Geologic Resource Evaluation Scoping Summary Santa Monica Mountains National Recreation Area, California

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The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resource evaluation report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

On May 7, 2008, the National Park Service held a GRE scoping meeting for Santa Monica Mountains National Recreation Area at the park headquarters building in Thousand Oaks, California. Supervisory Ecologist Ray Sauvajot welcomed the group and provided some background information about the national recreation area. Guy Cochrane (USGS Coastal and Marine Geology Program) presented information about the California Coast State Waters Mapping Project, which is mapping seafloor and benthic habitats. Chris Wills (California Geological Survey) presented information about the state survey's mapping program, which is driven by population growth and development. Eugene Fritsche (California State University Northridge) presented the geologic history of the Santa Monica Mountains. Greg Mack (Pacific West Region) facilitated the assessment of map coverage, and Bruce Heise (Geologic Resources Division) led the discussion regarding geologic processes and features at the national recreation area.

On May 8, 2008, Eugene Fritsche (California State University Northridge) led a field trip for scoping participants. Highlighting both the Pacific Coast Highway and Mulholland Drive, this trip was the quintessential tourist-geologist's dream come true. The Mulholland scenic corridor, named for Los Angeles water engineer William Mulholland, is the main artery through most of Santa Monica Mountains National Recreation Area (Tennesen 2007). In addition to perhaps the highest concentration of German sports cars—Porsche, BMW, Mercedes, and Audi—in the United States, participants saw landslides (Chris Wills proved that he could indeed point out a landslide deposit at practically every stop), fossils, feeder dikes, a sandstone dike, a sand dune, columnar jointing, folds, faults, slickensides, pillow basalts, and tar seeps, as well as flame structures and Bouma sequences that indicate deposition by turbidity currents on a submarine fan. As part of the trip, participants toured the inside and top of an ancient volcano that throughout its life was both submarine and subaerial.

Park and Geologic Setting

Akin to its ecology and geology, Ray Sauvajot described the management of Santa Monica Mountains National Recreation Area as "very complex and fragmented." More than 70 governmental entities share jurisdiction within the boundary. The entire city of Malibu is situated in the national recreation area. A total of 60,725 ha (150,050 ac) are divided among private landowners, local parks, California State Parks, and the National Park Service. The National Park Service is the steward of 8,700 discontinuous hectares (21,500 ac), though Congress is considering legislation to expand the boundary. A feasibility study is slated to begin in 2009.

In this web of protected places, visitors can see cityscapes, mountain and ocean views, rocky outcrops, riparian woodlands, and chaparral-covered canyons—all part of the Transverse Ranges of southern California. The spiny backbone of the range skirts the northern edges of the Los Angeles Basin and Santa Monica Bay before descending into the sea at Point Mugu (Tennesen 2007); the southwestern extension is the Channel Islands. Folded and faulted structures characterize these east-west–trending mountains, with five geologic stages having profoundly marked the more than 150-million-year history: (1) subduction; (2) rifting, rotation, and extension; (3) volcanic eruption; 4) compression and uplift; and (5) erosion (Stephanie Kyriazis, Santa Monica Mountains National Recreation Area, "Geologic Summary," May 2008).

Santa Monica Slate is the oldest rock unit exposed in the national recreation area; this rock was deposited as mud and other sediment on the ocean floor during the Late Jurassic Period (161–145 million years ago). The slate is overlain by an extensive sequence of Tertiary sedimentary and volcanic rocks, many of which have their type section in the Santa Monica Mountains. The Eocene–Early Miocene Sespe and Vaqueros formations represent coastal alluvial deposits (Sespe) with equivalent nearshore marine deposits (Vaqueros). The Miocene (20–10 million years ago) Topanga Formation is the most extensive geologic unit in Santa Monica Mountains National Recreation Area. This sequence of rocks consists of nonmarine and marine deltaic sandstone and conglomerate in the eastern Santa Monica Mountains and marine shelf and submarine deposits in the western Santa Monica Mountains (Eugene Fritsche, California State University Northridge, communication during field trip, May 8, 2008). Another widespread formation is the Conejo Volcanics. Stretching of Earth's crust during the rotation process allowed hot, melted rock to escape to the surface and produced a period of volcanism in the Santa Monica Mountains area (Eugene Fritsche, California State University Northridge, presentation, May 7, 2008). 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 Formation and Conejo Volcanics. Frequent landslides and occasional earthquakes remind visitors that the rocks and landforms at Santa Monica Mountains National Recreation Area have not stopped moving or forming. In addition, as discussed in the "Features and Processes" section of this summary, floods, waves, and wind continue to work the landscape, resulting in the diverse landforms (e.g., canyons, bluffs, and sand dunes) that decorate the recreation area.

