APPENDIX 3.7

Paleontological Resources Technical Report

DRAFT Paleontological Resources Technical Report for the 2020–2045 Regional Transportation Plan and Sustainable Communities Strategy for the Southern California Association of Governments

OCTOBER 2019

PREPARED FOR

Impact Sciences

PREPARED BY

SWCA Environmental Consultants

DRAFT PALEONTOLOGICAL RESOURCES TECHNICAL REPORT FOR THE 2020–2045 REGIONAL TRANSPORTATION PLAN AND SUSTAINABLE COMMUNITIES STRATEGY FOR THE SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS

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ABSTRACT/EXECUTIVE SUMMARY

Purpose and Scope: In support of the Southern California Association of Governments (SCAG) 2020–2045 Regional Transportation Plan and Sustainable Communities Strategy (2020 RTP/SCS, Connect SoCal or the Plan), Impact Sciences retained SWCA Environmental Consultants (SWCA) to summarize the existing conditions of paleontological resources within the study area, evaluate potential impacts that could occur to these resources because of the Plan, and to provide mitigation measures for potential impacts.

The SCAG region consists of six counties (Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura) and 191 cities. The 2020 RTP/SCS is a regional planning document updated every four years for the SCAG region. The 2020 RTP/SCS will outline the region's goals and policies for meeting current and future mobility needs, provide a foundation for transportation decisions by local, regional and state officials that are ultimately aimed at achieving a coordinated and balanced transportation system. The 2020 RTP/SCS will also identify the region's transportation needs and issues, recommended actions, programs, and a list of projects to address the needs consistent with adopted regional policies and goals, and document the financial resources needed to implement the 2020 RTP/SCS. It is important to note that SCAG does not implement individual projects in the RTP, as they will be implemented by local and state jurisdictions, and other agencies. SCAG has already initiated the development of the 2020 RTP/SCS and is working closely with county transportation commission to compile a regional transportation project list that will build upon the list identified in the 2016 RTP/SCS.

The following paleontological resources assessment was prepared under contract to Impact Sciences in order to characterize existing conditions in regard to the potential for paleontological resources in the six county area. This report compiles an extensive survey of geologic mapping and the scientific literature of paleontological discoveries in southern California. The assessment was conducted according to the methods and standards defined by the Society of Vertebrate Paleontology (1995, 2010) and the Bureau of Land Management (2009, 2016) and is consistent with laws, ordinances, and regulations pertaining to paleontological resources such as the California Environmental Quality Act (Appendix G) and the National Environmental Protection Act.

Dates of Investigation: This report was completed in July 2019.

Findings of the Investigation: The review of geologic mapping and scientific literature indicates southern California, including the six counties included in the SCAG region, has a rich history of fossil discoveries and a strong potential for future findings. Paleontological sensitivity varies across the region: igneous and high-grade metamorphic units have no paleontological sensitivity, whereas sedimentary units range from low to high sensitivities. Growth and development will inevitably lead to impacts on paleontological resources, but with the implementation of planning and mitigation measures, impacts to paleontological resources can be managed and minimized. Recommendations are provided for avoiding impacts to fossil resources during project planning and implementation.

Disposition of Data: Copies of this report will be retained by SWCA and submitted to Impact Sciences and SCAG.

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INTRODUCTION

In support of the Southern California Association of Governments (SCAG) 2020–2045 Regional Transportation Plan and Sustainable Communities Strategy (2020 RTP/SCS, Connect SoCal or the Plan), Impact Sciences retained SWCA Environmental Consultants (SWCA) to summarize the existing conditions of paleontological resources within the study area, evaluate potential impacts that could occur to these resources because of the Plan, and to provide mitigation measures for potential impacts.

SCAG is the lead California Environmental Quality Act (CEQA) agency for the proposed 2020 RTP/SCS. As the lead agency, SCAG has determined to prepare a Program Environmental Impact Report for the 2020 RTP/SCS.

SCAG is a federally designated Metropolitan Planning Organization (MPO) under Title 23, United States Code (USC) 134(d)(1). The SCAG region consists of six counties (Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura Counties) and 191 cities. The 2020 RTP/SCS is a regional planning document updated every 4 years for the SCAG region. The 2020 RTP/SCS will outline the region's goals and policies for meeting current and future mobility needs, provide a foundation for transportation decisions by local, regional and state officials that are ultimately aimed at achieving a coordinated and balanced transportation system. The 2020 RTP/SCS will also identify the region's transportation needs and issues, recommended actions, programs, and a list of projects to address the needs consistent with adopted regional policies and goals, and document the financial resources needed to implement the 2020 RTP/SCS. It is important to note that SCAG does not implement individual projects in the RTP, as they will be implemented by local and state jurisdictions, and other agencies. SCAG has already initiated the development of the 2020 RTP/SCS and is working closely with county transportation commissions to compile a regional transportation project list that will build upon the list identified in the 2016 RTP/SCS.

The following paleontological resources assessment was prepared for Impact Sciences, in support of the Program Environmental Impact Report, in order to characterize existing conditions in regard to the potential for paleontological resources in the six county area. This report compiles an extensive survey of geologic mapping and the scientific literature of paleontological discoveries in southern California. The assessment was conducted according to the methods and standards defined by the Society of Vertebrate Paleontology (SVP) (1995, 2010) and the Bureau of Land Management (BLM) (BLM 2009, 2016) and is consistent with laws, ordnances, and regulations pertaining to paleontological resources such as the CEQA (Appendix G) and the National Environmental Protection Act of 1969 (NEPA).

SWCA relied upon three main sources of data to conduct this paleontological assessment: 1) geologic mapping, 2) scientific literature, and 3) online records publicly available from the University of California Museum of Paleontology (UCMP) and the San Diego Natural History Museum (SDNHM). Due to the large size of the SCAG region, it is not feasible to analyze every geologic formation within the area. Rather, this analysis focuses on the broad geologic regions, referred to as geomorphological provinces, as commonly recognized in the paleontological community and summarized by Norris and Webb (1990), among others. For each region, the types of geologic units known for preserving paleontological resources are discussed.

SWCA used the paleontological assessment conducted here to develop a series of recommendations for the development of appropriate mitigation measures for potential projects within the SCAG region. Implementation of these recommendations will ensure CEQA and NEPA compliance and reduce the impacts to fossil resources to less than significant.

SWCA Senior Paleontologist Alyssa Bell, Ph.D. served as Principal Investigator and conducted the research and authored this report. SWCA Senior Paleontologist Russell Shapiro, Ph.D. reviewed this report for quality assurance/quality control. Heather Gibson, Ph.D., Registered Professional Archaeologist, served as project manager for SWCA's technical studies. Copies of the report will be retained SWCA and submitted to Impact Sciences and SCAG.

PROJECT DESCRIPTION

SCAG is the lead CEQA agency for the proposed 2020 RTP/SCS. SCAG is a federally designated Metropolitan Planning Organization under Title 23, USC 134(d)(1). The SCAG region consists of six counties (Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura) and 191 cities (Figure 1). The 2020 RTP/SCS is a regional planning document updated every four years for the SCAG region. The 2020 RTP/SCS will outline the region's goals and policies for meeting current and future mobility needs, provide a foundation for transportation decisions by local, regional and state officials that are ultimately aimed at achieving a coordinated and balanced transportation system. The 2020 RTP/SCS will also identify the region's transportation needs and issues, recommended actions, programs, and a list of projects to address the needs consistent with adopted regional policies and goals, and document the financial resources needed to implement the 2020 RTP/SCS. It is important to note that SCAG does not implement individual projects in the RTP, as they will be implemented by local and state jurisdictions and other agencies. SCAG has already initiated the development of the 2020 RTP/SCS and is working closely with county transportation commissions to compile a regional transportation project list that will build upon the list identified in the 2016 RTP/SCS.

In accordance with California Government Code 65080(b)(2)(B), the 2020 RTP/SCS will include a SCS, which details land use, housing and transportation strategies to reduce greenhouse gas emissions from passenger vehicles (automobiles and light-duty trucks). SCAG's SCS is required to meet reduction targets for greenhouse gas emissions of 8 percent per capita by 2020 and 19 percent per capita by 2035, as compared to 2005 emission levels, as set by the California Air Resources Board.

