2 RESOURCE DESCRIPTION

Top left: Oak woodland vegetation in Simi HIlls. Top right: Students at Audubon Center at Debs Park. Bottom: Detail of the front door of the Gamble House. Photos: NPS.

Chapter 2: Resource Description

This chapter describes the study area's natural, cultural, and recreational resources.

Introduction

The study area includes a diverse array of natural, cultural, and recreational resources. This chapter provides an overview of these resources as context for the new national park unit analysis described in *Chapter 3*, and the boundary expansion analysis presented in *Chapter 4* of this document. Additionally, this chapter describes the affected environment that is analyzed for environmental impacts in *Chapter 6*.

Geographic Scope

Generally, the resources described in this chapter correspond to those resources located within the 650,000-acre study area. However, in some cases the resource description goes beyond the study area to more fully describe the resources in their broader contexts. For example, the mountain systems within the study area are part of the Transverse Ranges Geomorphic Province which extends beyond the study area. For biological resources, where wildlife corridors and habitats extend beyond the study area, those areas are also described.

Physical Resources

Climate

The southern California region experiences a Mediterranean-type climate associated with areas located between the 30th and 45th parallels of latitude and on western continental borders (Bailey 1966). These areas are affected by subtropical high pressure masses that create a drought environment during summer, but shrink in winter, allowing storms to occur along the coast. Only two percent of the earth's surface has this type of climate. In addition to southern California, there are four other regions of the earth that experience Mediterranean-type climates including the Mediterranean basin, central Chile, the Cape Region of South Africa and the southern and western areas of Australia. Marine influences keep the coast cool in the summer and prevent it from getting very cold in the winter (Miller and Hyslop 1983).

At times, offshore winds from the east influence the climate. Between September and March, high pressure systems over the Great Basin, combined with a low pressure system to the southwest, creates warm, dry offshore winds that periodically circulate through the region. Known as Santa Ana winds, these winds have a significant impact on the local climate. After the long dry summers, the Santa Ana winds contribute to the fire regime which begins in the summer and continues until the wet winter ensues (Miller and Hyslop 1983).

Microclimates

Although the Los Angeles region is known for its year-round mild climate, there are many different microclimates in the valleys, mountains, hills, and coastal areas of the study area. Average rainfall and temperature varies significantly throughout the study area based on local microclimates. Microclimates are influenced by a variety of factors including topography, elevation, and distance from the ocean. For example, the average annual precipitation is 13 - 20 inches for Thousand Oaks, Simi Valley, and Los Angeles; 24 inches for Topanga Canyon in the Santa Monica Mountains; and 34 inches per year on average for Mount Wilson in the San Gabriel Mountains.

The Mediterranean-type climate and associated ecosystems that characterize southern California are found in only four other areas in the world. Photo: NPS.

Santa Monica Mountains National Recreation Area: Fundamental and Other Important Resources and Values

As described in *Chapter 1: Introduction*, each unit of the national park system will have a foundational document to provide basic guidance for planning and management decisions—a foundation for planning and management. Fundamental resources and values and other important resources and values are core components of the foundation document and help national park units make decisions about caring for those resources and values that relate to the park unit's national significance.

Fundamental resources and values are defined as those features, systems, processes, experiences, stories, scenes, sounds, smells, or other attributes determined to warrant primary consideration during planning and management processes because they are essential to achieving the purpose of the park and maintaining its significance. Other important resources and values other resources and values are those that are not fundamental to the purpose of the park unit and may be unrelated to its significance, but are important to consider in planning processes. Fundamental and other important resources and values of the Santa Monica Mountains are also reflected in resources beyond the national recreation area.

The following fundamental resources and values have been identified for Santa Monica Mountains National Recreation Area:

- *Fully Functioning Native Habitats with High Native Diversity* – Preserving the full range of native habitats ensures long-term preservation of the high biodiversity associated with the Mediterranean ecosystem.
- *Science-Informed Stewardship / Learning Laboratory* – Science guides park management, informs policy, and lays the groundwork for educating visitors and fostering stewardship. A wide range of resources at the wildland-urban interface in close proximity to research institutions and residents creates a learning laboratory for understanding the evolution of the landscape and its diverse ecosystems.
- *Habitat Connectivity* – Maintaining habitat connectivity both within and outside of the national recreation area is critical and essential for preserving native biodiversity and ecosystem function (e.g., maintaining genetic diversity, dispersal, and movement).
- *Access to Year-Round Recreation and Exploration Opportunities* – With a mild, Mediterranean type climate, the Santa Monica Mountains provide a wide variety of year-round, close to home, outdoor recreation activities. Beaches, scenic routes, and an extensive trail network provide avenues for escape and exploration.
- *Coastal and Mountain Landscapes* – Shaped by ongoing geologic forces, the Santa Monica Mountains' coastal and mountain scenery includes canyons, ridgelines, rocky outcrops, and 21 miles of seashore that provide the setting for visitors and residents to enjoy outdoor recreation.
- *Native American Archeology* – Santa Monica Mountains National Recreation Area contains more than 10,000 years of Native American history, as represented by hundreds of archeological sites such as large villages, gathering areas, and rock art. These sites, along with other evidence, are used to reconstruct ancient subsistence and settlement patterns throughout the Santa Monica Mountains and Simi Hills.
- *Filming Sites and Settings* – Filming sites and settings include movie ranches that served as an outdoor backdrop for Hollywood's Golden Era of the movie industry, as represented by the Paramount Ranch Historic District. Filming continues today at Paramount Ranch and other locations within the park, and offers the public an opportunity to experience filmmaking.

The following other important resources and values have been identified for Santa Monica Mountains National Recreation Area:

- *Sites and Landscapes Representative of Southern California History* – The Santa Monica Mountains contain archeological resources, cultural landscapes, and historic sites and structures that depict important periods of southern California history including Spanish exploration, Mexican ranchos, western expansion and settlement, and modern urbanization. Themes include architecture, environmental engineering to capture and control water, the role of the automobile in shaping culture and the landscape, and amusement / entertainment. Examples of locations that illustrate these themes include Peter Strauss Ranch (amusement and discovery), King Gillette Ranch (gentlemen's ranch/architecture), Rancho Sierra Vista (working ranches), Mulholland Highway (role of the automobile), and Franklin Canyon (environmental engineering).
- *Ethnographic Resources* – Santa Monica Mountains contain a wide range of landscapes and resources important to American Indian cultures. Satwiwa Native American Culture Center serves as a destination for a broad range of American Indian groups from across the nation. Satwiwa is a learning center for all people to share traditional and contemporary indigenous lifeways. The center is a collective effort among the Chumash, Tongva, other native peoples, and the National Park Service.
- *Paleontological Resources* – Santa Monica Mountains National Recreation Area has one of the most extensive and diverse assemblages of marine and terrestrial fossil material known in the national park system. There are at least 2,300 known fossil localities, representing more than a dozen fossiliferous geologic formations ranging from the late Jurassic Period to the Pleistocene Epoch.

One of the fundamental resources and values of the Santa Monica Mountains National Recreation Area is habitat connectivity, critical for preserving biodiversity and ecosystem function. This iconic image of a mountain lion NPS researchers have labelled P-22 gained national attention for traversing two freeways to reach Griffith Park. Photo: Steve Winter/National Geographic.

With most of the air moisture flowing inland from the ocean, mountains facing the coast receive more precipitation as this air rises and cools. This pattern creates a rain shadow effect on inland facing slopes, which receive less precipitation as a result. As elevation increases, precipitation increases and temperatures decrease. Above 4,000 feet, the environment is characterized by distinct seasonal differences in temperature and features the highest precipitation in the region, including winter snow.

Microclimates in the study area's valleys experience effects from temperature inversion layers. In most areas, the air temperature becomes cooler at higher elevations. In the study area's valleys, the opposite is typical. Cool air flows down into the valleys from the mountains as cool marine air also flows inland. This air becomes trapped through the combination of the valleys' surrounding mountains and onshore air flows. With the cold air trapped in the valleys, warmer air suddenly rises, creating an inverse temperature gradient. The inversion layer also contributes to photochemical smog in the valleys which is a combination of air moisture and pollutants (Schoenherr 1992). Within the study area, there are six defined microclimates (Nelson 1983).

Topography and Geology

Transverse Ranges Geomorphic Province

The study area is defined by general topographic features including a series of mountains, hills and valleys. Collectively, the mountains and hills are part of the broader Transverse Ranges Geomorphic Province which includes geologic structures along the southern California coastline that lie east-west or "transverse to" the prevailing northwest-trending character of the west coast. These east-west trending mountain ranges are interspersed with alluvium-filled basins that include the valleys of the Rim of the Valley Corridor study area. The primary mountains within the Transverse Ranges Province include

Although there are other east-west trending ranges in the continental United States, the geologic story of the Transverse Ranges is unique at this large scale in the United States.

the Santa Ynez Mountains (and Topatopa Mountains to the east), Santa Susana Mountains, Santa Monica Mountains (and northern Channel Islands to the west), San Gabriel Mountains, and San Bernardino Mountains (Norris & Webb 1990). Additionally, the Simi Hills, Conejo Mountain/Las Posas Hills (and nearby unnamed volcanic hills), Sierra Pelona, and Verdugo Mountains (including the San Rafael Hills) are all part of the Transverse Ranges Province. Five of the mountain ranges that comprise the Transverse Ranges Geomorphic Province are represented in the study area: the Santa Monica Mountains, Santa Susana Mountains, Simi Hills, Verdugo Mountains and San Gabriel Mountains. The populated urban valleys (Conejo, Simi, La Crescenta, and San Fernando) are not part of the study area and are shown as "holes in the donut" on the study area maps in this report (*Figure 2-1: Topography*).

The anomalous orientation of the Transverse Ranges resulted from the clock-wise rotation of a previously north-south trending block that was caught up in movement between the Pacific plate and the North American plate about 18 million years ago. As the block rotated beginning about 17 million years ago, the crust was stretched and thinned causing volcanic eruptions in the Santa Monica Mountains and Conejo Mountain area. Relative plate motions changed about 6 million years ago when Baja California broke off of the North American plate. Baja California became attached to the Pacific plate, moved to the northwest and pressed against the Transverse Ranges block. This compressive force uplifted the blocks that became mountains and forced the blocks that became basins downward (subsidence). This compression continues today and is pushing the mountain ranges higher while the basins are pressed lower (Fritsche et al. 2001).

Although there are other east-west trending ranges in the continental United States (e.g. the Uinta Mountains in Utah, the Ouashita Range in Arkansas), the geologic story of the Transverse Ranges is unique at this large scale in the United States. In Alaska, there are several east-west trending mountain ranges but they are covered with snow and ice for most of the year. The ranges in Alaska are the result of terranes that were transported north on the Pacific Plate and accreted to the North American Plate. In contrast, the Transverse Ranges are the result of a ninety degree rotation caused by the land block getting stuck under the North American Plate and pushed clockwise by the Pacific Plate. In addition, the geological formations of the Transverse Ranges are far more accessible to both scientists and visitors.

Scientists have analyzed rocks in the Santa Monica Mountains and from the Conejo Volcanic complex within the study area to piece together the current model of the Transverse Ranges rotation. In his 2001 publication, "Transverse/Peninsular Ranges Connection – Nine Lines of Evidence for the Incredible Miocene Rotation," geologist Eugene Fritsche summarized the scientific findings that provide evidence and support for the rotation theory. Seven of the nine lines of evidence cited in Fritsche's paper are based on discoveries made within the study area (Santa Monica Mountains and the Conejo Mountain area).

Santa Monica Mountains

The Santa Monica Mountains are the westernmost mountain range in the study area. This transverse range spans much of southeastern Ventura County and southwestern Los Angeles County. Characterized by a series of deeply incised north-south trending canyons that drain to the Pacific Ocean, the Santa Monica Mountains are approximately 46 miles long and 7.5 miles wide. The mean elevation is approximately 1,000 feet. The highest point is Sandstone Peak with an elevation of 3,111 feet (NPS 2002).

The spiny backbone of the Santa Monica Mountains skirts the northern edges of the Los Angeles basin and Santa Monica Bay before descending into the sea at Point Mugu. The northern Channel Islands are the western extension of the Santa Monica Mountains. Folded and faulted structures characterize the Santa Monica Mountains, with five geologic stages having profoundly marked their more than 150-million-year history: (1) subduction; (2) rifting, rotation, and extension; (3) volcanic eruption; (4) compression and uplift; and (5) erosion.

The exposed rocks in the Santa Monica Mountains are sandstone, siltstone, mudstone, and volcanic rocks ranging in age from the Jurassic to Quaternary. The Santa Monica Slate is the oldest rock unit exposed in SMMNRA;

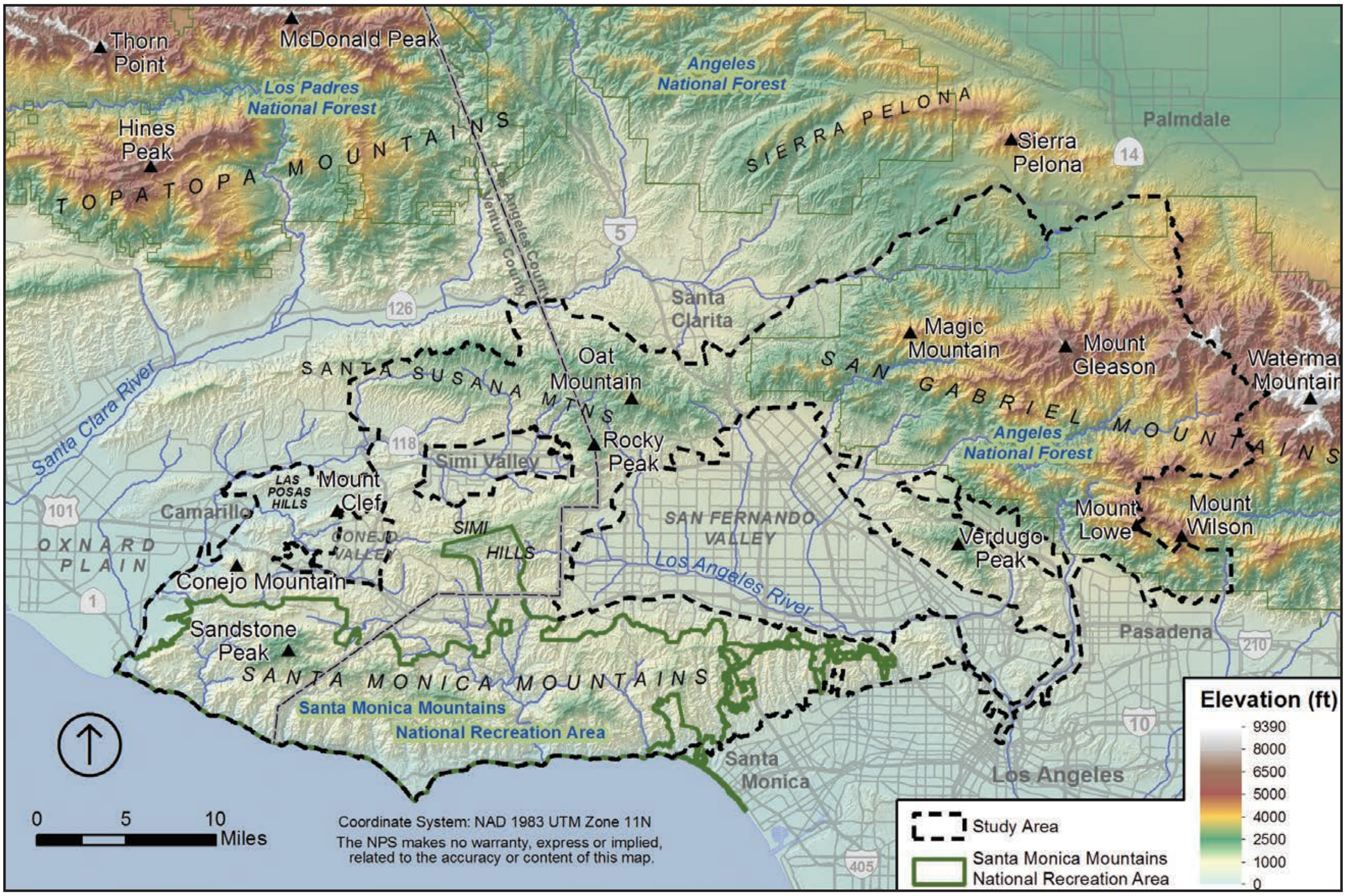


Figure 2-1: Topography

this rock unit was deposited as mud and other sediment on the ocean floor during the Late Jurassic Period (164–145 million years ago). The slate is overlain by an extensive sequence of Cretaceous and Cenozoic sedimentary and volcanic rocks, many of which have their type section (exposure for which a formation is named and described) in the Santa Monica Mountains. The Late Eocene–Early Miocene Sespe and Topanga Canyon formations (lower part of the Topanga Group) represent coastal alluvial deposits (Sespe) with equivalent nearshore marine deposits (Topanga Canyon). The Miocene (20–10 million years ago) Topanga Canyon formation is the most extensive geologic unit in the Santa Monica Mountains. This sequence of rocks consists of non-marine and marine deltaic sandstone and conglomerate in the eastern Santa Monica Mountains and marine shelf and submarine deposits in the western Santa Monica Mountains. Another widespread formation is the Conejo Volcanic complex (middle part of the Topanga Group), produced when hot molten rock escaped to the surface during the stretching of Earth's crust in the Santa Monica Mountains area 17 to 16 million years ago. The middle Miocene Calabasas formation is a marine sandstone and siltstone that overlies and interfingers with the Conejo Volcanics. The upper Miocene Modelo formation, representing a deep submarine fan complex, crops out in a belt along the northern Santa Monica Mountains stratigraphically above the Topanga Canyon formation, the Conejo Volcanic complex, and the Calabasas formation. Frequent landslides and occasional earthquakes serve as reminders that the rocks and landforms of the Santa Monica Mountains have not stopped moving or forming. In addition, floods, waves, and wind continue to work the landscape, resulting in the diverse landforms that characterize the recreation area. The Santa Monica Mountains include deeply carved canyons and gorges, streams, waterfalls, beaches, and rugged terrain. Malibu Creek bisects the mountains as it flows through Malibu Canyon to the Pacific Ocean. This antecedent creek originates in the Simi Hills and carves out gorges along its path to the ocean. Along the Pacific shoreline are steep cliffs and high bluffs that have eroded due to incessant wave action (NPS 2008).

