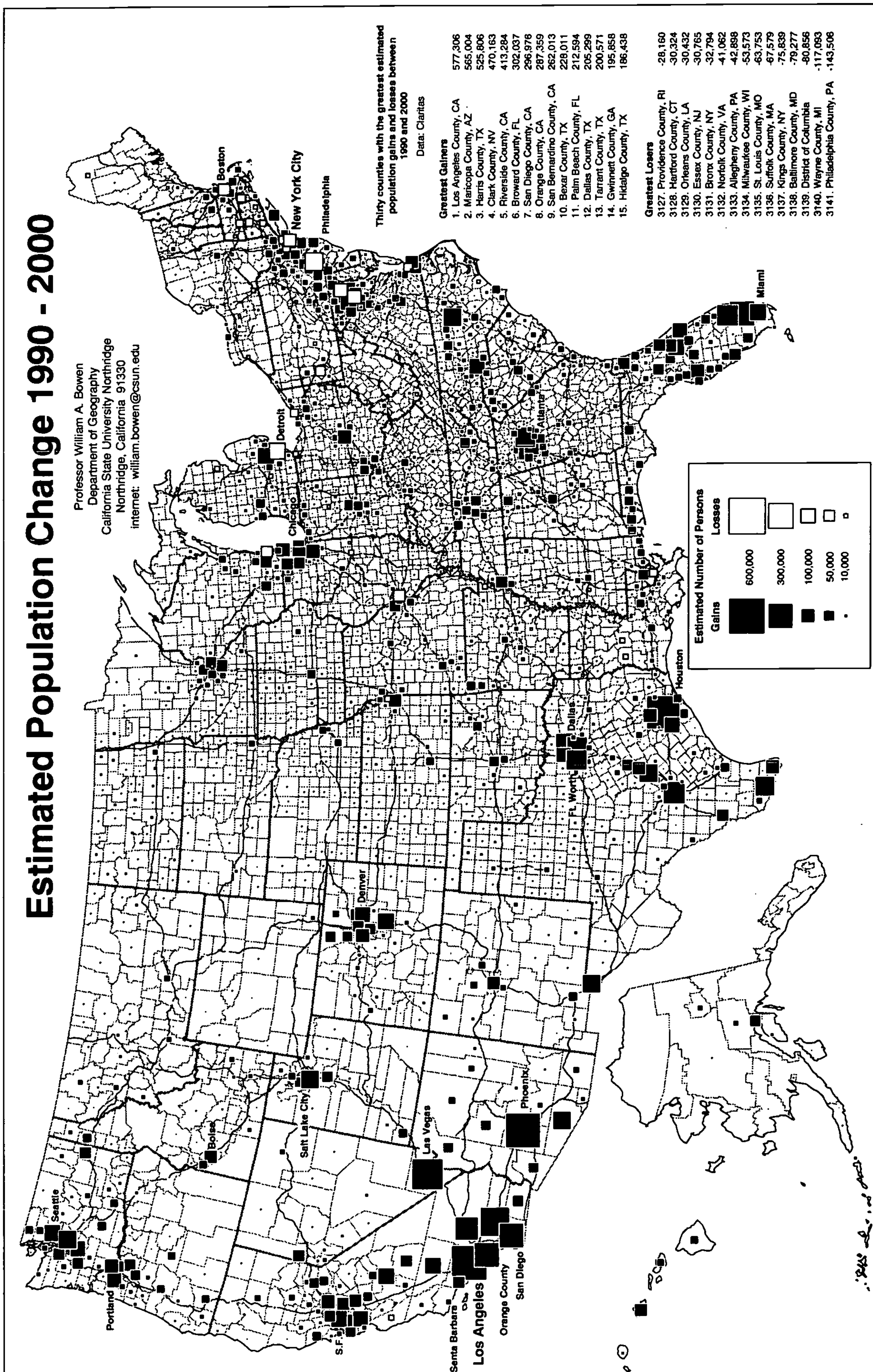


Figure 3.5


Estimated Population Change 1990 - 2000
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Las Vegas
S.F.
Santa Barbara
Los Angeles
Orange County
San Diego
Phoenix
Denver
Ft. Worth
Dallas
Houston
Chicago
Detroit
Atlanta
Miami
Boston
New York City
Philadelphia
Estimated Number of Persons
Gains
Losses
600,000
300,000
100,000
50,000
10,000
Thirty counties with the greatest estimated population gains and losses between 1990 and 2000
Data: Claritas
Greatest Gainers
1. Los Angeles County, CA 577,306
2. Maricopa County, AZ 565,004
3. Harris County, TX 525,806
4. Clark County, NV 470,163
5. Riverside County, CA 413,284
6. Broward County, FL 302,037
7. San Diego County, CA 296,976
8. Orange County, CA 287,359
9. San Bernardino County, CA 262,013
10. Bexar County, TX 228,011
11. Palm Beach County, FL 212,594
12. Dallas County, TX 205,299
13. Tarrant County, TX 200,571
14. Gwinnett County, GA 195,858
15. Hidalgo County, TX 186,438
Greatest Losers
3127. Providence County, RI -28,160
3128. Hartford County, CT -30,324
3129. Orleans County, LA -30,432
3130. Essex County, NJ -30,765
3131. Bronx County, NY -32,794
3132. Norfolk County, VA -41,062
3133. Allegheny County, PA -42,898
3134. Milwaukee County, WI -53,573
3135. St. Louis County, MO -63,753
3136. Suffolk County, MA -67,579
3137. Kings County, NY -75,839
3138. Baltimore County, MD -79,277
3139. District of Columbia -80,856
3140. Wayne County, MI -117,093
3141. Philadelphia County, PA -143,506

Figure 3.6

Many members of America's wealthy and highly educated classes dream of a "Rocky Mountain high." Thousand have invaded the mountain communities of Colorado to live it.

Migration Flows

High percentages of growth can indicate the direction of migratory flows. Hundreds of thousands of Californians, many of them retirees, have fled this state bound for what they hope is a better future in the towns of the Pacific Northwest and the Rocky Mountain states. Others from throughout the nation have chosen the suburbs of Atlanta; Washington, D. C.; Denver; and a score of other favored destinations. The Gulf Coast counties of Alabama and Florida have their attraction to some. For others migrating northward from Mexico, the southwestern border counties are at least satisfactory immediate destinations. Not all of the United States will increase in population. Few counties in the Great Plains have been able to sustain themselves. The lucky few sit on major transcontinental freeways or gas fields. Iowa farmers are diminishing in numbers. So also are the number of people willing to live on the flood plains of the Mississippi River.

The California situation follows national patterns. Some sparsely settled sections of the state are being brought within the web of modern urban life. Formerly small communities in the foothills of the Sierra Nevada east of Sacramento are experiencing high rates of growth, as are many Central Valley towns and cities such as Fresno, Bakersfield, Manteca, Yuba City, and Redding. As always, new communities are forming along the inland edges of the state's two great urban centers—Los Angeles and San Francisco.

The Future?

Projecting California's population into the more distant future is a task fraught with many uncertainties (Figure 3.6). The Census Bureau estimates that within 25 years California's residents will number 47,953,000 and account for 15 percent of the nation's population. Many of these will be the millions of new immigrants now arriving from lands touching the Pacific and Indian Oceans, people who are fleeing their impoverished homelands in search of better lives.

The future of California and its people is increasingly affected by unreported events occurring in far distant lands. The growth of an increasingly globalized economy and the development of new transportation and communications technologies bind our fate ever closer to the many peoples who live beyond our national, state, and regional borders. We should not lose sight, therefore, of the most ignored story of this century, the explosive growth of the earth's human population. At the beginning of this century, barely more than 1.5 billion people lived on the planet. By the time most of our students were born, the number had increased to more than three billion people. Four years from now the number will exceed six billion.

In economic, political, and even biological terms we live in new and uncertain times. We can be sure of one thing, however. The migration stream that has so fundamentally shaped California's last 200 years will continue to do so in the future.

Physical Geography of the Santa Barbara Area

Joel Michaelsen

Santa Barbara's geographic position is unique in several ways. It lies on the longest stretch of east-west trending coastline on the west coast of the United States. The ocean is to the south, and going along the coast means traveling almost directly eastward. Depending on one's point of view, Santa Barbara is either at the northern end of southern California or at the southern end of central California. Move eastward 40-50 miles (64-80 km) along the coast and the outlying settlements of the Los Angeles-San Diego megalopolis clearly signal southern California. Move westward 40-50 miles (64-80 km) along the coast around Point Conception and both the natural and human environments are similar to central Californian. The physical environment has elements of both regions, and, for the purposes of this discussion, the Santa Barbara area will be expanded 100 miles (160 km) or so in each direction to clarify relationships with similar and contrasting natural features outside the immediate area (Figure 4.1).

The geologic history of most of the region is short but very active. Recent and ongoing folding and faulting have produced young mountain ranges with steep slopes and rugged topography. The climate is Mediterranean, dominated by unrelenting summer drought and highly variable winter rainfall, by substantial temperature variations ranging from cool coast fogs to extremely hot interior deserts to cold, high-elevation alpine zones. Few places in the world probably have such a diverse set of physical environments in a comparable area. This diversity is at the heart of the appeal of the region while producing the hazards for which the area is infamous, e.g., earthquakes, floods, fires, landslides.

Geology

Southern Santa Barbara and Ventura counties occupy the western end of the Transverse Ranges of California. The mountain ranges in this geologic province have the distinction of being one of only two east-west trending ranges in the United States. As a result, the coastline runs almost directly east-west in contrast to the dominant north-south orientation of the rest of the Pacific Coast. The westernmost range in this transverse geologic province, the Santa Ynez Mountains, forms a backdrop for the city of Santa Barbara and extends westward to Point Conception. The Transverse Ranges continue eastward into the Topatopa and Pine Mountains of central Ventura County, the San Gabriel Mountains in Los Angeles County (north of Los Angeles), and the San Bernardino Mountains (farther east). Elevations generally increase eastward, starting with maximum elevations around 600 meters (2,000 ft) at the western end, rising to 1,300 meters (4,200 ft) north of Santa Barbara, 2,300 meters (7,500 ft) in the Pine Mountains, 3,000 meters (10,000 ft) in the San Gabriels, and 3,500 meters (11,500 ft) in the San Bernardinos. The Channel Islands, about 40 miles (64 km) to the south of Santa Barbara are extensions of the Santa Monica Mountains of Los Angeles County.

In the northern portions of the counties, the Transverse Ranges merge with the southern end of the north-south trending Coast Ranges that parallel the coast northward to the Oregon border and beyond. The San Rafael and Sierra Madre Ranges of northern Santa Barbara County are generally considered to mark the southernmost extent of the Coast Ranges geologic province. To the north, the Santa Lucia Range (part of the Coast Range) is responsible for the spectacular coastal scenery of Big Sur as the mountains rise to heights of more than 1,000 meters (3,300 ft) just a few kilometers from the shore.

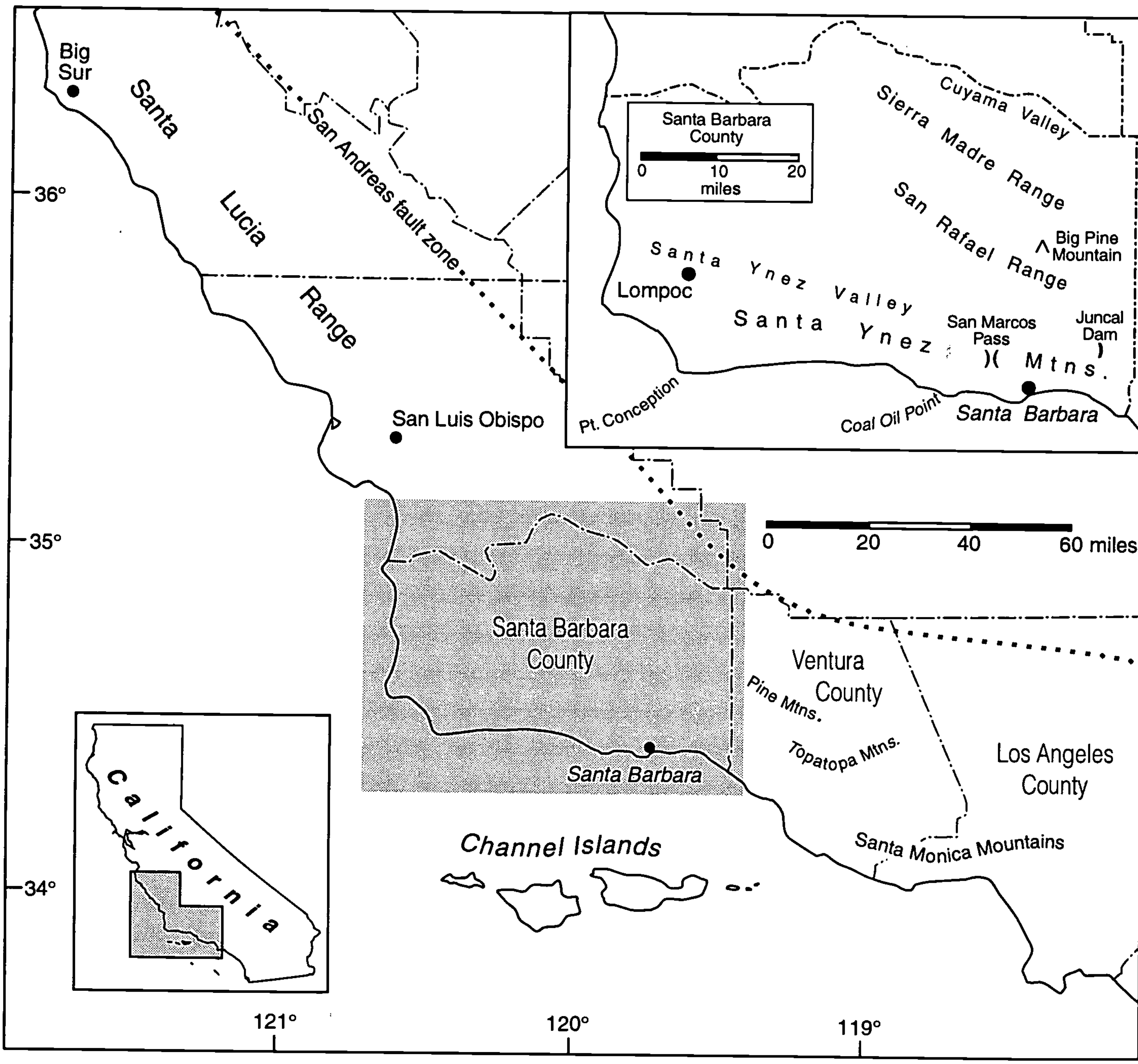

Figure 4.1 Santa Barbara County Physical Features

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Even though maximum elevations in the region are not spectacularly high, the terrain is frequently very rugged. As a result, a number of isolated, roadless areas lie within short distances of significant population centers and heavily traveled roadways. The Santa Lucias, for example, are crossed by only one minor road in a distance of around 175 kilometers (110 miles). Similarly, only one road heads north out of Santa Barbara and Ventura counties between Highway 101 and Interstate 5 (see Figure 7.1).

All of the Transverse and southern Coast Range provinces are west of the San Andreas fault zone. The region lies on the Pacific Plate and is being rafted northward as that plate moves past the North American Plate (see Figure 5.1). The ruggedness of the terrain, in part, is a result of the uplift of the current mountain ranges and is very recent in geologic time. All of the tectonic activity that produced the ranges in both provinces has occurred in the last five million years (Pliocene and Pleistocene Epochs).

The entire geologic history of the area is quite short. The oldest rocks are from the Franciscan formation of the late Jurassic to late Cretaceous Periods (roughly 150 to 75 million years ago). This formation is prominent in the Coast Ranges, but its origin was a mystery before the development of the theory of plate tectonics. It is a complex *melange* of sedimentary and volcanic rocks, all apparently deposited in deep ocean environments. It is now thought that this formation originated in a subduction zone produced as the Pacific Plate collided with and dove beneath the North American Plate—apparently the same event as the Nevadan Orogeny that produced the granitic rocks of the Sierra Nevada and the original Nevadan mountains on the site of the present-day Sierra Nevada.

The rocks that make up the western Transverse Ranges are mainly from the Eocene, Oligocene, and Miocene Epochs (53.5 million to five million years ago). Most are marine sandstones and shales indicating that the area remained beneath the sea for most of this period. For example, the sequence in the Santa Ynez Mountains north of Santa Barbara includes the Juncal and Matilija sandstones, the Cozy Dell Shale, and the Coldwater sandstone from the Eocene Epoch (53.5 million to 39 million years ago). The one major non-marine formation is the Sespe, which consists of floodplain deposits and is Oligocene in age (39 million to 23.5 million years ago). This formation is absent in the western Santa Ynez where the marine rocks continue throughout the Oligocene, indicating that the coastline ran through the region somewhere.

By the beginning of the Miocene Epoch (23.5 million years ago) the sea had re-advanced over the whole region. The Rincon Shale is the main formation of the early Miocene. This formation weathers into unstable clay soils that are prone to sliding and tend to swell and shrink substantially as moisture is added and removed. A number of Santa Barbara neighborhoods, particularly in the foothill areas, are built on these soils and have experienced significant structural problems as a result.

During the middle of the Miocene (15 to ten million years ago) deep marine basins formed throughout what is now coastal California between San Francisco and Orange County. These basins apparently resembled current features in the Gulf of California which is being split open by the spreading zone associated with the East Pacific Rise. It is thought, therefore, that the appearance of the basins may have signaled the passage of the area over the spreading zone. This is also about the time the San Andreas fault became active in this part of California, suggesting a shift in relative plate movements from the collision that produced the earlier subduction features to the shearing tangential movements associated with the modern San Andreas transform fault. The rocks formed in these basins (the shales of Monterey Formation) are composed largely of organic material, rather than terrestrial sediments. Much of the material is silica derived from diatoms, which are microscopic phytoplankton. The Monterey Formation is usually finely bedded and is exposed in many of the coastal bluffs in the Santa Barbara area.

The uplift that began during the Pliocene Epoch (five million to 1.8 million years ago) elevated the present mountain ranges in the area. The Santa Ynez Mountains were lifted by a combination of folding and faulting along the Santa Ynez fault just north of the crest of the range. The structure of the range does not follow the rock strata, which have been tilted 90° or more and which cross the crest of the ridge tangentially. As a result, one moves through successively older strata going north through San Marcos Pass. At the base of the mountains marine conditions persisted into the Pleistocene (1.8 to million to 10,000 years ago) as the youngest rock, the Santa Barbara Formation, was formed. The coastal plain probably emerged from the sea less than one million years ago. Frequent earthquakes and substantial deformation of recent alluvial deposits are compelling reminders that the uplift is continuing.

Considerable attention has been given to the cause of the east-west trend of the Transverse Ranges. The San Andreas fault, which forms the northern boundary of the province from Ventura County to San Bernardino County, deviates from its typical northwest-southeast trend to parallel the Transverse Ranges (see Figure 5.1). No generally accepted explanation can account for the bend, but it clearly creates strong compressive forces as the land west of the fault pushes against the westward bend in the fault. Evidence from paleomagnetic research studies in the University of California Santa Barbara's Geology Department suggest that the Transverse Ranges west of the San Andreas fault rotated clockwise 60° to 80° between 16 and six million years ago, possibly caused by shearing along the Pacific-North American plate boundary. This does not explain why the east-west trend continues through the San Bernardino Mountains, which are east of the San Andreas fault.

Petroleum has long been exploited in the area. The local Chumash in pre-contact times used tar from natural seeps to seal their boats. A number of natural seeps are still active, particularly offshore from Coal Oil Point just west of the University of California Santa Barbara (UCSB), and small blobs of tar are a common fixture on many local beaches. The Transverse Ranges have been a fertile area for oil and gas exploration since the nineteenth century. Major discoveries were made around the end of the last century in Ventura and the Santa Barbara Channel. The latter was the first offshore field developed in the United States when it opened in 1896. It also gained considerable notoriety when a well blew out in 1969 and produced the first major offshore oil spill in the United States.

Climate

The climate of all of coastal California is Mediterranean, with a strong alternation in precipitation between dry summers and wet winters. More than 90 percent of the annual precipitation falls in the November-April period. Amounts generally increase northward, with San Diego averaging about 25 cm (10 inches), Los Angeles 40 cm (15 inches), Santa Barbara 45 cm (18 inches), San Luis Obispo 55 cm (22 inches), and Big Sur State Park 100 cm (40 inches). This large scale trend is strongly modified by topography. Almost all precipitation is produced by large-scale mid-latitude storms moving off the Pacific, so west- and south-facing slopes are relatively wet, as average precipitation generally increases with elevation. Leeward slopes and interior valleys show strong rainshadow effects. In Santa Barbara County, for example, precipitation rises from 45 cm (18 inches) at sea level to 75 cm (29.5 inches) at 670 meters (2,200 feet) on San Marcos Pass to 92 cm (36 inches) at 1,900 meters (6,300 feet) on West Big Pine Mountain. Meanwhile Lompoc in the Santa Ynez Valley averages 36 cm (14 inches) and the Cuyama Valley in the interior of northern Santa Barbara County (the Cuyama River forms the eastern part of northern boundary of Santa Barbara) averages only 18 cm (7 inches), technically making it a desert. Snow levels typically range from around 1,000 to 2,000 meters (3,281 to 6,562 ft), so most precipitation in lowland areas falls as rain. Occasionally, unusually cold storms will produce snow almost to sea level, but only the higher elevation regions of the San Gabriel and San Bernardino Mountains accumulate significant snowpack.