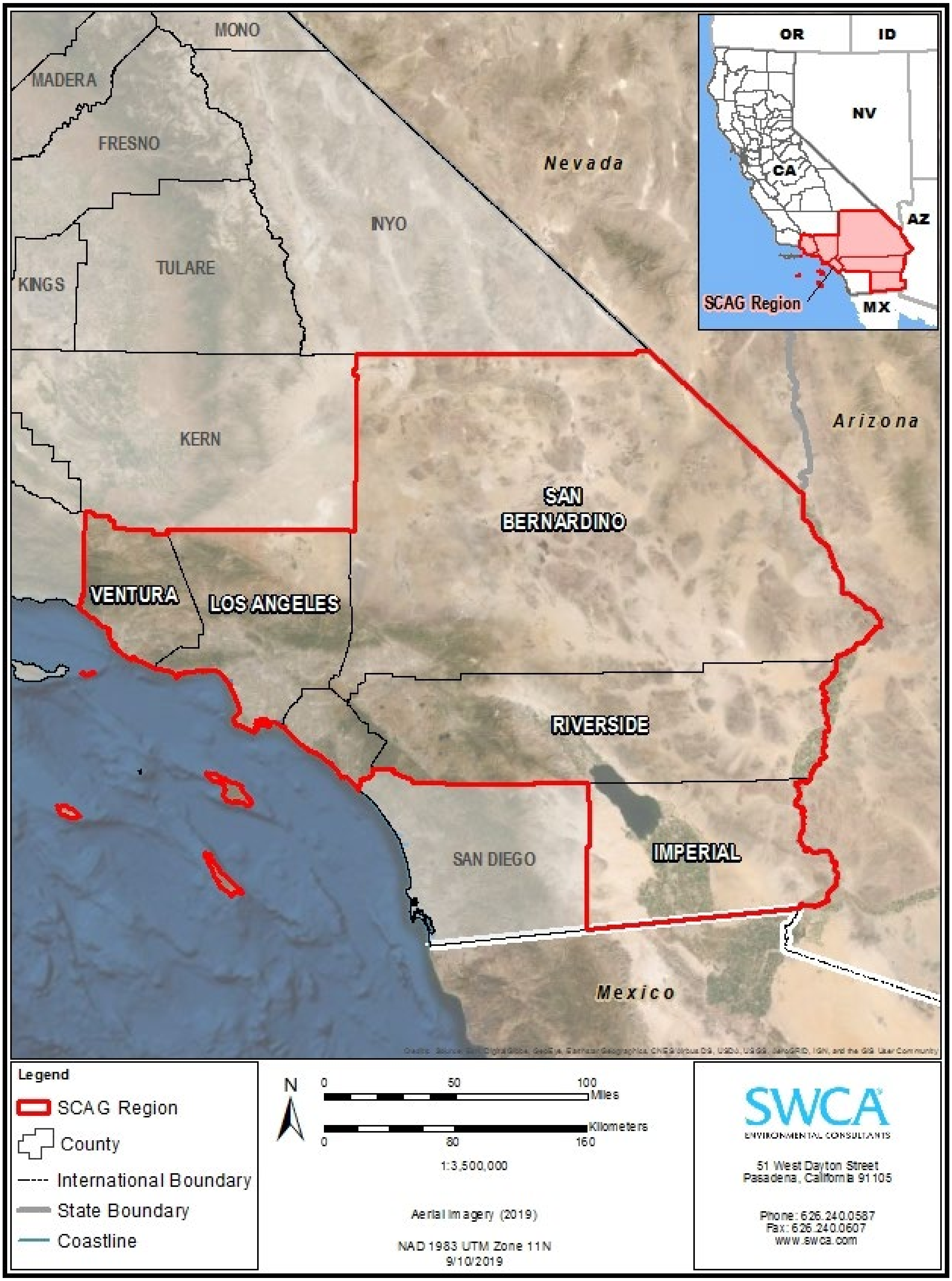

Figure 1. SCAG region.

REGULATORY SETTING

Paleontological resources are limited, nonrenewable resources of scientific, cultural, and educational value and are afforded protection under federal and state laws and regulations. This study satisfies project requirements in accordance with both federal and state regulations. This analysis also complies with guidelines and significance criteria specified by the SVP (1995, 2010).

Federal Regulations

Antiquities Act of 1906

The Antiquities Act of 1906 (16 USC 431–433) states, in part,

> That any person who shall appropriate, excavate, injure or destroy any historic or prehistoric ruin or monument, or any object of antiquity, situated on lands owned or controlled by the Government of the United States, without the permission of the Secretary of the Department of the Government having jurisdiction over the lands on which said antiquities are situated, shall upon conviction, be fined in a sum of not more than five hundred dollars or be imprisoned for a period of not more than ninety days, or shall suffer both fine and imprisonment, in the discretion of the court.

Although there is no specific mention of natural or paleontological resources in the Act itself, or in the Act's uniform rules and regulations (Title 43 Part 3, Code of Federal Regulations [43 CFR 3]), the term "objects of antiquity" has been interpreted to include fossils by the National Park Service (NPS), BLM, U.S. Forest Service (USFS), and other federal agencies. Permits to collect fossils on lands administered by federal agencies are authorized under this Act. However, due to the large gray areas left open to interpretation due to the imprecision of the wording, agencies are hesitant to interpret this act as governing paleontological resources.

The National Environmental Policy Act of 1969

NEPA, as amended (Public Law [PL] 91-190, 42 USC 4321–4347, January 1 1970, as amended by PL 94-52, July 3 1975, PL 94-83, August 9 1975, and PL 97-258 4(b), Sept. 13 1982) recognizes the continuing responsibility of the federal government to "preserve important historic, cultural, and natural aspects of our national heritage…" (Sec. 101 [42 USC 4321]). With the passage of the Paleontological Resources Preservation Act (PRPA), paleontological resources are considered a significant resource and it is therefore now standard practice to include paleontological resources in NEPA studies in all instances where there is a possible impact.

Federal Land Policy and Management Act of 1976

The Federal Land Policy and Management Act (FLPMA) of 1976 (43 USC 1712(c), 1732(b)); Section 2 of the Federal Land Management and Policy Act of 1962 [30 USC 611]; Subpart 3631.0 et seq.), *Federal Register* Vol. 47, No. 159, pg. 35914 (1982) do not refer specifically to fossils. However, "significant fossils" are understood and recognized in policy as scientific resources. Permits, which authorize the collection of significant fossils for scientific purposes, are issued under the authority of FLPMA. Under FLPMA, federal agencies are charged to

- manage public lands in a manner that protects the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, archaeological, and water resources, and, where appropriate, preserve and protect certain public lands in their natural condition (Section 102 (a)(8)(11));

- periodically inventory public lands so that the data can be used to make informed land-use decisions (Section 102(a)(2)); and
- regulate the use and development of public lands and resources through easements, licenses, and permits (Section 302(b)).

Paleontological Resources Preservation, Omnibus Public Lands Act of 2009

The Paleontological Resources Preservation Act was enacted as a result of the passage of the Omnibus Public Lands Act of 2009 (PL 111-011, Title VI, Subtitle D), which directs the Secretaries of the U.S. Department of the Interior (USDI) and U.S. Department of Agriculture to manage and protect paleontological resources on federal land using "scientific principles and expertise." To formulate a consistent paleontological resources management framework, PRPA incorporates most of the recommendations from the report of the Secretary of the Interior titled *Assessment of Fossil Management on Federal and Indian Lands* (USDI 2000). In passing the PRPA, Congress officially recognized the scientific importance of paleontological resources on some federal lands by declaring that fossils from these lands are federal property that must be preserved and protected. PRPA codifies existing policies of the BLM, NPS, USFS, Bureau of Reclamation, and U.S. Fish and Wildlife Service, and provides the following:

- uniform criminal and civil penalties for illegal sale and transport, and theft and vandalism of fossils from federal lands;
- uniform minimum requirements for paleontological resource-use permit issuance (terms, conditions, and qualifications of applicants);
- uniform definitions for "paleontological resources" and "casual collecting;" and
- uniform requirements for curation of federal fossils in approved repositories.

State Regulations

California Environmental Quality Act

CEQA is the principal statute governing environmental review of projects occurring in the state and is codified at Public Resources Code (PRC) Section 21000 et seq. CEQA requires lead agencies to determine if a proposed project would have a significant effect on the environment, including significant effects on paleontological resources. Guidelines for the Implementation of CEQA, as amended March 29 1999 (California Code of Regulations [CCR], Title 14, Chapter 3, Section 15000 et seq.), define procedures, types of activities, persons, and public agencies required to comply with CEQA, and include as one of the questions to be answered in the Environmental Checklist (14 CCR Section 15023, Appendix G, Section 14, Part a) the following: "Will the proposed project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?"

Public Resources Code Sections 5097.5

Requirements for paleontological resource management are included in the PRC Section 5097.5 , which states the following:

> No person shall knowingly and willfully excavate upon, or remove, destroy, injure or deface any historic or prehistoric ruins, burial grounds, archaeological or vertebrate paleontological site, including fossilized footprints, inscriptions made by human agency, or any other archaeological, paleontological or historical feature, situated on public lands, except with the express permission of the public agency having jurisdiction over such lands. Violation of this section is a misdemeanor.

These statutes prohibit the removal, without permission, of any paleontological site or feature from lands under the jurisdiction of the state or any city, county, district, authority, or public corporation, or any agency thereof. As a result, local agencies are required to comply with PRC Section 5097.5 for their own activities, including construction and maintenance, as well as for permit actions (e.g., encroachment permits) undertaken by others. PRC Section 5097.5 also establishes the removal of paleontological resources as a misdemeanor and requires reasonable mitigation of adverse impacts to paleontological resources from developments on public (state, county, city, and district) lands.