Frequent landslides and occasional earthquakes serve as reminders that the rocks and landforms of the Santa Monica Mountains have not stopped moving or forming.

Rock Formations in the Santa Monica Mountains

From oldest to youngest, the rock formations in the Santa Monica Mountains include the Santa Monica Slate, Trabuco, Tuna Canyon, Simi Conglomerate, Santa Susana, Llajas, Sespe, Topanga Group which includes Topanga Canyon (Lower Topanga in Dibblee), Conejo Volcanic complex, and Calabasas formations (Upper Topanga in Dibblee), Modelo (Monterey in Dibblee), Saugus and surficial terrace deposits (Fritsche 2012). The following descriptions of rock formations in the Santa Monica Moutains are primarily based on an internal National Park Service technical report from 2012 "Paleontological resource inventory and monitoring: Mediterranean Coast Network" by Tweet, Santucci, and Connors (*Figure 2-2: Geology*).

Santa Monica Slate (Late Jurassic)

The Santa Monica Slate is the oldest rock unit found in the Santa Monica Mountains. It is a metamorphosed dark-gray and bluish-gray-to-black slate with local schist zones exposed in the eastern mountains at Encino Reservoir, Mission Canyon and in Topanga State Park and east of Interstate 405 around Cahuenga Peak in Griffith Park.

Trabuco Formation (Late Cretaceous)

The thin Trabuco formation consists primarily of conglomerates from an alluvial fan.

Tuna Canyon Formation (Late Cretaceous)

The Tuna Canyon formation is a marine sedimentary unit that was deposited during a marine transgression, a time when the ocean encroached and covered land areas. It is found in the eastern Santa Monica Mountains.

Simi Conglomerate (Paleocene)

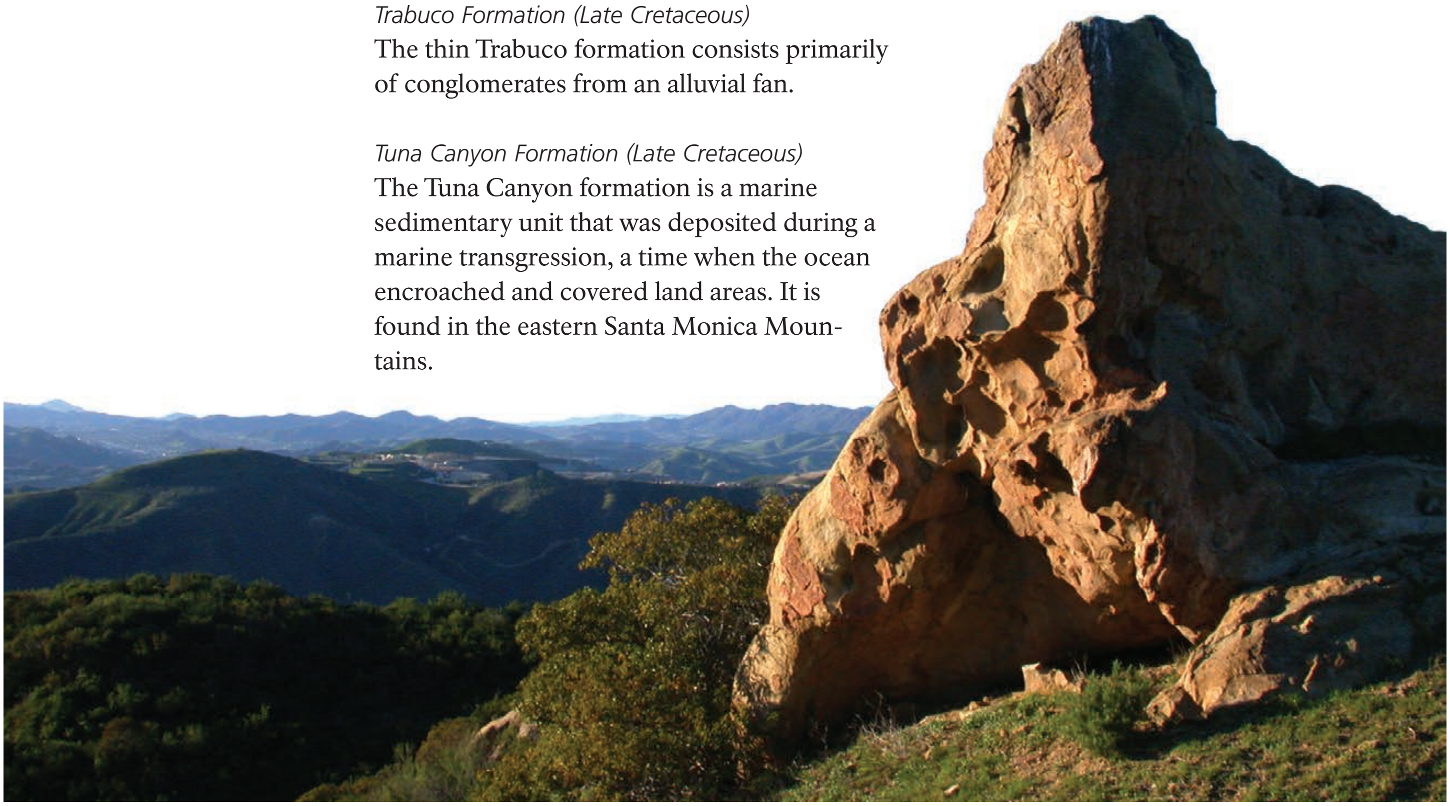
The Simi Conglomerate is best known from the Simi Hills, but is also present in the Santa Monica Mountains. It is a cobble and boulder conglomerate with some sandstone exposed from Solstice Canyon to Runyan Canyon. It includes both marine and nonmarine deposits.

Santa Susana Formation (Late Paleocene - Early Eocene) (also known as Coal Canyon or Martinez)

This formation includes a marine sequence of sandstone, pebble conglomerate, and siltsone. It includes white algal limestone beds, shales with intercalated sandstones, some massive beds of poorly sorted arkosic sandstone and conglomerate. It is found in the southern Santa Monica Mountains.

Llajas Formation (Middle-Late Eocene)

This unit contains gray claystones and siltstones that are exposed in Malibu Creek State Park and Trancas Canyon. The formation is best known in the Simi Hills and the Santa Susana Mountains north of Simi Valley where its namesake Las Llajas Creek and the fossil-rich "Stewart beds" have yielded many new species (Squires 1983b). Deposition of the Llajas formation occurred during a marine transgression and part of the following regression (a



The mountains in the study area are part of the Transverse Ranges Geomorphic Province which unlike most other mountain ranges, extend "transverse to" the prevailing northwest-trending character of the west coast. Photo: NPS.

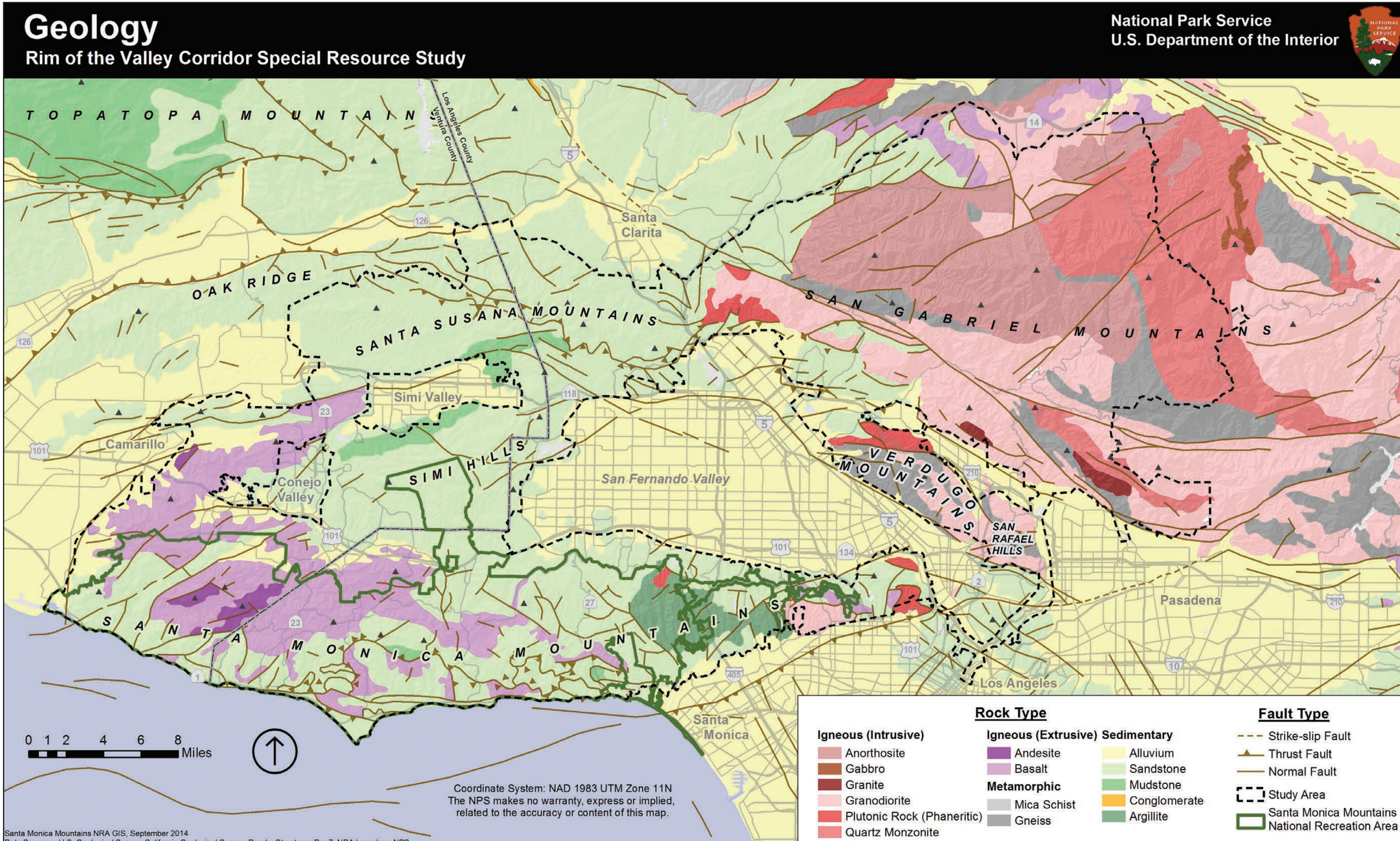


Figure 2-2: Geology

The Santa Monica Mountains, Simi Hills, Santa Susana Mountains, Verdugo Hills and San Gabriel Mountains represent the Transverse Range geomorphic province in the study area. Geologist Gene Fritsche explains connections between visible features and a geologic map. Photo: NPS.

marine retreat), leading depositional settings to change from nonmarine coastal alluvial fans, to shallow marine, to offshore, and back to shallow marine. The water was tropical (at least 68 degrees F).

Sespe Formation (Middle Eocene - Early Miocene)
The Sespe formation is well known from the Santa Monica Mountains and Simi Valley for its nonmarine redbed sequences of sandstone and claystone. It is part of a complex series of intertonguing terrestrial, nearshore shallow marine, and offshore deep marine formations. The Sespe formation was deposited during a time of low sea level when ice was developing in Antarctica and the Transverse Ranges block was uplifted while being transported northward on the Pacific Plate. Local sea level may have been more than 600 feet lower than present. The depositional setting included braided and meandering rivers, floodplain overbanks, salt marshes, and coastal environments. Braided rivers are prominent low in the formation, and are replaced by meandering rivers and finally coastal settings. A savanna with a gallery forest is now thought to have been present, with a seasonal climate.

Topanga Group (Late Oligocene – Middle Miocene)
This group consists of three formations: Topanga Canyon formation (lower), Conejo Volcanic complex (middle), and Calabasas formation (upper).

Topanga Canyon Formation (Late Oligocene - Early Miocene) (aka Lower Topanga Formation)
The Topanga Canyon formation is the most widely exposed geologic unit within the Santa Monica Mountains. The formation is sometimes split into three members: 1) the nearshore shallow water marine Saddle Peak Member, 2) the terrestrial Fernwood Member, and 3) the nearshore shallow-water Cold Creek Member.

Conejo Volcanic Complex (Early Miocene)
The Conejo Volcanic complex is widely exposed in the Santa Monica Mountains, particularly in the western half of the range. The lower rocks of this volcanic formation are submarine as evidenced by pillow lavas, but the middle and upper portions erupted above sea level. The elevation of the volcano may have been greater than 4,300 feet and there is evidence that a low montane subtropical forest grew in this volcanic highland. Eruptions occurred from about 17 million years ago to about 16 million years ago. Basalt is the most common extrusive igneous rock; basaltic andesite and volcanic mudflows (lahars) are also common. Other volcanic rocks of the same age include diabase and dacite.

Calabasas Formation (Middle Miocene) (aka Upper Topanga Formation)
The Calabasas formation, named for Calabasas Peak, consists chiefly of marine sandstone (medium- to thick-bedded medium- to coarse-grained wackes, commonly showing graded bedding) and inter-bedded silty shale (locally diatomaceous or phosphatic), with zones of large dolomitic concretions. This formation is exposed in the central and eastern Santa Monica Mountains, and also occurs in the Simi Hills and in the Santa Susana Mountains south of Big Mountain.

Modelo Formation (Middle - Late Miocene) (aka Monterey Formation)
The Modelo formation is a marine formation built by deposits from turbidity currents on submarine fans and settling sediments. It includes massive units of coarse gray and brown sandstones, calcareous and siliceous shales, and soft white diatomaceous shale. This formation can be found in the eastern Santa Monica Mountains.

Saugus Formation (Pleistocene)
Although the Saugus formation is better known from the hills and mountains of the former Ventura basin such as the Simi Hills and Santa Susana Mountains, a small area in the Santa Monica Mountains has been mapped as Saugus. This formation is divided into a shallow marine lower portion and a nonmarine upper portion.