Coastal central and southern California and the adjacent mountain ranges have exceptionally large interannual variability in precipitation, so averages must be interpreted with care. At many stations rainfall totals in the wettest years are as much as ten times greater than in the driest years, and the range extends from one-third of the mean to more than 2.5 times the mean. The driest and wettest winters in the 125-year Santa Barbara record are 11.5 cm (4.5 inches) and 114.8 cm (45.2 inches). The majority of winters are relatively dry with around 60 percent falling below the average, but occasional winters can be exceptionally wet. These wet winters are almost always characterized by a period of several weeks of persistent heavy rains produced by a sequence of very large warm, wet storms moving in from the southwest. Often associated with El Niño conditions in the equatorial Pacific, the link is not entirely consistent and the mechanisms are not fully understood. Rainfall totals can be very high, especially on south-facing slopes at middle and high elevations. In January 1969, Santa Barbara received 51 cm (15.5 inches), while 92.7 cm (36.5 inches) fell at San Marcos Pass, and Juncal Dam at 630 meters (2,060 feet) in the upper Santa Ynez Valley received 112.5 cm (44.3 inches). A single storm in a 12-hour period in January 1995, produced 20 cm (eight inches) in downtown Santa Barbara and as much as 50 cm (20 inches) in the higher elevations. Rainfall of these quantities and intensities, when combined with the steep slopes, shallow soils, and sparse vegetation cover characteristic of the area, can produce severe flooding and landsliding problems.

In contrast to the high variability in winter rainfall, summers are remarkably uniform in their drought. Less than 5 percent of the average annual precipitation falls between May and October and less than 1 percent in June, July, and August. Furthermore, only once in the last 125 years has more than 2.5 cm (one inch) of rain fallen at Santa Barbara in July or August. The wettest July in 115 years at Los Angeles produced only six mm (.25 inches) of rain, and 110 have had less than one mm (.04 inches).

This persistent drought results from the North Pacific High pressure cell that moves north and intensifies in the summer. It produces strong subsidence and blocks the westward penetration of moist, unstable air masses from the Gulf of Mexico and Gulf of California, which move north out of Mexico into the interior Southwest. The strong high is also responsible, along with the relatively cold ocean temperatures, for the temperature inversion and coastal fog that persist throughout the summer. Air near the ocean surface forms a cool, moist marine layer within which fog typically forms. The marine layer is capped by an inversion with a warmer, drier layer of subsiding air above. Since air rises only as long as it is warmer and less dense that the air around it, the inversion effectively puts a lid on the lowest layer of the atmosphere. This phenomenon greatly exacerbates the air pollution problems in the region because pollutants do not disperse upward through the inversion.

Coastal fog and cold ocean water have a moderating influence on summer temperatures at coastal stations, where average maximum temperatures are around 20°C (68°F). The cooling influence diminishes rapidly moving away from the coast, however, and average daily maxima in interior valleys are 35°C (95°F) or more. This temperature difference produces strong sea breezes blowing inland off the ocean and typically peaking in the afternoon. The winds are very dependable and can be quite strong in areas where they are concentrated by topography. A number of wind power farms have been established in gaps in the mountain barriers that separate coastal and desert valleys.

Winter temperatures tend to be mild in lowland areas, especially along the coast where sub-freezing temperatures are uncommon. Interior valleys are generally colder, and low-lying areas frequently become frost pockets because of cold air drainage. Frost-sensitive crops such as avocados are most commonly grown in coastal areas and in thermal belts on the slopes above the colder valley floor. If air masses are sufficiently moist fog will form at night in the valley bottoms. In most of coastal California, this radiation fog will burn off during the day, but in the Sacramento and the San Joaquin Valleys, where it is known as *tule* fog, it can persist for days or even weeks at a time. This type of fog produces severe hazards for traffic because it tends to be densest in low spots. Small drops in elevation can result in significant reductions in visibility. Large chain reaction accidents involving 100 or more vehicles are not uncommon.

Another distinctive weather type that occurs in spring and fall is the Santa Ana wind. When the typical pressure distribution of high pressure over the eastern Pacific and low pressure on the continent is reversed a circulation can develop that brings hot, dry desert air from the northeast into southern California. The general flow is perpendicular to the Transverse ranges, so the winds get funneled through passes and accelerate downslope toward the coast. In addition, compressional heating increases temperatures and reduces relative humidities—often to less than 10 percent. These strong, hot, dry winds create severe fire hazards, especially in fall when the natural vegetation is already dry after the long summer drought. Any fires started in the open chaparral-covered hill and mountain areas of southern California can grow quickly into large conflagrations that are impossible to contain until the winds die down, often three or four days later. Fires of this type have probably always been a natural part of the chaparral ecosystem, but they have been responsible for major property damage as people have built more and more homes (often large and expensive) in the hills.

Biogeography

The complex climate, geology, and topography of the Transverse Ranges and southern Coast Ranges combine to create very diverse and fragmented biogeographic patterns. Within 200 miles of Santa Barbara, vegetation communities range from nearly barren desert scrub to dense redwood forest, from subtropical palm oases to alpine meadows. This diverse set of modern environments, along with Pleistocene climatic change and continental movement on the order of 100 km (62.5 m) over the last ten million years have probably all contributed to produce the relatively high rates of *endemism* (species with very restricted ranges) observed among plants and animals of the region.

The unrelenting summer drought is a fundamental climatic constraint common to all of the region, no matter how wet or dry or warm or cold, to which all plants and animals must adapt. Southern California vegetation, in particular, is distinctive in its abundance of drought-adapted scrub vegetation, mainly different types of chaparral. Chaparral-like scrub communities are characteristic of Mediterranean climates throughout the world, although species compositions change from region to region.

Pronounced slope effects complicate efforts to subdivide scrub communities, but several reasonably distinct types can be associated with differing climatic zones. Coastal sage scrub grows at low elevations and, as the name implies, does best in maritime climates where summer fog is important. On the other hand, such areas generally have lower winter precipitation than foothill and mountain areas, so coastal sage scrub is well adapted to drought. Some of the community's plants and animals are also found in the desert and others have close relatives in the desert.

Coastal sage scrub is sometimes referred to as *soft chaparral* because many of the plants have soft, flexible leaves and branches. Most shrubs grow about knee-high, making them relatively easy to walk through in marked contrast to other chaparral communities. One of the most common species is California sagebrush, *Artemisia californica*, which is drought-deciduous and closely related to Great Basin sagebrush, *Artemisia tridentata*, the most common plant of the Great Basin Desert. Another common species is coast brittle-bush, *Encelia californica*, which is closely related to desert brittle-bush, *Encelia farinosa*. Several species (spp.) of true sages, *Salvia* spp., are also common drought-deciduous elements of the coastal sage scrub. Common species include black sage, *Salvia millifera*, and purple sage, *Salvia leucophylla*.

Most of the sage species, as well as some of the other shrubs, have strong, pungent odors and flavors. Many of the herbs commonly used in cooking originated in the Mediterranean climates of the Old World. Several good local substitutes abound, including Cleveland sage (fragrant sage), *Salvia clevelandii*, and California bay, *Umbellularia californica*, a riparian tree in southern California.

Considering the affinity of the coastal sage scrub for coastal plain areas of southern California, it is not surprising that it is a threatened community. It was formerly widespread from the coastal bluffs to the foothills but has been replaced throughout most of the region by urbanization, grazing, and agriculture.

Lower, or warm chaparral, is commonly found in foothill areas above the coastal sage scrub. The occurrence of frost is a factor that separates this community from coastal sage scrub, and where summer fog is less common and winter rain is somewhat higher. The upper limit of warm chaparral is probably related to the frequency of snowfall. Typical elevation ranges are from 1,000 feet (300 m) to 5,000 feet (1,600 m). In contrast to the drought-deciduous plants of the coastal sage scrub, most chaparral plants are evergreen. They have small waxy leaves and woody stems, and they grow much larger than plants of coastal sage scrub. A mature stand of warm chaparral can be ten feet high and nearly impossible to walk through, making the term *hard chaparral* well-deserved. The most abundant warm chaparral plant is chamise, *Adenostoma fasciculatum*, which is particularly dominant on south-facing slopes. The other major shrub on south-facing slopes is California lilac, *Ceanothus* spp. On north-facing slopes the dominant shrubs include California scrub oak, *Quercus berberidifolia*, holly-leafed cherry, *Prunus ilicifolia*, and California coffeeberry, *Rhamnus californica*. These shrubs generally have larger leaves than the dominants on south-facing slopes.

Warm chaparral is the scrub community most likely to burn. Wildfires have always been an important aspect of the environment, and most chaparral plants have evolved mechanisms for regenerating after burns. Common adaptations include the ability to sprout from roots, seeds that require intense heat to germinate, and thick fire-resistant bark. Since the foothills and lower mountain slopes dominated by warm chaparral are also some of the most desirable areas for upscale residential development, this natural tendency has led to a considerable amount of property damage and some loss of life. A lively controversy persists about the character of pre-twentieth century fire regimes and the long-term effects of fire suppression during the modern period. Some believe that the natural regime was characterized by small, low-intensity fires that would burn only older chaparral stands, leaving a mosaic of patches of differing ages. According to this theory, suppression has produced large patches of uniform old age with substantial accumulations of dead wood and other fuels. This, in turn, has tended to encourage the spread of large conflagration fires during periods of hot, dry Santa Ana winds. Others believe that large, infrequent fires were characteristic of pre-suppression fire regimes, noting that Santa Ana winds will always tend to encourage fire storms, even in relatively young chaparral stands, and that lightning-started fires are relatively rare in the western Transverse Ranges and southern Coast Ranges. Evidence from charcoal deposited on the floor of the Santa Barbara Channel suggests that large fires have been typical in the Santa Ynez Mountains for at least the last 1,000 years.

Above about 4,000-5,000 feet (1,200-1,600 m) snow becomes a common element of climate, and the cold chaparral community takes over on south-facing slopes. This community is dominated by several different species of manzanita, *Arctostaphylos* spp. On north-facing slopes drought-adapted conifers dominate, especially Coulter pine, *Pinus coulteri*, and big-cone Douglas fir, *Pseudotsuga macrocarpa*. The latter species has become a very useful indicator of past moisture fluctuations. Researchers in the UCSB Geography Department have produced dendrochronological reconstructions from sites in Santa Barbara and Ventura counties that provide year-by-year records of winter precipitation variability extending back 500-600 years. These reconstructions indicate that interannual precipitation variability has been large, but no long-term changes in average precipitation have been apparent.

Yellow Pine Forest covers the highest peaks in the area, usually becoming dominant above 6,000-7,000 feet (1,800-2,100 m). Jeffrey pine, *Pinus jeffreyi*, is the most common conifer, with ponderosa pine, *Pinus ponderosa*, also present. Black oak, *Quercus kelloggii*, is the main deciduous species. Much of the winter precipitation in the Yellow Pine Forest falls as snow, and the trees of the community are adapted to a summer growing season, making them dependent on groundwater remaining from winter precipitation.

In relatively moist, low elevation hill and valley areas, Oak Woodland is the main vegetation community. It is usually dominated by one of the large oaks, such as coast live oak, *Quercus agrifolia*. This woodland, or savanna, landscape is in many ways the quintessential idealized central and southern California country landscape. The oaks are drought adapted with large spreading root systems, and attempts to incorporate them into urban developments have met only with limited success. The biggest problems are fill soils, covering the extensive root system with concrete, or planting grass and ornamental plants requiring summer irrigation. This promotes the growth of a fungus that attacks the roots of the oaks and kills them.

One plant often found in association with Coast Live Oak and throughout the canyons and moister chaparral-covered slopes of southern California is poison oak, *Taxicodendron (Rhus) diversiloba*. People who are allergic to it can develop severe rashes from contact with any portion of the plant. Its leaves are most attractive in autumn when they turn bright red before falling, but the lack of leaves during winter can be particularly hazardous since it is much more difficult to identify and avoid.

Riparian Woodlands provide unique and distinctive environments contrasting strongly with the open scrub-covered slopes. Many of the riparian tree species are winter-deciduous, and they provide fine displays of fall color that belie the common misconception about seasonal displays held by people from the east. At the lower elevations the dominant trees are western sycamore, *Platanus racemosa*, and various willow species, *Salix* spp., white alder, *Alnus rhombifolia*, and big-leaf maple, *Acer macrophyllum* are common at intermediate elevations. Two evergreens, California bay, *Umbellularia californica*, and Pacific madrone, *Arbutus menziesii*, reach the southern extents of their ranges in cooler, north-facing slopes and canyons of the southern California mountains.

In addition to the complex climatic and topographic controls on vegetation, central California's geologic history has produced some unique edaphic plant communities associated with particular soil types rather than only to climatic and other physical conditions Probably the most noteworthy are the communities found on serpentine soils that extend from northern Santa Barbara County northward through the interior Coast Ranges. These soils tend to be drought-prone, but possibly more importantly they have relatively high concentrations of metals such as nickel and chromium, which most plants have difficulty tolerating. As a result, plant communities tend to be very different from those on other soils in surrounding areas, often with relatively few species and less continuous cover. An additional factor contributing to the latter may be the fact that the clay soils that often form on serpentine are unstable and prone to sliding on slopes.

Summary

This quick introduction to the physical environment demonstrates the uniqueness of central and southern California. Complex interactions between geology, climate, and vegetation have worked rapidly to produce the strikingly diverse environments of the area. The pace of change in the natural world has been and continues to be fast. In this century the pace of change has been accelerated greatly, however, by human activity.

The appealing physical environment and Mediterranean climate have contributed significantly to the tremendous population growth that has transformed the area in the last several decades. Inevitably, the very qualities that attracted immigrants have come under siege. Plants and animals have suffered from significant loss of habitat. Air pollution has had demonstrable adverse effects on vegetation throughout southern California. The

California condor no longer exists in the wild. Coastal sage scrub is nearly gone, as are some of its animal inhabitants

On the other hand, substantial areas remain that have not been overdeveloped where the effects of modern society, although not absent, are not overwhelming. Much has been lost, but much remains, providing hope and a challenge for future generations to do a better job of maintaining the beauty and living with the hazards of the natural environment.

5

The San Andreas Fault

Antony R. Orme[1]

The San Andreas Fault is the most striking physical lineament along the western margin of the United States. It also poses a significant hazard to human life and livelihood, dramatized in October 1989 by the Loma Prieta earthquake. This earthquake was, however, but one of many that have resulted from episodic shifts of the fault over the past several million years. The dramatic landscape and seismic expressions of the San Andreas Fault are the focus of much research, while the human implications of fault movement attract studies directed toward earthquake prediction and land-use planning.

Origins and Tectonic Significance

The San Andreas Fault extends 1,200 kilometers (744 mi) northwestward across California, from the Salton Trough to Cape Mendocino, and dips at 70° to 90° into the earth's crust to depths of over 18 kilometers (11 mi) (Figure 5.1). It is a right-lateral strike-slip structure in that land on the far side of the fault is displaced laterally to the right, and there is also some vertical slip. In places the fault is a narrow zone of broken and pulverized rock; elsewhere it is a complex belt of parallel fractures and deformed rocks as wide as ten kilometers (6 mi).

In terms of plate tectonics, the San Andreas Fault represents a transform margin between the North American and Pacific plates. Both plates have a westward component but, because of its northward component, the Pacific plate is moving northwestward relative to North America. In reality, the San Andreas Fault proper is part of a broader system of near parallel faults that reflect, to a greater or lesser extent, shearing between these plates over the past 15 Ma (million years ago). Whether active or not, these faults collectively form the San Andreas fault system, a zone of crustal wrenching as wide as 200 kilometers (124 mi) that now encompasses the populous Los Angeles and San Francisco metropolitan areas.

The origins of the San Andreas Fault lie within the margin that evolved during Cenozoic time between the North American continental plate and successive oceanic plates farther west (Figure 5.1 insets). In earlier Cenozoic time, this was a convergent margin wherein the westward-moving North American plate converged obliquely on and overrode the oceanic Farralon plate. As parts of the latter plate were subducted and the East Pacific Rise, an oceanic spreading center farther west, was in turn overridden, the North American plate began transferring onto the Pacific plate. The plate margin between this transferred mass and the main North American plate thus changed to a transform type, with the lateral shear being transmitted upward to the surface as strike-slip faults. Right-lateral movement along this margin probably began around 30 Ma and has dominated the past 15 Ma. Further, as the East Pacific Rise was progressively overridden, so lateral shear along this margin stepped farther eastward with time. Earlier strike-slip motion occurred along faults now off the California coast, then along the San Gabriel Fault, and now along the San Andreas Fault proper with some movement even farther east along the Hayward and Calaveras faults (Figure 5.1).

Farther south, initial shearing occurred along the Tosco-Abreojos-San Benito fault system off western Mexico. Later, as the North American plate overrode the East Pacific Rise, crustal extension formed the fledgling Gulf of California (Stock and Hodges 1989). About five Ma, the East Pacific Rise appeared beneath the mouth of the Gulf and the Baja California miniplate began accelerating away from mainland Mexico on the western limb of this spreading sea floor, namely the Pacific plate. Since then, as Baja California has been rafted

[1]Revised and reprinted, with permission, from the original in Donald G. Janelle, ed. *Geographical Snapshots of North America*, prepared for the 27th International Geographical Congress 1992 (New York: Guilford Press: 143-149).

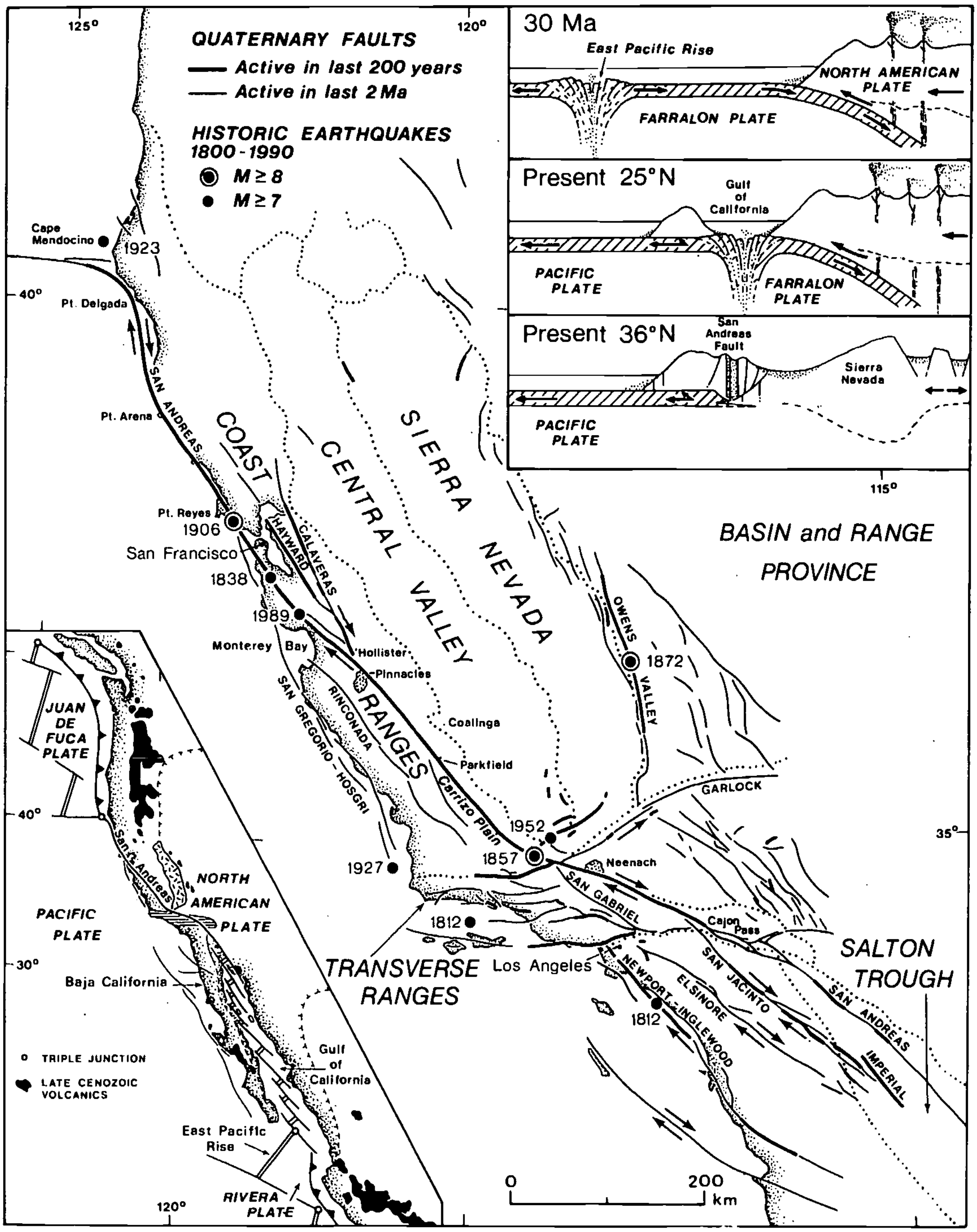

Figure 5.1
The San Andreas fault system, other Quaternary faults, and historic earthquakes in California. Insets show the evolution and present relations of the San Andreas transform margin. (Source: Orme, Antony 1992. "The San Andreas Fault," in Janelle, Donald G., ed. *Geographical Snapshots of North America*. New York: Guilford Press 144. Used by permission.)

northwestward at a mean rate of 56 to 60 millimeters (2.24 to 2.4 in) per year (Larson 1972; Minster and Jordan 1987), transform faults offsetting the East Pacific Rise within the Gulf have propagated northward into the continental crust of the Salton Trough, forming sequential right-lateral strike-slip faults of which the San Andreas is currently the most prominent. Furthermore, as the Baja California miniplate collided with the resistant roots of the Sierra Nevada, compression formed the Big Bend in the San Andreas Fault and severely buckled the Pacific Coast (Orme 1980). North of Cape Mendocino, these evolving plate relations remain at an earlier stage as fragments of the Farralon plate, namely the Gorda and Juan de Fuca plates, continue to be subducted beneath the North American plate, with associated volcanism in the Cascade Range farther east.