Local Regulations

Imperial County

The Imperial County General Plan does not address paleontological resources.

Los Angeles County

The Los Angeles County General Plan (Los Angeles County 2015) addresses paleontological resources in Section 8 of Chapter 9: Conservation and Natural Resources Element. This section identifies six policies for the protection of historic, cultural, and paleontological resources, of which Policies 1, 2, 5 and 6 pertain to paleontological resources:

> **Policy C/NR 14.1**: Mitigate all impacts from new development on or adjacent to historic, cultural, and paleontological resources to the greatest extent feasible.
>
> **Policy C/NR 14.2**: Support an inter-jurisdictional collaborative system that protects and enhances historic, cultural, and paleontological resources.
>
> **Policy C/NR 14.5**: Promote public awareness of historic, cultural, and paleontological resources.
>
> **Policy C/NR 14.6**: Ensure proper notification and recovery processes are carried out for development on or near historic, cultural, and paleontological resources.

Orange County

The Orange County General Plan includes paleontological resources in the cultural resources' management program (Orange County 2005:Chapter VI). Goal 2 states, "to encourage through a resource management effort the preservation of the county's cultural and historic heritage," (Orange County 2005:VI-123) and identifies the following objectives to preserve paleontological resources:

> **Objective 2.2**: Take all reasonable and proper steps to achieve the preservation of archaeological and paleontological remains, or their recovery and analysis to preserve cultural, scientific, and educational values.

Specifically, the General Plan identifies the following three policies to guide the management of paleontological resources:

1. To identify paleontological resources through literature and records research and surface surveys.
2. To monitor and salvage paleontological resources during the grading of a project.
3. To preserve paleontological resources by maintaining them in an undisturbed condition.

Riverside County

Paleontological resources are addressed in the Multipurpose Open Space Element (Chapter 5) of the Riverside County General Plan (Riverside County 2015). The following policies provide direction for paleontological resources:

> **Open Space Policy 19.6 –** Whenever existing information indicates that a site proposed for development has high paleontological sensitivity… a paleontological resource impact mitigation program (PRIMP) shall be filed with the County Geologist prior to site grading. The PRIMP shall specify the steps to be taken to mitigate impacts to paleontological resources.

> **Open Space Policy 19.7 –** Whenever existing information indicates that a site proposed for development has low paleontological sensitivity… no direct mitigation is required unless a fossil is encountered during site development. Should a fossil be encountered, the County Geologist shall be notified, and a paleontologist shall be retained by the project proponent. The paleontologist shall document the extent and potential significance of the paleontological resources on the site and establish appropriate mitigation measures for further site development.

> **Open Space Policy 19.8 –** Whenever existing information indicates that a site proposed for development has undetermined paleontological sensitivity… a report shall be filed with the County Geologist documenting the extent and potential significance of the paleontological resources on site and identifying mitigation measures for the fossil and for impacts to significant paleontological resources prior to approval of that department.

> **Open Space Policy 19.9 –** Whenever paleontological resources are found, the County Geologist shall direct them to a facility within Riverside County for their curation, including the Western Science Center in the city of Hemet.

San Bernardino County

The Conservation Element of the San Bernardino County General Plan (San Bernardino County 2007: Chapter 5) identifies paleontological resources as part of the heritage of San Bernardino County. Goal

CO3 states, "the County will preserve and promote its historic and prehistoric cultural heritage," and identifies the following policies to preserve paleontological resources:

> **Policy CO 3.4, program 4**: In areas of potential but unknown sensitivity, field surveys prior to grading will be required to establish the need for paleontologic monitoring.
>
> **Policy CO 3.4, program 5**: Projects requiring grading plans that are located in areas of known fossil occurrences, or demonstrated in a field survey to have fossils present, will have all rough grading (cuts greater than 3 feet) monitored by trained paleontologic crews working under the direction of a qualified professional, so that fossils exposed during grading can be recovered and preserved. Fossils include large and small vertebrate fossils, the latter recovered by screen washing of bulk samples.
>
> **Policy CO 3.4, program 6**: A report of findings with an itemized accession inventory will be prepared as evidence that monitoring has been successfully completed. A preliminary report will be submitted and approved prior to granting of building permits, and a final report will be submitted and approved prior to granting of occupancy permits. The adequacy of paleontologic reports will be determined in consultation with the Curator of Earth Science, San Bernardino County Museum.

Ventura County

The Ventura County General Plan addresses paleontological resources in Section 1.8: Paleontological and Cultural Resources (Ventura County 2019). The Plan identifies two goals, six policies, and three programs for the protection of paleontological resources, of which the following apply to paleontological resources:

> **1.8.1 Goals**
>
> 1. Identify, inventory, preserve and protect the paleontological and cultural resources of Ventura County (including archaeological, historical and Native American resources) for their scientific, educational and cultural value.
>
> 2. Enhance cooperation with cities, special districts, other appropriate organizations, and private landowners in acknowledging and preserving the County's paleontological and cultural resources.
>
> **1.8.2 Policies**
>
> 1. Discretionary developments shall be assessed for potential paleontological and cultural resource impacts, except when exempt from such requirements by CEQA. Such assessments shall be incorporated into a Countywide paleontological and cultural resource data base.
>
> 2. Discretionary development shall be designed or re-designed to avoid potential impacts to significant paleontological or cultural resources whenever possible. Unavoidable impacts, whenever possible, shall be reduced to a less than significant level and/or shall be mitigated by extracting maximum recoverable data. Determinations of impacts, significance and mitigation shall be made by qualified archaeological (in consultation with recognized local Native American groups), historical or paleontological consultants, depending on the type of resource in question.
>
> 3. Mitigation of significant impacts on cultural or paleontological resources shall follow the Guidelines of the State Office of Historic Preservation, the State Native American Heritage

Commission, and shall be performed in consultation with professionals in their respective areas of expertise

1.8.3 Programs

2. The Planning Division will continue to compile and retain a list of qualified archaeological, historical, and paleontological consultants to provide additional information to complete Initial Studies and Environmental Analyses.

EXISTING CONDITIONS

Methods

The following section presents an overview of the methodology used to identify the potential for paleontological resources within the SCAG region. This report is based on a desktop review of available scientific literature, geologic maps, and online museum records searches from the UCMP and SDNHM.

Professional Standards

Both the SVP (1995, 2010) and the BLM (2009, 2016) have established standard guidelines that outline professional protocols and practices for conducting paleontological resource assessments and surveys, monitoring and mitigation, data and fossil recovery, sampling procedures, and specimen preparation, identification, analysis, and curation. Most practicing professional vertebrate paleontologists adhere closely to the SVP's assessment, mitigation, and monitoring requirements, as specifically provided in its standard guidelines. Most state regulatory agencies with paleontological laws, ordinances, regulations, and standards accept and use the professional standards set forth by the SVP to meet the requirements of CEQA. The BLM's paleontological guidelines are designed to meet the requirements of NEPA and the FLPMA and are, in general, only relevant to projects on BLM-administered land or under the oversight of the BLM.

As defined by the SVP (2010:11), significant paleontological resources are

> …fossils and fossiliferous deposits, here defined as consisting of identifiable vertebrate fossils, large or small, uncommon invertebrate, plant, and trace fossils, and other data that provide taphonomic, taxonomic, phylogenetic, paleoecologic, stratigraphic, and/or biochronologic information. Paleontological resources are considered to be older than recorded human history and/or older than middle Holocene (i.e., older than about 5,000 radiocarbon years).

As defined by the BLM (2009:19), significant paleontological resources are

> …any paleontological resource that is considered to be of scientific interest, including most vertebrate fossil remains and traces, and certain rare or unusual invertebrate and plant fossils. A significant paleontological resource is considered to be scientifically important because it is a rare or previously unknown species, it is of high quality and well-preserved, it preserves a previously unknown anatomical or other characteristic, provides new information about the history of life on earth, or has identified educational or recreational value. Paleontological resources that may be considered to not have paleontological significance include those that lack provenience or context, lack physical integrity because of decay or natural erosion, or that are overly redundant or are otherwise not useful for

> research. Vertebrate fossil remains and traces include bone, scales, scutes, skin impressions, burrows, tracks, tail drag marks, vertebrate coprolites (feces), gastroliths (stomach stones), or other physical evidence of past vertebrate life or activities.

These definitions of significant resources are similar in that both recognize any type of fossil (invertebrate, vertebrate, plant, or trace fossils) can be scientifically significant if it is identifiable or well preserved and contributes scientifically valuable data.