Mapping Plan for Santa Monica Mountains National Recreation Area

During the scoping meeting, Greg Mack (Pacific West Region) showed some of the main features of the GRE Program's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRE Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, a Windows HelpFile that captures ancillary map data, and a map document that displays the map and provides a tool to directly access the HelpFile. Final products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

When possible, the GRE Program provides large-scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain parklands (fig. 1). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps in the vicinity of the park. Scoping session participants then discuss mapping needs and select appropriate source maps for the digital geologic data (table 1) or, if necessary, develop a plan to obtain new mapping.

The area of interest for Santa Monica Mountains National Recreation Area includes the following 7.5-minute quadrangles: Camarillo, Newbury Park, Thousand Oaks, Calabasas, Canoga Park, Van Nuys, Burbank, Point Mugu, Triunfo Pass, Point Dume, Malibu Beach, Topanga, Beverly Hills, Hollywood, Venice, and Inglewood (fig. 1). Park staff would also like to have the Moorpark and Simi Valley West quadrangles included in the area of interest because of a potential boundary expansion (fig. 1). The Santa Barbara, Los

Angeles, and Long Beach 30' × 60' sheets cover the area of interest at 1:100,000 scale (fig. 1). Each sheet include some offshore geology.

Maps from multiple entities—California Geological Survey, U.S. Geological Survey, and the Dibblee Foundation of the Santa Barbara Natural History Museum—cover the area of interest. Scoping participants concluded that each of these maps has strengths and weaknesses; the primary concern is that the U.S. Geological Survey and the Dibblee Geological Foundation maps include only selected surficial units and no offshore geology. The California Geological Survey (CGS) is in the process of compiling the Santa Barbara sheet with the "best available" bedrock, surficial, and offshore geology from USGS and Dibblee Foundation sources, as well as many university theses. The work is slated to be completed in 2008 and will resolve many of the concerns that participants discussed during scoping. A similar project for the Los Angeles sheet is scheduled for completion in 2011. As of August 2008, the California Geological Survey had completed 1:24,000-scale geologic mapping and landslide inventories for the Moorpark, Simi Valley West, and Venice quadrangles (Chris Wills, California Geological Survey, e-mail, August 25, 2008).