Surface Expression

The path of the San Andreas Fault across California may be divided into three segments. In the south, through the Salton Trough, a 50-kilometer- (31 mi-) wide fault zone trends N45°W for 300 kilometers (186 mi) and comprises several active faults that converge on the Cajon Pass. For 180 kilometers (112) mi from the Cajon Pass, the Big Bend of the San Andreas Fault trends N75°W as a narrow lineament north of the Transverse Ranges. The fault then trends N35°W over the remaining 720 kilometers (447 mi) to Cape Mendocino, crosses the coast just south of San Francisco, and passes east of the Point Reyes Peninsula and Point Arena to Point Delgada before turning west into the Mendocino fracture zone.

Because of intense deformation and recurrent fracturing or persistent creep, rocks along the fault are relatively soft and easily eroded. Thus, where the fault zone is narrow, its course is marked by a linear trough characterized by fault scarps, pressure ridges, and sag ponds. Repeated displacement along the fault is well shown by offset streams and dislocated alluvial fans, notably in the Carrizo Plain and Transverse Ranges. Fault-controlled groundwater barriers commonly lead to springs and surface seepage. Local compression often causes uplift within the fault zone, as in the Ocotillo badlands in the Salton Trough. Mountain fronts alongside the fault are markedly linear with numerous truncated spurs. During earthquakes, liquefaction at depth may cause sand boils or *mud volcanoes* at the surface as water-saturated sediments flow upward along fractures. Continuing geothermal and volcanic activity within the fault zone, as in the Salton Trough where five rhyolite domes have extruded onto Quaternary sediments, have led to the plate margin's designation as a "leaky transform" boundary.

At a regional scale, compression of the Pacific plate against the roots of the North American plate has forced excess mass upward to form prominent mountains, notably the Transverse Ranges, which rose rapidly when the transform boundary collided with the Sierra Nevada and created the Big Bend in the San Andreas Fault. As these mountains rotated to their present east-west alignment and continuing compression triggered thrust faulting, marginal pull-apart structures such as the Los Angeles and Santa Maria basins also formed. The 260-kilometer (161 mi) left-lateral Garlock Fault may have been created by related displacement southeast of the Sierra Nevada. Farther north, the Coast Ranges are being compressed by active thrusting along their eastern margins (Wentworth and Zoback 1989). Lateral displacement of regional drainage is illustrated by the San Benito River which flows northwest for 100 kilometers (63 mi) along the San Andreas fault zone before breaking seaward to Monterey Bay.

Fault Movement and Plate Displacement

Because plate displacement along the San Andreas Fault is usually associated with earthquakes, an understanding of slip rates along the fault is important, particularly as recent movement may be the best clue to future fault behavior and earthquake prediction. Displacement along the fault may be deduced from a variety of temporal evidence. Long-term displacement is indicated, for example, by early Miocene volcanic rocks at the Pinnacles and Neenach (west central California), which originated from a common eruptive center around 23 Ma and have since been separated by 310 kilometers (192 mi) of movement along the San Andreas Fault (Matthews 1976). Marine sediments beneath the southern Central Valley and the Santa Cruz Mountains have been similarly offset by 325 kilometers (202 mi) since early Miocene times (Stanley 1987). Geologic discordances across the Gulf of California indicate that Baja California has been rafted a similar distance northwest away from mainland Mexico during this interval. Although initial Miocene slip rates were as low as three millimeters (.12 in) per year, most evidence indicates a long-term slip rate of 13 to 14 millimeters (.52 to .56 in) per year over the past 23 million years. Such rates have not, however, been constant in time or space. For example, Colorado River deposits on the western margins of the Salton Trough have been displaced 130 kilometers (81 mi) from their source over the past 2.8 Ma, for a rate of 46 millimeters (1.84 in) per year (Winker and Kidwell 1986).

Medium-term displacement is indicated at Wallace Creek, in the Carrizo Plain, which has been offset 128 meters (420 ft) along the San Andreas Fault over the past 3,680 years for a mean slip rate of 35 millimeters (1.4 in) per year (Sieh and Jahns 1984). Nearby alluvial-fan deposits have been offset 475 meters (1,558 ft) over 13,250 years for a mean slip rate of 36 millimeters (1.44 in) per year. Near the Cajon Pass, dislocated alluvial deposits indicate a slip rate of 25 millimeters (1 in) per year over the past 14,400 years which, when added to slip of ten millimeters (.40 in) per year on the San Jacinto Fault, is comparable to the Wallace Creek data (Weldon and Sieh 1985). Late Quaternary slippage in the Salton Trough approximates 23 to 35 millimeters (.92 to 1.4 in) per year (Keller *et al.* 1982).

For the past 100 years, short-term slip rates of 32 to 36 millimeters (1.28 to 1.44 in) per year have been revealed between Parkfield and San Francisco Bay by periodic geodetic observations (for example, Prescott *et al.* 1981), augmented since 1985 by monthly observations of relative vectors using the Global Positioning System of survey satellites. The Farralon Islands on the Pacific plate 30 kilometers (19 mi) west of San Francisco are shifting northwards at this rate relative to *fixed* points east of the San Andreas Fault.

The medium- and short-term measurements together suggest a mean slip rate of 34 millimeters (1.4) per year for Holocene times. This is an order of magnitude greater than the inferred Miocene rate of three millimeters (.12 in) per year and larger than the long-term rate of 13 to 14 millimeters (.52 to .56 in) per year. Movement along the San Andreas Fault has thus accelerated in the recent geologic past and may be greater now than at any time over the past 30 Ma.

Magnetic anomalies and plate reconstructions across the Gulf of California indicate, however, plate separation of 56 to 60 millimeters (2.24 to 2.4 in) per year over the past four Ma (Larson 1972; Minster and Jordan 1987). To explain this discrepancy between plate displacement of 56 to 60 millimeters (2.24 to 2.4 in) per year and a San Andreas slip rate of 34 millimeters (1.4 in) per year, it is necessary to abandon rigid-plate concepts in favor of more deformable models and to invoke right-lateral motion of eight to 27 millimeters (.32 to 1.08 in) per year on faults to the west and the extension of the Basin and Range Province to the east by ten to 20 millimeters (.40 to .80 in) per year. These scenarios are well supported by evidence for slip along the 420-kilometer (260 mi-) San Gregorio-Hosgri fault system offshore, which may have been displaced 100 kilometers (62 mi) since Miocene times, and by normal faulting east of the Sierra Nevada, which gave rise, among others, to the great M8 Owens Valley earthquake of 1872. In the Santa Cruz Mountains, the San Andreas Fault accounts for only 13 millimeters (.52 in) per year of relative plate motion; the remainder is distributed east and west, along the Hayward-Calaveras and San Gregorio fault systems respectively.

Earthquake History and Prediction

California has a historic record of earthquake activity extending back for more than 200 years and mounting evidence is becoming available for datable prehistoric events. In 1769, the Portola expedition felt 24 earthquakes in one week as it crossed the Los Angeles basin. Franciscan missionaries, soldiers, and early newspapers later documented nineteenth century events but such records were inevitably incomplete, confined as they were to earthquakes actually felt in inhabited areas and uncertain as to which fault had moved.

The first permanent earthquake laboratories were established by the University of California in 1887 and statewide seismographic coverage existed by 1932. Based in part on earlier systems, the modified Mercalli scale (MM) of earthquake intensities, which ranks shaking in ascending order from MMI to MMXII, was defined in 1931, and the open-ended logarithmic scale of earthquake magnitude (M) was introduced by Charles Richter of the California Institute of Technology in 1935. Since then, both scales have been used to describe earthquakes and retrofitted, as far as possible, to past events.

Since 1800, California has experienced more than 70 earthquakes of M6 or larger, including ten over M7, of which three exceeded M8 (Figure 5). Of these, half have occurred along the San Andreas Fault proper, including the M8+ Fort Tejon earthquake of 1857 and the M8.3 San Francisco earthquake of 1906. The record of smaller but still troubling quakes is much larger: 188 events of M4 or greater occurred in California between 1975 and 1979, again about half along the San Andreas Fault. Most such earthquakes focus at shallow depths of less than 18 kilometers (11 mi) and the larger ones are thus particularly damaging at the surface.

In southern California, the 240-kilometer (149 mi) San Jacinto Fault is among the most seismically-active strands of the San Andreas system, having experienced nine events of M6 or larger since 1890. A complex freeway interchange between Interstates 10 and 15 straddles this fault! The nearby Imperial Fault has also been frequently active, with an M6.7 event in 1940 offsetting citrus groves, whereas an M6.6 event in 1979 caused 30 kilometers (19 mi) of ground rupture with 55 centimeters (22 in) of right-lateral and 19 centimeters (7.6 in) of vertical displacement. Indeed, in the pervasively faulted Salton Trough, earthquake swarms of low to moderate intensity are quite frequent as strain is released upwards through thick, poorly compacted Quaternary sediments.

The largest historic earthquake along the Big Bend segment was the M8+ Fort Tejon earthquake of 1857 when the San Andreas Fault sustained as much as 9.5 meters (32 ft) of lateral slip over the 320 kilometers (198 mi) between the Cajon Pass and Parkfield. The fresh tectonic relief of this segment includes numerous sag ponds and fault scarps produced during this event. Intensities of MMVII or larger were felt from Los Angeles to Monterey but, owing to the then-sparse population, damage was small (an MMVII event causes people to run outdoors, and damage to poorly built structures is considerable). Since 1857 this fault segment has remained locked, suggesting that stresses accumulate here over long periods until relieved during a great earthquake—the "big one" anticipated by southern California residents.

North of the Big Bend, tectonic creep increases to 32 to 36 millimeters (1.28 to 1.44 in) per year along the San Andreas Fault as it passes through the Carrizo Plain to Parkfield, and then diminishes farther north toward Monterey Bay, but is found along the Hayward-Calaveras system past Hollister. Creep may reflect the nature of basement rocks and structures. Because tectonic creep inhibits the accumulation of strain energy, which would otherwise be released by larger earthquakes, this fault segment has experienced mostly low to moderate events, notably the Parkfield earthquakes of 1932 (M6) and 1966 (M5.5). This creeping segment attracts scientific attention because periodic measurements of strain and creep may provide early detection of altered conditions preceding an earthquake.

The San Francisco region has suffered several moderate to large historic earthquakes within the San Andreas system. An M7 event caused 40 kilometers (25 mi) of surface ruptures along the main fault near San Francisco in 1838, whereas across San Francisco Bay two M6.8 events occurred on the Hayward Fault in 1836 and 1868. The great M8.3 earthquake of April 1906 ruptured along 450 kilometers (279 mi) of the San Andreas Fault from near Monterey Bay northwest to beyond Point Delgada, with up to five meters (17 ft) of right-lateral slip in the trough east of the Point Reyes peninsula. This event raised studies of the San Andreas Fault to a higher plane (Lawson *et al.* 1908). Furthermore, realization that displacement died out within 30 kilometers (19mi) east and west of the fault led to the theory of elastic rebound, which states that crustal rocks that are progressively strained by slow plate movement are returned to an unstrained state by the sudden fault displacements that cause earthquakes.

More recently, the M7.1 Loma Prieta earthquake of October 1989, whose epicenter lay in the Santa Cruz Mountains 100 kilometers (62 mi) south of San Francisco, was caused by compressive slip along a 40-kilometer (25 mi-) segment of the San Andreas Fault that ruptured the crust from a depth of 18 kilometers (11 mi) to within five kilometers (3.1 mi) of the surface. Between 1906 and 1989, this fault segment had remained relatively quiet, or aseismic, and a 30 percent chance of an M7 earthquake had been predicted for the period 1988 to 2018! Displacement on the 70° fault plane amounted to two meters (7 ft) laterally and 1.3 meters (4.3 ft) vertically, but little primary surface faulting occurred (Plafker and Galloway 1989). Instead, ten seconds of seismic shaking at depth caused extensive surface cracking and many landslides, while liquefaction of water-saturated sediments and artificial fills caused much damage around San Francisco and Monterey Bays. Intensities of MMVII or larger were felt from Salinas in the south to Berkeley in the north. The earthquake caused sixty-seven known deaths, more than $6 billion in property damage, the collapse of several bridge and freeway structures, and left more than 12 thousand people homeless. Some fifty-one aftershocks of M3 or larger occurred within twenty-four hours of the main shock. Despite this event, the probability of another M7 earthquake within the San Andreas fault system around San Francisco Bay remains high. There have also been frequent earthquakes at the far north end of the San Andreas Fault, notably the M7.2 event near Cape Mendocino in 1923. This area is a triple junction where the North American, Pacific, and Gorda plates meet.

Society is, of course, less concerned about past earthquakes than future events, and much scientific effort is now directed toward forecasting more precisely the time, place, and size of future shocks. Several avenues of inquiry are available for earthquake prediction but all have limitations. First, the historic record is useful in directing attention to active faults but is far too short for fine-tuned estimates of future earthquakes. The large 1838 and 1906 earthquakes on the San Andreas Fault near San Francisco occurred 68 years apart and, although strain was known to be accumulating, the next major event came in 1989, eighty-three years later, and focused on a different fault segment. Second, where the record can be extended back into prehistoric time, earthquake recurrence is better understood but still vague. For example, periodic fault displacement and liquefaction of radiocarbon-dated marsh sediments at Pallett Creek, 50 kilometers (31 mi) northeast of Los Angeles, have been attributed to nine large earthquakes between A.D. 575 and 1857 (Sieh 1978). Although an average recurrence interval of 160 years is suggested, the actual interval between events ranged from 55 to 275 years! Third, slip rates may be used to infer earthquake recurrence intervals. For example, the 9.5 meters (31 ft) of right-lateral slip sustained by the San Andreas Fault at Wallace Creek in the 1857 earthquake suggest, when compared with the medium-term slip rate of 34 millimeters (1.36 in) per year, that the 1857 event was preceded by 280 years of strain accumulation (Sieh and Jahns 1984). Variations in fault offset and other assumptions, however, indicate that the latest three recurrence intervals range from 240 to 450 years! Fourth, geodetic measurements and strain-meters measure currently accumulating strain with much greater precision than in the past, but earthquake prediction remains confounded by variable crustal behavior, especially between locked and creeping fault segments.

Finally, even where the past role and future significance of the San Andreas Fault can be evaluated, seismic prediction in California is confounded because many earthquakes occur along other faults within the straining plate margin and some occur on previously unknown or buried faults. For example, wrenching along the Newport-Inglewood fault zone caused the M6.3 Long Beach earthquake of 1933, the severe damage that resulted led to state regulation of public school construction (Field Act 1933). An M7 event on this fault would have a stronger impact on the Los Angeles metropolitan area than an M8 event on the San Andreas Fault 50 kilometers (31 mi) to the northeast (Toppozada *et al.* 1989). The M6.4 San Fernando earthquake of 1971, which occurred on a largely ignored east-west thrust fault in the Transverse Ranges within that metropolitan area, caused sufficient destruction and death to promote statewide studies designed to restrict construction in active fault zones (Alquist-Priolo Special Studies Zones Act 1972). (A pre-dawn earthquake struck the Northridge area of Los Angeles on 17 January 1994. It claimed 61 lives and caused widespread devastation. The main jolt lasted 30 seconds and measured M6.8. Damage was estimated at between $13 and $20 billion.) The destructive M6.7 Coalinga quake of 1983 occurred close to the San Andreas Fault but on a buried thrust fault whose existence has since led to reappraisal of plate relations along the eastern margin of the Coast Ranges.

In short, California is earthquake country and the San Andreas Fault is the principal, but not the only, cause of this activity. An earthquake of M7 or larger is likely to occur somewhere in California every 15 to 25 years, and the Loma Prieta event of 1989 emphasized the need for further diligence in developing and enforcing land-use policies designed to reduce the loss of life and property during future earthquakes. Scientific understanding of the physical dimensions of faults and earthquakes has increased rapidly in recent years and, whereas society may not yet be precisely forewarned, it must at least be prepared.

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Santa Barbara's Water Resources

Edited by Kate Rees[1]

Santa Barbara boasts a beautiful physical location overlooking a particularly attractive section of California coastline. Like the rest of coastal Southern California, it experiences a Mediterranean climate with hot, dry summers, cool, wet winters, and fairly low average rainfall. Because of these conditions and the many competing demands, water in Santa Barbara County has always been, and continues to be, a precious resource.

Surface Water Hydrology

The Santa Ynez River watershed encompasses about 900 square miles (2,331 sq km) and is located in the central part of Santa Barbara County (Figures 4.1 and 6.1). The majority of the Santa Ynez River watershed is undeveloped and consists mostly of brushlands, rangelands, and agricultural fields. The south side of the watershed is formed by the Santa Ynez Mountains. These mountains, ranging in elevation from 2,000 to 4,000 feet (610 to 1,219 m), separate the Santa Ynez River watershed from the South Coast of the county. The north side of the watershed is formed by the Purisima Hills and the San Rafael Mountains, which range in elevation from 4,000 to 6,000 feet (1,219 to 1,829 m).

The Santa Ynez River flows westerly about 90 miles (145 km) to the Pacific Ocean, passing through Jameson Lake, Gibraltar Reservoir, and Lake Cachuma. Immediately above Lake Cachuma, the river passes through a narrow valley between the San Rafael and Santa Ynez Mountains. Below Bradbury Dam, the river passes between the Santa Ynez Mountains and the southern edge of the Santa Ynez upland, and through the broad part of the valley near Buellton. West of Buellton, the river flows through a narrow meandering stretch to the Narrows and emerges onto the broad, flat Lompoc Plain. The Santa Ynez River flows across the Lompoc Plain for about thirteen miles (8 km) and empties into the ocean at Surf. Several major tributaries downstream of Bradbury Dam contribute significant flows to the river, including Santa Agueda, Alamo Pintado, La Zaca, Alisal, Salsipuedes, and San Miguelito Creeks.

The flow of the river has been intermittent, both in the past and under current dammed operations. Winter flows were largely uncontrolled prior to the construction of Bradbury Dam, with virtually no flow in the summer months. Since operations of Bradbury Dam began in 1953, the winter flows have been moderated by reservoir operations and previously nonexistent summer flows have been replaced with releases for downstream water rights.

Precipitation and Runoff in the Santa Ynez River Watershed

The Santa Ynez River watershed has a Mediterranean climate with hot, dry summers and cool, wet winters. Almost all precipitation occurs between November and April, although large variations in annual quantities occur within the watershed. Annual rainfall ranges from about 14 inches (36 cm) near the ocean to about 30 inches (76 cm) at Juncal Dam with higher rates in the headwater areas because of orographic effects.

The upper portion of the watershed is regulated by Juncal, Gibraltar, and Bradbury dams. Juncal and Gibraltar dams are located above Bradbury Dam (Lake Cachuma), and regulate 14 and 216 square miles (36 and 560 sq km) respectively. Lake Cachuma regulates about 417 square miles (1,080 sq km), or less than half of the Santa Ynez River basin. The average annual runoff of the Santa Ynez River at Bradbury Dam is about 71,400 acre feet per year.