A geologic unit known to contain significant fossils is considered sensitive to adverse impacts if there is a high probability that earth-moving or ground-disturbing activities in that rock unit will either disturb or destroy fossil remains directly or indirectly. This definition of sensitivity differs fundamentally from the definition for archaeological resources, as follows:

> It is extremely important to distinguish between archaeological and paleontological resources when discussing the paleontological potential of rock units. The boundaries of an archaeological resource site define the areal/geographic extent of an archaeological resource, which is generally independent from the rock unit on which it sits. However, paleontological sites indicate that the containing rock unit or formation is fossiliferous. Therefore, the limits of the entire rock unit, both areal and stratigraphic, define the extent of paleontological potential. (SVP 2010)

Many archaeological sites contain features that are visually detectable on the surface. In contrast, fossils are often contained within surficial sediments or bedrock and are, therefore, not observable or detectable unless exposed by erosion or human activity.

Numerous paleontological studies have developed criteria for the assessment of significance for fossil discoveries (e.g., Eisentraut and Cooper 2002; Murphey and Daitch 2007; Scott and Springer 2003). In general, these studies assess fossils as significant if one or more of the following criteria apply:

1. The fossils provide information on the evolutionary relationships and developmental trends among organisms, living or extinct;
2. The fossils provide data useful in determining the age(s) of the rock unit or sedimentary stratum, including data important in determining the depositional history of the region and the timing of geologic events therein;
3. The fossils provide data regarding the development of biological communities or interaction between paleobotanical and paleozoological biotas;
4. The fossils demonstrate unusual or spectacular circumstances in the history of life; or
5. The fossils are in short supply and/or in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and are not found in other geographic locations.

In summary, paleontologists cannot know either the quality or quantity of fossils prior to natural erosion or human-caused exposure. As a result, even in the absence of fossils on the surface, it is necessary to assess the sensitivity of rock units based on their known potential to produce significant fossils elsewhere within the same geologic unit (both within and outside the study area), a similar geologic unit, or based on whether the unit in question was deposited in a type of environment known to be favorable for fossil preservation. Monitoring by experienced paleontologists greatly increases the probability that fossils will be discovered during ground-disturbing activities and that, if these remains are significant, successful mitigation and salvage efforts may be undertaken to prevent adverse impacts to these resources.

Both the SVP and the BLM have developed a ranking system for assessing the paleontological sensitivity of a geologic formation. For projects with a state nexus, the SVP classification system is generally used, while for federal projects, the BLM's classification system is used. These systems are discussed below.

SVP Categories of Paleontological Potential

Paleontological potential is defined as the potential for a geologic unit to produce scientifically significant fossils. This is determined by rock type, history of the geologic unit in producing significant fossils, and fossil localities recorded from that unit. Paleontological sensitivity is derived from the known fossil data collected from the entire geologic unit, not just from a specific survey. In its *Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources*, the SVP (2010:1–2) defines four categories of paleontological sensitivity (potential) for rock units: high, low, undetermined, and no potential. These categories are defined as follows:

> **High Potential**. "Rock units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered are considered to have a high potential for containing additional significant paleontological resources. Rocks units classified as having high potential for producing paleontological resources include, but are not limited to, sedimentary formations and some volcaniclastic formations (e.g., ash or tephra), and some low-grade metamorphic rocks which contain significant paleontological resources anywhere within their geographical extent, and sedimentary rock units temporally or lithologically suitable for the preservation of fossils (e.g., middle Holocene and older, fine-grained fluvial sandstone, argillaceous and carbonate-rich paleosols, cross-bedded point bar sandstone, fine-grained marine sandstone, etc.). Paleontological potential consists of both a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, plant, or trace fossils and b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. Rock units which contain potentially datable organic remains older than late Holocene, including deposits associated with animal nests or middens, and rock units which may contain new vertebrate deposits, traces, or trackways are also classified as having high potential."

> **Low Potential**. "Reports in the paleontological literature or field surveys by a qualified professional paleontologist may allow determination that some rock units have low potential for yielding significant fossils. Such rock units will be poorly represented by fossil specimens in institutional collections, or based on general scientific consensus only preserve fossils in rare circumstances and the presence of fossils is the exception not the rule, e.g. basalt flows or Recent colluvium. Rock units with low potential typically will not require impact mitigation measures to protect fossils."

> **Undetermined Potential**. "Rock units for which little information is available concerning their paleontological content, geologic age, and depositional environment are considered to have undetermined potential. Further study is necessary to determine if these rock units have high or low potential to contain significant paleontological resources. A field survey by a qualified professional paleontologist to specifically determine the paleontological resource potential of these rock units is required before a PRIMP can be developed. In cases where no subsurface data are available, paleontological potential can sometimes be determined by strategically located excavations into subsurface stratigraphy."

> **No Potential**. "Some rock units have no potential to contain significant paleontological resources, for instance high-grade metamorphic rocks (such as gneisses and schists) and plutonic igneous

rocks (such as granites and diorites). Rock units with no potential require no protection or impact mitigation measures relative to paleontological resources" (SVP 2010:1–2).

BLM Potential Fossil Yield Classification

The Potential Fossil Yield Classification (PFYC) system was developed to provide baseline guidance for assessing paleontological resources and allow BLM employees to make initial assessments of paleontological resources. The presence of paleontological resources is correlated with mapped geologic units, and the PFYC was based on available geologic maps. The system assigns a class value to each geological unit, representing the potential abundance and significance of paleontological resources that occur in that geological unit. A complete discussion of the background and context for the PFYC system is provided in the BLM IM2016-124 document (BLM 2016). The following descriptions of paleontological sensitivity class rankings pertinent to this project and drawn directly from the BLM Guidelines are provided here:

Class 1–Very Low. Geologic units that are not likely to contain recognizable paleontological resources. Units assigned to Class 1 typically have one or more of the following characteristics:

- Geologic units are igneous or metamorphic, excluding air-fall and reworked volcanic ash units.
- Geologic Units are Precambrian in age.

(1) Management concerns for paleontological resources in Class 1 units are usually negligible or not applicable.

(2) Paleontological mitigation is unlikely to be necessary except in very rare or isolated circumstances that result in the unanticipated presence of paleontological resources, such as unmapped geology contained within a mapped geologic unit. For example, young fissure-fill deposits often contain fossils but are too limited in extent to be represented on a geological map; a lava flow that preserves evidence of past life, or caves that contain important paleontological resources. Such exceptions are the reason that no geologic unit is assigned a Class 0.

Overall, the probability of impacting significant paleontological resources is very low and further assessment of paleontological resources is usually unnecessary. An assignment of Class 1 normally does not trigger further analysis unless paleontological resources are known or found to exist. However, standard stipulations should be put in place prior to authorizing any land use action in order to accommodate an unanticipated discovery.

Class 2–Low. Geologic units that are not likely to contain paleontological resources. Units assigned to Class 2 typically have one or more of the following characteristics:

- Field surveys have verified that significant paleontological resources are not present or are very rare.
- Units are generally younger than 10,000 years before present.
- Recent aeolian deposits.
- Sediments exhibit significant physical and chemical changes (i.e., diagenetic alteration) that make fossil preservation unlikely.

(1) Except where paleontological resources are known or found to exist, management concerns for paleontological resources are generally low and further assessment is usually unnecessary except in occasional or isolated circumstances.

(2) Paleontological mitigation is only necessary where paleontological resources are known or found to exist.

The probability of impacting significant paleontological resources is low. Localities containing important paleontological resources may exist, but are occasional and should be managed on a case-by-case basis. An assignment of Class 2 may not trigger further analysis unless paleontological resources are known or found to exist. However, standard stipulations should be put in place prior to authorizing any land use action in order to accommodate unanticipated discoveries.

Class 3–Moderate. Sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Units assigned to Class 3 have some of the following characteristics:

- Marine in origin with sporadic known occurrences of paleontological resources.
- Paleontological resources may occur intermittently, but abundance is known to be low.
- Units may contain significant paleontological resources, but these occurrences are widely scattered.
- The potential for an authorized land use to impact a significant paleontological resource is known to be low-to-moderate.

(1) Management concerns for paleontological resources are moderate because the existence of significant paleontological resources is known to be low. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for casual collecting.

(2) Paleontological mitigation strategies will be proposed based on the nature of the proposed activity.

This classification includes units of moderate or infrequent occurrence of paleontological resources. Management considerations cover a broad range of options that may include record searches, pre-disturbance surveys, monitoring, mitigation, or avoidance. Surface-disturbing activities may require assessment by a qualified paleontologist to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources.

Class 4–High. Geologic units that are known to contain a high occurrence of paleontological resources. Units assigned to Class 4 typically have the following characteristics:

- Significant paleontological resources have been documented but may vary in occurrence and predictability.
- Surface disturbing activities may adversely affect paleontological resources.
- Rare or uncommon fossils, including nonvertebrate (such as soft body preservation) or unusual plant fossils, may be present.
- Illegal collecting activities may impact some areas.

(1) Management concerns for paleontological resources in Class 4 are moderate to high, depending on the proposed action.