Simi Hills and Santa Susana Mountains
The Simi Hills run east-west and extend approximately 26 miles with an average width of 7 miles. The Simi Hills separate the Conejo Valley (west), Simi Valley (east) and San Fernando Valley (north). These are lower elevation hills with a mean elevation of 1,500 feet. Simi Peak (2,403 feet) is the highest point in the Simi Hills. The Simi Hills also serve as an important ecological connection between the Santa Monica Mountains and the Santa Susana Mountains to the north.

The Santa Susana Mountains form the northwestern portion of the study area. The western extent of the Santa Susana Mountains, known as the South Mountain-Oak Ridge complex, terminates in the Oxnard Plain in Ventura County and is not included within the study area. The eastern edge of the Santa Susana Mountains is defined by Newhall Pass (aka San Fernando Pass), in Los Angeles County, which separates the range from the San Gabriel Mountains to the east. The Santa Susana Mountains divide the Santa Clara River Valley and the Santa Clarita Valley to the north, from the Simi Valley and San Fernando Valley to the south. The eastern Santa Susana Mountains (east of California State Route 23) are approximately 21 miles in length and average 6 miles in width. The mean elevation is approximately 2,000 feet. The highest point of the Santa Susana Mountains is Oat Mountain with an elevation of 3,747 feet.

Geologically, the Simi Hills and Santa Susana Mountains share many similarities. Both ranges are sedimentary in origin, uplifted from the Ventura basin. The stratigraphy of the ranges is similar, though the Santa Susana Mountains uplifted more recently, within the last million years. The Simi Hills date from the late Cretaceous (Chatsworth formation) to the present (surficial deposits). Rocks in the Santa Susana Mountains are primarily late Paleocene to the present in age, though there are some exposures of the much older Chatsworth formation in the vicinity of Rocky Peak where the Santa Susana Mountains meet the Simi Hills. The formations vary from deep to shallow marine, to terrestrial stream deposits or alluvium, due to changes in ocean levels and the location of the coast over time (*Figure 2-2: Geology*).

The stratigraphy in the Simi Hills and the Santa Susana Mountains generally includes the following formations from oldest to youngest: Chatsworth, Simi Conglomerate, Las Virgenes Sandstone, Santa Susana, Llajas, Sespe, Topanga Canyon, Conejo Volcanic complex, Calabasas, Modelo, Towsley, Pico, Saugus, and surficial terrace deposits. The following descriptions include the formations not already described in the "Rock Formations of the Santa Monica Mountains" section above.

Rock Formations in the Simi Hills and Santa Susana Mountains

The following descriptions of rock formations are primarily based on an internal National Park Service technical report from 2012 "Paleontological resource inventory and monitoring: Mediterranean Coast Network" by Tweet, Santucci, and Connors.

Chatsworth Formation (Late Cretaceous)

The colorful boulders of the Chatsworth formation, a deep marine sandstone, provide spectacular scenery in the vicinity of Santa Susana Pass between Chatsworth and Simi Valley. The Chatsworth formation is mostly composed of sandstone and mudstone beds formed by submarine fan deposits.

Las Virgenes Sandstone (Early Eocene – Late Paleocene)

The Las Virgenes Sandstone is part of the Lower Cenozoic section of the Simi Hills although it has also been reported from Solstice Canyon in the Santa Monica Mountains. It is found west of the Runkle Canyon – Burro Flats Fault zone. The formation is up to 640 feet thick and is composed of sandstone, mudstone, and carbonaceous silty sandstone. This sandstone was part of a marine transgression

The Simi HIlls and Santa Susana Mountains include colorful outcrops. Photo: NPS.

and deposition occurred in both marine and nonmarine settings. The formation changes from sandy fluvial deposition in the west to nearshore deposition to the east.

Towsley Formation (Late Miocene - Early Pliocene)
The Towsley formation consists of interbedded marine siltstone, mudstone and conglomerate.

Pico Formation (Late Pliocene - Early Pleistocene) (aka Fernando or Repetto Formations)
The Pico formation is named for Pico Canyon on the north side of the Santa Susana Mountains. It is made of shallow marine sediments, soft claystone, siltstone, and commonly fossiliferous sandstones. This oil-producing formation is intensely deformed and faulted.

Conejo Mountain/ Las Posas Hills

The Conejo Mountain area is not an official geographic term, but for the purposes of this study, this term is used to describe the upland hills located outside of the SMMNRA boundary to the northeast of the campus of California State University at Channel Islands, including the steep hillsides of the Conejo Grade along Highway 101, the volcanic ridges of Wildwood Park and Mount Clef Ridge near California Lutheran University in Thousand Oaks and the hills near the Ronald W. Reagan Presidential Library & Museum in Simi Valley. The highest point in this area is Conejo Mountain (elevation 1,814 feet). The Las Posas Hills are located north of the city of Camarillo on the north side of the Santa Rosa Valley. The highest point in these hills is Las Posas West (1,053 feet).

Molten rock erupted from beneath the sea near what is now Newbury Park when the rotation of the Transverse Ranges began 17 million years ago. The lava flows created short-lived islands in the area that were eroded away once volcanic action and rotation ceased. This volcanic sequence in the western Santa Monica Mountains is known as the Conejo Volcanic complex and is described above in the section on "Rock Formations of the Santa Monica Mountains."

Rock Formations in Conejo Mountain/Las Posas Hills

The Sespe formation, Conejo Volcanic complex, and the Calabasas formation occur as small exposures along the Simi-Santa Rosa Fault zone that runs east-west between the Conejo Mountain area and the Las Posas Hills (*Figure 2-2: Geology*).

The Conejo Mountain area south of the Santa Rosa Valley is primarily composed of rocks from the Conejo Volcanic complex. The Las Posas Hills to the north are almost entirely composed of rocks from the Saugus formation. Both formations are described above in "Rock Formations of the Santa Monica Mountains."

Verdugo Mountains/ San Rafael Hills

The Verdugo Mountains, located at the eastern edge of the San Fernando Valley, are a northwest-southeast trending, lens-shaped series of ridges approximately nine miles long and varying from three to four miles in width. The mountains are separated on the north and northeast from the main body of the San Gabriel Mountains by extensive alluvial fans of the Sunland-Tujunga and La Crescenta areas. Bordering the Verdugo Mountains on the north is Big Tujunga Wash. To the south, the Verdugo Wash separates the Verdugo Mountains from the San Rafael Hills. The highest point in the Verndugo Mountains is Mount Verdugo (3,126 feet) (City of Glendale 1993).

This primary ridgeline separates the San Fernando Valley from the La Crescenta Valley. The Verdugo Mountains are characterized by steep terrain, sharp ridgelines, and deep v-shaped canyons that contain ephemeral drainages and vegetation dominated by native species (City of Burbank 2012).

The San Rafael Hills are located east of the Verdugo Mountains and are bordered on the west by Verdugo Canyon and on the east by the Arroyo Seco. The San Rafael Hills are approximately three and one-half miles wide and are nearly four and one-half miles long on their north-south axis. These hills are dissected by two distinct canyon areas, Scholl and Sycamore canyons. Flint Peak rises to 1,887 feet,and is the highest elevation in the San Rafael Hills.

The Verdugo Mountains and San Rafael Hills are separated from the San Gabriel Mountains by a sunken block that has filled with alluvium (La Crescenta Valley). The geology of the Verdugo Mountains is similar to that of the San Gabriel Mountains (*Figure 2-2: Geology*).

The region is experiencing active mountain building and the San Gabriel Mountains are some of the fastest growing mountains in the world, rising an average of two inches a year (Murphy 1985).

The Verdugo Mountains are composed of metamorphic and igneous basement rocks of Precambrian to Early Cretaceous age. A thin soil mantle that varies in depth throughout the mountains generally overlies these basement rocks (Burbank 2012).

San Gabriel Mountains

The San Gabriel Mountains are approximately 50 miles long and 15 miles wide. The western portion of the mountain range is within the study area. The San Gabriel Mountains contain some of the steepest and most rugged terrain of all the mountains in the Transverse Ranges. The highest peak, located east of the study area, is Mount San Antonio. Also known as "Mt. Baldy" or "Old Baldy," this peak reaches a height of 10,064 feet. Mountains on the western end of the range are generally lower in elevation, around 4,000 to 6,000 feet above sea level. The highest peak in the western San Gabriel Mountains is Mount Gleason, elevation 6,520 feet.

The San Gabriel Mountains are a high, rugged geologic block located between the Los Angeles basin and the Mojave Desert. The Sierra Madre Fault zone forms the range's southern boundary. The northeastern boundary is the San Andreas Fault zone, which crosses through Cajon Pass and separates the higher San Bernardino Mountains. The San Gabriel Mountains face the Soledad basin on the northwest and the San Fernando Valley on the west, and the San Gabriel Valley to the south.

The San Gabriel Mountains rise quickly from the foothills, with slopes as steep as 65-70%. This can be attributed to the fact that the San Gabriel Mountains are a young mountain range. The region is experiencing active mountain building and the San Gabriel Mountains are some of the fastest growing mountains in the world, rising an average of two inches a year (Murphy 1985).

The geologic history of the San Gabriel Mountains and the Los Angeles basin involves vertical and lateral movements of great magnitude. The San Gabriel Mountains are a remarkable range that provides a window deep into the ancient crust of the earth and a key for understanding the evolution of the San Andreas Fault in southern California. The diverse assemblage of rocks in the San Gabriel Mountains includes some of the oldest rocks in California.

Rock Formations of the San Gabriel Mountains

Rock formations in the San Gabriel Mountains are quite diverse in age and composition (*Figure 2-2: Geology*). The formations range from Precambrian igneous and metamorphic rocks to recent alluvium deposited by streams and rivers. Bedrock units in the San Gabriel Mountains are composed primarily of crystalline basement rocks that range in age from the Precambrian to Mesozoic eras. Cenozoic beds, including the fossiliferous and terrestrial Mint and Tick formations, are located only along the range's western and northern margins (see descriptions below under "Rock Formations in the Soledad Basin/Upper Santa Clara River").

Basement rocks exposed in the western San Gabriel Mountains, the upper-plate rocks of

The Conejo Mountain/Las Posas Hills area (foreground) are adjacent to the Santa Monica Mountains (background). From this area are views of the Pacific Ocean and Channel Islands National Park (right, background). Photo: NPS.

the Vincent thrust, include Mendenhall gneiss, augen gneiss, and the anorthosite-syenite-gabbro complex. Augen gneiss in the western San Gabriel Mountains has been dated as the oldest rocks in the Transverse Ranges (1.7 billion years). Triassic granitic rocks associated with the Mount Lowe plutonic suite are also exposed here (Dibblee 1982; Norris and Webb 1990). The anorthosite complex includes an anorthosite pluton, syenite and mafic rocks of a Proterozoic age. This type of complex is rare, particularly in a relatively young geological landscape (Dibblee 1982).

In the southwest corner of the mountains, the Tujunga Terrane, named for rocks exposed in lower Tujunga Canyon, contains basement rocks such as gneisses, late quartz diorite, and granodiorite-quartz, as well as metasedimentary rocks associated with the pre-Triassic Placerita formation.

Upper Santa Clara River (Soledad Basin)
The Soledad basin lies at the northwestern base of the San Gabriel Mountains. On the north, it is defined by the Sierra Pelona. The San Andreas Fault and the San Gabriel Fault bound the basin on its northeast and southwest borders. The Upper Santa Clara River and its headwaters drain from both the San Gabriel Mountains and the Sierra Pelona into the Soledad basin and Santa Clarita Valley.

A large syncline forms the structure that is known as the Ventura basin in the west and the Soledad basin in the east. This structure is about 120 miles long and includes the Santa Barbara Channel between the Channel Islands and the Santa Ynez Mountains as well as the uplifted Simi Hills and the Santa Susana Mountains. The Ventura basin is famous for its remarkably thick section of mostly marine sedimentary rocks, which totals more than 58,000 feet thick (Norris and Webb 1990). The Soledad basin east of the San Gabriel Fault contains mainly middle and late Cenozoic nonmarine sedimentary rocks that rest on the crystalline basement of the San Gabriel Mountains to the south and the Sierra Pelona to the north. Geologic features of the Soledad basin include the prominent hogback ridges at Vasquez Rocks and the borax deposits at Tick Canyon. Except for the Santa Barbara Channel, the entire area was subjected to strong uplift, folding, and faulting during the middle Pleistocene. This produced today's topography and created the structures in which the region's prolific oil fields developed.

Rock Formations in Soledad Basin/Upper Santa Clara River
The Soledad basin contains various Cenozoic rock units (*Figure 2-2: Geology*). The marine Martinez formation of Paleocene age is the oldest sedimentary unit in the region.

Vasquez Formation (Oligocene)
The Martinez formation is overlaid by the Oligocene Vasquez formation of andesite volcanic rocks, non-marine red beds, sedimentary breccia, claystone, mudstone and limestone. The Vasquez formation is spectacularly displayed at Vasquez Rocks County Park just north of the study area (Weigand 1982).

Tick Canyon Formation (Miocene)
Overlaying the Vasquez formation is the Miocene Tick Canyon formation, which is composed of conglomerate sandstone and siltstone of fluvial origin (Oakeshott 1971).

The Verdugo Mountains (foreground) and the San Gabriel Mountains (background) border the La Crescenta Valley which is largely developed. Photo: NPS.

Mint Canyon Formation (Miocene)
The most widespread formation in the Soledad basin is the Mint Canyon formation. Its distinctive reddish beds of arkosic and conglomerate sandstone formed from silt deposits in an ancient Miocene lake. A considerable number of fossils have been identified in the Mint Canyon formation (see "Paleontological Resources" section below).

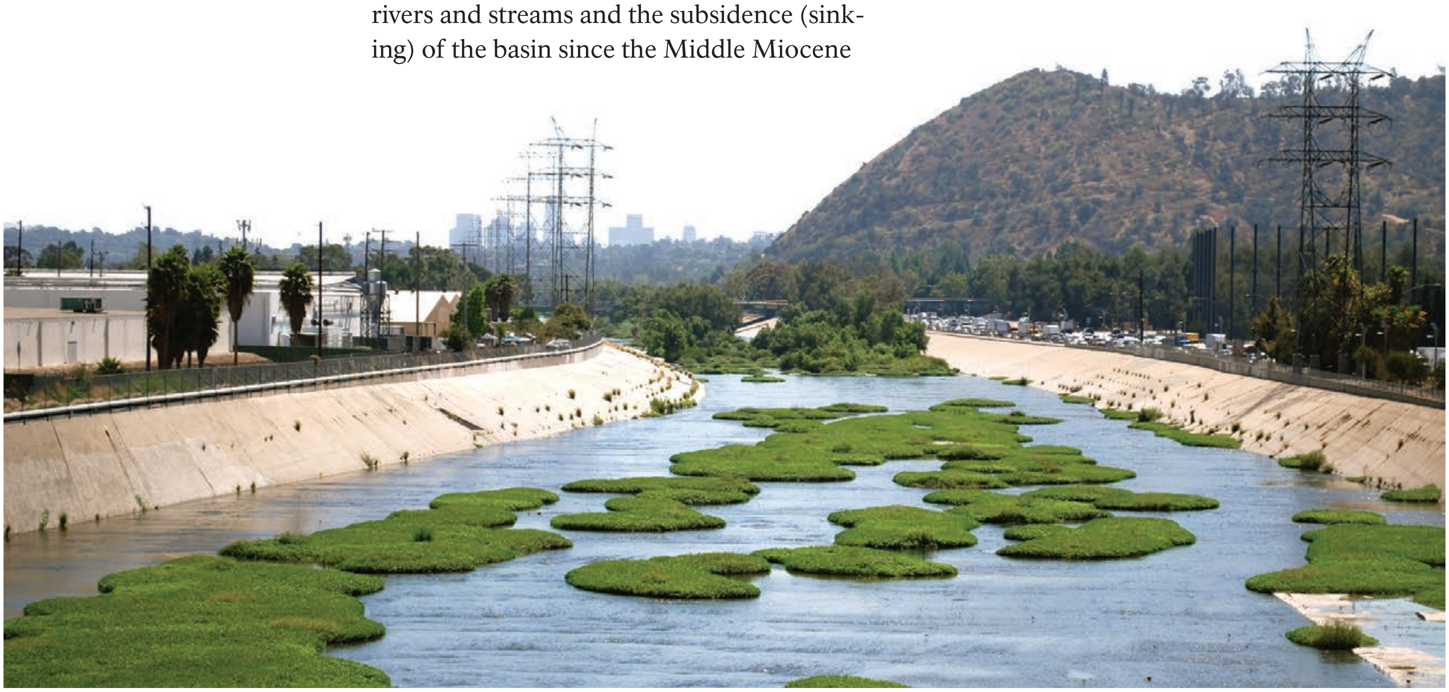
Other Formations
Younger Cenozoic formations in the Soledad basin include the Towsley formation (described above under "Rock Formations of the Simi Hills and Santa Susana Mountains") and the Saugus formation (described above under "Rock Formations of the Santa Monica Mountains").