[1]Taken from the *Environmental Impact Statement-Environmental Impact Report, Cachuma Project Contract Renewal*, December 1995.

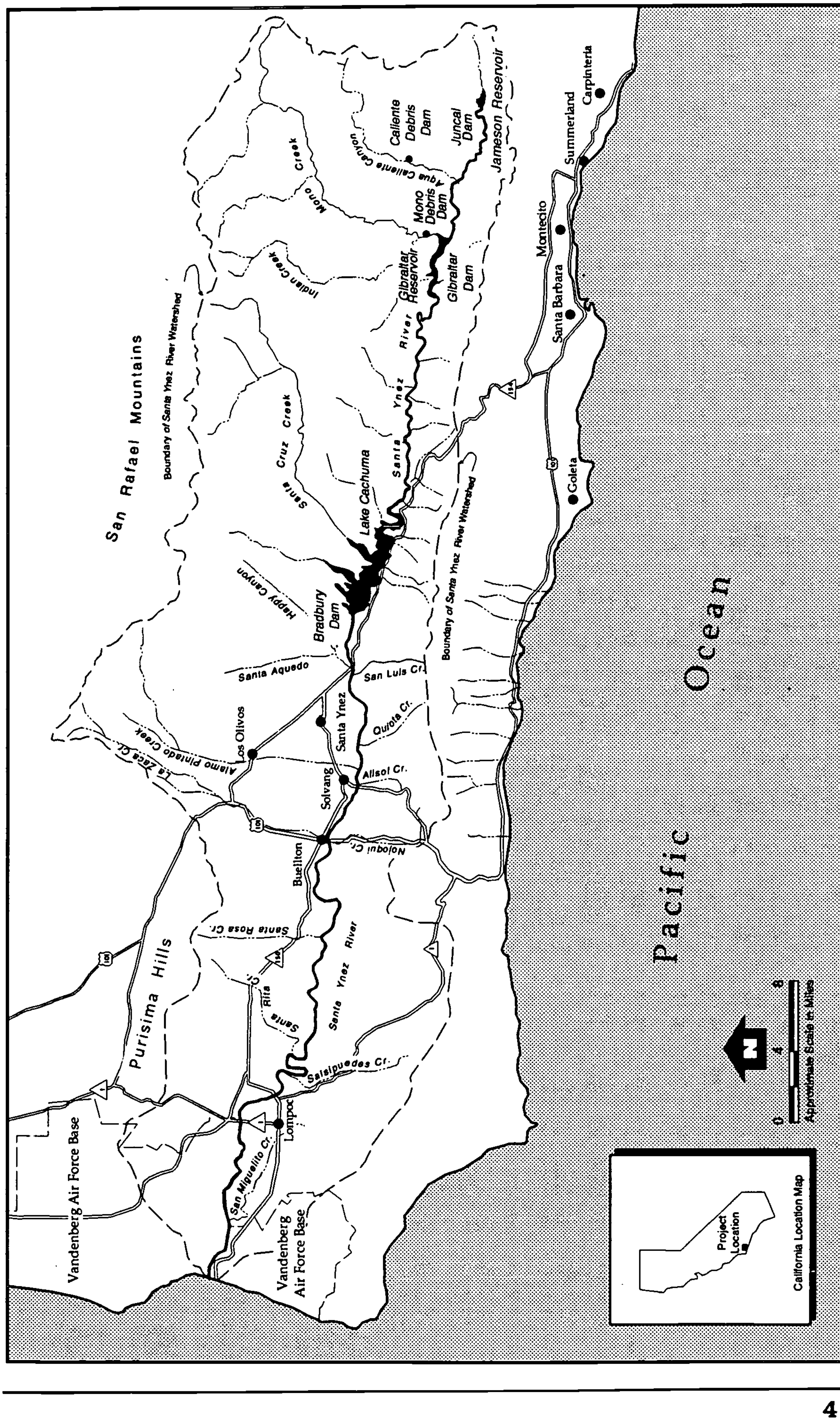

Figure 6.1 Santa Ynez River Watershed

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Weather modification, in the form of cloud seeding to augment natural precipitation within winter storms, has been applied intermittently in Santa Barbara County during the majority of the winter seasons since 1950. Statistical studies showed that the natural precipitation above Jameson Lake or Reservoir (behind Juncal Dam) and Gibraltar Reservoir could be increased through cloud seeding efforts by an average of about 21 percent during the October through April period. Winter storms are presently being seeded in various parts of Santa Barbara County depending on hydrologic, watershed, and reservoir storage conditions.

Surface Diversions

Surface water diversions from the Santa Ynez River watershed are made primarily from Juncal, Gibraltar, and Bradbury dams. These facilities divert water for agricultural, municipal, and industrial uses in the Santa Ynez Valley and on the South Coast of Santa Barbara County.

Juncal Dam (Jameson Lake), completed in 1930, is owned and operated by the Montecito Water District. Diversions of Jameson Lake regulated flows, averaging 1,750 acre-feet per year, are made to Montecito on the South Coast through the 2.14-mile (3.44-km) long Doulton Tunnel. Flows from Alder Creek can be diverted by flume into Jameson Lake. The Doulton Tunnel intake location also allows for diversions from Fox Creek and for minor diversions of downstream tributary inflow. Tunnel infiltration is also delivered to Montecito at a rate of about 400 to 500 acre-feet per year.

Gibraltar Dam was constructed by the City of Santa Barbara in 1920. Gibraltar Reservoir's constructed capacity of 14,500 acre-feet had been reduced because of siltation to about 7,600 acre-feet by 1947. The dam was subsequently raised 23 feet (7 m) in 1948 to increase the capacity to 14,777 acre-feet. However, due to continuing siltation, Gibraltar Reservoir capacity has been reduced once again to about 8,600 acre-feet. Diversions from Gibraltar are made to the City of Santa Barbara through the 3.7-mile (5.95-km) long Mission Tunnel. Annual diversions have ranged from more than 9,000 acre-feet in very wet years to nearly zero in extreme drought years. Infiltration from Mission Tunnel is also delivered to the City.

Bradbury Dam (Lake Cachuma) was constructed by the U.S. Bureau of Reclamation in 1950-1953 as part of the Cachuma Project. Diversions from Lake Cachuma are made to five-member units, one in the Santa Ynez Valley and four on the South Coast, including the Santa Ynez River Water Conservation District; Improvement District #1, Goleta; the cities of Santa Barbara, Montecito, and Carpinteria. Water is delivered to the Santa Ynez Valley area through a buried pipeline, and to the South Coast, through the 6.4-mile (10.3 km) long Tecolote Tunnel. Tecolote Tunnel infiltration can also be delivered to the South Coast member units at an average rate of about 2,000 acre-feet per year.

The minimum operating pool for Lake Cachuma is about 12,000 acre-feet. Diversions when the lake has 30,000 acre-feet or less in storage require pumps to deliver water to the South Coast member units, as was experienced for several months during the 1988-91 drought. In recent years, annual diversions from Lake Cachuma have been as high as 31,021 acre-feet. These diversions exceeded the recently reevaluated Lake Cachuma operational target yield of about 25,908 acre-feet per year. As a result of these relatively high diversions in the early years of the drought, only 17,000 acre-feet could be delivered in 1990, about a 40 percent reduction from normal.

Historical Flood Flows

Several major flood events occurred along the Santa Ynez River over the past 100 years—in 1907, 1914, 1938, 1969, and 1978. Reported peak discharges for these storms ranged from 45,000 to 120,000 cubic feet per second (cfs), and the floods caused much damage to the Lompoc Valley. The most devastating flood occurred in January and February 1969. Although the 1969 flood was reportedly lower in magnitude than the 1907 flood, it caused more damage because the county was relatively undeveloped in 1907.

The river channel capacities vary greatly along the river below the dam. With the exception of the 1969 floods, river channel capacities have been adequate to pass historic flood flows without damage to urban areas such as Solvang, Buellton, and Lompoc. However, past flood events have caused flooding and erosion to undeveloped and agricultural lands, and have damaged or destroyed numerous bridges at various locations along the river.

Riparian growth in the Santa Ynez River channel west of Lompoc has been enhanced by the effluent from the Lompoc Regional Wastewater Treatment Plant, and flooding of agricultural lands to the west is of particular concern. The dense vegetation in the river channel creates a flood hazard by reducing the conveyance capacity. In addition, it reduces water velocities, which in turn, increase sediment deposits that further decrease the capacity. Finally, trees in the riverbed can become uprooted during flood events and block the channel under bridges thereby causing additional flooding upstream and serious damage to the bridges. Some vegetation cutting has been done, and a long term channel maintenance project is currently being developed by the County of Santa Barbara Flood Control District to improve channel capacity, however, to date the required permits have not been acquired. The river channel capacity is currently below 20,000 cfs. In 1993 and 1995, several events of approximately 15,000 to 17,000 cfs barely passed through the constricted reach, and flooding occurred in 1993 on the adjacent low-lying agricultural fields.

Cachuma Project Facilities: Bradbury Dam and Lake Cachuma

Bradbury Dam is located on the Santa Ynez River approximately 25 miles (40.23 km) northwest of Santa Barbara. It is an earth-filled structure with a structural height of 190 feet (58 m). The spillway crest is at elevation 720 feet (219 m) and the top of the spillway gates is at elevation 750 feet (229 m). An outlet at the base of the dam has a maximum capacity of 300 cfs; however, it is rarely used above 100 cfs. The reservoir, Lake Cachuma, has a surface area of 3,043 acres (1,232 ha). The original reservoir capacity was 205,000 acre-feet, but the capacity has been reduced by siltation to 190,406 acre-feet. The Bureau of Reclamation established the *dead pool* at elevation 600 feet (183 m) and has a capacity of 12,000 acre-feet.

Conveyance Facilities

Water from Lake Cachuma is conveyed to the South Coast member units through the Tecolote Tunnel intake tower at the east end of the reservoir. The seven-foot diameter Tecolote Tunnel extends 6.4 miles (10.3 km) through the Santa Ynez Mountains from Lake Cachuma to the headwaters of the South Coast Conduit. The South Coast Conduit is a high pressure concrete pipeline that extends from the Tecolote Tunnel outlet to the Carpinteria area, a distance of more than 24 miles (39 km), and includes four regulating reservoirs. The Sheffield Tunnel is located along the conduit. This mile-long (1.6 km) concrete tunnel was bored through a high ridge within the city limits of Santa Barbara. The South Coast Conduit extends through the tunnel. Water is delivered to the Santa Ynez Valley through Bradbury Dam's outlet works into the Solvang-Santa Ynez Conduit.

Groundwater Resources: South Coast Basins

Four major South Coast groundwater basins are used by the member units. These basins lie between the Santa Ynez Mountains to the north and the Pacific Ocean to the south. They are the Carpinteria Basin, the Montecito Basin, the Santa Barbara Basin, and the Goleta Basin.

The South Coast groundwater basins are bordered by the mountains and relatively non-water yielding rocks on several sides and the ocean on the south side. The basins consist of layers of coarse-grained, water transmissive sedimentary units, interbedded with fine-grained less transmissive units. Wells are typically drilled to great depths (hundreds to a thousand feet below groundwater surface) and are completed to produce from multiple vertical intervals so as to draw water from as many water transmissive units as possible. Historically, and during extended wet periods, groundwater levels in some wells rise above land surface because some of the transmissive units are confined aquifers. Groundwater in overlying transmissive units is recharged at higher elevations in the basins (commonly from short coastal streams exiting canyons), which in effect fills confined portions of the aquifers, causing the aquifers to be pressurized in lower elevations of the basins. When the pressure becomes large enough, flowing wells will result.

The South Coast basins are recharged by seepage from streams, percolation of precipitation, subsurface inflow from materials underlying the Santa Ynez Mountains, and return flow of imported water such as surface water from Lake Cachuma. Much of the recharge occurs along the northern boundaries of the basins, where the water transmissive units that extend deep into the basins are exposed at or near the surface. Therefore, most recharge occurs in periods of extended rainfall and less recharge occurs in dry periods or when rainfall and runoff occur over short periods. Discharge from the basins is to the ocean, to pumping, and to a limited extent, to streams at lower elevations in the basins. In general, the pattern of groundwater flow follows the surface topography of the basin, from areas of high elevation towards the ocean. Pumping has become the most significant discharge component since the turn of the century.

The Carpinteria Groundwater Basin is an elongate northwest-southeast trending basin that occupies approximately 7,620 acres (3,085 ha) and is separated into two storage units by the Rincon Creek Thrust Fault. Pumping of the basin occurs both by the Carpinteria Valley Water District and by a large number of agricultural users operating private wells.

The Montecito Groundwater Basin is a smaller basin of 4,300 acres (1,741 ha) located between the Santa Ynez mountains to the north, the offshore Rincon Thrust Fault to the south, the Carpinteria Basin to the east, and the Santa Barbara Basin to the west. Although the Montecito and Santa Barbara Basins are hydrologically connected, the boundary between them follows a politically-designated line.

A topographic divide west of Arroyo Burro Creek is generally accepted as the boundary between the Goleta and Santa Barbara Basins. The southern boundary is an offshore fault, which reportedly seals off the lower aquifers from the ocean. The Mesa and Mission Ridge Faults divide the Santa Barbara Basin into three storage units which together currently have a usable storage of approximately 10,000 acre-feet. The basin, pumped by the City for municipal and industrial use, occupies an area of about 7,400 acres (2,996 ha) in and around the City of Santa Barbara.

The Goleta Groundwater Basin is a narrow east-west trending basin, between the Santa Ynez Mountains to the north and the More Ranch Fault to the south. The basin is more than eight miles (12.9 km) long and up to four miles (6.5 km) wide, occupying approximately 9,200 acres (3,725 ha). The Modoc and Goleta Faults run through the interior of the basin, however, the Goleta Fault is not thought to be an effective groundwater barrier, so the central and north subbasins are now considered to be one unit. Groundwater levels fluctuate in response to changes in pumping, injection, and precipitation, and declined by more than 50 feet ((15.2 m) between 1971 through 1989. Groundwater levels appear to be recovering because of injection and significant reductions in pumping since 1989 by the Goleta Water District.

Groundwater Resources: Downstream Basins
Five groundwater basins lie along the Santa Ynez River downstream of Bradbury Dam: the Santa Ynez River Riparian Basin, the Santa Ynez Uplands Basin, the Buellton Uplands Basin, the Santa Rita Uplands Basin, and the Lompoc Basin.

Groundwater Resources: Santa Ynez River Riparian Basin
The Santa Ynez River Riparian Basin comprises shallow alluvial material adjacent to, and hydrologically connected with, the Santa Ynez River. The basin is approximately 36 miles (58 km) long, and has been subdivided into the Santa Ynez subarea; the Buellton subarea; and the Santa Rita subarea. The total storage capacity of the alluvial deposits is about 105,000 acre-feet.

Groundwater storage and groundwater levels fluctuate in response to streamflow, releases from Bradbury Dam, groundwater pumping, and to a lesser extent, other recharge and discharge conditions. Groundwater storage and water table elevations generally increase during winter and spring, and other wet periods, when flow in the Santa Ynez River loses water to the underlying alluvial aquifer. Under average water supply conditions, net demand from the riparian basin does not exceed recharge, however, monitoring wells showed that storage did decline during the recent drought indicating that demand is greater than recharge under dry conditions. The riparian basin usually becomes full shortly after the onset of wet conditions and then it no longer accepts additional water. Surface water will pass through the basin with very little percolation under high streamflow conditions or when the basin is full.

Groundwater storage and groundwater levels decrease in the riparian basin during summer, fall, and dry periods through pumping, groundwater discharge back into the river as base flow, and by underflow through the alluvium downstream toward the Lompoc Basin. The longer the dry period, the greater the decline in groundwater storage and elevation. The upper reaches of the riparian basin will drain first, analogous to a long pipe at one end. Therefore, if a dry period is long enough, the upper reaches of the riparian basin may drain completely even though the lower reaches may remain full.

Groundwater Resources: Santa Ynez Uplands and Buellton Basins

The Santa Ynez Uplands and Buellton Basins are large groundwater basins that do not receive recharge from the Santa Ynez River. In these basins, typical hydrologic processes, such as recharge by precipitation and streams, and discharge by pumping and subsurface outflow, largely control groundwater storage and groundwater levels.

The Santa Ynez Uplands groundwater basin is the largest in the county occupying about 88,000 acres (35,628 ha). The main water-bearing units are the continental, Plio-Pleistocene Paso Robles Formation and the marine, Pliocene Careaga Sand. The total groundwater usable storage today is estimated to be 900,000 acre-feet. The perennial yield of the basin is currently about 11,500 acre-feet per year, which is somewhat greater than the annual recharge.

The Buellton Uplands groundwater basin occupies about 16,400 acres (6,640 ha) north of the Santa Ynez River near the City of Buellton. The basin is bounded by bedrock outcrops to the north and south, a narrow connection to the Santa Ynez Uplands Basin to the east, and a groundwater divide on the west with the Lompoc Basin.

Groundwater Resources: Lompoc Basin

The Lompoc Groundwater Basin occupies an area of approximately 48,600 acres (19,676). This basin comprises three subareas including the Lompoc Plain, the Lompoc Terrace, and the Lompoc Basin. These subareas are hydrologically connected so they are often treated together along with the Santa Rita Uplands Basin, for the purposes of determining storage and perennial yield. The Lompoc Plain is the only subarea of the Lompoc Basin that receives recharge directly from the Santa Ynez River.

It is estimated that the total available groundwater storage in the Lompoc Basin is 170,000 acre-feet, 135,000 acre-feet of which is stored in the Lompoc Plain. Recharge to the Lompoc Plain comes from percolation of precipitation, seepage from the Santa Ynez River, agricultural return flows, sewage effluent, and underflow from deeper aquifers of the Lompoc Terrace and Basin, which extend beneath the plain. In addition, recharge that would have occurred but does not because of the operation of Bradbury Dam is calculated and credited to a Lompoc water account known as the Below Narrows Account. The account water is stored in Lake Cachuma and is released in such a way that it recharges the Lompoc Plain.

As this chapter has illustrated, water in Santa Barbara County has always been, and will continue to be, a precious resource. As urban populations expand around dense nodes of settlement at, for example, Santa Barbara, Montecito, Carpinteria, Goleta, and Lompoc, the availability of a clean water supply will become an increasingly important consideration in the new century.

7

Agricultural Patterns in Ventura County's Heartland

Chris Mainzer

Driving through Ventura County's heartland along U.S. 101, the major coastal route between Los Angeles and San Francisco, the traveler is suddenly struck by the abundance and variety of irrigated fields of tree crops, fruits, vegetables, and flowers that cover the Oxnard Plain and nearby river valleys (Figure 7.1). The bountiful agricultural harvests from this broad stretch of coastal plain, a mere 60 miles (97 km) from the Los Angeles Civic Center, are possible under southern California's sunny skies and the moderating influences of the Pacific Ocean. Ventura County's top ten cash crops of lemons, celery, strawberries, nursery stock, avocados, oranges, lettuce, cut flowers, broccoli, and cabbage all flourish under ideal climatic conditions (Tables 7.1 and 7.2).

The Southland's climate is often described as Mediterranean, or of dry subtropical character. The average precipitation for the Oxnard region is only 15 inches (38 mm) annually. The wet season, influenced by the Westerlies pattern, usually extends from November through March producing very mild winters, in sharp contrast to long periods of summer drought dominated by a subtropical high pressure system. The coastal site of this rich agricultural belt in Ventura County further enhances a low yearly temperature range of 12°F (8°C) with a 62°F (17°C) average annual temperature. The ocean provides a cool, marine layer and a summer sea breeze cycle that maintains a high relative humidity, and, that in winter, reduces the risk of frost damage to the high value crops grown in the area.

An example of how crucial is the marine influence can be seen in a visit to the Seaside Banana Garden at La Conchita, ten miles (16 km) northwest along the coast (near Rincon Point) from the city ofVentura. This 12-acre (4.9 ha) plantation raises more than 50 varieties of bananas, normally associated with tropical climates such as those found in Hawaii, Latin America, Asia, or Africa, and is a one-of-a-kind farm operation in the continental United States. Buffered by the Pacific Ocean on one side and sheltered from inland temperature extremes on the other side by a 300-foot (92 m) high sea cliff, it has become a unique cultural feature on the Ventura shoreline.

Arable Lands

Arable lands occupy only one-third of the county's total land area, the rest of the region is somewhat mountainous and primarily of high relief. The calcium-rich, sandy-to-silt loam soils of the coastal alluvial lowland and adjacent stream valleys are remarkably fertile and afford excellent drainage for irrigated crop production. The natural stream- laid deposits of clay, silt and sand, especially from the Santa Clara River, have contributed to the deep and rich mineral quality of the Class I soils of the Oxnard Plain.