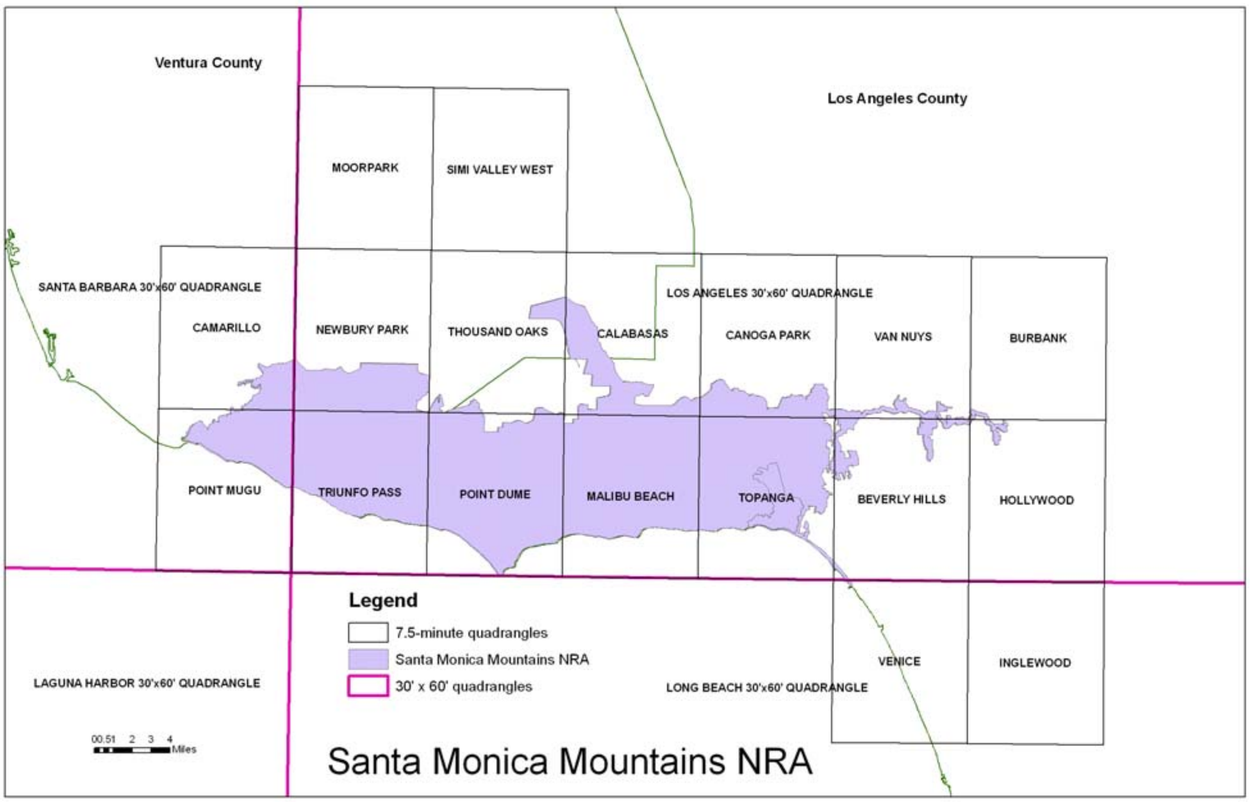

Figure 1. Area of Interest for Santa Monica Mountains National Recreation Area. Eighteen 7.5-minute quadrangles cover the area of interest for Santa Monica Mountains National Recreation Area. These quadrangles are labeled and outlined in black. Also covering the area of interest are the Los Angeles, Santa Barbara, and Long Beach 30' × 60' sheets, which are indicated by the pink dividing lines. The national recreation area is highlighted in purple.

Park staff also expressed an interest in detailed landslide mapping to identify unstable areas that pose a threat to park infrastructure and resources. The California Geological Survey has submitted a proposal for GRE support to produce a landslide map of the park area which, depending on budget considerations, may be funded in 2009.

Summary of Mapping Plan

- Obtain written permission from the Dibblee Geological Foundations to scan and digitize the maps of interest (table 1).
- Once the release is in hand, digitize the maps for bedrock geology (table 1).
- At the time of digitizing (2009 or 2010), review the status of the California Geological Survey's Santa Barbara, Los Angeles, and Long Beach sheets. If completed, convert the digital database of these maps instead of hand digitizing the Dibblee Geological Foundation quadrangles. *Note*: Although the California Geological Survey completed printed maps are at a scale of 1:100,000, CGS geologists compile the data 1:24,000 scale.
- Convert digital data of the new CGS landslide map, if available.

Table 1. Source Maps for Bedrock Geology at Santa Monica Mountains National Recreation Area

GMAP ID[1]	Quadrangle Name	Reference	Format
2912	Camarillo Newbury Park	Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1990. *Geologic map of Camarillo and Newbury Park quadrangles*. Scale 1:24,000. DF-28. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2913	Point Magu Triunfo Pass	Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1990. *Geologic map of Point Magu and Triunfo Pass quadrangles*. Scale 1:24,000. DF-29. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2909	Hollywood Burbank	Dibblee, T. W., Jr. 1991. *Geologic map of Hollywood and Burbank (south 1/2) quadrangles*. Scale 1:24,000. DF-30. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2908	Beverly Hills Van Nuys	Dibblee, T. W., Jr. 1991. *Geologic Map of Beverly Hills and Van Nuys (south 1/2) quadrangles*. Scale 1:24,000. DF-31. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
7660	Topanga Conoga Park	Dibblee, T. W., Jr. 1992. *Geologic map of Topanga and Conoga Park (south 1/2) quadrangles*. Scale 1:24,000. DF-35. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2901	Calabasas	Dibblee, T. W., Jr. 1992. *Geologic map of Calabasas quadrangle*. Scale 1:24,000. DF-37. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2915	Malibu Beach	Dibblee, T. W., Jr. 1993. *Geologic map of Malibu Beach quadrangle*. Scale 1:24,000. DF-47. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2899	Point Dume	Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1993. *Geologic map of Point Dume quadrangle*. Scale 1:24,000. DF-48. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
2900	Thousand Oaks	Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1993. *Geologic map of Thousand Oaks quadrangle*. Scale 1:24,000. DF-49. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
	Venice Inglewood	Dibblee, T. W., Jr., and J. A. Minch. 2007. *Geologic map of Venice and Inglewood quadrangles*. Scale 1:24,000. DF-322. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
	Moorpark	Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1992. *Geologic map of the Moorpark quadrangle, Ventura County, California*. Scale 1:24,000. DF-40. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF
	Simi Valley West	Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1992. *Geologic map of the Simi quadrangle, Ventura County, California*. Scale 1:24,000. DF-39. Santa Barbara, CA: Dibblee Geological Foundation.	Paper/PDF