Arroyo Seco and Los Angeles River Corridors (Los Angeles Basin)
The Arroyo Seco and Los Angeles River subgeographic areas are narrow river corridors that traverse the Los Angeles basin. The Los Angeles basin is a depositional basin and alluvial fan which lies at the northern extent of the Peninsular Ranges Geomorphic Province and the southernmost extent of the Transverse Ranges Geomorphic Province (Yerkes et al. 1965, Bilodeau et al. 2007).

Most of the Los Angeles basin area consists of alluvium, thousands of feet deep in some areas, compiled from years of deposits from rivers and streams and the subsidence (sinking) of the basin since the Middle Miocene (*Figure 2-2: Geology*). During this time ranges like the San Gabriel and Santa Monica Mountains were rapidly rising and eroding. The sedimentary deposits are believed to be more than 20,000 feet thick, highly fossiliferous, and oil-producing (Yerkes et al. 1965, Bilodeau et al. 2007).

The Arroyo Seco corridor below the San Gabriel Mountains extends to the Los Angeles River. The Arroyo Seco is characterized by alluvial fan deposits on its flanks and younger alluvium, colluvium, and man-made artificial fill in the river channel. Bedrock units include the Miocene-age Topanga formation consisting of sandstone and conglomerate, and an igneous body of quartz diorite (USACOE and Los Angeles County Department of Public Works 2011).

The Los Angeles River corridor within the study area, and extending west into the San Fernando Valley, contains layers of alluvium and colluvium primarily derived from Miocene sedimentary rock eroded from the Santa Monica and Santa Susana Mountains. Further east along the river corridor, alluvium and colluvium are derived from granitic and metamorphic terrain. Similar to the Arroyo Seco, within the river channel itself are areas of man-made artificial fill as a result of flood protection engineering (USACOE 2013).



The Los Angeles River flows through valleys characterized by alluvium and colluvium eroded from the surrounding mountains. Photo: William Preston Bowling.

As one of the few places on Earth where a transform-fault plate-boundary occurs on land rather than beneath the sea, the San Andreas Fault system is one of the most studied structural features on the planet.

Tectonic Setting and Major Faults in the Study Area

Faults

A number of significant fault systems are located in or near the Rim of the Valley Corridor study area (*Figure 2-2: Geology*). The following section provides a short description of the study area's major faults.

Generally, the Rim of the Valley Corridor study area is defined on the south by the Santa Monica-Hollywood-Raymond-Sierra Madre Fault Zones. Geologically, this is where the Transverse Ranges Geomorphic Province meets the Peninsula Ranges Geomorphic Province. The Raymond Fault extends east from the Santa Monica Mountains to the Sierra Madre-Cucamonga Fault Zone near Arcadia. This fault produces a very obvious south-facing scarp along much of its length. Similarly, the Verdugo Fault marks the southwest facing scarp of the Verdugo Mountains.

The San Gabriel Mountains are bounded by fault systems including the San Andreas Fault system to the north and the Cucamonga-Sierra Madre Fault complex to the south and southwest. On the east the mountains are bounded by faults in the San Jacinto Fault Zone, an extension of the San Andreas Fault system. The San Gabriel Fault Zone cuts through the heart of the San Gabriel Mountains and extends northwest through the Sierra Pelona.

The Sierra Madre Fault Zone is a steep, north dipping, front-range fault along which most of the uplift of the San Gabriel Mountains has occurred. Activity on this fault is very recent (Norris and Webb 1990).

At the western end of the study area where the Santa Monica Mountains meet the Oxnard Plain lies the Bailey Fault. Other faults within the study area include the Oak Ridge Fault, the Simi-Santa Rosa Fault Zone, the Santa Susana Fault, the Chatsworth Fault, the Northridge Hills Fault, the Mission Hills Fault, the Verdugo Fault, the Vazquez Creek Fault, and the Soledad Basin Faults.

In addition to these mapped faults, the region contains blind thrust faults. Blind thrust faults are shallow-dipping reverse faults that lie entirely below the earth's surface. Although many of these faults remain unknown, two regional examples are the Puente Hills Blind Thrust, which runs underneath downtown Los Angeles and was the source of the 1987 Whittier Narrows earthquake, and the Northridge Thrust Fault, which ruptured in the 1994 Northridge earthquake. A summary of significant earthquakes is provided in *Table 2-1: Significant Earthquakes Within or Near the Study Area*.

San Andreas Fault System

The San Andreas Fault system formed along the translational boundary between the North American and Pacific Plates. As one of the few places on Earth where a transform-fault plate-boundary occurs on land rather than beneath the sea, the San Andreas Fault system is one of the most studied structural features on the planet. Convergent transform movements are responsible for the mountain building activities which continue to form the San Gabriel Mountains and other Transverse Ranges. Although the rate of movement varies over time, geologists believe that the Pacific Plate is currently moving northwest at a rate of almost 5 centimeters (1.96 inches) per year.

Throughout the year the San Andreas Fault experiences many small earthquakes as the Pacific Plate continues its journey north. Large earthquakes are also associated with this fault. Several miles north of the study area, the Fort Tejon earthquake of 1857 (7.9 magnitude) was one of the largest earthquakes experienced in southern California. An extensive rupture was accompanied by the greatest right-lateral offset yet observed on the San Andreas system, some 30 feet (Norris and Webb 1990).

The San Gabriel Fault is an older strand of the San Andreas Fault system. Credited with defining the general east-west trend of Transverse Range structure, the San Gabriel Fault strikes southeast from Frazier Mountain and enters the San Gabriel Mountains on the western end. It appears to be offset in the San Antonio Canyon by north-south trending San Antonio and Stoddard Canyon Faults, with the eastern segment terminating against the San Jacinto Fault. The San Gabriel Fault's wide crush zone has strongly affected topography and drainage. For example, the east and west forks of the San Gabriel River follow the fault for most of their lengths.

During the last 12 million years, the San Gabriel Fault is estimated to have undergone about 60 kilometers/40 miles of right slip movement which is thought to have ceased about 5 million years ago. The San Gabriel Fault has also experienced varying degrees of vertical displacement. Along the southwest side of the Ridge basin, vertical displacement is as much as 14,000 feet. The San Gabriel Fault has experienced only minor activity in recent times (Norris and Webb 1990).

San Fernando Fault Zone

The San Fernando Fault Zone is a zone of thrust faults in the northern San Fernando Valley. The San Fernando earthquake of 1971 (also known as the Sylmar earthquake, 6.6 magnitude) was one of the strongest earthquakes experienced in this area in modern times. The earthquake caused over $500 million in property damage and 65 deaths. Although this earthquake was set off by the San Fernando Fault Zone within the study area, seismologists have shown that the San Fernando earthquake defined a north-dipping reverse fault that corresponded to the surface breaks observed along segments of the Sierra Madre Fault zone. The San Fernando earthquake alone caused a three foot uplift of the San Gabriel Mountains (Norris and Webb 1990).

Oak Ridge Fault Zone

This fault dips to the south, at a fairly shallow angle. Thus, epicenters of earthquakes on this fault may appear far removed from the surface trace. The surface trace of the Oak Ridge thrust is roughly paralleled by both the Santa Clara River and California State Route 126 just north of the study area. At its eastern end, the Oak Ridge thrust appears to be overthrust by the Santa Susana Fault, thus becoming a blind thrust fault. Indeed, the fault associated with the 1994 Northridge earthquake is probably part of the Oak Ridge Fault system, since it shares many of the characteristics of this fault (Southern California Earthquake Data Center 2014, Jennings 1994).

Soledad Basin Faults

Numerous northeast-striking faults cut across the sedimentary and basement rocks of the Soledad basin including the Lone Tree and Soledad Faults (Wilson and Hernandez 2003). The Soledad fault runs through Soledad basin where it brings the crystalline basement rocks of the San Gabriel Mountains in contact with tertiary rocks to the west.

Landslides

Landslides form widespread and important physiographic elements in the highly fractured rocks of the Transverse Ranges. Activity along the San Andreas Fault zone has caused some of the largest landslides in California. Examples include Crystal Lake in the San Gabriel Mountains, Cow Canyon, Manker Flats and Coldwater Canyon. Some of the largest landslides in southern California (including Crystal Lake) are located in the Angeles National Forest (USFS 2005). Moderate to large landslides also occur in the Santa Monica Mountains, Santa Susana Mountains, and Simi Hills, predominantly in weak, folded and faulted tertiary sedimentary rocks. Large landslides are infrequent occurrences but demonstrate the potential hazards to development below unstable areas (California Department of Conservation 2013).

Erosion and Debris Flows

The highly erosive steep slopes of the San Gabriel Mountains produce considerable amounts of sand, mud, and aggregate. After fires clear steep slopes of vegetation, winter rains may cause these materials to move in debris flows which can be highly destructive to anything in their path.

Table 2-1: Significant Earthquakes Within or Near the Study Area (Magnitude > 6.5 or that caused loss of life or more than $200,000 in damage)

Date	Magnitude	Name, Location, or Region Affected	Loss of Life and Property
1857, Jan. 9	7.9	Great Fort Tejon earthquake	1 dead; damage from Monterey to San Bernardino County
1899, July 22	6.4	Wrightwood	Chimneys knocked down; landslides reported
1933, Mar. 11	6.4	Long Beach	115 dead; $40 million in property damage
1971, Feb. 9	6.6	San Fernando (aka Sylmar)	65 dead; more than 2,000 injured; $505 million in losses
1987, Oct. 1	6.0	Whittier Narrows	8 dead; $358 million in property damage to 10,500 homes and businesses
1994, Jan. 17	6.7	Northridge	57 dead; more than 9,000 injured; about $40 billion in property damage

Source: California Geological Survey 2004

In the 1920s, Los Angeles County was the world's fifth largest oil producer.

As described later in the *Water Resources, Flood Management* section of this chapter, Los Angeles County has constructed a series of debris basins along the foothills of the San Gabriel Mountains to protect foothill residents from debris flows.

Mineral Resources

The study area is rich in a variety of mineral resources including petroleum, gravel products, metals, and other commodities.

Petroleum Products

The study area overlies the Los Angeles and Ventura oil basins, geologic areas well known for their petroleum resources. The source of oil resources is primarily lower Pliocene and upper Miocene strata.

Native Americans used seeps of asphalt that oozed to the surface on the north side of the Santa Susana Mountains from Pico Canyon to Placerita Canyon. The oldest producing oil field in California is in Pico Canyon near Newhall. Oil was collected here as early as 1850 (Norris and Webb 1990). In the 1920s, Los Angeles County was the world's fifth largest oil producer. Presently, oil production is less prevalent than it was almost a century ago, although some oil and natural gas wells are still in production, primarily in the Santa Susana Mountains. While many older mines and oil wells have been abandoned, recent oil price increases have prompted drilling of new wells and reopening of some idle wells (California Department of Conservation 2009). In addition, natural gas is stored subsurface in gaps in the rock layers where oil was previously extracted. The 3,600 acre Aliso Canyon Storage Facility, north of Porter Ranch, is one of the largest of these storage facilities in the country.

Sand, Gravel, and Other Rock Products

The erosive San Gabriel Mountains provide a seemingly endless source of aggregate which is an ingredient for building roads and concrete structures. Sand, gravel, and other rock products are the most significant mineral resources, exclusive of petroleum, in the Transverse Ranges (Morton 1982; Dibblee 1982). Generally, aggregate mining sites are located in the Upper Santa Clara River including Canyon Country, Agua Dulce, Mint Canyon, and Soledad Canyon. Sand and gravel resources are primarily concentrated along waterways, including the Santa Clara River, the South Fork of the Santa Clara River, and east of Sand Canyon Road. A significant deposit of construction-grade aggregate extends approximately 15 miles from Agua Dulce Creek in the east, to the Ventura County line on the west.

In addition, there is a small gravel quarry operation located west of Conejo Mountain area in the westernmost part of the study area. In Grimes Canyon, just west of the study area in the Santa Susana Mountains, there is a rock quarry that harvests rock products including "smoking shale," a decorative rock used for pavers and hard scape which was valued by prehistoric Native Americans for making arrowheads and tools.

Metallic and Non-metallic Mineral Resources

The San Gabriel Mountains are rich in both metallic and non-metallic mineral resources. Most notably, Placerita Canyon, located on the northwestern slopes of the San Gabriel Mountains was a discovery site for gold in 1842, six years before gold was discovered in the Sierran foothills. In the past, Upper Santa Clara River sites yielded, copper, iron, quartz and titanium.

Old terranes in the western San Gabriel Mountains have also been mined for gold. Active gold mining still takes place near Acton where there are quartz vein gold deposits (Morton 1982). Historically, minor amounts of gold were obtained from the Mount Lowe plutonic suite southwest of Soledad Pass (Dibblee 1982). Although small amounts of gold were mined in basement rocks prior to 1940, most have not been profitable.

Other known commodities in the San Gabriel Mountains include aluminum, asbestos, asphalt, barite, clays, beryllium, copper, diatomite, feldspar, graphite, iron, limestone products, manganese, mica, oil and gas, platinum, silica, slab rock, silver, titanium, tungsten, uranium, and zirconium. (NPS 2013f)

Paleontological Resources

Paleontological resources are fossilized remains of non-human organisms. Most paleontological sites include remains of species that are now extinct. The study area contains a diverse assemblage of paleontological resources that are sought by collectors, universities, and

Santa Monica Mountains National Recreation Area contains one of the most extensive and diverse assemblages of fossil material known in the national park system.

Many "type specimen" fossils have been found in SMMNRA. Type specimens serve as a standard for other fossil comparisons and are the specimens on which a scientific name is based. Fossil type specimens have been found in 55 national park units; SMMNRA is ninth on the list for number of type specimens discovered. Photos: NPS.

museums (*Table 2-2: Known Fossiliferous Formations of the Rim of the Valley Corridor Study Area and Types of Fossils found in the Formation*).

Santa Monica Mountains

Santa Monica Mountains National Recreation Area (SMMNRA) contains one of the most extensive and diverse assemblages of fossil material known in the national park system. Within SMMNRA there are at least 2,300 known fossil localities found in more than a dozen fossiliferous geologic formations. Invertebrate, vertebrate, botanical, protist, and trace fossils occur, ranging in age from the Late Jurassic to Pleistocene. Fossils that provide the basis for description of species that are new to science are called type specimens. The Santa Monica Mountains have yielded at least 50 type specimens (J. Tweet, pers. comm., Sept. 2014). The most abundant of the fossils found at SMMNRA include bivalves, cephalopods and gastropods while the least abundant fossil remains are plant material. Fossilized fish make up the majority of the vertebrate material and can be found in Late Cretaceous, Miocene, and Quaternary deposits. Other fossil remnants include arthropods, echinoderms, amphibians, reptiles, birds, and mammals (Tweet, et al. 2012).

The quality of preservation is remarkable in many specimens, especially the fully articulated skeletons of fossil fish that can be compared to the caliber of the world-famous Eocene Green River formation fossil fish from Wyoming (Fossil Butte National Monument), Utah, and Colorado. The two most noteworthy fossil localities in the Santa Monica Mountains are the Old Topanga Canyon (Amphitheater) site, which is on private land within SMMNRA, and the fossil fish localities in the Modelo formation, some of which are on private land and some of which are preserved within Fossil Ridge Park, a Santa Monica Mountains Conservancy property (Koch 2004).