Water

Because the region receives sparse rainfall in summer, water is a precious commodity. In order to make commercial agriculture succeed, imported water from the State Water Project must be allocated for farming this semi-arid alluvial plain. This much-needed water begins its long journey in northern California's huge Oroville Reservoir that is part of the state's Feather River project, and travels almost 450 miles (724 km) to its final destination in eastern Ventura County's Lake Piru facility. Local well water has also been mined since the 1890s from some of the deep-seated aquifers below the Oxnard Plain and supplements the fresh water supply for Ventura County. This last action has triggered the gradual process

Table 7.1 Ventura County: Ten Leading Crops 1993

RANK	CROP	VALUE
1st	LEMONS	$216,129,000
2nd	CELERY	113,823,000
3rd	STRAWBERRIES	110,447,000
4th	NURSERY STOCK ***	81,588,000
5th	AVOCADOS	49,906,000
6th	VALENCIA ORANGES	45,034,000
7th	LETTUCE	28,704,000
8th	CUT FLOWERS	23,060,000
9th	BROCCOLI	12,828,000
10th	CABBAGE	8,975,000

*** Does not include Cut Christmas Trees

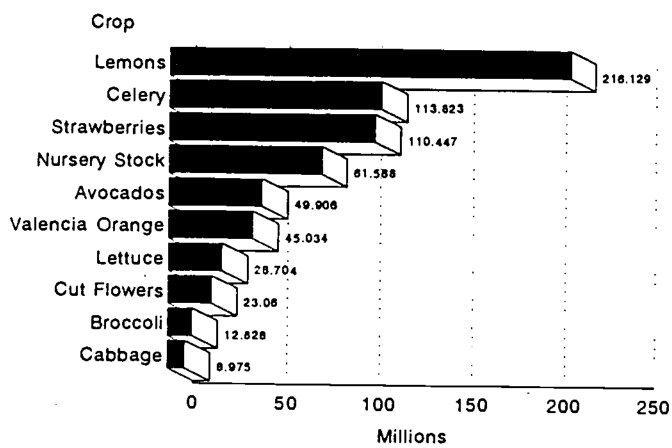

Table 7.2 Ventura County: Other Million Dollar Crops 1993

Onions (all)	$13,380,000	Livestock	$4,659,000
*Veg. Transplants	7,797,000	Cauliflower	4,629,000
*Chrysanthemums	7,592,000	Beans (all)	3,108,000
Peppers	7,442,000	Kale	3,074,000
Cilantro	6,642,000	Grapefruit	2,847,000
Spinach	6,405,000	Sweet Corn	2,520,000
Oriental Vegetables	6,357,000	Carrots	2,334,000
Parsley	5,615,000	*Poinsettias	2,294,000
Tomatoes	5,068,000	Cucumbers	1,749,000
**Gypsophila	4,991,000	Navel Oranges	1,634,000

*included in Nursery Stock total above

**Included in Cut Flowers total above

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of seawater intrusion, the continuous contamination of a shallow groundwater aquifer with saltwater from the ocean. This results from overdrafting fresh water in a dry environment where natural replenishment is at a minimum. Several local measures implemented to control the high water consumption in the agricultural sector include the Freeman Diversion Improvement Project along the Santa Clara River. The project can divert floodwaters into spreading basins so water can percolate into the ground and recharge the nearby permeable aquifers. Introduction of a drip irrigation system in the citrus and avocado orchards will provide water more efficiently than other systems of irrigation.

Agricultural Connections

Like California's primary industry, agriculture, Ventura County's farming is highly commercialized, highly specialized, highly diversified, and highly mechanized. The latest innovations in farming allow the Oxnard Plain region to compete in both domestic and foreign markets. Tractors are equipped with a high-tech laser leveling feature that survey and grade the fields for irrigation. Biotech labs in Santa Paula use a micropropagation procedure for plants to control disease and improve the yields of crop production. With the completion of the largest refrigerated warehouse complex on any dock in the Western Hemisphere, the county's Port Hueneme facility currently ships about 200,000 tons of citrus annually to Pacific Rim consumers. Local growers can now efficiently export lemons and avocados to Japanese markets.

As we approach the next millennium, the success of Ventura County's agricultural output is continuously being threatened by a dwindling labor force (strawberries still have to be harvested by hand), escalating irrigation costs, foreign competition, urban encroachment and rising utility costs. To safeguard prime farming land from uncontrolled city growth (according the U.S. Census Bureau, Ventura County's population reached more than 710,000 in 1995—almost double that of 1970), an Agricultural Lands Preservation Program was implemented that zones land for agricultural use to keep it in farms. For example, a 4,500-acre (1,882 ha) coastal greenbelt was established between the two largest cities in the county, Ventura and Oxnard. Ventura County should continue to maintain its ranking as the primary lemon producing county in the nation with a steady vigilance and continual preservation of our society's precious resource, agriculture.

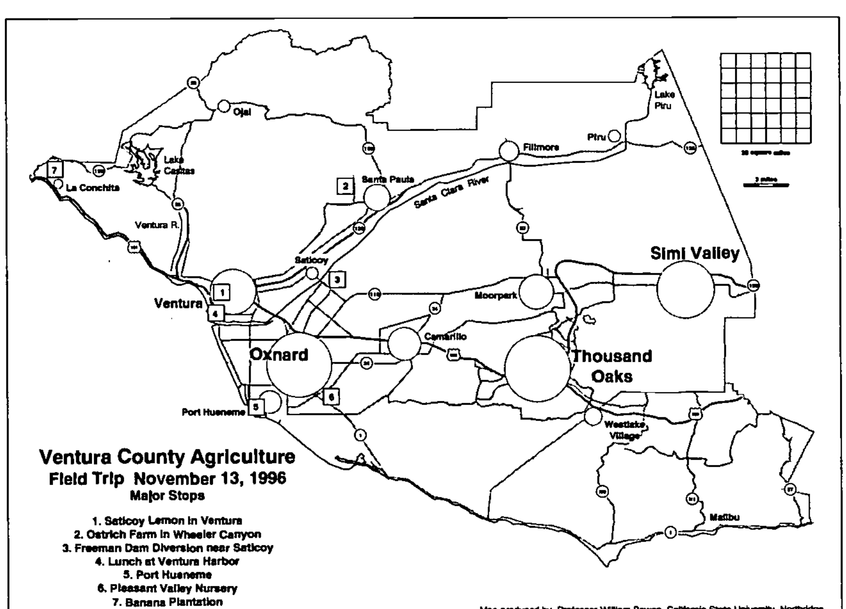

Figure 7.1 Ventura County Agriculture

Wines of Santa Barbara County: A Geographic Perspective

Vatche P. Tchakerian and Robert S. Bednarz

The viticultural area in Santa Barbara County (known as the South Central Coast), is a triangular region roughly enclosed by the cities of Santa Maria and Lompoc on the west, to Santa Ynez and San Marcos Pass on the east. In this relatively small geographic region, more than 9,700 acres (3,927 ha) of vineyards yield an average of four tons/acre (9.88/ha). The unique geomorphologic setting, climate, soils and the ability of the winemakers to take advantage of these characteristics, have made the region one of the premier producers of excellent wines and has allowed it to take its rightful place alongside its more famous neighbors to the north.

Historic Background

Historically, the region has been known primarily for cattle grazing and farming. The earliest winemaking attempts began with the Spanish missions in the late eighteenth century. Not until the mid-1960s, however, were modern vineyards planted. The landmark establishments of Firestone Vineyard, Zaca Mesa Winery and Rancho Sisquoc Winery date back only to the early 1970s. These and other early wineries took advantage of the low cost of land, excellent climate, and a unique geomorphic environment (Figure 4.1). One of the reasons earlier attempts in viticulture met with limited success, is that wine growers perhaps placed too much emphasis on such Bordeaux varieties as Cabernet Sauvignon rather than varieties better suited to the climatic and soil conditions of the area.

Physical Geography

The physical geography of today's South Central Coast is primarily the result of the geologic movements (still continuing) associated with the formation of the San Andreas Fault and the resulting Transverse Ranges. The latter, one of two major east-west trending mountain ranges in the United States, begins as the San Bernardino Mountains (to the southeast) and continues westward and ends as the Santa Ynez Mountains.

The Santa Barbara viticulture region is bounded on the north by the Sierra Madre and San Rafael Mountains, on the south and east by the Santa Ynez Mountains, and on the west by the Pacific Ocean. Between these ranges, east-west-trending valleys open to the Pacific Ocean (Figure 4.1). During the late spring and most of the summer, coastal fog, developed because of the presence of the cool, California Current off the coast, surges inland, along with light winds and higher humidities, thus keeping temperatures moderate (see Chapter 4).

The cool, coastal winds and fog have their greatest influence on those vineyards closest to the coast. The continentality effect is most pronounced on vineyards farthest from the coast, since the fog dissipates with distances inland, both spatially and in intensity. Therefore the vineyards located closest to the foothills of the main ranges in the easternmost section of the county tend to have higher daytime temperatures, higher potential evapotranspiration rates, and higher soil temperatures (requiring more moisture intake than those at lower elevations). Because of these climatic variations, the vineyards closest to the coast are similar to the Burgundy region of east-central France (hence the first-rate Pinot Noirs from Sanford). On the other hand, the vineyards in the warmer interiors are climatically similar to Bordeaux (southwestern France) and the southern Rhône (southeastern France).

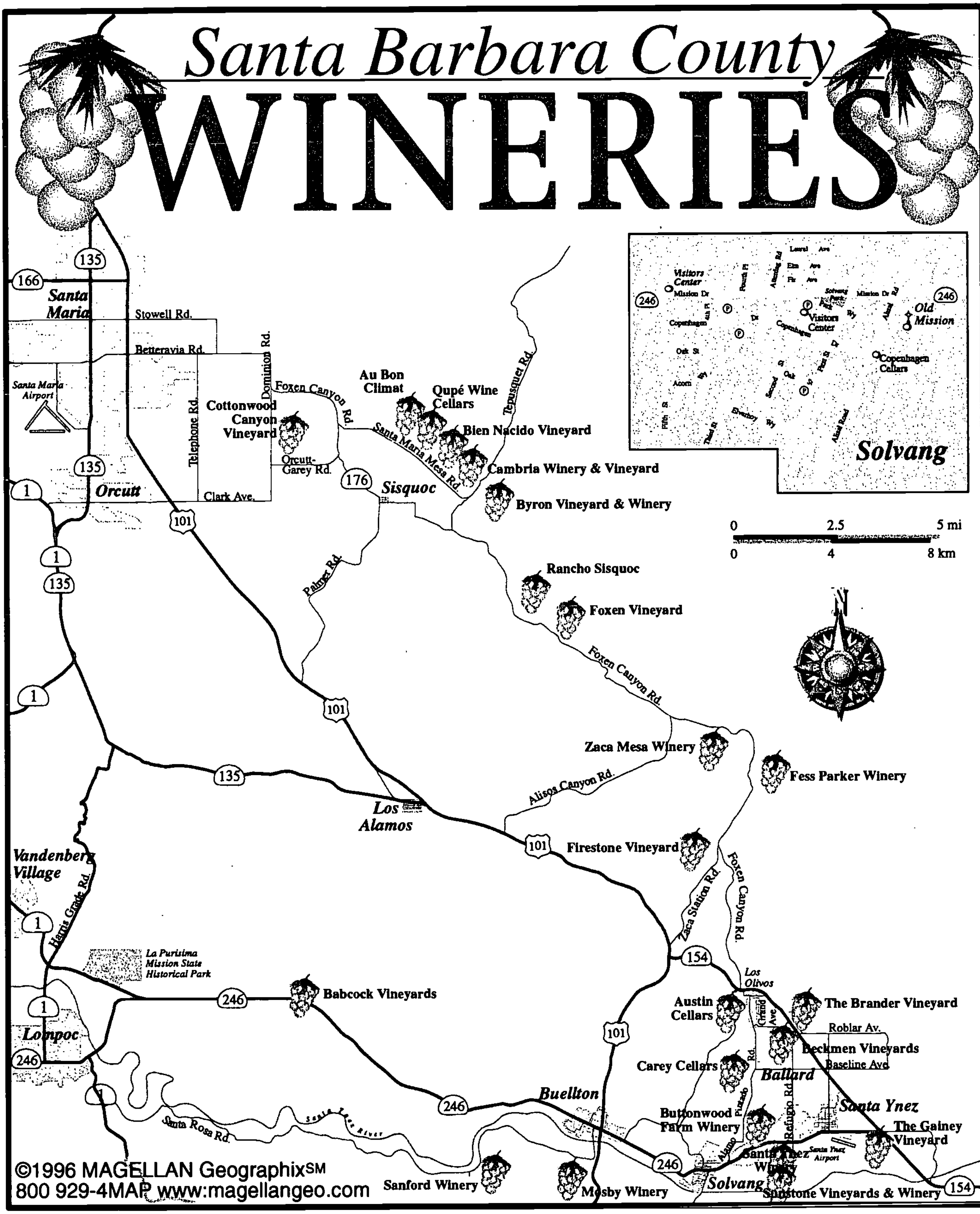
Santa Barbara County
WINERIES
Santa Maria
Stowell Rd.
Betteravia Rd.
Santa Maria Airport
Dominion Rd.
Foxen Canyon Rd.
Telephone Rd.
Cottonwood Canyon Vineyard
Orcutt-Garey Rd.
Clark Ave.
Orcutt
Au Bon Climat
Qupé Wine Cellars
Bien Nacido Vineyard
Tepusquet Rd.
Santa Maria Mesa Rd.
Cambria Winery & Vineyard
Byron Vineyard & Winery
Sisquoc
Palmer Rd.
Rancho Sisquoc
Foxen Vineyard
Foxen Canyon Rd.
Solvang
Old Mission
Visitors Center
Copenhagen Cellars
0 2.5 5 mi
0 4 8 km
Zaca Mesa Winery
Fess Parker Winery
Alisos Canyon Rd.
Los Alamos
Firestone Vineyard
Vandenberg Village
Harris Grade Rd.
Zaca Station Rd.
Foxen Canyon Rd.
La Purisima Mission State Historical Park
Babcock Vineyards
Los Olivos
Austin Cellars
The Brander Vineyard
Roblar Av.
Beckmen Vineyards
Baseline Ave
Carey Cellars
Ballard
Lompoc
Buellton
Santa Rosa Rd.
Santa Ynez River
Buttonwood Farm Winery
Santa Ynez
The Gainey Vineyard
Santa Ynez Winery
Santa Ynez Airport
Solvang
Sunstone Vineyards & Winery
Sanford Winery
Mosby Winery
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Figure 8.1

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Microclimate is one of the most important geographic factors controlling the production of wines. The vineyard owners and winemakers of Santa Barbara County analyzed the microclimates of the region in great detail, leading to the proper selection of vineyard sites and grape varieties. The proper understanding of factors such as the spatial and temporal variability of the coastal fog during the critical months of May through August, vineyard aspect (north-south facing slopes), microtopography, wind speed (persistence, direction, turbulence, mixing) and evapotranspiration, and a detailed knowledge of soils and geomorphology played a key role in the success of this viticulture region.

The vineyards follow closely the microtopography of the South Central Coast (Figure 1.2). Typical vineyard elevations are between 200 and 1,500 feet (61 and 457 m). Because of the presence of various soil subtypes in this geomorphologically varied region, wine makers have been able to match the different soil types to those grape varieties that do best under given soil conditions. River valleys, terraces, floodplains and interfluves, along with their soils, have all been studied and analyzed in great detail and vines planted accordingly.

Wines and Wineries

The area is home to more than 30 wineries, more than 75 percent of them established after 1982 (Figure 8.1). Approximately 400,000 cases of wine are produced annually. About 35 percent of the grapes grown in this geographical region are crushed by local wineries. Although all major grape varieties are produced successfully, the reputation of the region rests firmly on the excellent qualities of Pinot Noir, Chardonnay, and more recently, Syrah and other southern Rhône-type varieties. The two distinct and approved viticulture regions in Santa Barbara County include the Santa Maria Valley in the northern part and the Santa Ynez Valley in the southern part. Among the excellent wineries are such established names as Firestone, Rancho Sisquoc, Sanford, Santa Ynez, and Zaca Mesa. A second wave of vintners such as Au Bon Climat, Byron, Fess Parker, Foxen, and Qupe, along with many others, have continued to push the region's wines to an outstanding level, particularly with their innovative techniques for matching the right grape varieties to the physical geography of the region as well as in pooling resources and wine-making infrastructures (such as sharing the Central Coast Wine Warehouse in Santa Maria). One of the most famous and largest vineyards is the 600-acre (243-ha) Bien Nacido Vineyard in the Santa Maria Valley, which sells its fruit to numerous wineries in the region and outside. Some of the most sought after chardonnays from Au Bon Climat and syrahs from Qupe come from this vineyard.

Keeping in mind the vicissitudes and vagaries of the climate (as witnessed by heavy rains and unusually cold weather in the spring of 1995), the high quality of wines, the dedication of grape growers and winemakers, and the planting of new acreage in vines, this renaissance in Santa Barbara County wines will most likely continue and increase in the near future.

9

The View from Paradise: Problems and Prospects of the California Central Coast

William C. Halperin
Lisa Knox Burns

Ventura, Santa Barbara, and San Luis Obispo counties make up the Tri-County area of the California Central Coast. In the southeast portion of Ventura County, the Conejo Grade (on Highway 101 where it intersects with Route 23) acts as a physical barrier to the tentacles of *Los Angelization*. Similarly, Santa Barbara County on its southeastern border is fortunate to have a 30-mile (48 km) greenbelt between it and the City of San Buenaventura (the official name for Ventura). In this narrow stretch of Highway 101, fragile palisades with steep slopes make urban development prohibitive. Here one only finds the small, scattered residential enclaves of Solimar-Faria Beach, Sea Cliff, La Conchita, and Mussel Shoals. The Santa Barbara County line begins at Rincon Point, a famous surf break .

Summary of Geographical Phenomena

Santa Barbara County comprises nearly 2,750 square miles (7,123 sq km) of land and inland water area (about 1.45 times the size of the state of Delaware). Approximately rectangular in shape, Santa Barbara County is bordered on the north by San Luis Obispo County, on the east by Ventura County, and on the south and west by 107 miles (172 km) of Pacific coastline. Facing south rather than west, the south coast of Santa Barbara is geographically unique among California coastal areas. The Santa Ynez Mountains, part of the Transverse Ranges behind Santa Barbara, extend predominately in an east-west direction, the only range system on the West Coast where this occurs. Along the south coast a relatively narrow strip of coastal valleys and foothills, no greater than six miles in width, stretches from Carpinteria on the east to Gaviota at the west end (see Figures 1.2 and 4.1). The California Channel Islands of Santa Rosa, San Miguel, Santa Cruz, Anacapa, San Clemente, and Catalina buffer the coastline. Both on land and in the sea, Santa Barbara County is blessed with abundant habitats as it is the northernmost extent of flora and fauna common to southern California, and the southernmost extent of flora and fauna common to northern California. The largest variety of birds in the nation can be found in Santa Barbara during the winter months, according to annual estimates made by the Audubon Society.

Economics of the Area

Within Santa Barbara County are numerous fertile agricultural areas, including the Santa Maria, Cuyama, Lompoc, and Santa Ynez Valleys, and the southeast coastal plain. These areas, which include most of the developed land, also accommodate the majority of the population. Los Padres National Forest, in the eastern part of the county, covers approximately 44 percent of the total county area (see Figure 1.2). As one drives north leaving the City of Santa Barbara, the cities and towns become widely spaced nodes of urban development, surrounded by open space and agricultural land. Locals have reported that pundits have described Santa Barbara County as a little like Disneyland. Frontierland can be found in the historic towns of Santa Ynez, Ballard, and Los Olivos. Solvang looks like a Danish town. Vandenberg Air Force Base (VAFB), where Titan rockets are launched from SLC-6 ("Slick-six"), is Tomorrowland. The City of Santa Barbara is a Fantasyland dressed in red-tile roofs and bougainvillea vines. The rest of the joke states that public restrooms can be found in Santa Maria.

During the past three decades, the economy of Santa Barbara County has changed from a predominantly agricultural-based economy to a diversified agricultural-industrial complex. It started with the establishment of VAFB in 1957, and a subsequent acceleration of defense-related and space research firms moving to the Santa Barbara-Goleta area. However, in the first half of the 1990s, Santa Barbara experienced a loss in high-technology employment, from a high of 15,260 jobs in 1986, down to 9,373 in 1992, a 39 percent loss of employment in this sector. Although tourism, retail trade, and service industries have remained strong, these industries pay less than one-half of the average rate of high technology employees. In general, the economy is an interesting mix of agriculture (strawberries, wine grape production, flower seeds, broccoli, lettuce, cattle in the north county, and greenhouses, tree crops, and organic farms in the south county), service industries (food, hotels, private schools), finance (banking, real estate, insurance), medical services, and high tech (R&D, software, medical manufacturing). Oil production, still prominent in off-shore oil and gas platforms is waning because of the cost of recovering the resource relative to other worldwide opportunities.

