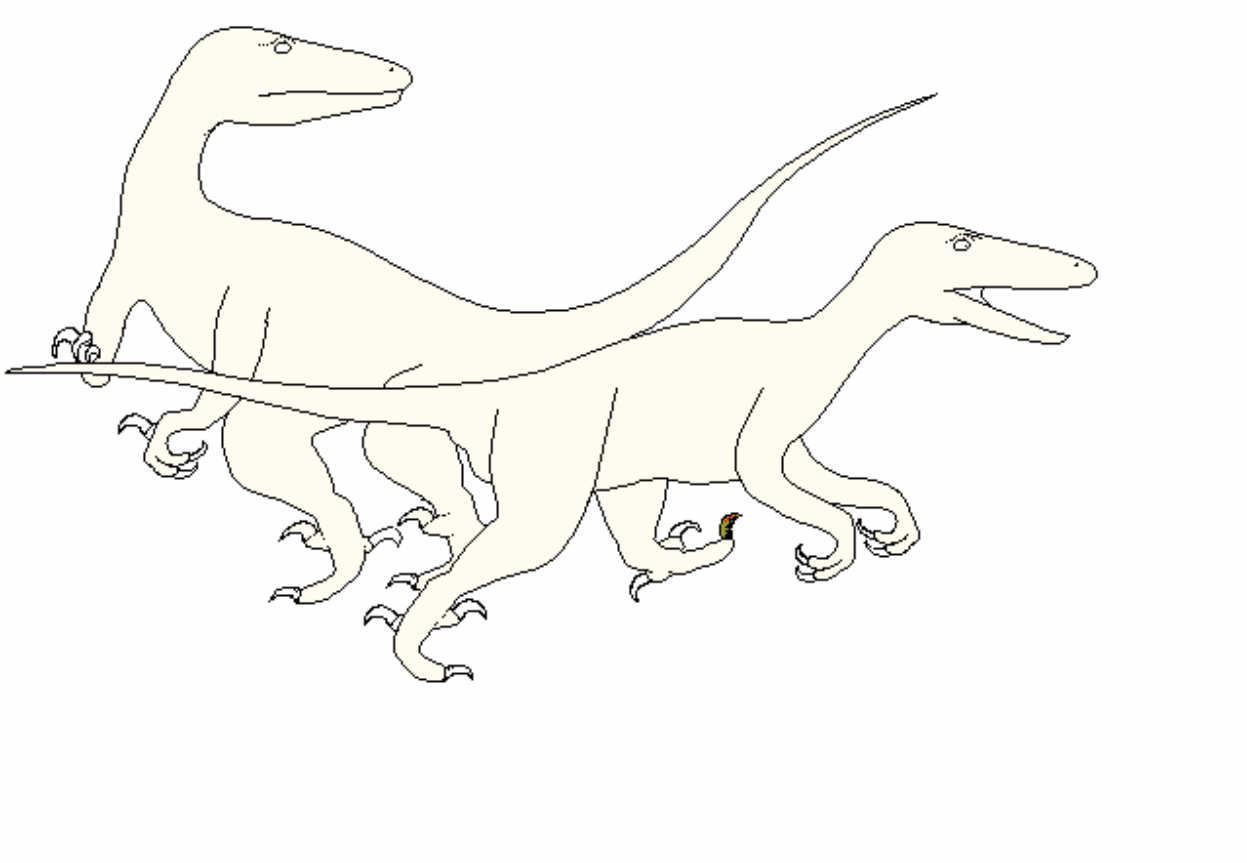
The Importance of Landfills on Paleontologic Resources And The Need for Expediting the Recovery of Fossils



The Importance of Landfills on Paleontologic Resources And The Need for Expediting the Recovery of Fossils

Landfills, as well as many other large excavation projects, can provide a significant avenue for paleontological research throughout California. The nature of these projects allows for large-scale removal of earth materials, which would otherwise be unavailable to the paleontological research community. Landfills are located in every region of California, from the state's coasts to the inland deserts. This wide dispersal of landfills provides opportunities for excavations in every geologic province of the state. With this wide range of geographic and geologic variety, the possibility of new fossil discoveries is significant.

The smallest landfill may be 1 to 5 acres in size by 20 feet deep. The largest landfills can cover 700 acres and exceed 100 feet in depth. As landfills operate, there is the potential for expansion as older cells are filled and closed, and new cells are excavated. The continual need for borrow material, as daily cover, and excavation for roads and other facility functions expands impacts created by excavations. These operations can provide research opportunities for paleontologists that can span many years or decades.

Operators of landfills have a goal, to develop a landfill and get it operational to receive waste as quickly as possible. Part of the permit review process includes the assurance of compliance with the California Environmental Quality Act (CEQA), which addresses the potential impacts a project may impart on the environment. CEQA mandates that archaeological and paleontological impacts of a project be addressed and that a project be suspended until a qualified Paleontologist or Archaeologist is called in to evaluate or assess the find. In reference, the CEQA guidelines Appendix G only states "Would the project directly or indirectly destroy a unique paleontological resource or site…"

It is important that an effective site appraisal for paleontologic resources is conducted prior to the excavation of a landfill site. An effective contact procedure should be in place prior to excavation that will enable a quick response from a regional institution once resources are discovered. This procedure would provide a coordinated program to remove fossil materials quickly from the landfill and allow the operator to proceed with excavation of the landfill. In turn, the procedure will provide more opportunities for the paleontology community to gain new fossils for research and insure that the fossils are stored in a museum repository, where they will be made available for future study.