Simi HIlls and Santa Susana Mountains

Although many of the rock formations exposed in the Simi Hills and Santa Susana Mountains are the same as those in the Santa Monica Mountains, the fossil species represented here may be distinct due to the changing position of the coastline through the geologic ages. Particularly fossiliferous formations in the Simi Hills and Santa Susana Mountains that also occur in the Santa Monica Mountains are the Llajas and Sespe formations. In addition, there are at least two fossiliferous formations, the Towsley and Pico formations, which are represented in the Simi Hills and Santa Susana Mountains but not in SMMNRA. Numerous type specimens have been found in these formations.

Paleontologists have found dozens of foraminifera micro-fossil species and dozens of mega-fossil species in the Pico formation on the north side of the Santa Susana Mountains in Pico Canyon eastward to the contact with the San Gabriel Mountains in Elsmere Canyon. The upper part of the Pico formation is quite fossiliferous, including marine species such as sand dollars, oysters, and mollusks, particularly in the area around San Fernando Pass (Winterer and Durham 1962).

The Las Virgenes Sandstone formation is present in SMMNRA but is not fossiliferous in the Santa Monica Mountains or Simi Hills within SMMNRA. In the Simi Hills outside of SMMNRA, the Las Virgenes Sandstone formation contains some logs, clams, snails and burrows (Parker 1983a and 1983b, Saul 1983, Squires 1997). In the Santa Susana Mountains, paleontologists have found an abundance and diversity of fossils in the Llajas formation in the Las Llajas drainage on the south side of the range (Squires 1979, 1981a, 1983a, 1983b, 1984, and 2001).

Significant fossil material was also recovered from the Simi Valley landfill during an environmental mitigation for a recent expansion of the landfill. Similarly, construction projects in the Santa Monica Mountains, Simi Hills and Santa Susana Mountains have yielded many specimens. In all, more than 100 fossil mammal species from 35 families have been recognized in the Sespe formation (Lander 1983 and 2011).

Conejo Volcanic Complex

A large portion of the Conejo Volcanic complex, which contains some fossils, is located within the study area outside of SMMNRA. Fossil deposits have been identified on Conejo Mountain in Newbury Park, and on other volcanic hills in the city of Thousand Oaks. These contain sparse fauna (Yerkes and Campbell 1979), fossil wood (Stadum and

Table 2-2: Known Fossiliferous Formations of the Rim of the Valley Corridor Study Area and Types of Fossils Found in the Formation

Geologic Epoch (Million Years Ago, Ma)	Formation (alternate names)	Type	Notable fossil groups
Late Jurassic (157-152 Ma)	Santa Monica Slate	Deep marine	Ammonites, clams
Late Cretaceous (93-75 Ma)	Tuna Canyon	Shallow to moderate depth marine	Foraminifera (amoeba-like protists that secrete shells), ammonites, clams, nautiloids, snails, plant fragments. A number of new species described from this formation in the Santa Monica Mountains.
Late Cretaceous (90-69 Ma)	Chatsworth	Deep marine	Ammonites, nautiloids, snails, shark teeth
Late Paleocene (58-57 Ma)	Simi Conglomerate	Marine and Non-marine	Fossiliferous within SMMNRA. Includes plant fragments, clams, snails, burrows.
Late Paleocene to Early Eocene (57-56 Ma)	Las Virgenes	Marine and Non-marine (fluvial)	Not fossiliferous within SMMNRA. Sparsely fossilferous in Simi Hills and Santa Susana Mountains where logs, clams, snails and burrows have been found.
Middle to Late Paleocene (56-55 Ma)	Santa Susana (Coal Canyon, Martinez)	Shallow marine	Algal limestone reefs, foraminifera, clams, snails, corals, crabs, echinoids, plant fragments, mollusks, pollen, shark teeth. A number of new species described from this formation in Santa Monica Mountains.
Middle to Late Eocene (41-36 Ma)	Llajas (Tejon)	Marine (varying depth)	Foraminifera, petrified wood, corals, cephalopods, shark and ray teeth, Turritella "reefs." Many new species described from this formation in the Santa Susana Mountains.
Late Eocene toEarly Miocene (30-26 Ma)	Sespe	Terrestrial ("redbeds")	More than 130 fossil mammal species from 35 families, petrified logs, palms, tortoise, opossum, rodents, pikas, camels, horses, frogs, insects, birds, snakes, bears, dogs, cats, tapirs, rhinoceroses, hippos, oreodonts (sheep-like ungulate).
Late Oligocene to Early Miocene (25-18 Ma)	Topanga Canyon and Non-marine	Marine (various)	Extensively fossiliferous in SMMNRA. Plant fragments and foraminifera. The privately owned Old Topanga amphitheater site is a marine layer of this era. It is the best known fossil site in Santa Monica Mountains (133 species). Fossils found here include whales, sea lions, sharks, rays, snails, clams and many more.
Early to Middle Miocene (20-15 Ma)	Tick Canyon (Soledad basin only)	Terrestrial	Pocket mice, rabbits, horse, oreodonts, camels, hawk
Early to Middle Miocene (17-15 Ma)	Conejo Volcanic	Volcanic (submarine and subaerial)	Petrified wood of various tree species, more than 70 species of invertebrate taxa including clams, snails, and barnacles considered rare from this era on the Pacific coast, and fish scales.
Middle Miocene (15-14 Ma)	Calabasas (Upper Topanga)	Deep marine	Foraminifera, diatoms, plant casts, clams, snails, barnacles, echinoids, fish scales, whales. Whale bones also found in Santa Susana Mountains and Simi Hills.
Middle to Late Miocene (13-6 Ma)	Modelo (Monterey)	Deep marine	Clams, snails, plant leaves, echinoids, shark teeth, sea lion, dolphin, and whale bones, and horse bones. This formation includes the spectacular cartilaginous and boney fish of Fossil Ridge Park and vicinity. 20 genera of fish from 18 families have been described from this site; 6 of these were new to science. This formation includes the extinct large "toothed" bird (Osteodontornis orri) found in the Sherman Oaks area and the Lincoln Heights Whale.
Late Miocene to Early Pliocene (6-4 Ma)	Mint Canyon (Soledad basin only)	Terrestrial	Horses, camels, rhinoceros, antelope, carnivores
Late Miocene- Early Pliocene (6-4 Ma)	Towsley	Shallow to deep marine	Foraminifera, mollusks, bi-valves, pelecypods, gastropods, (6-4 Ma) brachiopods, shark teeth, paleo-currents
Pliocene (4-3 Ma)	Pico (Repetto/Fernando)	Shallow marine	Brachiopods, clams, snails, echinoids in SMMNRA. Foraminifera, mollusks, gastropods, bivalves in Santa Susana Mountains and San Gabriel Mountains.
Lower Pleistocene (3-1 Ma)	Saugus	Terrestrial	Near Moorpark/Simi Valley fossils found include rodents, rabbits, mammoths, tapirs, horses, and llamas.

Sources: Tweet et al. 2012, Koch et al. 2004, Winterer and Durham 1962, NPS 2013, and Fritsche 2012
Note: Although the formations are listed from oldest to youngest, the stratigraphy of the study area varies by location.

A layer of scallop fossils up to several feet thick, known to paleontologists as the "pectinid marker bed," can be found in roadcuts throughout the central Santa Monica Mountains. This 20 million year old layer of fossil bi-valves is used by scientists to date rock layers in the field. Photo: NPS.

These 12 million year old herring fossils are one of twenty genera of fossil fish from 18 different families that have been identified in the Miocene Modelo formation in the eastern Santa Monica Mountains. SMMNRA contains one of the most extensive and diverse assemblages of fossil material known in the National Park Service. Photo: NPS.

Weigand 1999), and pockets of invertebrates in calcareous sandstone (Stanton and Alderson 2006, 2010).

San Gabriel Mountains (including Upper Santa Clara River)

The San Gabriel Mountains are primarily igneous in nature and therefore do not contain many fossils. The major exceptions are the Mint Canyon and Tick Canyon formations, which occur on the north side of the western San Gabriel Mountains within the study area. Neither of these formations is found within the SMMNRA boundary. The Mint Canyon formation includes vertebrate fossils such as Merychippus, Hipparion, Alticamelus, rhinoceroses, antelopes, and carnivores (Mount 1971). The Tick Canyon formation includes pocket mice, rabbits, grazing horses, oreodonts, camels and a hawk (Savage et al. 1954) (Oakeshott 1958).

Water Resources

Geographic Scope

The major rivers and tributaries of the study area in many cases have watersheds that extend beyond the Rim of the Valley Corridor. Descriptions of the broader watersheds of major river systems are described in this section.

Major Watersheds

The study area contains portions of four major watersheds: the Santa Clara River watershed, the Calleguas Creek watershed, the Santa Monica Bay watershed, and the Los Angeles River watershed. (*Figure 2-3: Major Watersheds*). The study area is located within the South Coast Hydrologic Region, which includes seven percent of the state's total land area and approximately 54% of the state's population (USACOE 2013).

Rivers and creeks in the study area have undergone significant changes since European settlement, most notably where there is urban development. Early explorers and surveyors provided detailed descriptions of water features in the Los Angeles basin and Santa Clara River valley. In the mountains and foothills, coastal watersheds feature largely natural streams with flows that range from intermittent to year round. In the northern study area, the Upper Santa Clara River remains largely natural, without major modifications. Where Calleguas Creek flows through the eastern Oxnard Plain near the base of the Santa Monica Mountains, it is channelized for flood protection. In the urbanized Los Angeles basin, river systems have been engineered to protect homes and businesses from flooding.

Santa Clara River Watershed

The Santa Clara River is the largest river system in southern California that remains in a relatively natural state. The river flows approximately 84 miles and drains 1,200 square miles from its headwaters to into the Pacific Ocean at the border between the cities of Ventura and Oxnard (City of Santa Clarita 2011). Principal tributaries to the Upper Santa Clara River include creeks located in Mint, Bouquet, San Francisquito, Castaic, and Oak Spring Canyons north of the Santa Clara River; and Soledad, Sand and Placerita Canyons south of

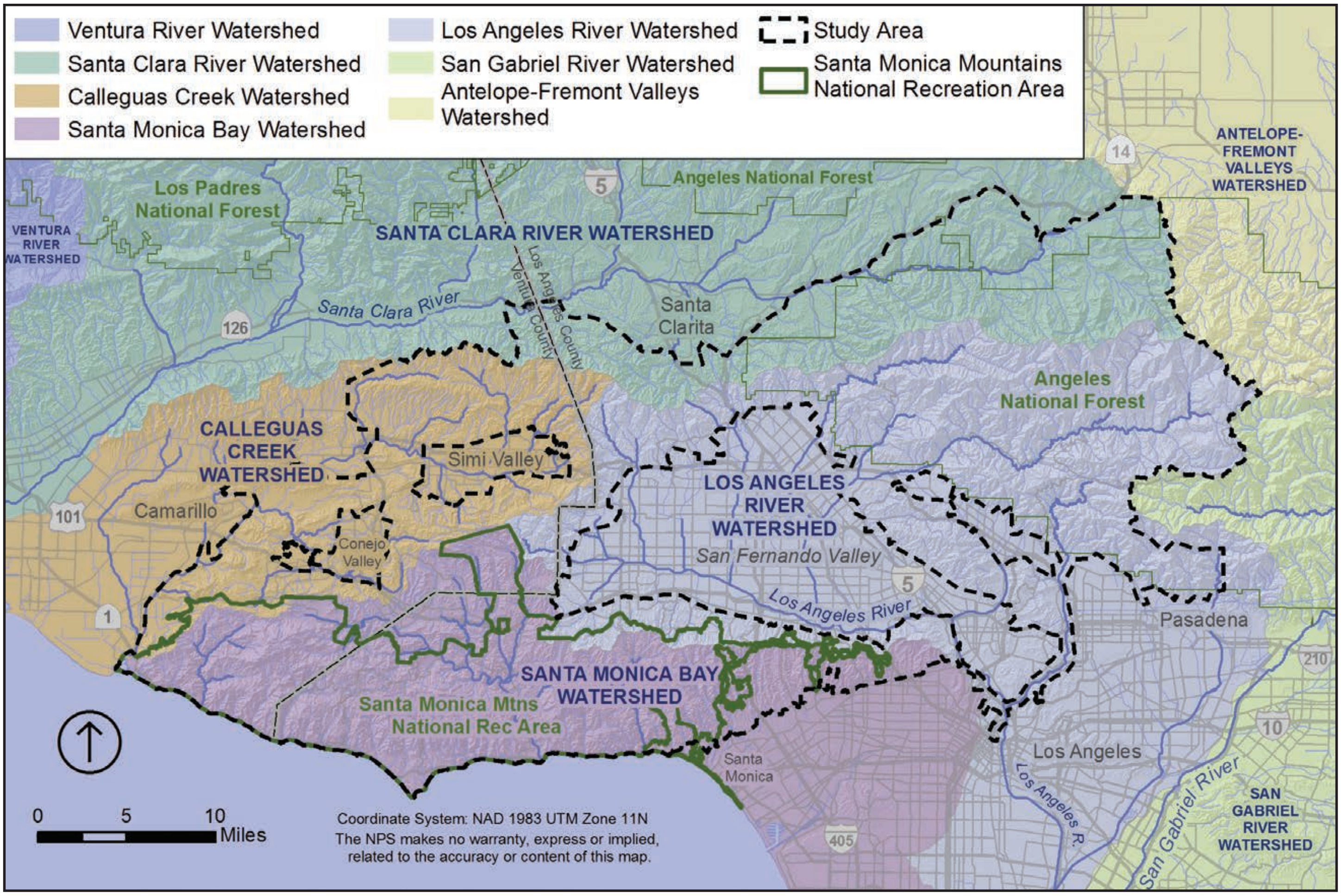


Figure 2-3: Major Watersheds

> The Santa Clara River is the largest river system in southern California that remains in a relatively natural state.

the Santa Clara River. The Upper Santa Clara River Watershed is located within the study area, including the north facing slopes of the San Gabriel and Santa Susana Mountains, and the southern area of the Santa Clara River Valley basin.

The Santa Clara River was described by early European settlers in the mid-1700s as having lush vegetation such as oak, cottonwood and willow that would be consistent with a steady source of water. Tributaries in the upper river, such as San Francisquito Canyon were described as dense riparian vegetation, which in places would fill entire canyons. Wetlands were also common as part of the watershed system, supporting wetland plants and a diverse array of birds (VCWPD & LACDPW 2005). Like other river systems in southern California, the Santa Clara River flooded periodically.

Flooding from the Santa Clara River periodically damaged agricultural lands and destroyed homes and infrastructure in the early part of the 20th century. Some physical alteration to the river from railroad development occurred as small agricultural towns established along the rail routes. The Saint Frances Dam was constructed in San Francisquito Canyon between 1924 and 1926 by the City of Los Angeles as part of the Los Angeles Aqueduct system. Only two years after its completion, the dam failed catastrophically, flooding the canyon and Santa Clara River Valley below, and significantly altering the physical shape of the river valley. The resultant flood killed over 400 people, destroyed 1,250 homes, and washed away 23,700 acres of orchards in what was one of the worst civil engineering disasters of the 20th century. A series of protective levees and groins were installed as a result. These became some of the earliest public works along the Santa Clara River (VCWPD & LACDPW 2005). Because of agricultural uses in the Santa Clara River Valley and less development, the river was not channelized to the same extent as the Los Angeles River, and thus remains in a more natural condition.

The only major dams in the watershed are located outside of the study area in the Sierra

Due to development in the watershed, Calleguas Creek is now a perennial stream and continuously fed by treated wastewater flows.

Pelona, north of the Santa Clara River. No major dams have been located on the main river channel, although the Vern Freeman Diversion Dam, downstream of the study area, diverts water for the United Water Conservation District. The Santa Clara River is also the last free-flowing riparian and wildlife corridor in the region, providing the primary remaining east-west biological connection between the San Gabriel Mountains and the Pacific Ocean (California Coastal Conservancy 2001).

The Upper Santa Clara River is largely ephemeral. As the river exits the confinement of the mountains, it has braided stream geomorphology characterized by the frequent shifting network of channels and intervening bars in a broad floodplain, which is typical of braided streams (LADPW 2005).