(2) Paleontological mitigation strategies will depend on the nature of the proposed activity, but field assessment by a qualified paleontologist is normally needed to assess local conditions.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation plans must consider the nature of the proposed disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access that could result in looting. Detailed field assessment is normally required and on-site monitoring or spot-checking may be necessary during land disturbing activities. In some cases avoidance of known paleontological resources may be necessary.

Class 5–Very High. Highly fossiliferous geologic units that consistently and predictably produce significant paleontological resources. Units assigned to Class 5 have some or all of the following characteristics:

- Significant paleontological resources have been documented and occur consistently.
- Paleontological resources are highly susceptible to adverse impacts from surface disturbing activities.
- Unit is frequently the focus of illegal collecting activities.

(1) Management concerns for paleontological resources in Class 5 areas are high to very high.

(2) A field survey by a qualified paleontologist is almost always needed. Paleontological mitigation may be necessary before or during surface disturbing activities.

The probability for impacting significant paleontological resources is high. The area should be assessed prior to land tenure adjustments. Pre-work surveys are usually needed and on-site monitoring may be necessary during land use activities. Avoidance or resource preservation through controlled access, designation of areas of avoidance, or special management designations should be considered.

Class U–Unknown Potential. Geologic units that cannot receive an informed PFYC assignment. Characteristics of Class U may include:

- Geological units may exhibit features or preservational conditions that suggest significant paleontological resources could be present, but little information about the actual paleontological resources of the unit or area is known.
- Geological units represented on a map are based on lithologic character or basis of origin, but have not been studied in detail.
- Scientific literature does not exist or does not reveal the nature of paleontological resources.
- Reports of paleontological resources are anecdotal or have not been verified.
- Area or geologic unit is poorly or under-studied.
- BLM staff has not yet been able to assess the nature of the geologic unit.

(1) Until a provisional assignment is made, geologic units that have an unknown potential have medium to high management concerns.

(2) Lacking other information, field surveys are normally necessary, especially prior to authorizing a ground-disturbing activity.

An assignment of "Unknown" may indicate the unit or area is poorly studied, and field surveys are needed to verify the presence or absence of paleontological resources. Literature searches or consultation with professional colleagues may allow an unknown unit to be provisionally assigned to another Class, but the geological unit should be formally assigned to a Class after adequate survey and research is performed to make an informed determination.

Results

Geologic Setting

The SCAG region covers most of southern California and an incredible diversity of geology. Rocks found in the region span over two billion years of Earth's history, from Precambrian granite and metasedimentary rocks to Holocene alluvium, the deposition of which is ongoing today (see Figure 2 for geologic time scale). The state of California has been divided into 11 geomorphic provinces in order to accurately generalize the distinctive geologic regions of the state. Five of these provinces compose the SCAG region: Basin and Range, Colorado Desert, Mojave Desert, Peninsular Ranges, and Transverse Ranges (Figure 3). These provinces and their generalized geology and paleontology are discussed below.

BASIN AND RANGE

Within the SCAG region, the southernmost edge of the Basin and Range Geomorphic Province occurs in northern San Bernardino County. The Basin and Range Geomorphic Province extends from the Sierra Nevada Mountains in the north and east into Nevada in the west and is bounded by the Garlock Fault in northern San Bernardino County to the south (Norris and Webb 1990). This province is characterized by high geographic relief, with steep mountain ranges separated by deep valleys, such as Death Valley, Owens Valley, and Saline Valley. These basins have very little permanent water supplies, with the exception of Mono Lake and the Owens River (Norris and Webb 1990).

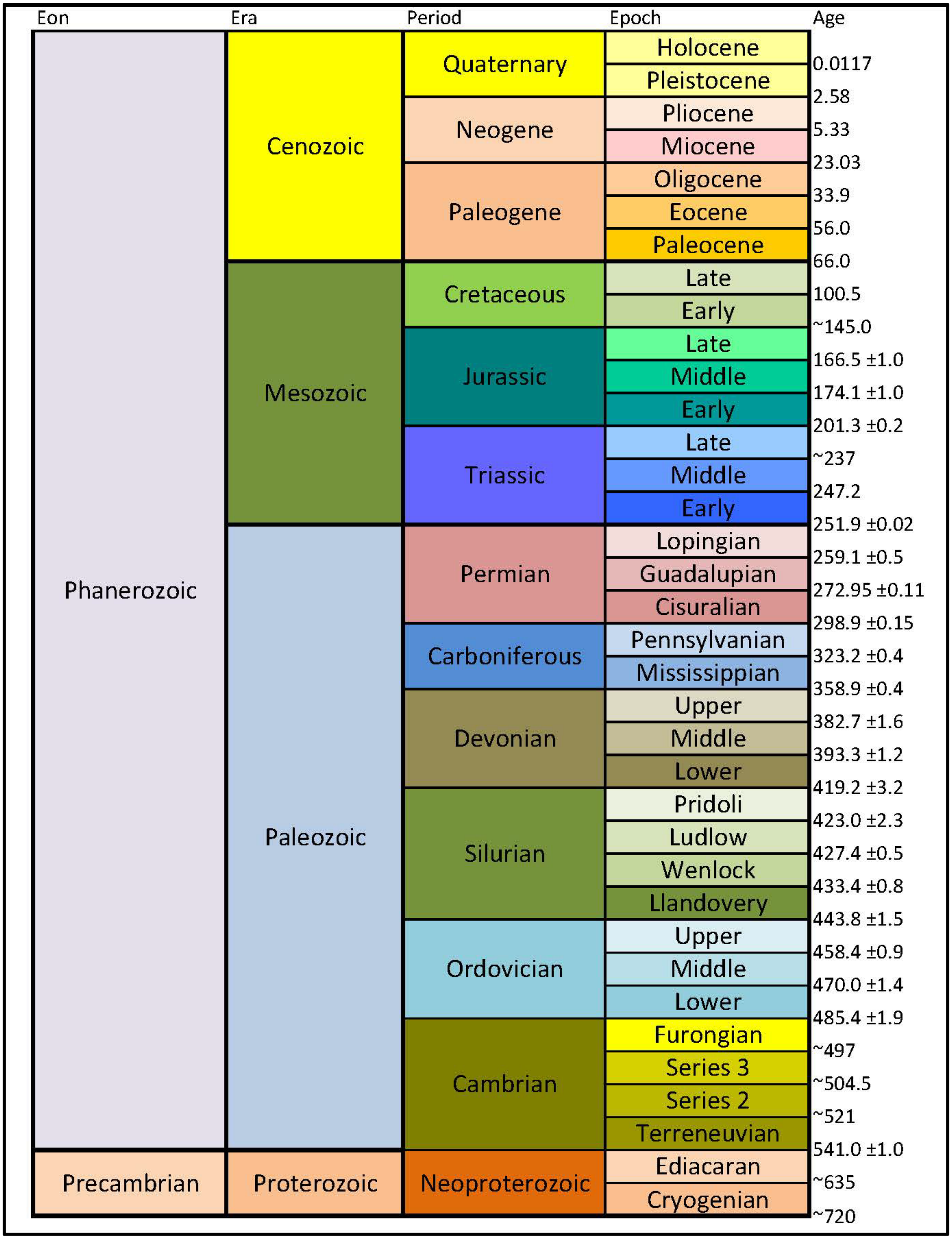

Figure 2. Geologic timescale.