[1]GMAP numbers are identification codes for the GRE Program's database.

Geologic Features and Processes and Related Management Issues

The scoping session for Santa Monica Mountains National Recreation Area provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRE report. During the meeting, participants did not prioritize the issues, but discussion made it clear that hillslope processes, seismicity, and paleontological resources are of high management significance. These are discussed first, followed alphabetically by other features and processes.

Hillslope Features and Processes

Hillslope processes pose a significant threat to park infrastructure and human safety: big, deep landslides destroy roads; small quick landslides kill people. In addition to landslides, rockfall is another hazard, for example in Malibu and Topanga canyons, and soil creep is pervasive on shale-rich units. In 1975 Russ Campbell authored a USGS professional paper soil slips and debris flows in the Santa Monica Mountains (see Campbell 1975). Based on variables such as slope, rock type, and debris availability, the California Geological Survey has compiled maps of debris-flow potential (scale 1:24,000). For instance, the Malibu Beach and Point Dume quadrangles contain thousands of flows, and maps at this scale most likely do not capture all debris flows.

Work by Sue Cannon at the U.S. Geological Survey may also help resource managers identify high risk areas. Cannon's work focuses on the cycles of landsliding and fire. Generally speaking, big fires followed by wet winters result in increased landsliding. After a fire, burned materials move into stream channels or canyons, which are washed out as debris flows during the next heavy rain. Loose soil and debris called dry ravel also plays a role in landslide susceptibility.

Seismic Features and Processes

Faults define the southern boundary of Santa Monica Mountains National Recreation Area. The primary faults in the area are the Anacapa Dume Fault, which is mostly offshore, and the Malibu Coast Fault, which is both onshore and offshore. Earthquakes along the coast have included a Magnitude 5.9 earthquake near Point Mugu in 1973, but larger earthquake up to Magnitude 7.2 are possible (Chris Wills and Pam Irvine, California Geological Survey, written communication, August 25, 2008). For interpretive purposes, the Red Rock and Boney Mountain faults provide good exposures and folds are pervasive locally.

Because much of the coast is protected by the Channel Islands and the offshore shelf and slope, the potential for tsunamis is low, though not improbable in low-lying areas. Scoping participants thought large, submarine landslides had the potential to cause local-scale tsunami. Large submarine slides have occurred in the Santa Barbara Basin and off the northwest edge of the San Pedro shelf (into the Santa Monica Basin) (Chris Wills, California Geological Survey, e-mail, September 16, 2008).

Paleontological Resources

According to Koch et al. (2004), "Santa Monica Mountains National Recreation Area contains one of the most extensive and diverse assemblages of fossil material known in the National Park Service. There are at least 2,300 known fossil localities, representing over a dozen fossiliferous geologic formations. Invertebrate, vertebrate, paleobotanical, protista, and trace fossils occur….The diversity of the fauna, both marine and terrestrial, is extraordinary with many [type] species named from the Santa Monica Mountains. The quality of preservation is remarkable in many specimens, especially the fully articulated skeletons of fossil fish [in the upper diatomaceous portion part of the Monterey Formation] that are comparable to the world-famous Eocene Green River Formation fossil fish from Wyoming, Utah, and Colorado." Also, fossils in volcanic rocks are rare, yet within a small area of Malibu Canyon in Santa Monica Mountains National Recreation Area, more than 200 fossil localities occur in the lenses of calcareous sandstone interbedded within volcanic rocks.