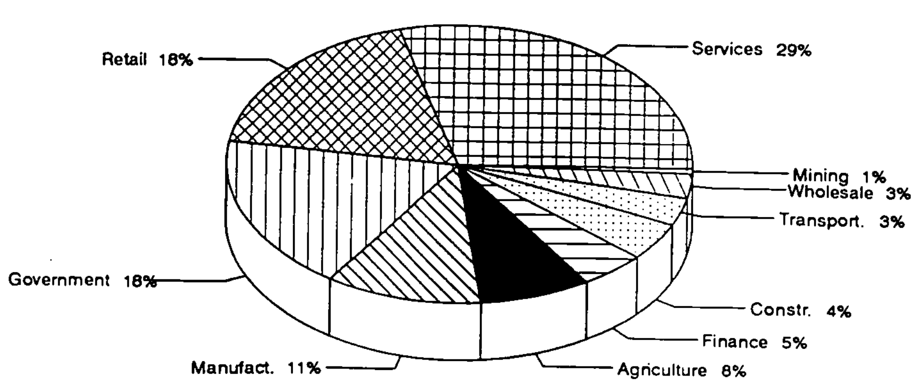
Regional Growth Forecast

The *Regional Growth Forecast '94*, prepared by the Santa Barbara County Association of Governments, is a forecast of employment opportunities by sector. This forecast indicates that by the year 2015, services, retail, and government will make up two-thirds of the wage and salary employment in Santa Barbara County, followed by manufacturing, agriculture, finance, construction, transportation, wholesale, and mining (Figure 9.1). As the information age develops, work sites will depend less on the critical locational factors than on the traditional local labor requirements for primary and secondary economic activities. The central coast of California may be the nearest retreat from the asphalt jungles of the San Diego-Orange County-Los Angeles megalopolitan area.

Figure 9.1

Santa Barbara County

Employment by Sector, 2015



Wage and Salary Employment

203,846 Total

70

San Luis Obispo and Santa Barbara counties have restrained rampant urban growth primarily because the urban service infrastructure, particularly for water, was limited. San Luis Obispo and Santa Barbara counties rely almost exclusively on recapturing rain water to supply urban needs. Vast groundwater basins under Paso Robles in San Luis Obispo County and Santa Maria in Santa Barbara County have been mined in recent years to supply water. Coastal cities such as Goleta, Santa Barbara, and Montecito in Santa Barbara County, and Cambria, Cayucos, Morro Bay, and Los Osos in San Luis Obispo County have faced periods of severe restrictions for municipal water use. Some communities have had long-standing moratoria on new water hook-ups. The scarce water situation for some communities, however, mainly in Santa Barbara County, is about to change with the addition of the State Water Project (SWP) supplies in 1997. The SWP is nearly complete from Polonio Pass on Highway 46 in northeastern San Luis Obispo County to Lake Cachuma along Highway 154 in Santa Ynez Valley where the Central Coast Water Authority pipeline terminates. According to estimates, 1,500 residential units in Goleta alone are pending development, as they await the arrival of state water.

Preserving the Quality of Life

The debate in the coming years will center on whether persons in elected and appointed offices who control comprehensive plans and zoning permits, can retain the small town charm of Santa Barbara and San Luis Obispo counties, and resist the homogeneity that regional shopping centers, fast-food restaurants, and residential planned developments bring. For Santa Barbara and San Luis Obispo, growth has been kept in check and in line with environmental resources. As the lack of potable water recedes as a rationale for controlling growth, other issues such as traffic, air quality, and agricultural land preservation become the focus of citizens concerned with preserving our quality of life. Quality of life is a priceless commodity that most people who live in Santa Barbara and San Luis Obispo value highly enough to forgive the little negatives of living in paradise: high housing prices, lack of megastore outlet centers, fewer chain stores, more one-way streets, and higher gasoline prices.

Lesson Plan A

Weather or Not: Making and Using a Climograph

Terry Williams and Jerry R. Williams

California is generally described as having a Mediterranean climate; in reality, the state has a variety of different climates. Description of climate are based on the long-term (30 years) statistical averages of the atmospheric conditions of temperature and precipitation (weather) in a particular location. Weather varies from day to day whereas climates tend to be stable and change only slowly over time. The climate of a particular location is influenced by such factors as: latitude, elevation, mountain barriers, ocean currents, air masses, pressure cells, storms, and continentality (interior vs. coastal locations). Climate is an abstract concept—a mental construct, but one that we frequently use to describe the character of places. Climographs are charts used to record climate data.

Level: Middle and Secondary Schools

Objectives *(See sources on geographic skills and perspectives and standards at the end of this lesson.)

- To practice graphing climatic data for a specific location on a climograph.
- To compare climates in various locations and hypothesize on the local influences of latitude, elevation, and mountain barriers.
- To discuss how climate affects the daily life of local inhabitants.

Procedure

1. Introduce the concept of weather and climate by comparing recent events in California: the six-year drought, the unusually wet winter of 1992-1993 with floods and heavy winter snow pack.
2. Use a transparency to demonstrate a climograph and how to plot climate data on a climograph.
3. Graph climate data from one of the locations on the data sheet.
4. Prepare photocopies of the climograph and climate data and distribute to students or perhaps to pairs or small groups of students.
5. Locate and label (or circle) each of the cities from the data sheet on a wall map of California or on a California base map. See Lesson Plan B for county base map of California.
6. Post the completed climograph for each city above its location on the map.
7. Compare the climographs for various Northern California locations and discuss the major factors that influence the amount and distribution of precipitation and temperature ranges.
8. Repeat procedure #7 using Central California, Southern California, and Coastal California.
9. Discuss how climate affects the daily life, throughout the year, of a student living in a coastal location, central location, and eastern location.

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Extensions

- Prepare a climograph for other locations in the United States and compare them to those from California. Possible locations might include New York City, Chicago, Miami, Denver, Tucson, Cheyenne, St. Louis, and New Orleans. Do the same with cities from around the world, perhaps at similar latitudes (see U.S. and World base maps at end of lesson).
- Use the weather section from a local newspaper to compile a record of local temperatures and precipitation. How do we compute an *average* temperature for one month? Consult an atlas to see climate classifications for these regions of California and then locate places around the world with similar climates. Map their locations and discuss.

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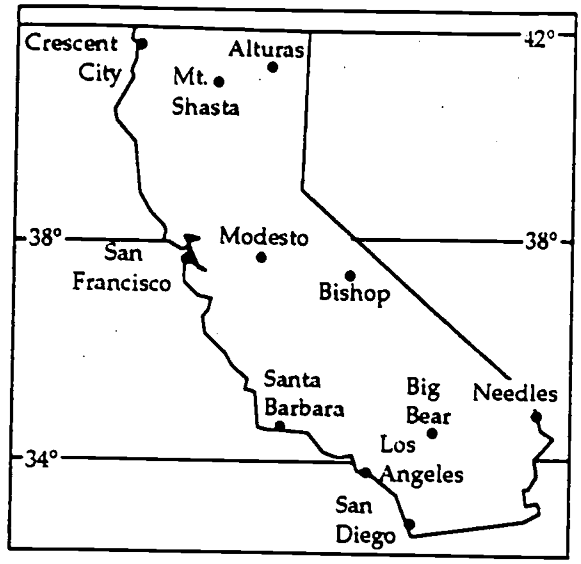
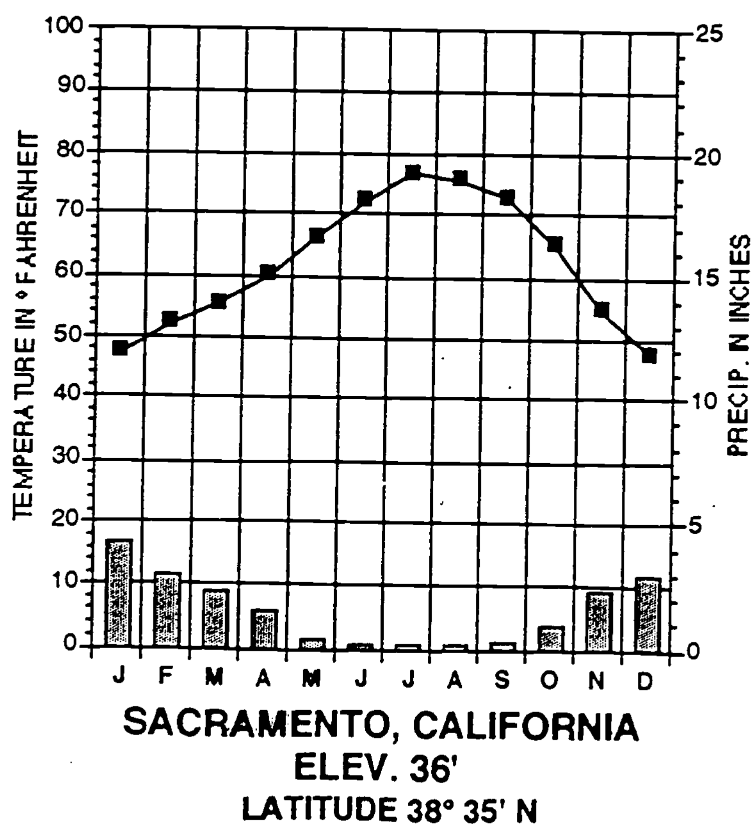
For climate Data Sheet;
Durrenberger, Robert W. and Robert B. Johnson 1976. *California: Patterns on the Land* 5th ed. Palo Alto, Calif.: Mayfield Publishing Company.

Hornbeck, David and David L. Fuller 1983. *California Patterns: Geographical and Historical Atlas.* Palo Alto, Calif.: Mayfield Publishing Company.



Relative location of selected cities with climate data to be used in climograph activity.



Sample climograph using Sacramento, California.

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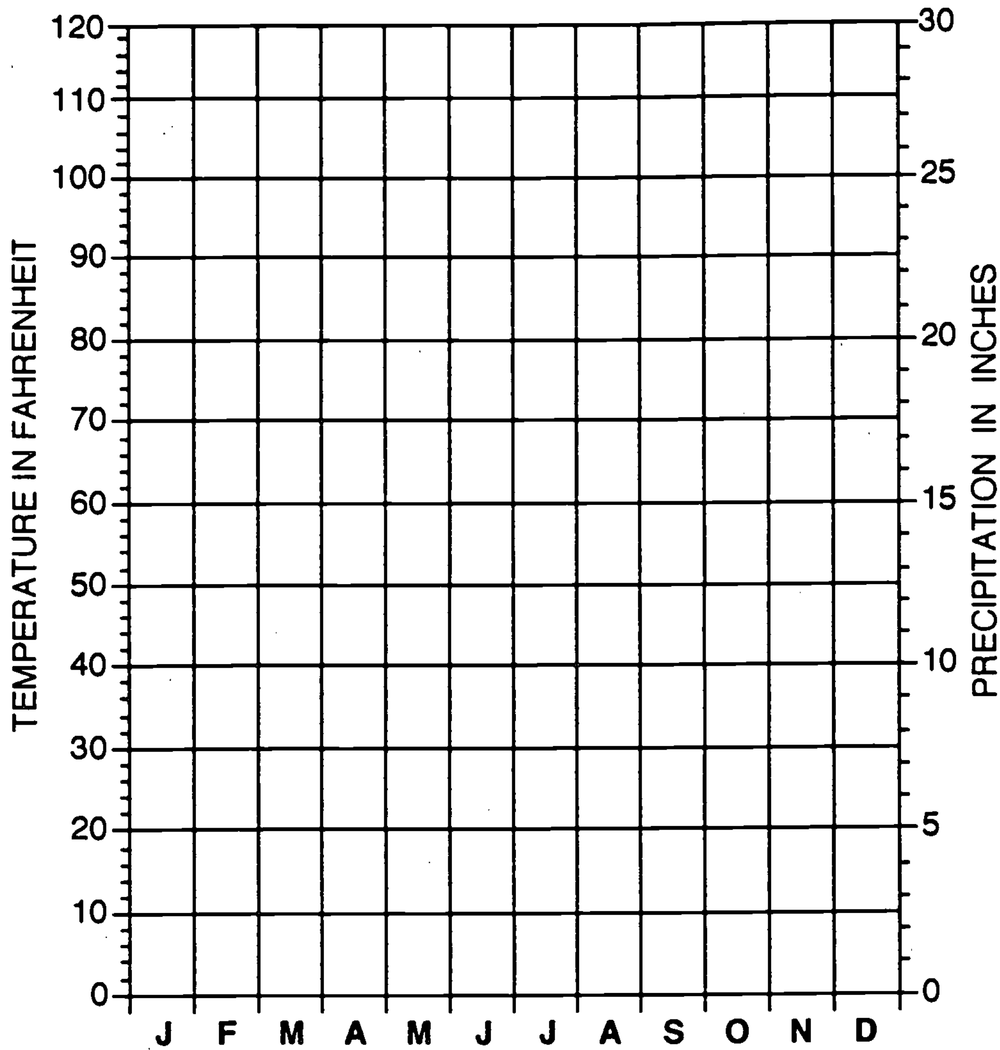
CLIMOGRAPH



CITY: ____________

ELEVATION: ________

LATITUDE: _________

LONGITUDE: _________

75

CLIMATE DATA SHEET- SELECTED CITIES IN CALIFORNIA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ALTURAS: Elev. 4365 ft. Latitude 41° 29′ N													
Av. Temperature (° F)	28	31	38	46	53	59	66	64	57	48	38	42	
Av. Precipitation (in.)	1.7	1.5	1.4	1.1	1.3	1.0	0.3	0.2	0.4	1.1	1.3	1.7	13.0
BISHOP: Elev. 4108 ft. Latitude 37° 22′ N													
Av. Temperature (°F)	37	42	46	54	62	70	77	74	68	57	46	39	
Av. Precipitation (in.)	1.2	1.1	0.4	0.4	0.3	0.1	0.2	0.1	0.1	0.3	0.6	1.1	5.8
BIG BEAR Elev. 6800 ft. Latitude 34° 15′ N													
Av. Temperature (°F)	29	30	34	41	59	55	61	61	56	47	38	33	
Av. Precipitation (in.)	5.5	7.3	7.1	3.0	0.3	0.1	0.7	0.4	0.9	1.7	2.9	7.4	37.3
CRESCENT CITY Elev. 45′ Latitude 41° 46′ N													
Av. Temperature (°F)	45	47	48	50	53	56	58	58	58	55	57	48	
Av. Precipitation (in.)	10.7	9.3	7.8	4.2	3.0	1.8	1.5	0.3	1.2	8.1	7.1	10.4	65.4
LOS ANGELES Elev. 312′ Latitude 33° 56′ N													
Av. Temperature (°F)	55	56	56	59	62	65	69	70	69	65	61	57	
Av. Precipitation (in.)	2.5	2.3	1.7	1.1	0.1	T	T	T	0.1	0.2	1.8	1.8	11.6
MODESTO Elev. 91′ Latitude 37° 39′ N													
Av. Temperature (°F)	46	51	54	59	66	72	77	75	71	63	53	46	
Av. Precipitation (in.)	2.3	1.7	1.5	1.3	0.3	0.1	0.1	T	0.2	0.6	1.7	2.2	12.0
MT. SHASTA CITY Elev. 3535′ Latitude 41° 19′ N													
Av. Temperature (°F)	34	38	40	46	53	60	68	66	61	51	42	36	
Av. Precipitation (in.)	6.7	5.6	4.0	3.1	1.9	1.1	0.3	0.3	0.7	2.5	5.1	6.3	37.6
NEEDLES Elev. 913′ Latitude 34° 46′ N													
Av. Temperature (°F)	52	57	62	70	80	89	96	94	87	74	61	52	
Av. Precipitation (in.)	0.4	0.3	0.4	0.2	0.1	T	0.5	0.7	0.3	0.3	0.4	0.4	4.0
SAN DIEGO Elev. 19′ Latitude 32° 44′ N													
Av. Temperature (°F)	55	57	58	61	63	66	70	71	70	66	61	57	
Av. Precipitation (in.)	1.9	1.5	1.6	0.8	0.2	0.1	T	0.1	0.1	0.3	1.3	1.7	9.6
SAN FRANCISCO Elev. 52′ Latitude 37° 37′ N													
Av. Temperature (°F)	48	51	53	55	58	62	63	63	64	61	55	50	
Av. Precipitation (in.)	4.4	3.0	2.5	1.6	0.4	0.1	T	T	0.2	1.0	2.3	4.0	19.5
SANTA BARBARA Elev. 120′ Latitude 34° 26′ N													
Av. Temperature (° F)	52	54	55	57	59	62	65	66	65	62	57	52	
Av. Precipitation (in.)	3.8	3.0	2.0	1.5	0.2	T	T	T	0.1	0.3	2.2	2.5	15.6

T = Trace

Sources Consulted: Durrenberger, *Patterns on the Land* and Hornbeck, *California Patterns: A Geographical and Historical Atlas.*