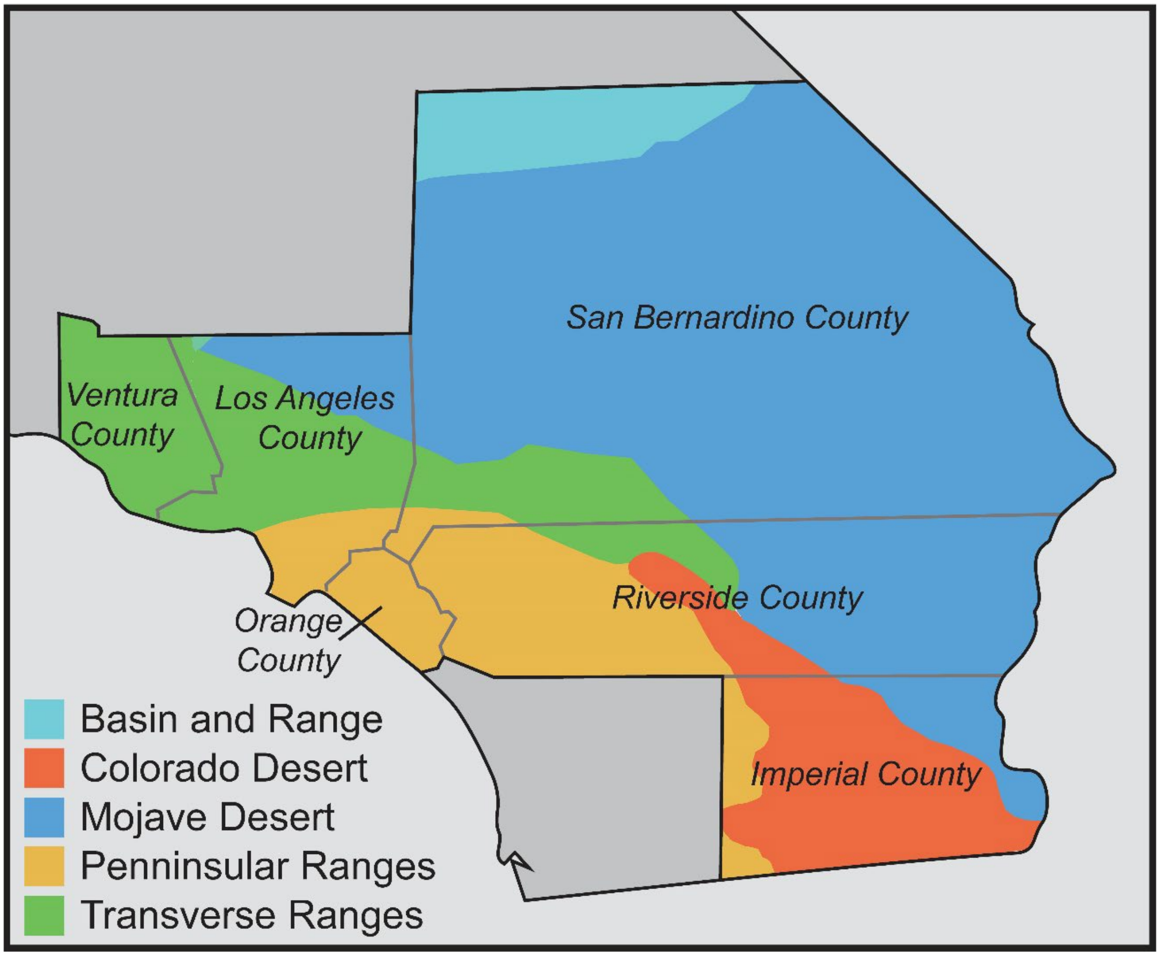

Figure 3. Geomorphic provinces in SCAG region.

The Basin and Range Province preserves some of the oldest rocks in the state, exposed around Death Valley, a sequence of early to middle Proterozoic metamorphic and granitic rocks that date to 1.8 billion years old (Norris and Webb 1990). A thick sequence of younger Proterozoic rocks composed of slightly metamorphosed sedimentary rocks deposited in a nearshore marine environment overlies these basement rocks, which are best exposed around Death Valley and in the Mojave as well (Corsetti and Hagadorn 2000). This sequence is in turn overlain by rocks that preserve the Proterozoic-Paleozoic transition, with rocks in the White-Inyo Mountains preserving fossils of the first organisms to evolve hard shells at the beginning of an evolutionary radiation paleontologists refer to as the Cambrian Explosion (Waggoner and Hagadorn 2005). Younger Paleozoic rocks are represented by beds of limestone and dolomite that are thickest in the Inyo Mountains and thin towards the east and indicate deposition along the slope and shelf of an ancient ocean margin (Norris and Webb 1990). Few sedimentary rocks are preserved from the Mesozoic in the Basin and Range Province, where rocks of this age are primarily intrusive igneous rocks and volcanic deposits (Ingersoll 1983). Cenozoic deposits in the Basin and Range date back to the Oligocene and preserve terrestrial environments with continued volcanic input (Norris and Webb 1990).

The modern topography of the Basin and Range began forming in the Miocene, when crustal extension, or stretching, began as a result of a change in plate motion between the Pacific and North American plates (Zoback 1989). This extension resulted in prominent horst-and-graben fault block patterns, where basins are formed along normal faults between down-dropped blocks lowered relative to the upward moving mountain blocks (Zoback 1989). Continual tectonic activity resulted in the basins observed today, many of which host playa beds and saline deposits deposited during wetter periods toward the end of the last glaciation (Reheis et al. 2002). Volcanism also continued in the Basin and Range, with abundant volcanic rocks dating from the Late Pliocene to Holocene. The youngest of these deposits are in the Coso Mountains around Red Hill, and date to slightly over 10,000 years old (Crowley et al. 2007).

COLORADO DESERT

The Colorado Desert Geomorphic Province is bounded to the east by the Colorado River, to the south by the international border, and to the west by the Peninsular Ranges, occupying the majority of Imperial County and extending northwards into central Riverside County within the SCAG region. Norris and Webb (1990) define the northern border as the southern edge of the eastern Transverse Ranges and the San Bernardino-Riverside County line.

The Colorado Desert is similar geologically to the Mojave Desert (see below) and generally only distinguished from the Mojave by being lower in elevation, and, thereby, with a slightly different climate and vegetation (Norris and Webb 1990). The dominant feature of this province is the Salton Trough, a large depression extending from the San Gorgonio Pass in the north to the Gulf of California in Mexico. Within this large structural depression, the Salton Basin is restricted to the portion draining into the Salton Sea in southern Riverside and northern Imperial counties (Dorsey 2010).

The stratigraphy of the Colorado Desert is much like that of the Mojave, discussed in more detail below, with Proterozoic granitic rocks forming the core of scattered mountain ranges, which have been intruded by younger igneous bodies dating from the late Paleozoic to the middle Cenozoic (Norris and Webb 1990). Preserved sediment dates to the Eocene, with alternating periods of terrestrial and marine-dominated deposition. Uplift of the mountains present in the Colorado Desert today began in the Mesozoic, and, since that time, the uplifted areas have been actively eroding, leading to large deposits of sedimentary rocks that date from the middle Cenozoic to modern times (Davis et al. 1994).

MOJAVE DESERT

The Mojave Desert occupies about 65,000 square kilometers (km) (25,097 square miles), bounded to the northwest by the Transverse Ranges and to the southeast by the Colorado Desert. The Sierra Nevada and the Basin and Ranges provinces establish the northern boundary and the Nevada state line and Colorado River establish the eastern boundary (Norris and Webb 1990). The Mojave Desert province is wedged in a sharp angle between the Garlock Fault (southern boundary Sierra Nevada) and the San Andreas Fault, where the latter bends east from its northwest trend. The northern boundary of the Mojave is separated from the prominent Basin and Range by the eastern extension of the Garlock Fault (Dokka and Travis 1990). Roughly half of the SCAG region, divided diagonally, occurs in the Mojave Desert: the majority of San Bernardino County, the eastern half of Riverside County, and the northeastern corners of Los Angeles and Imperial counties.

The province is very similar in terms of geology to the Colorado Desert, discussed above, differing by being at a generally higher elevation. The Mojave Desert is characterized by scattered mountain blocks bounded by normal and strike-slip faults and the broad alluvial basins between them (Dibblee 1967). Basin fill ranges from thick sequences of Miocene sediments north of Barstow to more recent Quaternary depressions north of Baker, and even rock-floored pediments in the northeastern Mojave (Norris and Webb 1990). Lava flows that date from the Cenozoic are also common features across the Mojave, such as Amboy Crater, Cima Dome, and around Pisgah, with volcanic sediments intermixed with terrestrial sediments dating as far back as the Miocene (Dibblee 1967). A more recent feature are the many playas scattered across Mojave, these being particularly numerous in the eastern Mojave (Norris and Webb 1990).

The sedimentary record in the western Mojave is dominated by Cenozoic deposits, with earlier deposits of Mesozoic and Paleozoic to Precambrian age generally limited to the eastern Mojave (Dibblee 1967). The Cenozoic record in the western Mojave is predominantly non-marine except for a few thin, restricted lower Miocene marine sediments. The western Mojave region includes extensive thicknesses of non-marine alluvium, with widespread tuff, ash and other volcaniclastics, interbedded with lake-bed sediments and evaporates. Miocene-aged rocks are prominent among the Cenozoic basins of the western Mojave, and occur where tectonic activity has exposed these sequences, such as within the Barstow Basin north of Barstow (Norris and Webb 1990).

PENINSULAR RANGES

The Peninsular Ranges extend from the Mexican border in the south to the Transverse Ranges in the north and northeast and are bordered by the Pacific Ocean on the west and the Colorado Desert on the east. Within the SCGA region, southern Los Angeles County, southeastern-most San Bernardino County, western Riverside and Imperial Counties, and all of Orange County occur in the Peninsular Ranges. The Peninsular Ranges are a series of northwest-trending mountain ranges extending approximately 240 km (149 miles) to the Mexican border, where they then continue for an additional 1,200 km (746 miles) along the Baja Peninsula (Harden 2004).