Two NPS publications document the paleontological resources of Santa Monica Mountains National Recreation Area: Koch and Santucci (2003) and Koch et al. (2004). Both publications contain an extensive reference list, and Koch et al. (2004) provides a list of paleontological species. Hoots (1930) recorded many fossil localities, which may be useful for the national recreation area's GIS. Areas of particular sensitivity are the along Old Topanga Canyon Road and Mulholland Drive.

Fossils at the recreation area range in age from Jurassic to Pleistocene. More than 134 species of gastropods and bivalves occur in the lower Topanga Canyon Formation (Miocene) in a localized area near the type locality; many more fossil localities exist at this stratigraphic horizon, and some localities contain species not present near the type locality (John Alderson, Los Angeles County Museum, e-mail, September 21, 2008). Vertebrates include a pygmy baleen whale. Participants also mentioned rodents and frogs from the Lower Miocene Sespe Formation near Saddle Peak.

In addition to fauna, recent discoveries highlight the national recreation area as a notable fossil flora site. Since 2003, investigators have found exceptional samples of petrified wood from the Fernwood Member of the Topanga Canyon Formation; one specimen is a 15-m- (50-ft-) long log, though not intact (John Alderson, Los Angeles County Museum, personal communication during scoping, May 7, 2008). Also, algal limestone occurs in the Santa Susana Formation (Paleocene) in the national recreation area.

Caves

No karst occurs in Santa Monica Mountains National Recreation Area, but sandstone caves are scattered throughout. These caves are erosional features in the Topanga, Chatsworth, and Sespe formations. Eagle Rock, Eagle Springs, and Garapito Canyon are notable areas for caves. The “Bat Cave” of Batman and Robin fame is a tunnel in an old quarry near Hollywood, within the national recreation area. Within the area of interest, though outside the boundary, the Simi Hills contain many small caves and rock shelters. These are significant cultural sites and highlighted in archaeological studies and reports for Santa Monica Mountains National Recreation Area. The recreation area does not have a comprehensive cave inventory, but park staff would like one.

Coastal and Marine Features and Processes

Santa Monica Mountains National Recreation Area hosts 56 km (35 mi) of coastline. The coast is known for both sand and cobble beaches, though none fall within the jurisdiction of the National Park Service. However, the National Park Service is the steward of many rocky intertidal benches with tide pools and a number of coastal lagoons (e.g., Malibu, Topanga, and Zuma). Coastal processes include both erosion—evidenced by wave-cut cliffs and an arch—and accretion. The National Park Service has conducted studies of coastal vulnerability to sea-level rise and other hazards. For more information contact Rebecca Beavers (Geologic Resources Division) at 303-987-6945 or rebecca_beavers@nps.gov, or Mark Borrelli (Geologic Resources Division) at 303-969-2171 or mark_borrelli@partner.nps.gov.

The recreation area’s boundary stops at mean high water, so marine resources are minimal by comparison to other “coastal parks.” Although shipwrecks and kelp forests are notable submerged resources off the coast, the National Park Service has no management obligations for these. Of interpretive interest are submarine canyons; for instance, the west end of Mugu Canyon is one of deepest submarine canyons in North America. Also, the only natural deepwater port between San Diego and San Francisco occurs off the coast of Hueneme.

Unlike private beach houses and the Pacific Coast Highway, no armoring occurs within the national recreation area.

Climate Change

Losing Ground: Western National Parks Endangered by Climate Disruption states, “A climate disrupted by human activities poses such sweeping threats to the scenery, natural and cultural resources, and wildlife of the West’s national parks that it dwarfs all previous risks to these American treasures” (Saunders et al. 2006). The authors contend that “a disrupted climate is the single greatest threat to ever face western national parks.” Because of the potential disruption that climate change could cause to park resources, including geologic features and processes, the GRE Program has begun to include a discussion of the effects of climate change to park resources as part of scoping meetings. During scoping at Santa Monica Mountains National

Recreation Area, participants mentioned that private houses along the coast are at risk from sea-level rise, in particular the historic Adamson House, which is part of a state park within the national recreation area. Climate change could alter recreational opportunities such as surfing and ecosystems such as beaches and kelp forests.