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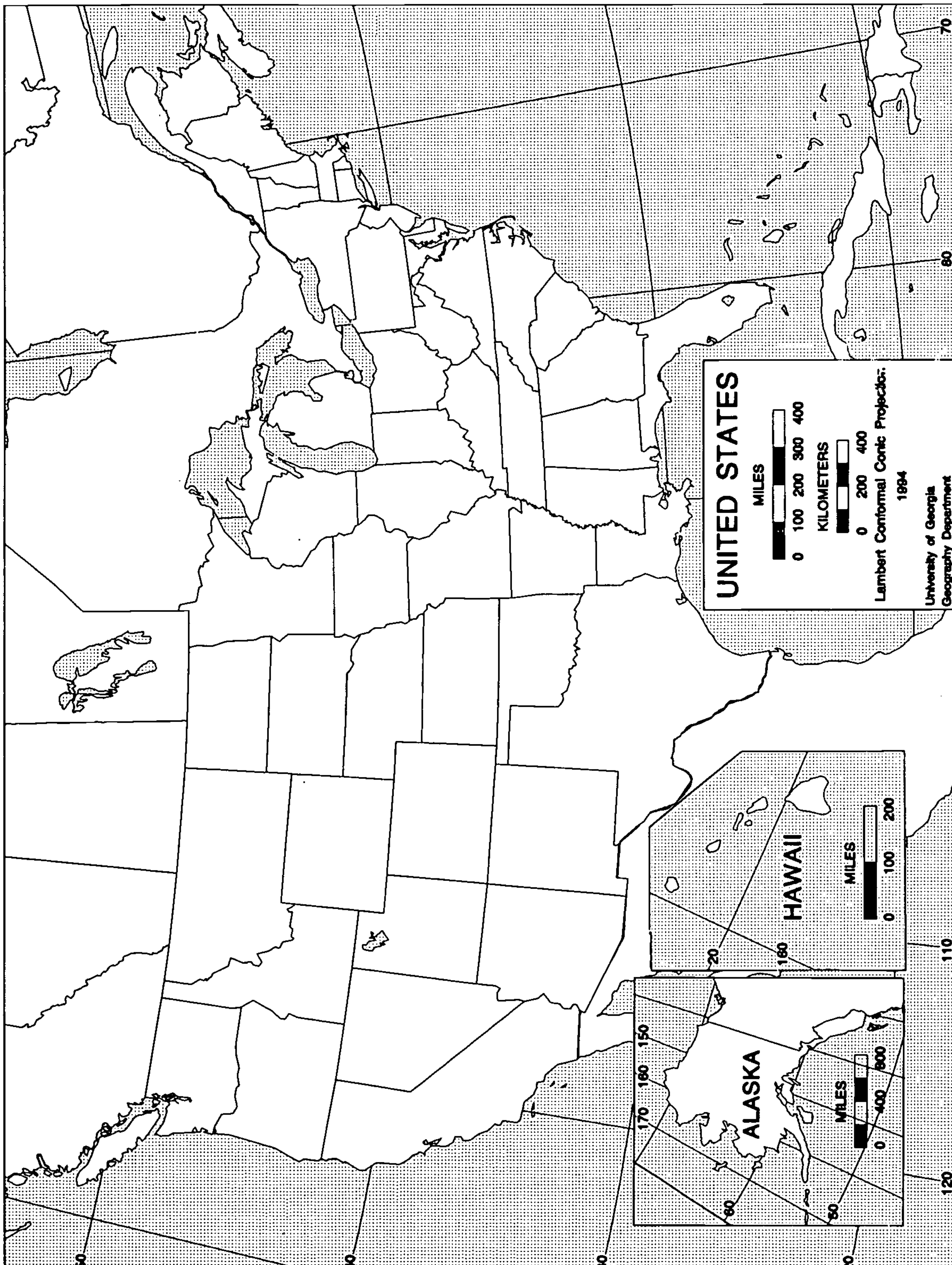
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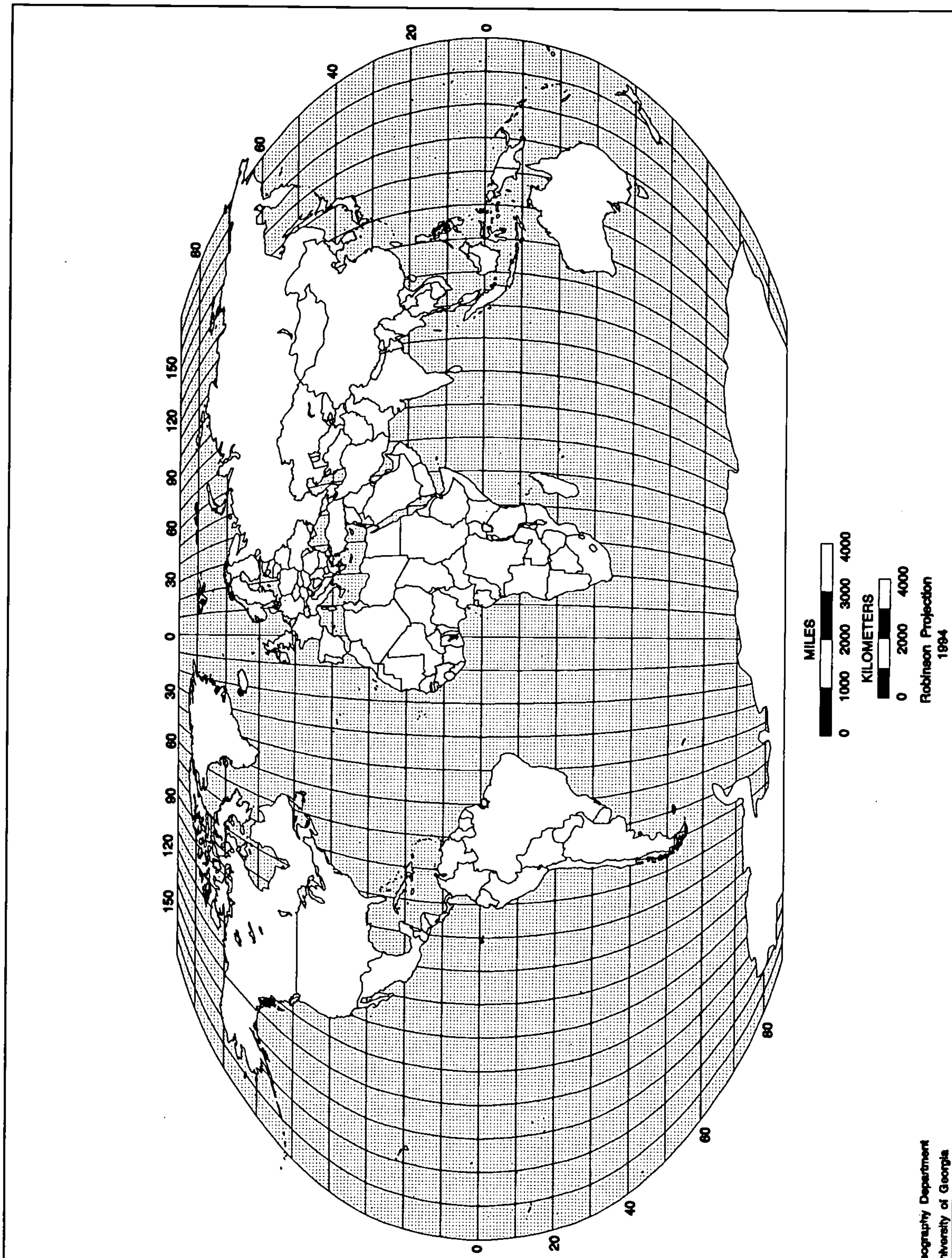
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1984
Geography Department
University of Georgia

Lesson Plan B

California's Mountain Lions

Terry Williams and Jerry R. Williams

Popularly referred to by some as cougar, panther, or puma, the California mountain lion is the last proud symbol of real wilderness in a state where more than 90 percent of the 32 million inhabitants live in ever-expanding urban settings. As our urban lifestyle continues to spread into once rural environments, the chance of contact between people and mountain lions increases. Such contact is usually detrimental to one or the other. Since 1986, nine verified mountain lion attacks on human beings have been reported in California of which two were fatal. Increased attacks on livestock and pets have also been reported. When such attacks occur, the California Department of Fish and Game is required, by law, to issue a depredation permit to remove the offending lion. Even though a permit is issued, not all efforts to find the lion are successful. The permit process, however, provides us with an excellent source of data on the number of permits issued, by county, between 1972-1994 and how many of those permits resulted in the removal of lions.

The publicity on recent mountain lion encounters and the death of two women attacked by lions resulted in an initiative on a March 1996 ballot to determine how California should manage its mountain lion population. As informed citizens, we need relevant information on the status of the mountain lion in California. An excellent source is a recent special edition of *Outdoor California* in 1995 devoted entirely to California's mountain lions. *Outdoor California* is an excellent publication by the California Department of Fish and Game that every school library in the state should have.

Level: Middle and Secondary Schools

Purpose
Mountain lions are the current focus of a controversy related to human-environment interactions—the relationship between human beings and their environment. The purpose of this activity is to improve students' awareness of the nature of the current mountain lion controversy and to provide data on the subject that they can use to help understand the issues.

Objectives: *(See sources for geographical skills and perspectives and standards at the end of this lesson plan.)
Students will practice how to rank numerical data, separate rankings into logical categories, assign colors or patterns to the various categories, plot the data on outline maps, and use the completed maps to make comparative evaluations about the status of mountain lions in California.

Materials
County outline map of California, data on depredation permits, an atlas of California, and an almanac that contains current population data by county for California.

Procedure

1. California has fifty-eight counties. Based on the data for depredation permits, use a map of California to determine in which counties the California Department of Fish and Game issued *no* depredation permits between 1972-1994. Locate those counties on a map. What do those counties have in common? (You can photocopy the county map of California included with this lesson plan as student handouts.)
2. Make a rank listing (highest to lowest) of the total number of permits issued in individual counties between 1972-1994. Divide the rank listing into natural categories and use these data to make a map showing which counties fall into which categories. Does the map show any obvious pattern of the location of mountain lions?
3. Make a rank listing (highest to lowest) of the total number of mountain lions reported killed with depredation permits in each county between 1972-1994. Divide the rank listing into natural categories and use that data to make a map showing which counties fall into which categories. Does the map show any obvious pattern reflecting the location of lions?
4. Make a rank listing (highest to lowest) of the population of each county in California. Compare this ranking with the ranking of counties that received depredation permits between 1972-1994. Did the counties with the largest populations obtain the fewest permits? Did the counties with the smallest populations obtain the most depredation permits?
5. Use an almanac or atlas to determine how many square miles (or square kilometers) are in each of the 11 counties where the greatest number of mountain lions have been removed with depredation permits. If a mature male mountain lion requires a territory of 100 square miles (259 sq km), how many mature male mountain lions would you expect to live in each of these 11 counties?
6. Compare the map for depredation permits with the map showing the number of mountain lions killed. Based on the data on your maps, describe the relative location patterns of mountain lions in California. Where are they located? Why?

**Geography for Life: National Geography Standards* 1994. Washington, D.C.: National Geographic Society. See especially : "Geographic Skills and Perspectives," 49-55 and "Standards," 75-77, 156-159, 197 and 96-97, 173-175, and 214-215. (Available from the National Council for Geographic Education, 16A Leonard Hall, Indiana University of Pennsylvania, Indiana, PA 15705, $7.00 plus postage and handling.)

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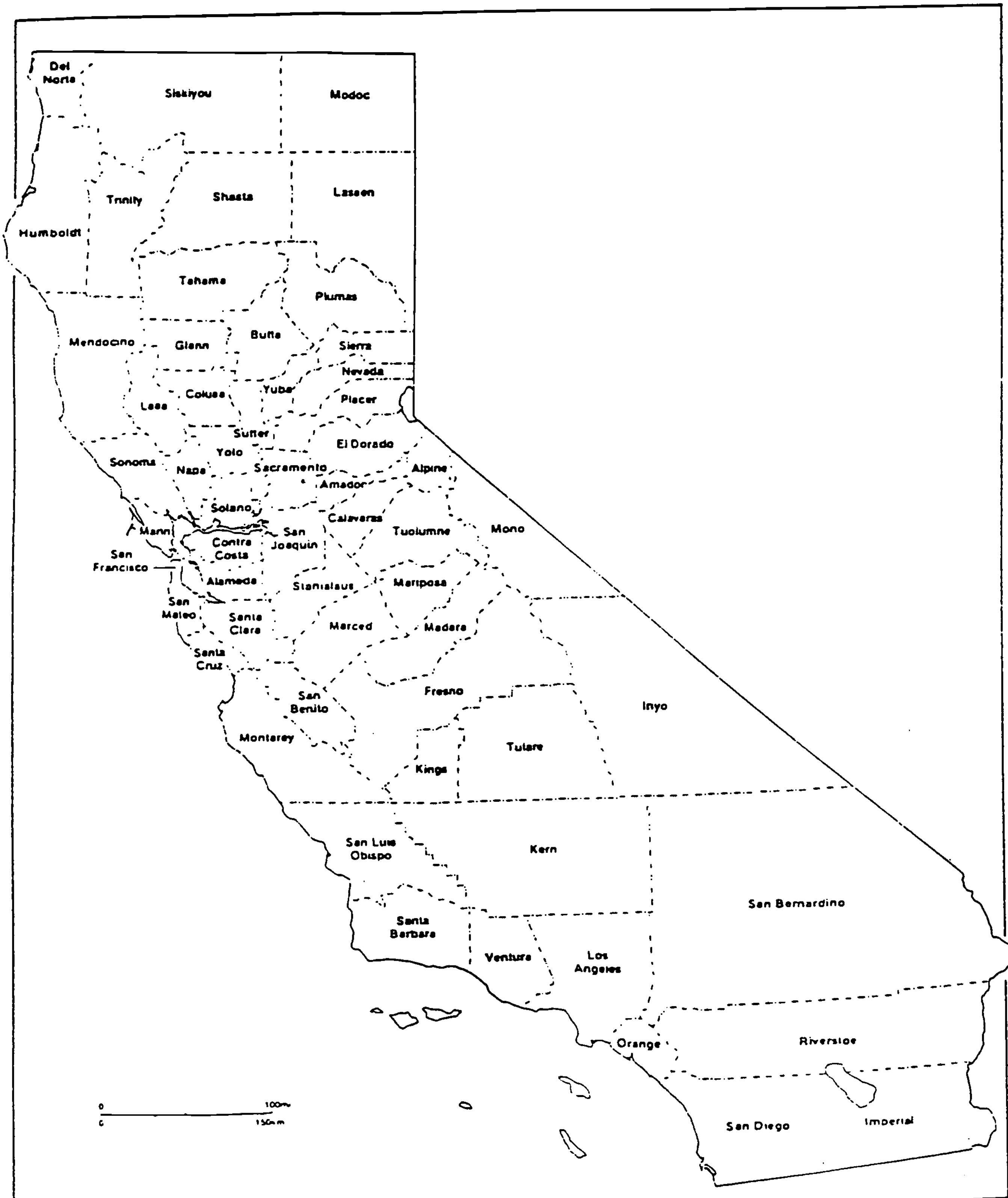

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Mountain Lion Depredation Permits and Removals
by County, 1972-1994

County	Permits	Killed	County	Permits	Killed
Alameda	17	0	Placer	45	20
Alpine	7	6	Plumas	22	12
Amador	82	30	Riverside	27	7
Butte	13	4	Sacramento	1	0
Calaveras	115	34	San Benito	6	1
Colusa	6	1	San Bernardino	1	0
Contra Costa	3	0	San Diego	42	10
Del Norte	5	0	San Luis Obispo	97	32
El Dorado	102	32	Santa Barbara	64	26
Fresno	56	9	Santa Clara	28	7
Glenn	22	10	Santa Cruz	1	0
Humboldt	186	75	Shasta	123	37
Inyo	34	12	Sierra	10	7
Kern	95	42	Siskiyou	106	59
Lake	70	25	Solano	1	0
Lassen	21	9	Sonoma	37	21
Los Angeles	8	1	Stanislaus	1	1
Madera	24	11	Sutter	1	0
Marin	1	0	Tehama	34	7
Mariposa	40	20	Trinity	58	27
Mendocino	248	110	Tulare	50	16
Modoc	21	7	Tuolumne	62	30
Mono	74	19	Ventura	15	1
Monterey	118	45	Yolo	5	1
Napa	33	2	Yuba	16	7
Nevada	40	19			
Orange	9	3	TOTAL	**2,303**	**855**

Source: *Outdoor California: Special Mountain Lion Issue* 1995. 57 (3), California Department of Fish and Game, Sacramento, Calif.

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Lesson Plan C

Water and the California Landscape: A Geographical Perspective

Terry Williams and Jerry R. Williams

Introduction
The availability of water has always been of concern in California and, as the population of the state continues to grow, the concern over the continued availability of water grows with it. Climatically speaking, much of California has a semi-arid or desert environment. In addition, annual precipitation is concentrated in a few winter months and in the northern part of the state.

Level: Middle and Secondary School

Objective :* (See sources on geographical skills and perspectives and standards at the end of this lesson.)

To demonstrate how the people of California have compensated for the seasonal and locational characteristics of precipitation and, in the process, created a unique water-oriented landscape.

Materials
This activity lends itself to students working in teams of two with laminated desk maps of the state. You can also use a wall map of California or handout base maps of the state.**

Water For Agriculture
The long hot summers of California are ideal for growing crops. In addition to hot weather, however, farmers need water to make the crops grow. California has developed a number of water transfer projects during the twentieth century. One of the first was in the Imperial Valley in southern California.

1. The Imperial Valley is a desert, seldom receiving 5" of precipitation a year with slightly larger amounts received during the winter than the summer.
2. The growing season in the Imperial Valley ranges from 275 to 335 days.
3. The Colorado River carries runoff from the Rocky Mountains through the southwestern United States, along the southern border of California into Mexico and eventually to the Gulf of California.
   a. Much of the Imperial Valley lies below sea level. In the 1890s, local landowners decided to dig ditches from the Colorado River to the valley to provide a much needed source of water.
   b. In 1905, a major flood occurred on the Colorado River and the entire river broke through the natural levees and followed the course of the new irrigation ditches into the Imperial Valley. The break was not filled until 1907 and the river was diverted back into its natural channel. The flood waters from the Colorado River created a huge lake in the Imperial Valley known as the Salton Sea.
   c. Today the Salton Sea covers about 360 square miles (829 sq km). Circle the Salton Sea on your map and write *HUMAN- MADE SEA* next to it.
4. After the Colorado River was diverted back into its old channel, a new canal, The All

American Canal was dug to bring water to the southern part of the Imperial Valley. Find the beginning of the canal at Imperial Dam, north of Yuma, Arizona, and trace its route on your map. Label the canal *A.A.C.* and draw arrows indicating its direction of flow.
a. To get water to the northern part of the Imperial Valley, another canal was constructed along the eastern side of the valley. Trace the route of the Coachella Canal from where it starts at the All American Canal northward. Label this canal *C.C.* and draw short arrows indicating its direction of flow.

5. The great Central Valley of California was the site of the next major water transfer project for agriculture in California. Proposed in the 1920s, the federal government did not begin construction until 1940 on the Central Valley Project, and it was promoted and designed as a multi-purpose project. In addition to providing irrigation water, it would provide flood control, recreation facilities, and wild life enhancement.
6. The major source of water for the Central Valley Project is Shasta Lake. The lake has a storage capacity of 4.5 million acre feet of water. Locate and circle Shasta Lake behind Shasta Dam near Redding.
   a. Label it *SHASTA LAKE–C.V.P.*
   b. List the names of the three rivers that flow into Shasta Lake.
      1. (McCloud River)

      2. (Sacramento River)

      3. (Pit River) and also (Squaw Creek)

   c. Underline the names of those three rivers on your map.
7. From Shasta Lake, the water for the Central Valley Project flows down the Sacramento River to the delta at Rio Vista. Trace the route of the Sacramento River from Shasta Dam to Rio Vista. Label it *SACRAMENTO RIVER* and draw short arrows on the river indicating its direction of flow.
8. Water for the Central Valley Project is lifted out of the delta at a pumping plant located at 38°N 121° 3' W and put into the Delta-Mendota Canal. Water flows down the canal from the delta to the Central Valley town of Mendota.
   a. Trace the route of the Delta-Mendota Canal from the pumping plant in the delta to the town of Mendota.
   b. Label this line *DELTA-MENDOTA CANAL-C.V.P* and draw short arrows along it indicating which way the water is flowing.
   c. Along the canal's route irrigation water is drawn off to irrigate crops along the western side of the Central Valley.
   d. Show water being used for irrigation by a series of short arrows pointing from the canal toward the San Joaquin River.
   c. Any surplus water in the Delta-Mendota Canal flows into the San Joaquin River at Mendota and back to the delta.
   d. Trace the San Joaquin River from Mendota to the delta.
   e. Label it *S. J. RIVER* and draw arrows along it showing which way the water is flowing.
9. To provide irrigation water for part of the eastern side of the Central Valley, the Central Valley Project built Friant Dam on the upper San Joaquin River near where the river crosses 37° N latitude. The dam has a storage capacity of about 520,000 acre-feet of water.
   a. Draw a dam across the San Joaquin River at 37° N latitude and label it *FRIANT DAM-C.V.P.*
   b. From Friant Dam, the Madera Canal delivers water north. Trace the route of the Madera Canal and label it *MADERA CANAL-C.V.P.*
   c. Draw short arrows showing the direction water is flowing in the Madera Canal.
   d. Along the route of the Madera Canal, water is removed to irrigate the land between the canal and the San Joaquin River. Draw short arrows indicating this flow of water.
   e. From Friant Dam, the Friant-Kern Canal delivers water south. Trace the route of the Friant-Kern Canal and label it *FRIANT-KERN CANAL-C.V.P.*
   f. Draw short arrows showing the direction the water is flowing in the Friant-Kern Canal.
10. Today the Central Valley Project includes 20 reservoirs with a total storage capacity of about 11 million acre-feet of water. It also includes more than 500 miles (805 km) of major canals and aqueducts and provides irrigation water to 3.25 million acres (1.3 million

hectares) of agricultural land.

11. As California continued to grow, new plans were developed to transfer more water within the state. In the 1960s, the state undertook a massive new project, the California Water Project.
    a. The primary water storage area for the California Water Project is Oroville Lake. It has a storage capacity of about 3.5 million acre-feet of water. Locate and circle Oroville Lake, about 100 miles (160 km) north of the state capital.
    b. Label it *OROVILLE LAKE-C.W.P.*
    c. Name the major rivers that flow into Oroville Lake.
    (Feather River-North Fork, Feather River-Mid Fork and Feather River-South Fork)
12. From Oroville Lake, the water for the California Water Project flows in the Feather River until it empties into the Sacramento River north of the city of Sacramento. Trace the course of the Feather River and label it *FEATHER RIVER-C.W.P.*
13. After it flows into the Sacramento River, water for the California Water Project flows into the delta to a huge pumping plant next to the Delta-Mendota Canal pumping plant. At the pumping plant water is lifted up into the California Aqueduct and begins its journey south.
    a. Trace a line along the aqueduct to the San Luis Reservoir and label it *CALIFORNIA AQUEDUCT-C.W.P.*
    b. Draw short arrows along the route of the California Aqueduct indicating the direction the water is flowing.
    c. The San Luis Reservoir (southwest of Merced) is a storage place for excess water from Oroville Lake. It can store about two million acre-feet of water. Circle it and label it *SAN LUIS RESERVOIR-C.W.P.*
    d. From San Luis Reservoir, the aqueduct continues south to the end of the Central Valley near 35° N 119° W. Trace a line along the aqueduct's route to this point.
    e. Label it *CALIFORNIA AQUEDUCT-C.W.P.* and draw short arrows indicating the direction the water is flowing in the aqueduct.
14. At the southern end of the Central Valley, water in the California Aqueduct is pumped up and over the Tehachapi Mountains and into southern California where it finally ends at a reservoir near Moreno Valley (east of Riverside).
    a. Trace the remainder of the route of the California Aqueduct.
    b. Label it *CALIFORNIA AQUEDUCT-C.W.P.*
    c. Draw short arrows indicating the direction the water in the aqueduct is flowing.