The core of the Peninsular Ranges is made up of Mesozoic plutonic rocks and represents the roots of a magmatic arc formed by active subduction along the Pacific Plate boundary (Harden 2004). Two main batholiths (western and eastern) form the core of the Peninsular Ranges. The western batholith is 140 to 105 million years old (Ma) and consists of mafic plutonic rocks, while the eastern batholith is 99 to 92 Ma and is made of more silica-rich granodiorites and tonalities (Kimbrough et al. 2001). These plutonic rocks intruded into the older rocks of a Paleozoic through Jurassic carbonate platform and forearc basin, heavily metamorphosing them locally (Harden 2004). Above these plutonic rocks, around 130 to 120 Ma, the Santiago Peak Volcanics were deposited as primarily andesitic and silicic flows, and then metamorphosed by the batholith emplacement (Fife et al. 1967). Cretaceous sedimentary rocks deposited as turbidity currents overlie the plutons and volcanic rocks (Kimbrough et al. 2001). These rocks are in turn overlain by more recent sedimentary deposits leading up to the present day. These deposits were marine through the Eocene and then shifted to terrestrial volcanic and sedimentary strata by the Oligocene and lower Miocene (Powell 1993).

TRANSVERSE RANGES

The Transverse Ranges run from west to east across the northwestern SCAG region, crossing all of Ventura County, central Los Angeles County, southwestern San Bernardino County, and north-central Riverside County. The Transverse Ranges Geomorphic Province consists of a complex series of young, east/west-trending mountain ranges and valleys that contradict the general north/south orientation of California's other mountain ranges, such as the Peninsular Ranges and Coastal Ranges (Matti et al. 1992). The Transverse Ranges begin at Point Conception in Santa Barbara County and extend in an easterly direction, terminating at the San Bernardino Mountains in San Bernardino County. Westerly, the Transverse Ranges continue offshore as the northern Channel Islands. Most of the ranges are bounded to the north and east by the San Andreas Fault System, which separates the ranges from the Coastal Ranges and Peninsular Ranges. Components of the ranges that lie north of the San Andreas Fault are the Tehachapi Mountains and San Bernardino Mountains. Most of the tallest peaks are in the eastern portion of the range and include Mount San Gorgonio and San Bernardino Peak. The Transverse Ranges are noted for being extremely steep and difficult to traverse.

The Transverse Ranges include a wide variety of geologic units, ranging in age from the Proterozoic to the recent (Norris and Web 1990). The Transverse Ranges are underlain by a thick sequence of late

Mesozoic- and Cenozoic-age strata that rest uncomfortably on a variety of basement rocks (Namson and Davis 1988). These ranges are undergoing active north/south shortening due to faulting (Dibblee 1967), which causes a significant rise in elevation on an annual scale. These fault-bounded ranges are mainly composed of two distinct types of crystalline basement rocks that are separated by thrust faults. The lower rocks consist of metamorphosed sedimentary and volcanic rocks known as the Pelona Schist.
The uppermost rock comprises older metamorphic and plutonic rocks that originally formed part of the ancient North American continental platform known as Mendenhall Gneiss and gabbro (Norris and Web 1990).

Paleontologic Setting

Given the diversity of geologic units found in the SCAG region, the paleontology is equally diverse, and, in some areas, fossils are quite abundant. A detailed analysis of the paleontological sensitivity of each geologic formation in the SCAG region is beyond the scope of this analysis and should be the subject of project-specific paleontological assessments (see recommendations below). The SVP (2010) defines fossils as being over 5,000 years in age, while the BLM (2009, 2016) generally considers fossils to be Pleistocene in age or older (11,700 years in age). Therefore, sediments younger than middle or early Holocene are too young to preserve fossil resources and have low (SVP) or PFYC 2 (BLM) paleontological sensitivity. Other types of geologic units with low sensitivity are moderately metamorphosed rocks, as the heat and pressure associated with metamorphism is likely to destroy fossils. High grade metamorphic rocks, as well as igneous rocks, have no paleontological sensitivity.

Some generalizations about the primary types of fossil bearing rocks can be made, based on the 1:750,000 scale geologic mapping by Jennings et al. (2010), as discussed below.

CENOZOIC MARINE DEPOSITS

Cenozoic marine deposits date from the Paleocene to the Pliocene and were deposited on the ancient seafloor. These geologic formations are well known for being highly fossiliferous in southern California and may preserve a wide variety of marine fauna: invertebrates such as mollusks, crustaceans, echinoderms, and others; marine vertebrates such as shark and other fish, whales, seals, sea lions, and others; and even terrestrial vertebrates such as horse, camel, bison, and others that washed out to sea and where buried in the near-shore marine deposits.

These deposits are particularly common at the surface in the Transverse Ranges in Ventura County, where Eocene and Miocene units are prevalent, coastal Orange County, central Imperial County as scattered outcrops around the Salton Sea, and central Los Angeles County. In the subsurface, these deposits are likely to be encountered underlying the younger surficial alluvium across large parts of the Los Angeles and San Bernardino basins.

Some of these units with the highest paleontological sensitivity (BLM PFYC class 4 or 5, SVP high potential) are discussed below:

> **Shallow Marine Deposits**. Shallow marine deposits such as the San Pedro Sand and the Palos Verdes Sand have a strong record of preserving Pleistocene-aged marine and terrestrial fossils. The San Pedro Sand has yielded a diverse fauna of nearshore marine invertebrates such as crabs, snails, bivalves, gastropods, and echinoids (Kennedy 1975; Valentine 1989; Woodring 1957) and vertebrates such as sharks, bony fish, amphibians, reptiles, birds, whales, antelopes, mammoth, dire wolves, rodents, and bison (Barnes and McLeod 1984; Fitch 1967; Kennedy 1975; Woodring 1957). These units are common along coastal southern California, including Ventura, Los Angeles, and Orange Counties in the SCAG region. Many abundant fossil localities have been collected from excavations in San Pedro around the Port of Los Angeles, where the setting is very

similar to that of the program area, with artificial fill covering old marine deposits. These deposits have yielded thousands of specimens of marine invertebrates that are significant for reconstructing changes in shallow marine ecosystems as the climate has changed since the Pleistocene (DeBusk et al. 2009; Jacobs 2005; Powell and Stevens 2000).

Fernando Formation. The Fernando Formation dates to the Pliocene and consists of marine siltstone, sandstone, pebbly sandstone, and conglomerate (Morton and Miller 2006).
The Fernando is common in the Transverse Ranges, particularly in Los Angeles County, where it is found extensively in the subsurface throughout the Los Angeles Basin. The lower part of the Fernando Formation consists of a pebble-cobble conglomerate in a sandstone matrix that fines upwards into a coarse sandstone and then a silty sandstone (Schoellhamer et al. 1981). The upper Fernando Formation consists of coarse-grained sandstone with conglomerate lenses (Schoellhamer et al. 1981). The Fernando Formation has an extensive record of preserving scientifically significant fossils, including invertebrates such as mollusks, echinoids, and bryozoans (Groves 1992; Morris 1976; Woodring 1938), fish (Huddleston and Takeuchi 2006), squid (Clarke et al. 1980), and a number of unidentified megafossils (Schoellhamer et al. 1981).

Bouse Formation. The Bouse Formation spans the early Pliocene to the late Miocene and has been interpreted to represent either a marine estuarian or lacustrine depositional environment (Spencer and Patchett 1997). The Bouse Formation is found in the Mojave Desert Geomorphic Province and consists of calcareous clay, silt, and sand (Carr and Dickey 1980). Abundant common invertebrate fossils such as gastropods, ostracodes, barnacles, and foraminifera, as well as fish and plants are known from the Bouse Formation (Carr and Dickey 1980; Spencer and Patchett 1997).

Puente Formation. The Puente Formation, often synonymous with the Modelo Formation, consists of marine sandstone, siltstone, and shale that dates from the early Pliocene to the Miocene (Critelli et al. 1995; Morton and Miller 2006). The Puente Formation has a history of preserving both invertebrate and vertebrate marine fossils, such as cephalopods (Saul and Stadum 2005), crustaceans (Feldman 2003), fishes (Carnevale et al. 2008; David 1943; Hilton and Grande 2006; Huddleston and Takeuchi 2006), and other marine and terrestrial vertebrates (Barboza et al. 2017; Leatham and North 2017). The Puente Formation is common in the Peninsular Ranges and Transverse Ranges provinces.

Monterey Formation. The Monterey Formation records the filling of a deep basin formed by tectonism along the California margin (Pisciotto and Garrison 1981) and constitutes one of the major elements of California geology and can range up to several thousands of feet thick (Bramlette 1946). The Monterey ranges in age from the Pliocene to middle Miocene (Obradovich and Naeser 1981) and can be found throughout the basins of the Peninsular Ranges and Transverse Ranges provinces in the subsurface. The Monterey has yielded a diverse fauna consisting of some mollusks (Bramlette 1946) and common fish skeletons (Bramlette 1946; Dibblee 1973), and remains of larger marine macrofauna such as whales (Pyenson and Haasl 2007) and the giant extinct Desmostylus (Hannibal 1922), as well as birds (Warheit 1992), crocodiles (Barboza et al. 2017) and rare land organisms such as horse and land plants (Bramlette 1946).