Calleguas Creek Watershed

The Calleguas Creek watershed is located in southwestern Ventura County, and drains 343 square miles of land including the western slopes of the Santa Monica Mountains, the Conejo and Simi Valleys and surrounding mountains and hills, and southern portions of the Oxnard Plain. Calleguas Creek enters the Pacific Ocean at Mugu Lagoon. Major tributaries to Calleguas Creek include Revolon Slough, Conejo Creek, Arroyo Santa Rosa, Arroyo Conejo, Arroyo Las Posas, and Arroyo Simi.

Historically, Calleguas Creek and its tributaries were intermittent and flowed seasonally, entering the Oxnard Plain somewhere between Somis and Mugu Lagoon, never reaching the Pacific Ocean. The Oxnard Plain was built from the sediments carried by the flood waters of the Santa Clara River starting about 300,000 years ago. A combination of rapid uplift of onshore areas and a later warming trend resulted in the creation of Mugu Lagoon and a shift of the Santa Clara River to its current location. Due to continued flood damage to lowland agricultural areas, local farmers from Somis began to channelize Calleguas Creek beginning in 1884, and Revolon Slough around 1924. Eventually, the creek was completely channelized (VCWPD 2010).

Due to development in the watershed, Calleguas Creek is now a perennial stream and continuously fed by treated wastewater flows, with secondary surface flows originating from rising groundwater, agricultural and urban runoff, and periodic stormwater flows (VCWPD 2010). The creek now drains through Mugu Lagoon to the ocean.

Mugu Lagoon is part of the Point Mugu Naval Air Weapons Station and is one of the largest relatively undisturbed salt marshes in southern California. The lagoon is a vital stop on the Pacific Flyway, a nursery ground for many marine fish and mammals, and is also a vital habitat for several threatened and endangered species. Some of these include the California least tern, light-footed clapper rail, Belding's savannah sparrow, and the tidewater goby. Although Mugu Lagoon has not been affected as much as other lagoons and estuaries in southern California, it has been altered. The effects of agriculture and urbanization within the Calleguas Creek watershed and past base construction and other activities in the lagoon area by the U.S. Navy have resulted in significant changes and loss of habitat (Stoms et al. 2013).

Santa Monica Bay Watershed

The Santa Monica Bay watershed includes many smaller watersheds that drain directly into the Pacific Ocean via intermittent and perennial streams. Numerous north-south trending canyons in the Santa Monica Mountains create more than 40 separate subwatersheds of Santa Monica Bay. Malibu Creek is one of the larger subwatersheds and is unique as the only waterway that cuts through the Santa Monica Mountains, draining the Simi Hills as well as portions of the Santa Monica Mountains.

The Malibu Creek subwatershed includes 105 square miles and incorporates several major drainage basins (Medea Creek, Triunfo Creek, Cold Creek, Malibu Creek, Sleeper, Las Virgenes, and Potrero Valleys). The Malibu Creek watershed contains a total of 225 stream segments within six major drainages (Stoms et al. 2013). The watershed terminates at the estuarine wetlands and salt marsh of Malibu Lagoon which provides habitat to numerous migratory water birds, supports a dense riparian forest, includes habitat for the endangered tidewater goby and supports the southernmost reliable run of steelhead trout in the United States. There have been many altera-

Because most of the watersheds in the Santa Monica Mountains have not been extensively developed, historic conditions largely exist, with springs and seeps common and widespread, supplying numerous streams.

tions to the lagoon, from stream channelization to bringing in fill to construct baseball fields (Stoms et al. 2013).

Because most of the watersheds in the Santa Monica Mountains have not been extensively developed, historic conditions largely exist, with springs and seeps common and widespread, supplying numerous streams (NPS 2002). Although most streams within the mountains flow seasonally, additional runoff generated from developed areas has contributed to changes in stream flows. For instance, in the Malibu Creek watershed, wastewater treated at the Tapia Water Reclamation Facility is either discharged to Malibu Creek or sold for local landscape irrigation. Additionally, the residences and businesses of Malibu use septic systems for wastewater disposal, potentially affecting quality of local groundwater and coastal and lagoon waters.

Other changes to historic conditions include the introduction of road culverts, low-water crossings, and small and large dams such as Rindge Dam that affect aquatic habitat connectivity (NPS 2002). Within the Santa Monica Mountains, it is believed that self-sustaining populations of southern steelhead trout once resided in Big Sycamore, Arroyo Sequit, Zuma, Malibu, Solstice and Topanga Creeks, among others. Today, however, only a small number of steelhead trout spawn in Arroyo Sequit, Topanga and Malibu creeks because of these barriers to steelhead migration (NPS 2002).

Los Angeles River Watershed

The Los Angeles River watershed is approximately 834 square miles and includes the most urbanized portions of the study area. It also drains the Santa Monica Mountains, Simi Hills, Santa Susana Mountains, Verdugo Mountains, San Gabriel Mountains, and Los Angeles basin, before reaching the Pacific Ocean in Long Beach.

In the Los Angeles basin, which has probably experienced the most modification of any of the natural waterway systems in the study area, rivers and creeks were wide, gravelly channels referred to as washes. Many were a half a mile wide or more. Most of the waterways were ephemeral, appearing dry for much of the year only to become powerful torrents during the rainy season, depositing sediment across the basin as the water would slow and spread (USACOE 2013). As these water systems shifted dramatically across the basin over time, complex landscape patterns were created that supported a variety of habitat types. These patterns became even more intricate as streams would "disappear" into the gravels and then later rise to the surface, creating wetlands, some of which were fed by springs, particularly in areas near geologic faults such as the Raymond basin beneath the Pasadena area.

With expanding human settlement in the Los Angeles basin, rivers and streams became constrained while both surface and groundwater resources were tapped for agriculture, domestic and eventually industrial uses. In the late 19th and early 20th centuries, periodic major storms caused catastrophic flooding resulting in significant loss of life and property, prompting public support for flood protection, which eventually resulted in the network of stormwater and sediment basins, dams, and channelized rivers and streams that characterize many of southern California's urban and suburban watersheds today.

Featuring one of the most extensive flood protection systems, virtually the entire main stem of the river has been channelized and paved to protect downstream urban areas from flooding. Portions of the watershed in the mountainous areas have year round water supplied by springs. These areas provide high quality habitat for plants and animals.

The Los Angeles River has seven main tributaries and subwatersheds. Portions of six of these are within the study area. They include: the Burbank Western Channel, Pacoima Wash, Tujunga Wash, Verdugo Wash, Arroyo Seco, and Rio Hondo subwatersheds. The upper watersheds are characterized by steep sloping channels that are among the most prolific sediment-producing channels in the world. The watershed is characterized by a series of flood management facilities including sediment basins, dams and engineered channels.

A small portion of the northwestern area of the Rio Hondo River is included with in the study area. The Rio Hondo formerly meandered across the basin as a channel to the San Gabriel and Los Angeles Rivers. The Rio

In the late 19th and early 20th centuries, periodic major storms caused catastrophic flooding prompting public support for flood protection, which eventually resulted in today's network of stormwater and sediment basins, dams, and channelized rivers and streams.

Hondo has now been engineered as a permanent tributary to the Los Angeles River for flood control, while continuing to provide a hydrological connection between the two rivers (LADPW 2006; California Coastal Conservancy 2001).

Flood Management

Flood management in the study area is largely the role of the U.S. Army Corps of Engineers, Los Angeles County Flood Control District, and Ventura County Watershed Protection District, which was known as the Ventura County Flood Control District prior to 2003. Many flood management facilities serve multiple functions by also conserving and storing water as well as sediment.

Episodic heavy rains combined with the steep terrain within the study area results in periodic floods of sediment and debris-laden water. Conflicts with human settlement, particularly in the 20th century, have made flood management a priority. Extensive flood protection and water conservation systems were constructed by Los Angeles County and the Army Corps of Engineers throughout the first half of the 20th century in the Los Angeles basin. Formal flood management was established later in Ventura County when the Ventura County Watershed Protection District (then known as the Ventura County Flood Control District) was formed in 1944.

There are a number of different types of facilities that contribute to flood management systems. Dams and reservoirs provide for flood protection while often contributing to water conservation efforts by facilitating groundwater infiltration. Debris and detention basins capture sediment, debris and water, and are typically located at the mouths of canyons. The purpose of these basins is to remove sediment from water to prevent scouring and damage to engineered channels downstream. Downstream of most dams, reservoirs and debris basins, rivers and creeks have been straightened (channelized) and hardened to confine flow during heavy rains.

Flood management structures are a dominant feature in the study area, primarily in the Los Angeles basin. Within the study area there are numerous dams and debris and detention basins, mostly within Los Angeles County (*Table D-1: Dams within the Study Area* and *Table D-2: Debris and Detention Facilities in the Study Area* in *Appendix D; Figure 2-4: Flood Protection and Water Storage/Transfer Facilities*).

A brief history of the Los Angeles County flood protection and water conservation system is described in the Cultural Resources section of *Chapter 2*.

Water Conservation and Supply

Water is a scarce resource in the region, and the role of the natural landscape in providing it has been significant. The importance of the San Gabriel Mountains as a water source was apparent to early settlers who relied on the mountains to provide water from the canyons to farmlands (Robinson 1991). The City of Pasadena petitioned the California Board of Forestry in 1888 to protect the San Gabriel Mountains for its watershed values. During this time, excessive timber harvest was impacting water quality and destroying mountain springs and watercourses used to irrigate the San Gabriel Valley. In response, the State of California established the San Gabriel Forest Reserve in 1891. Watershed protection was the primary impetus for its establishment.

Groundwater and Water Conservation Systems

Groundwater basins, or aquifers, are natural underground formations filled with water and sediment, including sand and gravel. The study area is located within the South Coast Hydrologic Region and includes all or portions of 17 groundwater basins (*Table D-3: Groundwater Basins* in *Appendix D*). Wells drilled into the basins provide water for municipal and agricultural uses.

Groundwater has been used in southern California for well over 100 years and continues to provide a significant portion of the region's water supply. The amount varies depending on the water supplier, but in the City of Los Angeles, groundwater contributes to approximately 12% of the City's supply and up to 30% during droughts (LADWP 2010). At the other end of the spectrum, groundwater is the primary source of locally used water in Ventura County, supplying 67% of water (VCWPD 2013).

High demand and use of groundwater in southern California has given rise to many disputes over management and pumping rights,

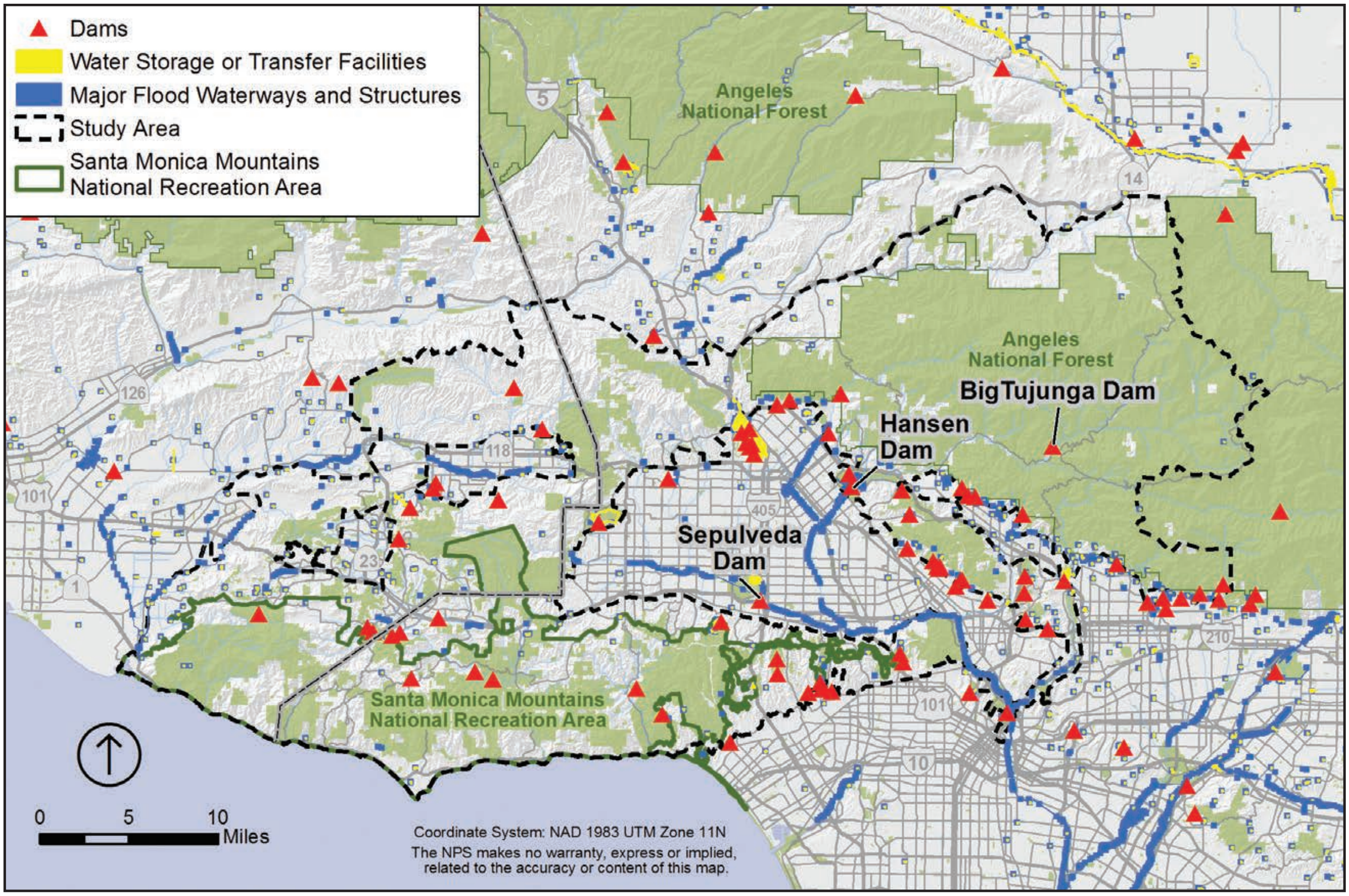


Figure 2-4: Flood Protection and Water Storage/ Transfer Facilities

with the resolution of these cases playing a large role in the establishment and clarification of water rights law in California. Raymond groundwater basin, located in the eastern portion of study area, was the first basin in California to have water rights determined through an administrative or judicial process known as adjudication. Of the 16 adjudicated groundwater basins in California, 11 are in the South Coast Hydrologic Region (California Department of Water Resources 2003).

Use of groundwater in the region combined with surface water use has evolved into a practice referred to as "conjunctive use." During wet years, when more surface water is available, it is directed into water conservation facilities known as spreading basins, which are typically located along rivers and tributaries downstream of reservoirs. In these spreading basins, water percolates into groundwater aquifers where it is stored for future use. During dry years, the stored water is available to supplement or replace diminished surface water supplies. Spreading basin facilities are also used to move imported water into groundwater basins for storage purposes. Some of the largest of the region's water conservation facilities are located within the San Gabriel River watershed, outside of the study area. However, there are several spreading basin facilities throughout the study area. Along tributaries of the Los Angeles River there are six spreading basins (LADPW 2013b).

Imported Water

A major challenge in water management in the region is the variability in available surface water due to the region's climate. Imported water supplements local surface and groundwater resources for municipal use in the greater Los Angeles metropolitan region. The Metropolitan Water District of Southern California (MWD), a consortium of 26 cities and water districts, functions as a water wholesaler that bridges the gap between local water supplies and demand. MWD receives water via the Colorado River Aqueduct and the State Water Project's California Aqueduct, the latter of which conveys water from northern California. The other major source of imported water to the area is the City of Los Angeles'



Left photo: Basins to retain stormwater runoff, like these along the Arroyo Seco, are common features in the San Gabriel foothills. Basins capture water and recharge it in groundwater basins for future use. Center photo: Hahamongna Watershed Park, located along the Arroyo Seco corridor at the base of the San Gabriel Mountains, is a major flood management basin behind Devils Gate Dam. The basin contains large areas of riparian and oak woodland habitat, with remnants of alluvial fan sage scrub. Right photo: Like many natural waterways through the Los Angeles basin, the Arroyo Seco was channelized for flood protection. Photos: NPS.