This activity gives an overall impression of how the California landscape has been changed in the process of making use of the state's water resources to satisfy the needs of the inhabitants. It also illustrates changes in technology. The earlier Central Valley Project, with the one exception of lifting the water initially into the Delta-Mendota Canal, relies on gravity flow to move the water. The use of arrows in the exercise illustrates how the engineers were able to take advantage of the natural topography to facilitate the flow of water. In contrast, the later California Water Project uses massive amounts of energy to pump the water. Although the systems in this exercise are critical to California agriculture, the California Water Project also provides water for urban uses, as do a number of other major projects not included in this activity.

Since the last major water project was initiated in California, the size of the state's population has grown by approximately ten million people. Where will the water supply for the state's increasing population come from? How might people modify the landscape in the future to meet those needs? Those topics lend themselves to important discussions that will affect the lives of all the inhabitants of this state in the future. For example, what are the advantages and disadvantages of each of the following alternatives?

1. New water projects
    a. Are there any other major sources of water in the state that have not already been used?
    b. Is water that is allowed to flow to the sea really being wasted?
    c. What happens if we drill more wells and try to make more intensive use of ground water?

d. Is the available ground water close enough to the demand, or will it also have to be transported?
e. Is desalinization of ocean water a viable water supply alternative for major urban centers in the immediate future?

2. Can we transfer water to California from Washington, Alaska, or Canada, as some people suggest, to solve our water needs?
   a. What are the implications of such massive water transfer systems?
   b. Is it feasible to tow icebergs from Antarctica to the coast of California to supply our needs?
3. Is conservation and more efficient use of existing water supplies the answer to our water needs?
4. How do we balance the environmental needs for water with our urban and commercial needs?
5. Are there other alternatives?

References and Sources

* *Geography for Life: National Geography Standards* 1994. Washington, D.C.: National Geographic Society. See especially pp. 46-56 for "Skills and Perspectives" and pp. 92-95, 96-97 for "Standards." (Available from the National Council for Geographic Education, 16A Leonard Hall, Indiana University of Pennsylvania, Indiana, PA 15705, $7.00 plus postage and handling)

**The Department of Water Resources and the Water Education Foundation each has a large California water map that provides an excellent overview of water delivery systems in California. A Water Project Facilities in California map is included at the end of this lesson.


Water Project Facilities in California
N
Clair Engle Lake
Shasta Lake
Redding
Lake Oroville
Tehama-Colusa Canal
Folsom Lake
Folsom South Canal
Sacramento
North Bay Aqueduct
Mokelumne Aqueduct
Hetch Hetchy Aqueduct
San Francisco
Delta-Mendota Canal
South Bay Aqueduct
Madera Canal
Millerton Lake
San Felipe Unit
San Luis Reservoir
Monterey
Fresno
Coalinga Canal
Friant-Kern Canal
Coastal Branch
California
Cross Valley Canal
Los Angeles Aqueduct
San Luis Obispo
Kern Water Bank
Bakersfield
Aqueduct
East Branch
West Branch
Santa Barbara
Colorado River Aqueduct
Los Angeles
Coachella Canal
San Diego Aqueducts
All American Canal
San Diego
State Water Project Facilites
Federal Water Project Facilities
Local Water Project Facilities

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Lesson Plan D

The Travels of a Monarch

Carol Douglass

Through aeons of time, the approach of winter in North America has initiated a natural phenomenon that has become the delight of both children and adults. In the autumn, countless thousands of Monarch butterflies leave Canada and the northern United States and fly to Mexico or California, where they spend the winter. In early spring, adults mate and begin their journey back north, with females laying eggs along the way. The distribution and density of Monarch butterfly populations is regulated by the common milkweed plant; it provides nectar for the adult butterfly, a depository for eggs, and a food source for the larva or caterpillar stage of the butterfly. The eggs hatch, metamorphose, and a new butterfly joins the on-going migration.

The Monarch butterfly, *Danaus plexippus*, is an ideal insect for students of all ages to study. By observing the transformations involved in insect metamorphosis, mapping their distribution in other lands, tracing their migratory routes in North America, writing and illustrating a story about their life cycle, or calculating the distance they travel from Canada to Mexico, Monarch butterflies can provide the focus for an integrative approach to science, geography, language arts, art, and mathematics.

Level: Elementary and Middle Schools

Purpose
To learn about the migration of the Monarch butterfly.

Objectives: (See sources for geographic skills and perspectives and standards in *Geography for Life*, noted with the sources at the end of this lesson.)

To trace the geographical routes of the Monarch butterfly from Canada to Mexico and from the northwestern United States to California using landforms and map symbols.

Materials
- Wall map of North America.
- Laminated desk maps or paper outline maps of North America (included at the end of this lesson). Story of the Monarch's journey.
- Pictures of landforms for reference.

Activity
Follow the journey of the Monarchs from Canada to Mexico or from the northwestern United States to California, using terms that refer to landforms, states, and directions. A condensed version of the journey would include:

Story of the Monarch's Journey—Canada to Mexico
Some Monarchs began their life cycle near **Highland Creek, Toronto, Canada.** As they started their migration **south** in September, they encountered rain and wind as they crossed southern **Lake Ontario**; they soon came to an **open field** and continued to fly southward over northern **Lake Erie**. As they flew across **Pennsylvania**, the country became **hilly** and in **West Virginia** they crossed over the **forested Appalachian Mountains**. By

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early October, they were feasting on flower nectar near the **city of Charlotte, North Carolina**. Their **southward** journey took them to the great **Okefenokee Swamp** in southern Georgia where the sleeping Monarchs were attacked by shrews (small, nocturnal, insect-eating mammals, about the size of mice, but with a long snout and shorter tail). Now the Monarchs turned westward, crossing the **Suwannee River**, and followed the **coast** of the **Gulf of Mexico**. In southern **Mississippi**, the Monarchs rested on the many islands in the **Pascagoula Swamp**. As they flew along **Lake Ponchartrain** in **Louisiana** and crossed the **Mississippi River**, a storm struck the **Gulf Coast**. Monarch wings were wet and limp, some were killed, but the others dried out and continued their journey **westward**. In early December, they flew into **Texas**, north of the city of **Galveston**, and began to travel **southward** again along the coast, crossing the **Rio Grande** into **Mexico**. Always flying **southward**, they flew through a **pass** in the **Sierra Madre Oriental (Eastern)**[1] and past small Mexican **villages**. One of the Monarchs was captured in the Mexican state of **San Luis Potosi** and identified by a wing tag attached by workers in a museum in Toronto. Other Monarchs continued southward until they reached their overwintering sites high in the **Southern Sierra Madre Oriental** of Mexico.

Additional Routes from Canada to Mexico (Optional)

1. Start in Detroit, Michigan, go across Indiana to Evansville, cross the Ohio River into western Kentucky, cross the Mississippi River into eastern Arkansas, and continue south into Louisiana. Connect with the previous route near Galveston, Texas.

2. Start near Milwaukee, Wisconsin, go south, then west across Illinois, cross the Mississippi River near Hannibal (northeastern Missouri), and continue southward across the Ozark Plateau in Missouri and Arkansas, over the Ouachita Mountains westward into Oklahoma, and south into Texas toward Austin. Connect with the previous route near Laredo.

Routes from Northwestern United States to California

1. Start in Lewiston, Idaho (west, northwest border of Idaho), go south across the Salmon River (a large eastern tributary of the Snake River), southwestward across the Snake River and the Columbia Plateau into northeastern Oregon, southward across the Basin and Range country of western Nevada, past Pyramid Lake (northwestern Nevada) and Lake Tahoe (along the Nevada-California border where it bends sharply southeastward), across the Sierra Nevada, westward into the Central Valley of California near Stockton, and across the Coast Ranges to the overwintering site near Monterey, California (near the Pacific coast).

2. Start in Yakima, Washington, go south across the Columbia River into central Oregon, westward across the Cascade Mountains, southward through the Willamette River Valley south of Eugene, and cross the Coast Range near Medford (southern Oregon). Continue south along the Pacific Coast, past San Francisco Bay, to the overwintering site near Monterey.

3. Additional routes can start near Logan, Utah, and Pocatello, Idaho. These routes should also end up near Monterey.

Extensions

Teachers can use the story of the migration from Canada to Mexico to begin a unit on insect migration or life cycles. The map and landforms can be used to emphasize the route, hazardous encounters, weather, and directionality of the journey. You can also help students calculate the distance on the map one Monarch might travel from Toronto to Mexico and back to Toronto during its life cycle. Children can create a map legend and make small drawings to add to the map. Teachers might also use modeling clay or similar commercial products such as Goop™, or constructions of a mixture of flour, salt, and water to build landforms and recreate the journey.

Sources

Hitchins, Ross 1966. *The Travels of Monarch X.* Chicago, Ill.: Rand McNally, 1966.

Mudd, Maria M. 1991. *The Butterfly*, Dimensional Nature Portfolio Series. New York: Stewart, Tabori, and Chang (Contains a beautiful, three-dimensional Monarch butterfly).

"My Mexican Monarchs," *Ranger Rick*, October 1991.

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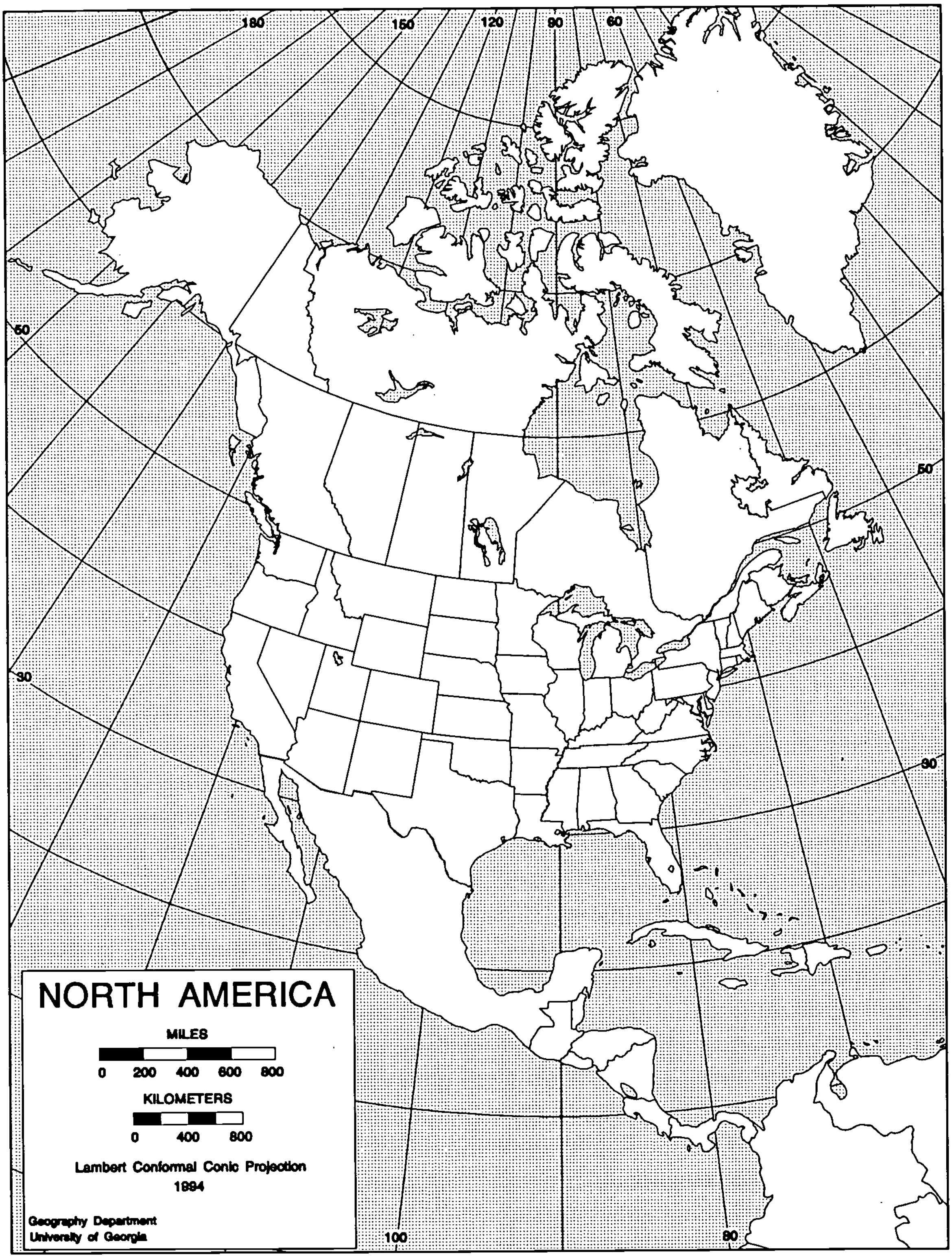
[1] *Sierra* means mountains or mountain range in Spanish and *oriental* means eastern. The eastern mountains of the high Plateau of Mexico are called the Sierra Madre Oriental and western mountains along the Plateau of Mexico are called the Sierra Madre Occidental (*occidental* is Spanish for western). Where the western coast of southern Mexico trends southeastward, the Sierra Madre Occidental become the Sierra Madre del Sur (*sur* is Spanish for south).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Lesson Plan E

Rice: A World Food

Eunice Gavin

Several thousand years ago, somewhere in southeast Asia, rice was gradually transformed from a wild grass to a domesticated grain-producing plant. Today one of the several thousand varieties of rice that now exist can be found growing on every continent except Antarctica. The cultivation of rice ranges from the deserts of Egypt to the slash-and-burn agriculture of the Amazon Basin and everywhere in between. Rice is a major food source for half of the world's population. Although the United States produces only about one percent of the total world production, it accounts for 18 percent of all rice exports. In contrast to most of the rest of the world, where rice production is highly labor-intensive, rice production in the United States is highly mechanized and capital-intensive.

Level: Elementary and Middle Schools

Purpose
This lesson will introduce students to the history and cultivation of rice and focus on rice production in California. Using a piece of children's literature, this lesson will also examine the cultural diversity of a neighborhood and highlight a food that is common to each of the cultures—rice.

Objectives: (See *Geography for Life* for geographical skills and perspectives and standards listed at the end of this lesson.)
- Students will identify the rice producing regions of California, the United States, and the world.
- Students will acquire knowledge about rice production in California.
- Students will identify the geographic location of the families mentioned in the literature.

Materials
- A copy of the book, *Everybody Cooks Rice* by Norah Dooley (Minneapolis: Carolrhoda Books 1991).
- A world desk map for every two students (master supplied in Lesson Plan A).
- An outline map of California and the United States (supplied in Lesson Plans A and B). A copy of the pamphlet, *Facts About USA Rice*, for each student (see how to procure this under references at the end of this lesson).

Procedure
Rice—Part I
1. Skim the history article in *Facts about USA Rice* to find the importance of the following dates in U. S. History—1726, 1849, 1884, and 1920.
2. Find and outline South Carolina on the U.S. map. Write inside South Carolina "**1726—4,500 Metric Tons of Rice Exported.**"
3. On the U.S. map, find and outline, as one region, the states of Missouri, Arkansas, Louisiana, Mississippi, and Texas. Inside the region write "**1884—Beginning of Major U. S. Rice Production.**"

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4. Find California on the U.S. map. Write **"1849—40,000 Chinese Inhabitants and 1920—Major U.S. Rice Producer."**
5. Find Florida on the U.S. map. Outline the state and write **"Newest Rice-Producing State."**
6. Rice is grown in 14 counties throughout California's Central Valley. However, the primary rice growing region lies north of Sacramento in the counties of Butte, Colusa, Glenn, Sacramento, Sutter, Tehama, Yolo, and Yuba. Shade in those counties on a California map.
7. As the second largest producer of rice in the United States, after Arkansas, California accounts for about 20 percent of all rice grown in this country. California rice growers produce the highest average annual yield, i.e., production per unit area, of rice per acre (or per hectare) in the world. Approximately 392,000 acres (158,700 hectares) of land are devoted to rice production in California. There are 640 acres in one square mile (or 259 hectares). Calculate how many square miles of agricultural land are used to produce rice in this state. (A little more than 600 square miles— 612.5 sq. mi. or 1586 sq km.)
8. All of the land devoted to rice production in California is about equal to the total land area of one of the rice-producing counties. Use an almanac or an atlas to determine the area, in square miles, of each of the major rice-producing counties. Identify which county is most equal in size to the total land devoted to rice growing in California. Draw an arrow pointing to that county and label it **"Approximate Area Used to Grow Rice."** (Sutter—607 sq. mi. or 1572 sq km; Yuba—639 sq. mi. or 1655 sq km)
9. Climate, soil, and water are major physical factors influencing rice production. Examine the map and an atlas to see what the eight counties listed above have in common that make them a major rice producing region.
10. Read the article on cultivation and discuss how rice farming today is different from rice farming long ago and how it differs in the U.S. from many other countries. What is the procedure for growing rice?

Rice—Part II

1. Read the story, *Everybody Cooks Rice*, to the class.
2. On a world desk map, locate the country of origin of each family mentioned in the story. Put an X on each country (Barbados, Puerto Rico, Vietnam, India, China, and Haiti).
3. Discuss similarities of the families in the story with families typical of many California communities.
4. As a class project, compile a list of all the different types of food with which the students are familiar that contain rice.

Rice—Part III

1. Skim the history article in *Facts about USA Rice* to find the first recorded account of rice cultivation.
2. Find and outline China on the world map. Write **"2,800 B.C.—1st Documented Account of Rice Planting"** across the country of China. Based on the written record, determine how many years rice has been grown in China (at least 4,795 years—probably 5,000 years).
3. Today, rice is a staple crop for much of the world's population. Most of the rice is eaten in the countries where it is grown. Ask the students to identify the countries, they think, are the top ten rice-producers in the world today. Based on their discussion, record their choices on the board.
4. Identify the top ten **rice-producing countries** and compare these to the class list. Students should locate the countries on their world map and underline the country's name. Draw a rice grain for each 10 million tons produced next to each country listed on the following table.
5. After they have located the countries, students should draw in the appropriate numbers of grains of rice on each of the top ten rice-producing countries.

Top Ten Rice-Producing Countries (in millions of metric tons)

1. China	19 grains	6. Thailand	2 grains
2. India	11 grains	7. Myanmar	1 grain
3. Indonesia	5 grains	8. Japan	1 grain
4. Bangladesh	3 grains	9. Brazil	1 grain
5. Vietnam	2 grains	10. Philippines	1 grain

Note: *The United States ranks 12th*

6. Rice is also an important world trade crop. Some countries do not produce enough rice to satisfy the demand within their country, therefore they must buy rice from countries that have a surplus. Ask the students to identify the countries, they think, are the top ten rice-exporters. Based on their discussion, record their choices on the board.
7. Use a recent world almanac to identify the top ten rice-exporting countries and compare to the class list. Students should locate the countries on their world map, write the rank next to the name and circle the country name and rank.

Top Ten Rice-Exporting Countries in 1992 (in thousands of metric tons)

1. Thailand	5,152	6. Italy	739
2. United States	2,164	7. India	560
3. Vietnam	1,950	8. Austraila	518
4. Pakistan	1,511	9. Uruguay	328
5. China	1,034	10. Spain	219

8. Most rice is eaten in the countries where it is grown. Only about 4 percent of the annual production of rice ends up in world trade. As the major exporter, Thailand ships about 5 million tons a year to the Middle East, Europe and Africa. On the world map, draw an arrow with three branches representing the flow of rice from Thailand to the Middle East, Europe, and Africa.
9. Vietnam has traditionally been a rice surplus area, but from the end of the Vietnam War until 1988, Vietnam suffered shortages of rice. After the new communist government lifted restrictive rules and price controls, production increased again. Since 1989, Vietnam has been exporting more than a million tons of rice a year.
10. Discuss with students what the statistics, that show the United States to be 12th in world production but the second largest exporter of rice, illustrate about rice consumption in the United States?

    Note: The U.S. population has doubled its consumption of rice in just more than a decade. Americans now consume an average of 22 pounds of rice a year, up from about 8 pounds in 1967. Consumption of rice in the U.S. has been increasing about four percent annually and rice authorities expect this trend to continue. In California consumption of rice is expected to climb even faster because of the growing number of Asian and Latin American immigrants who typically consume more rice than the average U.S. citizen.

References

Geography for Life: National Geography Standards 1994. Washington, D.C.: National Geographic Society: "Skills and Perspectives," pp. 41-45, "Standards" pp. 58, 61-63, 106-107, 146-147. (Available from the National Council for Geographic Education, 16A Leonard Hall, Indiana University of Pennsylvania, Indiana, PA 15705, $7.00 plus postage and handling)

White, Peter T. 1994 "Rice—The Essential Harvest," *National Geographic* 185 (May) 48-79.

**Facts About United States Rice* is available from the California Rice Promotion Board, P.O. Box 507, Yuba City, CA 95992, (916) 674-1221, or from USA Rice Council, P.O. Box 740123, Houston, TX 77274, (713) 270-699.

NOTES

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