A standard, effective protocol for personnel contact and the appraisal, removal, and storage of fossil remains will increase operators' confidence in contacting institutions regarding future finds. This protocol will prove beneficial to the research community and improve compliance with the mandates of CEQA. A standard protocol also will allow operators to resume construction excavation quickly, possibly while fossil retrieval is being conducted on site.

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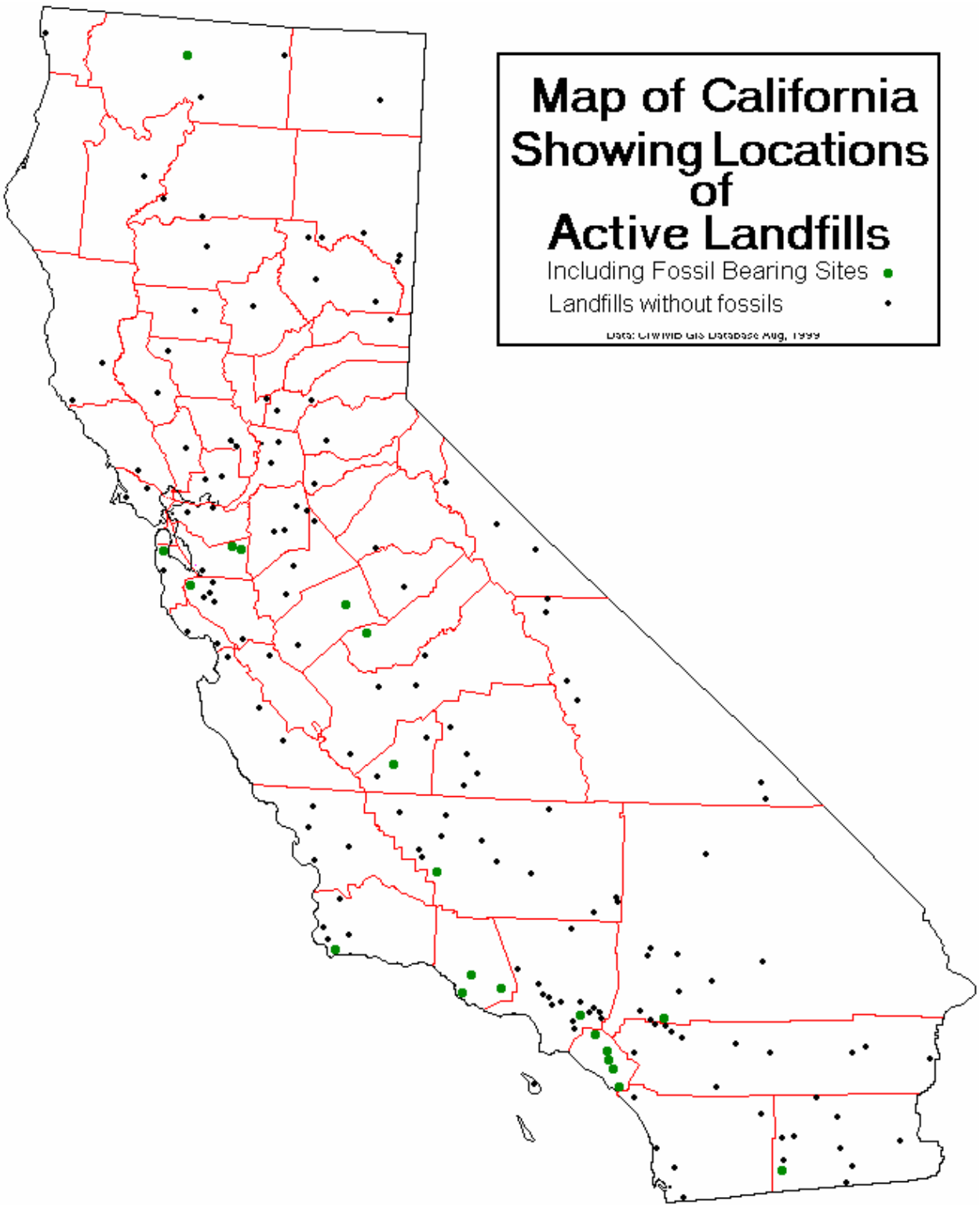
Landfills, as well as many other large excavation projects, can provide a significant avenue for paleontologic research throughout California. For Paleontologists, the nature of these projects allows for large-scale and often long-term removal of earth materials, which would otherwise be unavailable to the paleontological research community at large. For landfill owners/operators, an amenable and cooperative approach toward paleontological research would not only provide important contributions to paleontologists, but it also would provide an excellent public and community relations venue for the operator through media coverage, education opportunities, and public outreach.