Los Angeles Aqueduct, which conveys water from the Eastern Sierra Nevada Mountains, Mono basin, and Owens Valley in California (LADWP 2011). The conveyance facilities for these sources of imported water include a series of canals, reservoirs, and spreading basins. A history of these conveyance systems is provided in the cultural resources description that follows.

Wastewater and Recycled Water

Recycled water is used for municipal use such as irrigation, industrial applications, environmental uses, groundwater replenishment, or maintenance of seawater barriers to groundwater basins along the coast. The remainder is discharged into creeks and rivers. In some cases, this input of water into waterways has transformed historically intermittent streams into perennial streams. There are ten water reclamation plants within the study area (*Table D-4: Water Reclamation Plants in the Study Area* in *Appendix D*).

Biological Resources

Geographic Scope

The geographic scope of the biological resources description primarily corresponds to the study area. However, because wildlife rely on broader migration and habitat corridors that extend beyond the study area, the extent and importance of those corridors to the biological resources of the study area is described in this section. *Figure 2-8: Wildlife Linkages* conveys the extent of areas important for maintaining healthy wildlife populations.

Historic Ecological Conditions

Although no comprehensive inventories and studies of the region's biological resources were conducted by early Spanish explorers, diaries and journals kept during expeditions help paint a picture of the pre-European landscape. Diaries kept by Juan Crespi, a padre in the overland expedition led by Captain Gaspar de Portola in 1769-1770, provide some of the most detailed early descriptions of the study area's plants and animals. Accounts written by Pedro Fages of the Portola expedition, Pedro Font of the Juan Bautista de Anza expedition in 1775, and early settlers also provide insights into the historic conditions of the area. As settlement increased in the region, more formal surveys of the area's resources were conducted, including railroad surveys and vegetation mapping projects. These accounts help to illustrate both the historic array of plant and animal species of the area as well as the structure and dynamics of the landscape.

The natural communities that dominated the pre-European settlement landscape of the Los Angeles region included chaparral, coastal sage scrub and prairie (Schiffman 2005). Woodlands and forests of walnut and oak could be found in canyons and adjacent hillsides, and along waterways and floodplains, riparian plants, including willow, cottonwood, mulefat and sycamore, were common. All of these have been reduced over time by human settlement and associated agriculture, ranching, introduction of invasive plant and animal species and development. Although chaparral

Although chaparral and coastal sage scrub still characterize many of the region's undeveloped steep hillsides and mountain slopes today, the plains and valleys of the Los Angeles region have undergone the most change from the loss of the California prairie that once covered these wide valleys.

Purple needlegrass (*Nasella pulchra*) is a dominant species in the California prairie which has been significantly reduced in the Los Angeles region. Photo: NPS.

and coastal sage scrub still characterize many of the region's undeveloped steep hillsides and mountain slopes today, the plains and valleys of the Los Angeles region have undergone the most change from the loss of the California prairie that once covered these wide valleys. The vegetation of these prairies included grasses, wildflowers and forbs, with as many as half of the species being opportunistic annuals that were adapted to periodic drought and soil disturbance (Schiffman 2005). Dominant species included perennial bunchgrasses such as purple needlegrass (*Nassella pulchra*), nodding needlegrass (*Nassella cernua*), foothill needlegrass (*Nassella lepida*), and crested needlegrass (*Achnatherum coronata*). Herbaceous plants such as wildflowers, sedges, and bulbs were also common (Burcham 1957).

A substantial amount of riparian habitat has also been lost due to flood management facilities, water infrastructure, and development. Native grasses and prairie vegetation have been largely displaced by invasive grass and forb species introduced by Spanish explorers and settlers. These introduced plants easily naturalized in southern California's Mediterranean-type climate, in part due to the similar conditions in Spain (Schiffman 2005).

Father Crespi described the Los Angeles River as a "good sized, full flowing river…with very good water, pure and fresh." "Very large, very green bottomlands" spread from the banks as far as he could see, "looking from afar like nothing so much as large cornfields." He also observed the Arroyo Seco draining into the Los Angeles River, noting that the bed was dry, but "the beds of both are very well lined with large trees, sycamore, willows, cottonwoods, and very large live oaks." Other vegetation near the Los Angeles River included brambles, native grapevines, and wild roses (Gumprecht 1999).

Early explorers described the Los Angeles region as being rich in wildlife. Large mammals included coyote, wolf, fox, deer, antelope, mantugar (described as "like a suckling pig"), mountain lion, and grizzly bear (Fages 1919, USACOE 2013). There were also many reptiles and amphibians (Crespi 2001, Fages 1919). A wide variety of birds occupied the river and surrounding landscape, including large populations of species now considered rare, such as yellow-billed cuckoo, least Bell's vireo, clapper rail, golden eagle, and burrowing owl (USACOE 2013). It is estimated that the varied nature of the river created a highly diverse environment and the floodplain forests formed one of the most biologically rich habitats in southern California (USACOE 2013). Bird species adapted to wide open spaces were also common, including the western meadowlark and horned lark. The California condor was also present in the San Fernando Valley (Schiffman, n.d.).

The Portola and Anza expeditons observed pronghorn antelope (*Antilocarpa americana*) in the San Fernando and Conjeo valleys. Early settlers noted vast populations of rabbits, hares and rodents, and expansive networks of burrows across the plains and valleys (Schiffman 2005). Grizzly bears (*Ursus arctos*) were also a noted inhabitant of the area and associated with open landscapes, particularly given the presence of small mammals that would provide food for these large predators. One of the last surviving grizzly bears in southern California was killed in 1916 in Big Tujunga Canyon. Other predators likely included coyotes, long-tailed weasels (*Mustela frenata*), and badgers (*Taxidea taxus*). In the mid-1850s the U.S. government commissioned surveys of the region to identify the best route for a railroad, which also made several observations about the Santa Clara River area. At the upper end of the river,"…the growth of timber and willows along the creek, … filled the whole valley between the ridges on either side… we were obliged to cut our way out through the thickets and form a road for the wagon." They also observed a black-shouldered hawk (*Elanus leucurus*), "…hovering over a freshwater marsh," and found and named the unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) near the river's headwaters. Later surveys in the 1870s and 1880s noted tule (*Scirpus validus*) in the swampy areas of the river. A list of birds observed indicates species closely associated with riparian habitats including several birds widely distributed in the 19th century but now rare, such as Ross' goose, trumpeter swan, white-tailed kite, golden eagle, bald eagle, peregrine falcon, and osprey (VCWPD and LADPW 2005).

In 1917, a committee of the Ecological Society of America was charged with "the listing of all preserved and preservable areas in North America in which natural conditions persist."

Of the predators that inhabitated the region historically, coyotes are among those that remain. Photo: NPS.

Significant portions of the native plant cover in the region have been lost due to grazing, agriculture, and ultimately, urban development.

The summary was published in 1926 and in the section that addresses California, several descriptions of different natural communities were outlined and specific sites recommended for preservation. In describing chaparral, it was noted that, "…chaparral is of little economic value except as a soil cover in preventing erosion and retarding floods…in this field it is of primary importance…to protect the watersheds of southern California." Watershed protection was a key factor in designating the Angeles National Forest.

A dataset of vegetation types was compiled in the 1920s and 1930s for most of California. The Wieslander Vegetation Type Map (VTM) data includes photos, species inventories, plot maps, and vegetation maps. Although there had already been significant changes in vegetation patterns at the time these data were collected, the maps help to illustrate the plant communities of the early 20th century and provide a baseline for assessing change over time. In the Santa Monica Mountains, the VTM maps show that 19% of the area had already been converted to agriculture and urban uses in 1945. A comparison of the maps to 2009 data showed that 22-24% of chaparral and coastal sage scrub present in the Santa Monica Mountains has been converted to human-dominated uses (Stoms et al. 2009).

In recent decades, many biological surveys and inventories have been conducted within the study area, including vegetation inventories, surveys associated with environmental impact reports, studies of individual species locations and movement, reports on habitat, flora, and fauna of various public lands, and more. However, these studies have all been limited to particular geographic areas, and often to particular biota, meaning that biological data does not exist at an equal level of detail throughout the study area. In addition, this means that biological resources, such as rare plants, animals, and habitats, may exist in unsurveyed areas beyond their current known locations.

Ecological Overview

The varied landscape and microclimates of the study area contain examples from most of the vegetation types and wildlife found in southern California today. From the high peaks of the San Gabriel Mountains to the coast of the Santa Monica Mountains, differences in climate, soils, and geology set the stage for a wide array of plant communities. Montane forest, scrub, desert, grassland, and coastal communities can all be found within relatively short distances. These plant communities provide habitat to an abundance of wildlife.

The study area is part of the large California Floristic Province which is defined by natural characteristics rather than political boundaries and includes the geographic area containing plants that are characteristic of California and that are best developed in the state (Ornduff 1974; Howell 1957). This boundary includes portions of southern Oregon and northern Baja California but excludes the deserts and Great Basin areas of the state that are more floristically related to adjacent provinces. The California Floristic Province contains a remarkable number of habitats and species, including a very high proportion of endemic species found only within the province.

The study area lies within the southernmost portion of the California Floristic Province, an area often referred to as the South Coast ecoregion. This ecoregion extends north into the Transverse Ranges and is bordered to the east by the Sonoran and Mojave Deserts.

California's South Coast Ecoregion exhibits high biological diversity, supporting more than 33% of California's native plant species in only eight percent of the land area (Sawyer et al. 2009). More endemic plant and animal species occur in this ecoregion than any other ecoregion in the country (Stein et al. 2000). This species richness and high endemism is contained within a comparable diversity of vegetation assemblages generally characterized by evergreen shrublands typical of Mediterranean-climate regions (Rundel and Tiszler 2007). Vegetation consists primarily of sclerophyllous (hard-leaved) chaparral and drought-deciduous coastal sage scrub occurring in association with woodlands, grasslands, and riparian habitats. These general types are acted upon by complex geology and topography, soils, differences in moisture and temperature regimes, and varying fire histories to create a diverse array of vegetation alliances and associations unique to the region (CBI 2001, Barbour et al. 2007, Keeler-Wolf et al. 2007).

California's South Coast Ecoregion is exhibits high biological diversity, supporting more than 33% of California's native plant species in only eight percent of the land area (Sawyer et al. 2009). More endemic plant and animal species occur in this ecoregion than any other ecoregion in the country (Stein et al. 2000).

Significant portions of the native plant cover in the region have been lost due to grazing, agriculture, and ultimately, urban development. Because of this almost all of the native plant communities that remain contain sensitive, rare or endangered flora and fauna. The South Coast ecoregion contains the mega-city of the greater Los Angeles area, which both further highlights the remarkableness of its current diversity and the ongoing threats to this hotspot of biodiversity.

The following sections give a broad overview of the vegetation and wildlife resources found in the study area. Examples in text boxes throughout highlight species and habitat that represent the unique Mediterranean-type ecosystems and high levels of biodiversity found in the study area.

Vegetation and Habitat

The vegetation and habitat of the study area is described below according to the California Wildlife Habitat Relationships System (CWHR) habitat classification scheme which was developed to support the CWHR System, a wildlife information system and predictive model for California's regularly occurring birds, mammals, reptiles, and amphibians (CDFG 2008) (*Figure 2-5: Vegetation*).[1]

Within the broad habitat classifications described below are many more specific vegetation communities, several of which are sensitive or rare. Over 30 vegetation alliances considered imperiled under NatureServe's Heritage Methodology[2] have been identified in the study area. Because comprehensive biological surveys have not been conducted for all portions of the study area, it is likely that additional imperiled alliances exist or might be found in new locations within the study area. Known imperiled vegetation associations are listed in *Table D-5: Imperiled Vegetation Communities* in *Appendix D.*

Grassland

Annual grassland

Annual grassland primarily occupies what was once California prairie. Introduced annual grasses are the dominant plant species in this habitat. These species include wild oats (*Avena* spp.), soft chess (*Bromus hordeaceus*), red brome (*Bromus madritensis* ssp. *rubens*), wild barley (*Hordeum murinum* ssp. *leporinum*), true clovers (*Trifolium* spp.), and many others. Remnants of native plants and grasses are also found in this habitat including California poppy (*Eschscholzia californica*), purple needlegrass (*Nassella pulchra*), and Idaho fescue (*Festuca idahoensis*) (CDFG 2008).

Within the study area, annual grasslands are primarily found in the Santa Susana Mountains, Simi Hills, and Conejo Mountain areas, as well as the Upper Santa Clara River and San Gabriel Foothills. Remnant native grasslands in these areas typically occur in scattered patches. These include foothill needlegrass, giant wild rye, nodding needle grass, and purple needle grass grassland communities. Several good examples of native grasslands are found within the study area, particularly at Laskey Mesa in the Simi Hills.

Shrub Dominated Communities

Chaparral

Chaparral is the most common vegetation type in the study area. Chaparral consists of a broad mix of robust, woody, predominantly evergreen shrubs that generally occur on steep slopes and hillsides below 5,000 feet elevation. Dominant species consist of broad-leaved or needle leaved sclerophyllous (hard-leaved) shrubs that often grow in 5-10 foot high nearly impenetrable stands with little or no understory. Where shrub stands are less dense, understory plants can include nonnative grasses

[1] The CWHR classification scheme gives a broad perspective of the habitat types in the study area, but does not represent the diversity of distinct plant communities. The California Manual of Vegetation (Sawyer et al. 2009) is widely recognized as the standard classification system for California vegetation. This scheme includes over 450 communities, which generally require field visits for accurate identification and mapping. Plant community data at this level of detail is not available for the entire study area. The CalVeg system from the USFS uses remote sensing to map state-wide vegetation according to a national vegetation classification scheme, which is more specific than the CWHR, but less specific than the California Manual of Vegetation. According to CalVeg, the study area contains 83 vegetation dominance types.

[2] Nature Serve 2013, the accepted standard by the California Department of Fish and Game, California Native Plant Society and the California Manual of Vegetation.

Coastal sage scrub is one of the most threatened plant communities in California. Only 15% of coastal sage scrub's historic range remains in southern California. This habitat is of the highest priority for preservation (CBI 2001, Davis et al. 1998, NPS 1973).

and forbs. Dominant shrubs include chamise (*Adenostoma fasciculatum*), laurel sumac (*Malosma laurina*), various ceanothus species including chaparral whitethorn (*Ceanothus leucodermis*), scrub oak (*Quercus berberidifolia*), and toyon (*Heteromeles arbutifolia*). In higher elevations, shrubs are frequently interspersed as understory vegetation within oak and conifer woodlands (LADRP 2012a).

Mixed chaparral is the most common vegetation type in the study area. It is floristically diverse and contains approximately 240 species. Typically associated shrubs include chamise, silk-tassel (*Garrya elliptica*), toyon, yerba-santa (*Eriodictyon californicum*), California fremontia (*Fremontodendron californicum*), scrub oak, and several species of ceanothus and manzanita (*Arctostaphylos* spp.). *Chamise-redshank chaparral* is also found throughout the study area, and consists of nearly pure stands of chamise or redshank (*Adenostoma sparsifolium*). *Montane chaparral* is less common within the study area, found only above 7000 feet elevation in the San Gabriel Mountains and the Upper Santa Clara River area. The structure and species composition of montane chaparral varies greatly by location, soil type, and aspect (CDFG 2008, Davis et al. 1994).

Coastal Sage Scrub

Coastal sage scrub is the second most common vegetation type in the study area, found throughout the study area at elevations below 1,500 feet. It typically occurs on hot or dry south or west-facing slopes and forms dense stands which grow three to four feet in height. Coastal sage scrub is dominated by drought-deciduous, low, soft-leaved shrubs and herbs. Dominant species typically include California sagebrush (*Artemisia californica*), purple sage (*Salvia leucophylla*), black sage (*S. mellifera*), white sage (*S. apiana*), goldenbush (*Ericamerica* sp.), buckwheat (*Eriogonum fasciculatum*), foothill yucca (*Hesperoyucca whipplei*), California brittle bush/sunflower (*Encelia californica*), golden yarrow (*Eriophyllum confertiflorum*), chamise, hoary-leaf lilac (*Ceanothus crassifolius*), and a variety of annuals and bulbs. Coastal sage scrub also often intergrades with mixed chaparral (LADRP 2012a).