Vaqueros Formation. The Vaqueros Formation consists of predominately limey sandstone interbedded with siltstone and shale deposited in an offshore basin (Bartow 1974; Morton and Miller 2006). The Vaqueros Formation is common in the Peninsular Ranges and Transverse Ranges provinces and dates from the early Miocene to the late Eocene (Morton and Miller 2006). Common fossils in the Vaqueros include marine invertebrates such as barnacles, ostreids, pectinids and marine ichnofossils (Bartow 1974), as well as terrestrial vertebrates (Whistler and Lander 2003) and marine megafauna (Morton and Miller 2006).

CENOZOIC TERRESTRIAL DEPOSITS

Cenozoic terrestrial deposits date from the Paleocene to the Pleistocene and were deposited in terrestrial environments as alluvial sediments, fluvial sediments, and lacustrine deposits. These geologic formations are well known for being highly fossiliferous in southern California and may preserve a wide variety of terrestrial fauna: invertebrates such as mollusks; plants; and abundant terrestrial vertebrates such as horse, camel, bison, and others.

These deposits are particularly common at the surface in the Mojave and Colorado Desert provinces but are found scattered across the entire SCAG region. Some of these units with the highest paleontological sensitivity (BLM PFYC class 4 or 5, SVP high potential) are discussed below.

Pleistocene Alluvium. Pleistocene alluvium consists of sand, silt, and gravel deposited in terrestrial environments as the result of erosion of surrounding highlands and dates to the Pleistocene (11,000–2.58 ma; Jennings et al. 2010). Pleistocene sediments have a rich fossil history in southern California (Hudson and Brattstrom 1977; Jefferson 1991a, 1991b; McDonald and Jefferson 2008; Miller 1941, 1971; Roth 1984; Scott 2010; Scott and Cox 2008; Springer et al. 2009). The most common Pleistocene terrestrial mammal fossils include the bones of mammoth, horse, bison, camel, and small mammals, but other taxa, including lion, cheetah, wolf, antelope, peccary, mastodon, capybara, and giant ground sloth, have been reported (Graham and Lundelius 1994), as well as birds, amphibians, and reptiles such as frogs, salamanders, snakes, and turtles (Hudson and Brattstrom 1977). In addition to illuminating the striking differences between Southern California in the Pleistocene and today, this abundant fossil record has been vital in studies of extinction (e.g., Sandom, et al. 2014; Scott 2010), ecology (e.g., Connin et al. 1998), and climate change (e.g., Roy et al. 1996).

An excellent example of the striking abundance and diversity of these Pleistocene sediments comes from Riverside County, just south of San Bernardino County, where nearly 100,000 identifiable fossil specimens representing 105 vertebrate, invertebrate, and plant species were collected from more than 2,000 individual localities during the construction of the dam at Diamond Valley Lake (Springer et al. 2009) and are now housed at the Western Science Center in Hemet, California. This site represents the second largest late Pleistocene fossil assemblage known from the American Southwest after the La Brea Tar Pits in Los Angeles (Springer et al. 2009). Other Ice Age fossils have been found throughout the inland valleys (Miller 1971; Reynolds and Reynolds 1991; Reynolds et al. 2012) and the Mojave Desert (Jefferson 1987, 1988; Scott et al. 2004, 2006; Scott and Cox 2008).

Manix Formation. The Manix Formation consists of around 40 m of lacustrine, fluvial, and alluvial sediments deposited in and around the Middle to late Pleistocene Lake Manix (Jefferson et al. 2003). This formation occurs to the east of Barstow in the Mojave Desert. The lacustrine and fluvial deposits in this formation have yielded a diverse fauna, preserving invertebrates such as mollusks and ostracods as well as aquatic and terrestrial vertebrates such as fish, birds, and numerous Ice Age mammals (Jefferson et al. 2003).

San Timoteo Formation. The San Timoteo Formation dates from the Pleistocene to the Pliocene and consists of stream-deposited alluvial sediments that are made up of detritus eroded from the San Bernardino Mountains in the Mojave Desert and southeastern Transverse Ranges provinces. A number of significant fossil deposits have been discovered in the San Timoteo.
The construction of the El Casco Substation in San Timoteo Canyon between September 2009 and January 2011 produced numerous fossils, including riparian and aquatic plants, insects, slugs and snails, fish, tortoise, lizards, snakes, small mammals, birds, a giant camel, a llama, two ground sloths, and two different types of saber tooth cats (Reynolds et al. 2012). The Shutt Ranch fauna is a collection of hundreds of significant fossils belonging to 37 species of small mammals,

as well as larger macrofauna such as sloth, camel, deer, horse, and others, found in the San Timoteo beds (Albright 1999). The scientific literature records a rich fossil history from this unit that includes fossils of more than 30 plant taxa (Axelrod 1966, 1979) and over forty animal taxa, including camels, deer, sloth, elephants, bears, rabbits, and rodents (Albright 1999). This fauna has been the subject of study for almost 100 years (Frick 1921, 1933; Matti and Morton 1975; Reynolds and Reeder 1991).

Avawatz Formation. The Avawatz Formation consists of four members: conglomerate, siltstone and sandstone, breccias, and sandstone, siltstone, and tuff deposited in alluvial fans, floodplains, and lakes, spanning a period of around 40 Ma, during the late Miocene (Spencer 1977). The Avawatz Formation is found in the Avawatz Mountains in the Mojave Desert province (Spencer 1977). The Avawatz preserves a typical Miocene mammalian fauna of early ancestors of horses and camels, as well as abundant rodents and some reptiles. In addition, the Avawatz is known for preserving exceptional fossil trackways from dozens of different types of animals, including birds, camels, and cats (Lofgren et al. 2006; Reynolds and Milner 2012; Sarjeant and Reynolds 2001). Trackways are significant fossil resources, and provide valuable information on not only foot morphology, but also how an animal moved and potentially whether it was part of a herd. The Raymond M. Alf Museum in Claremont, California, has more than 100 fossil trackways collected from the Avawatz (Lofgren et al. 2006) in San Bernardino County.

Topanga Group. The Topanga Group is predominantly composed of sandstone but also some siltstone, breccia, and shale (Morton and Miller 2006; Vedder 1972). Formations within the Topanga Group are common across the basins of the Peninsular Ranges and Transverse Ranges provinces. The Topanga is interpreted to represent wave-dominated coastal deposits grading into river-dominated deltaic deposits and fluvial deposits in the upper parts of the formation (Critelli and Ingersoll 1995). The Topanga Formation dates to the middle Miocene, around 20 to 16 Ma (Morton and Miller 2006). Fossils from the Topanga Formation include numerous invertebrate and vertebrate remains from both marine and terrestrial settings, including sharks, bony fishes, birds, whales, dolphins, and land mammals (Boessenecker and Churchill 2015; Campbell and Yerkes 1980; Morton and Miller 2006; Whistler and Lander 2003).

Barstow Formation. The Barstow Formation is composed of fluvial and lacustrine sediments interbedded with air-fall tuff beds deposited in lakes from around 14.8 to 19.3 ma (Woodburne et al. 1990). This formation crops out across the Mojave Desert province (Woodburne et al. 1990). The fossil mammal fauna of the Barstow is so abundant it has been used to define a biostratigraphic portion of the middle Miocene called the Barstovian North American Land Mammal Age (Pagnac 2009; Wood et al. 1941). The University of California, Berkeley, conducted extensive excavations of the mammal fossils shortly after they were first discovered in the Mud Hills (Baker 1911). The most common fossils from the Barstow Formation include early ancestors of horses, antelope, and camels, as well as small mammals such as mice and rabbits, with birds, fish, invertebrates, reptiles, and early ancestors of canines and elephants less common but well represented. In addition to the vertebrate fauna, an extensive record of exceptionally preserved small organisms, such as insects and arthropods, are known from the Barstow (Leggitt 2006; Miller and Lubkin 2001; Park and Downing 2001). These fossils have been extensively studied and reported on in the scientific literature, leading to a better understanding of the early evolution of many modern animals ranging from horses (Forsten 1973; MacFadden 1986) and camels (Pagnac 2005) to insects (Lister 1981), as well as paleoecology (Brattstrom 1961; Park and Downing 2001).

Sensitivity Assessment

The review of geologic mapping, scientific literature, and online records of the UCMP and SDNHM indicate that the six counties comprising the SCGA region record the diverse geologic history of southern California, including an abundant and significant fossil record. Paleontological resources range from the fossils of ancient marine creatures to land-dwelling plants and animals.

Paleontological sensitivity is tied to the potential of mapped geologic units, whether at the surface or in the subsurface, to preserve fossils. This analysis has highlighted a number of the best examples of high sensitivity geologic formations in the SCAG region, such as the Monterey and Topanga formations, as well as alluvial sediments that date to the Pleistocene. This overview is not exhaustive as there are numerous other geologic units that are more limited in occurrence and therefore cannot be included in this overview. For example, the most abundant fossil deposits in the SCAG region are from the La Brea Tar Pits, which preserve millions of Pleistocene fossils outside downtown Los Angeles.

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