Disturbed Lands

Disturbed lands are those parklands where the natural conditions and processes have been directly impacted by mining, development (e.g., facilities, roads, dams, abandoned campgrounds, and user trails), agricultural practices (e.g., farming, grazing, timber harvest, and abandoned irrigation ditches), overuse, or inappropriate use. The NPS Disturbed Land Restoration Program, administered by the Geologic Resources Division, usually does not consider lands disturbed by natural phenomena (e.g., landslides, earthquakes, floods, hurricanes, tornadoes, and fires) for restoration unless influenced by human activities.

Scoping participants identified some disturbances at Santa Monica Mountains National Recreation Area; access roads onto private lands are a particular management concern. Compared to other ranges in the area, very little historic prospecting occurred in the Santa Monica Mountains. Nevertheless, mineral exploration and development resulted in a few quarries in Santa Ynez Canyon. These limestone quarries are World War II–vintage. Oil and gas exploration and development produced some dry holes on Point Dume.

Eolian Features and Processes

Windblown sand and dust are prevalent throughout the area, but the only “charismatic” eolian feature is “the Great Dune,” which scoping participants saw during the field trip (i.e., half a mile west of Sycamore Canyon). In actuality, this dune is not particularly “great” (i.e., not of huge dimensions), but it is the only one of any size in the national recreation area and is a good example of eolian processes occurring there.

Fluvial Features and Processes

Malibu, Solstice, and Topanga creeks are perennial streams that flow through the national recreation area; other streams have sections that are perennial. Runoff from developed areas creates unnatural streams and provides a perennial source of surface water. Subterranean flow occurs all year long. For example, a stream runs through and around the Grotto at Circle X Ranch. Some springs have flow significant enough to create year-round waterfalls.

During the winter rainy season, streams may flow out of their channels, flooding park infrastructure. During such events, parking lots have washed out. High waters also threaten cultural resources at Peter Strauss Ranch. In an effort to protect houses and roads from flood-induced debris flows, private citizens and government agencies have constructed “debris basins” to catch boulders and sediment. These are usually on upslope sides of roads and need to be continuously emptied in order to remain functional. Culverts under roads constantly fill up with debris, blocking wildlife corridors and resulting in flooding.

Malibu Creek and the stream running through Solstice Canyon have been dammed; excessive, “stranded” sedimentation is a management issue in these areas.

Lacustrine Features and Processes

As part of a national wetlands inventory, park staff documented all known vernal ponds in the national recreation area. The inventory is ongoing. One notable observation is that most natural ponds have been dammed to increase their areas. This results in the potential for dam failure and damage to downstream cultural resources. Park managers are questioning whether to maintain these small reservoirs or restore the ponds to natural conditions. The estimated 10 larger reservoirs in the national recreation area do not belong to the National Park Service. The primary concern with these reservoirs is dam failure and damage to homes below.

Volcanic Features and Processes

Although the national recreation area is not experiencing active volcanic processes, Miocene volcanism left many features worthy of interpretation. During the field trip, Eugene Fritsche (California State University Northridge) pointed out a cross section of an ancient volcano, the basal volcanic conduit of which he calls the "Bowels of Hades" or "Gates of Hell." Furthermore, the Conejo Volcanics contain evidence of both submarine origins (pillow basalts at the base) and subaerial origins (volcanic bombs at the top). An unusual phenomenon is the interbedding of calcareous sandstone and volcanic rocks. The Conejo Volcanics also contain rare oil seeps.

Unique Geologic Resources

Unique geologic resources include natural features mentioned in a unit's enabling legislation, features of widespread geologic importance, geologic resources of interest to visitors, and geologic features worthy of interpretation. The GRE Program also considers type localities and age dates as unique geologic resources. At Santa Monica Mountains National Recreation Area hosts many type sections: Santa Monica Formation, Tuna Canyon Formation, Topanga Canyon Formation, Conejo Volcanics, Calabasas Formation, Zuma Volcanics, Trancas, and Coal Canyon Formation. Yerkes and Campbell (1979) documented many of these type sections; the U.S. Geological Survey lexicon records them at http://ngmdb.usgs.gov/Geolex/geolex_home.html. Various investigators have dated the rocks in the national recreation area: Lee Silver (plutonic rocks), David Turner (K-Ar of volcanic rocks) (Turner 1970), and Phil Gans (Ar-Ar of volcanic rocks). The work by Silver and Gans has not been published yet (Eugene Fritsche, California State University Northridge, e-mail, August 17, 2008)

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