Coastal sage scrub is one of the most threatened plant communities in California. Since 1945, the majority of coastal sage scrub vegetation in California has been lost to urban and agricultural land use (Kirkpatrick and Hutchinson 1980). Only 15% of coastal sage scrub's historic range remains in southern California. This habitat is of the highest priority for preservation (CBI 2001, Davis et al. 1998, NPS 1973).

Desert Scrub

Desert scrub consists of an open, scattered assemblage of broad-leaved shrubs, often with more than 50% bare ground between plants. It is typically found on valley floors at low elevations. Within the study area, desert scrub is found occasionally in the Upper Santa Clara River Area, but is widespread in California deserts farther east (CDFG 2008).

Sagebrush

Sagebrush forms an open scrub community on dry slopes and flats at middle to high elevations. It is typically dominated by big sagebrush (*Artemisia tridentata*), but under certain conditions other species of sagebrush may predominate. In favorable sites, an herbaceous understory may exist, but is often excluded through root competition from the dominant shrubs. Within the study area, sagebrush is found occasionally in the Upper Santa Clara River area but is much more common in the Great Basin floristic province (CDFG 2008).

Woodlands and Forests

Coast Live Oak Woodland

Coast live oak woodlands commonly occur along canyon bottoms that experience at least a seasonal stream flow or in other areas under mesic (wet) conditions, such as on north-facing slopes, erosional plains, and lower slopes in chaparral and coastal sage scrub communities. Soil structure and soil moisture are the most important limiting factors for the survival of oak woodlands; soils must be deep, uncompacted, fertile, well-aerated, and well-drained. This community is dominated by coast live oak, but can also include significant canyon oak (*Quercus chrysolepis*), particularly on steep, north-facing canyon walls such as in the San Gabriel foothills. Some coast live oak woodlands, such as in the Tujunga Valley and Hansen Dam area, include scattered California black walnut (*Juglans californica*) or valley oak (*Q. lobata*). In higher elevations, coast live oak woodland intergrades with coniferous forest (CDRP 2008). If sufficient groundwater is present, western sycamore (*Platanus rac-*

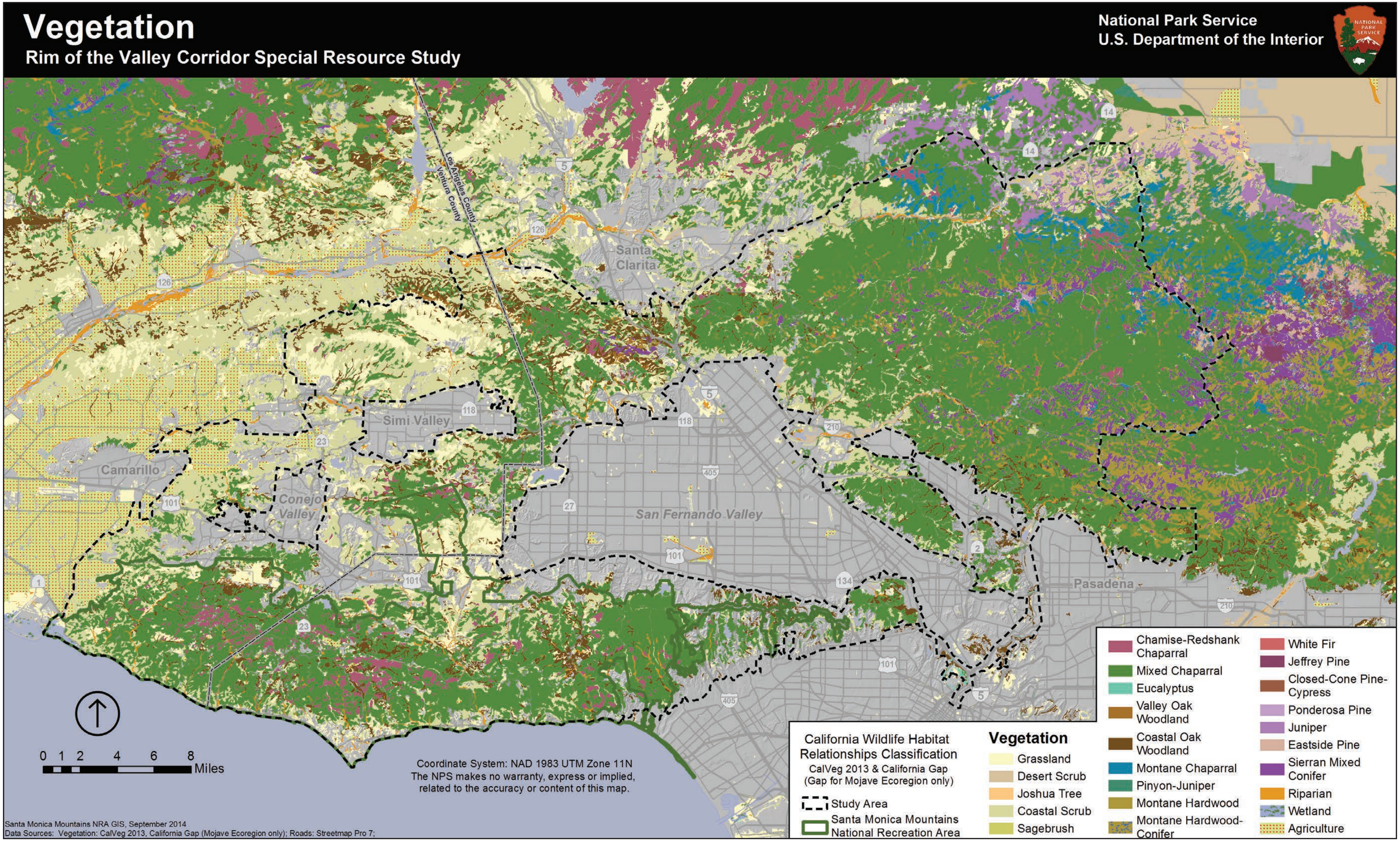


Figure 2-5: Vegetation

Laskey Mesa, in the Simi Hills, contains an unusually large area of native perennial grassland. The endemic San Fernando Valley spineflower, once thought extinct, was rediscovered at Laskey Mesa. Photo: NPS.

The Verdugo Mountains are characterized by steep slopes dominated by chaparral plant communities. Photo: NPS.

The Conejo Canyons area is characterized by a mix of coastal sage scrub and annual grassland. Photo: NPS.

The western San Gabriel Mountains are characterized by steep slopes dominated by chaparral vegetation. Photo: NPS.

The slopes of the Santa Monica Mountains include coastal sage scrub and chaparral. Photo: NPS.

Typical vegetation in the Santa Susana Mountains in the "wedge" between Interstate 5 and Highway 14. Photo: NPS.

The upper Santa Clara River basin includes components of desert scrub and sagebrush vegetation. Photo: NPS.

Examples of Biodiversity: Conejo Mountain Area

The Conejo Mountain area is characterized by at least five examples of sensitive natural communities, including southern riparian scrub, southern willow scrub, thick leaf yerba santa scrub, valley needlegrass grassland, and valley oak woodland.

The volcanic geologic features and soils of this portion of the study area have resulted in the presence of many endemic plant species not found elsewhere. The geologic composition also contributes to the presence of a number of sensitive dudleya plant species.

At the nearby Mount Clef Ridge, rare plants include Lyon's pentachaeta and Conejo buckwheat as well as several other sensitive species associated with the area's volcanic geologic features and soils are found

Sources: Riefner et al. 2004, pers. comm. Edelman 2011, pers. comm. David Magney 2011, pers. comm. Suzanne Goode 2011.

emosa), which is usually associated with riparian habitats, may also occur in the oak woodland. Shrubs such as western blue elderberry (*Sambucus nigra* var. *caerulea*), chaparral currant (*Ribes malvaceum*), skunk bush (*Rhus aromatica*), and California peony (*Paeonia californica*) are frequent in the understory, particularly on slopes, while annual grasses and forbs are often found as understory species in flatter areas(LADRP 2012a). Extensive stands of coast live oak woodland occur at elevations below 2500 feet throughout the study area, primarily in canyons and along waterways.

Valley Oak Woodland (Savanna)
Valley oak woodland forms an open-canopy woodland found on deep, well-drained alluvial soils below 2000 feet. In the study area, this community is almost exclusively dominated by valley oak, sometimes with scattered coast live oaks (*Quercus agrifolia* var. *agrifolia*), with a grassy understory to form a savanna-like community often referred to as valley oak savanna. Los Angeles County includes the southernmost distribution of valley oak in California. Valley oak woodlands are found in scattered patches in the Simi Hills and Santa Susana Mountains within the study area (LADRP 2012a, CDFG 2008).

Montane Hardwood
Montane hardwood occurs at middle to high elevations in the transverse and peninsular ranges. Within the study area, it is found in the San Gabriel Mountains. At higher elevations, formations typically have an overstory of conifers such as pines (*Pinus* spp.), bigcone Douglas-fir (*Pseudotsuga macrocarpa*), incense cedar (*Calocedrus decurrens*), and California black oak (*Quercus kelloggii*). At lower elevations overstory species typically include oaks, white alder (*Alnus rhombifolia*), bigleaf maple (*Acer macrophyllum*), bigcone Douglas-fir, and California bay laurel (*Umbellularia californica*). Understory vegetation usually is dominated by chaparral species. Within the study area, this habitat is found throughout the San Gabriel Mountains (CDFG 2008, Davis et al. 1994).

Montane Hardwood-Conifer
Montane hardwood-conifer includes both hardwood and coniferous trees with very little understory. Dominant species include canyon live oak, Pacific madrone (*Arbutus menziesii*), pines, and incense-cedar. This is a transitional habitat between mixed chaparral, dense coniferous woodlands, montane hardwood, and open woodlands, which provides important forage for birds and mammals. Within the study area, this habitat is found in the San Gabriel Mountains (CDFG 2008, Davis et al. 1994).

Sierran Mixed Conifer
Sierran mixed conifer forests are typically found in the Sierra Nevada. Stands in the San Gabriel Mountains and other areas in southern California are disjunct populations. Dominant species include Douglas-fir, white fir (*Abies concolor*), ponderosa pine, sugar pine (*Pinus lambertiana*), incense cedar, and California black oak. This habitat has a high degree of species richness and is found in the study area at high elevations in the San Gabriel Mountains (CDFG 2008).

Eastside Pine
The eastside pine habitat is typically found in northeastern California and into Oregon, but

Portions of the Simi Hills are characterized by oak savanna where grasses dominate the understory vegetation and oak trees are found in scattered patches. Historically, many oak savanna areas would have had an understory of perennial native grassland, remnants of which are present in the study area.. Photo: Steve Matsuda.

Coast live oak woodland, like this example in the Arroyo Seco, is typically found along canyon bottoms or in other areas under mesic (wet) conditions, such as on north-facing slopes, erosional plains, and lower slopes in chaparral and coastal sage scrub communities. Photo: NPS.

Big-cone Douglas fir is an ancient relic species found within montane hardwood vegetation in the Santa Susana Mountains. Photo: NPS.

Remnants of riparian habitat in the flood plains of Los Angeles can still be found, such as near the Flint Wash – Arroyo Seco confluence. Photo: NPS.

Riparian vegetation forms along waterways and is typically dominated by tree species. This example in the Simi Hills is typical of foothill riparian vegetation. Photo: NPS.

Examples of Biodiversity: Verdugo Mountains

The Verdugo Mountains are essentially an island of nature in the middle of the urbanized metropolitan area. With their rugged terrain, the Verdugo Mountains have remained largely undeveloped and reflects a wide range of natural communities that support abundant wildlife and several sensitive plant and animal species. At least six sensitive natural communities are found in the Verdugo Mountains including bush monkeyflower scrub, California bay forest, California brittlebush scrub, chamise-white sage chaparral, holly leaf cherry chaparral, and white sage scrub.

The geographic location of the Verdugo Mountains makes them important for genetic interchange between otherwise isolated populations. The Verdugo Mountains, as a relatively isolated natural area, also provides a potential ecological stepping stone between the Santa Monica Mountains and the San Gabriel Mountains. Genetic interchange, by way of this linkage is important in perpetuating the genetic variability in isolated populations, and the maintenance of healthy ecosystems. Mountain lions are known to live and successfully reproduce in the Verdugo Mountains.

Source: LADRP 2012a.

a few stands are located in the San Gabriel Mountains within the study area. This habitat is dominated by short to moderate height ponderosa pine, along with some Jeffrey pine, lodgepole pine, white fir, incense-cedar, Douglas-fir, California black oak and western juniper. The understory tends to be open, with low shrubs and a grassy herbaceous layer (CDFG 2008).

Jeffrey Pine
Jeffrey pine forest occurs between subalpine conifer and pinyon-juniper habitat. The dominant species is Jeffrey pine with an understory of scrub oak, various species of ceanothus, Sierra chinquapin, and manzanita. The species richness of Jeffrey pine forest exceeds that of surrounding habitat, since Jeffrey pine seeds, bark, and foliage are important to wildlife. This habitat is found very occasionally in the study area in the San Gabriel Mountains (CDFG 2008, Davis et al. 1994).

Ponderosa Pine
Ponderosa pine (*Pinus ponderosa*) forest includes 50% or more of this species. Shrub layer species include mountain misery (*Chamaebatia foliolosa*), manzanita (*Arctostaphylos* spp.), ceanothus, and Pacific dogwood (*Cornus nuttallii*). This habitat occurs occasionally in the study area at higher elevations in the San Gabriel Mountains (CDFG 2008a, Davis et al. 1994).

Pinyon-Juniper Woodland
Pinyon-juniper woodland consists of a mixture of single leaf pinyon pine (*Pinus monophylla*) and California juniper, forming an open woodland of low, bushy trees with an understory of herbs and large shrubs. This habitat is found in the Upper Santa Clara River watershed and along the northern slopes of the San Gabriel Mountains at middle elevations (LADRP 2012a, CDFG 2008).

Juniper Woodland
Juniper woodlands are dominated by California juniper (*Juniperus californica*), often with an understory of desert scrub species including foothill yucca and buckwheat. Within the study area, juniper woodlands are typically found on northern slopes of the San Gabriel Mountains and lower slopes within the eastern portion of the Upper Santa Clara River watershed (CDFG 2008, Davis et al. 1994).

Joshua Tree
This habitat consists of an open woodland of widely scattered Joshua trees with an understory of shrubs typical of desert scrub habitat. This habitat is found very occasionally in the study area in the easternmost portions of the Upper Santa Clara River valley, but is more common in the Mojave Desert region (CDFG 2008).

Closed-Cone Pine-Cypress
Closed-cone pine-cypress habitat is found scattered among chaparral and hardwood forests. Typically dominated by single species of closed-cone pines or cypress with an understory of chaparral species, this habitat is found in areas with rocky, infertile soils. This habitat is found very occasionally in the study area in the San Gabriel Mountains (CDFG 2008).

Riparian Communities
Riparian communities are found along permanent or nearly permanent waterways, which provide moisture throughout the year. Riparian vegetation stabilizes streambanks, filters water, and often serves as a primary conduit for wildlife movement. Dominant plants often include trees such as California bay, white alder, coast live oak, western sycamore (*Platanus racemosa*) and willow (*Salix* spp.). Riparian forest often includes hydrophytic (water-dependent) plant species in the understory. The study area contains both montane and valley foothill riparian communities. *Valley foothill riparian* habitat occurs along slow-moving waterways on gentle terrain, and possesses a thick impenetrable understory. *Montane riparian* habitat is found at higher elevations, and generally has a more open understory (CDFG 2008, LADRP 2012a).

Wetland Communities

Freshwater Wetlands
Freshwater marsh develops in still or slow-moving freshwater habitats that provide perennially shallow water or saturated soils. This community is dominated by perennial, emergent cattails (*Typha* spp.), which reach a height of four to five meters and often form a closed canopy. Bulrushes (*Schoeneoplectus* spp.) are dominant below the cattail canopy. Deeper water supports submerged plants and a variety of aquatic species. Freshwater marsh