Landfills generally are located in every region of California, from the state's coastal areas, to the deserts (fig.1). Approximately 186 landfills currently are operating in the state. This wide distribution of landfills provides opportunities for excavating in every geologic province of the state. With this wide range of geography and geology, the possibility of new fossil discoveries is significant.

In addition, the geographic range of over 1,000 miles from northern to southern California provides an excellent opportunity to better define geographic distributions, based upon latitude and temporal range, of fossil species in similar time periods.

Many landfills are located in remote or rural areas of California. Landfills, where operators recover and retain some fossils on site, have an opportunity to foster positive public and community relations and to provide an educational experience for local school students, who might otherwise not have such an opportunity, to view fossils. Fairmead landfill in Madera County, the Frank R. Bowerman Landfill, Orange County and the Simi Valley Landfill, Ventura County, each retain small samples of fossils at their operations offices for the visiting public to view. Several California landfills have had significant, positive, media exposure due to new fossil specimens being discovered on site.

The volumes and depths landfills attain, as well as the rapidity at which these dimensions are achieved, would be impossible for paleontologists to accomplish on their own through conventional removal practices and without the support of the landfill operator. This rapidity of excavation can allow for the discovery of new specimens in only months rather than the years or lifetimes such a discovery might require with standard paleontologic procedures. The long-term nature of landfill operation also offers an opportunity for the continual recovery of new specimens that would otherwise not be available to most conventional paleontological projects. Stratigraphic information for a continuous sequence of fossil bearing strata can be garnered as landfill grading proceeds over the succeeding days, weeks, months or years.


Map of California
Showing Locations
of
Active Landfills
Including Fossil Bearing Sites
Landfills without fossils

Operators of landfills have an explicit goal, to develop a landfill and to get it operational in order to receive waste as quickly as possible. The process required to get a landfill sited, constructed, and operating is long and involved, requiring many steps in the permitting and siting processes, before the project can be constructed and put into operation. In addition to the city and county agency permitting requirements, the landfill operator also must meet various State and federal agency requirements. Many landfills are expanding continually to accept more waste. Eventual closure of sites can require additional borrow excavation for final cover soils.

Fossils are a significant non-renewal paleontological resource which are afforded protection under Federal, State and Local environmental laws and guidelines The evaluation of the potential for construction impacts to paleontological resources on public lands (Federal, State, County and City) and private land resources includes:

(a) Assessment of the potential for property to contain significant non-renewable paleontologic resources that might be directly, or indirectly impacted by development.
(b) Formulation or implementation of measures or procedures to mitigate possible adverse impacts including transport to, and preservation in an established museum or university.

This evaluation can require a rating of potential for paleontological resources as:

(a) Assessment of the potential for property to contain significant non-renewable paleontologic resources
(b) Low potential for containing non-renewable paleontological resources and
(c) Undetermined potential

Part of the State of California's permit review process includes permit application procedures with the California Integrated Waste Management Board and satisfying the requirements of the California Environmental Quality Act (CEQA), which addresses the potential impacts a project might impart upon the environment. As part of the environmental review process, CEQA mandates that archaeological and paleontological impacts of a project be addressed.

Appendix G, Part (5e) of the CEQA Guidelines specifies that a project will normally result in a significant effect on the environment if it will disrupt or adversely affect a paleontological site. The possible resulting delay can cost the operator valuable time and money as the evaluation and recovery are being carried out. To reduce the potential impact on a landfill, and the paleontologic resources, authorizing agencies often require that a qualified paleontologist be retained by the operator to monitor excavation and to evaluate, and if warranted, remove any fossil remains uncovered by excavation. However, ignoring the requirement can result in the destruction of significant fossil remains.

Doing so would be in violation of the National Natural Landmark Program of 1962, the Surface Mining and Control and Reclamation Act of 1977 (when mining or gravel extraction sites are involved), the Federal Land Management and Policy Act of 1976, California Public Resources Code (PRC) Section 5097.5, and the National Environmental Protection Act of 1969.

To avoid this scenario, it is important that the Lead Agency and local enforcement agencies (LEA), for Solid Waste Facilities, such as the County Health Departments or Environmental

Health Departments for the county or region, be in communication with a local or regional agency contact person versed in paleontology or with a paleontologist and with the operator.

As part of an overall project plan, a pre-construction paleontologic site survey might be a possible leading activity for sites in regions with a high potential for fossils. A preliminary review of the proposed project area through a regional institution or through literature or other archival sources for paleontology such as the San Bernardino County Museums **Regional Paleontologic Locality Inventory** (RPLI), or by a paleontologic consultant could provide insight into the paleontologic resources of a planned site.

It is important that an efficient contact procedure be implemented between the operator and a contact person that will facilitate a quick response from the contact person. The contact person should be a qualified professional paleontologist from a regional institution or a consulting firm. In addition, the operator should have a curatorial agreement with a museum already in its project documentation, should the need for its use arise.

This agreement would allow for a coordinated program to recover fossil remains from the landfill excavation, and allow the operator to proceed with excavation of the landfill as quickly as possible. In turn, the procedure of evaluation, salvaging, and collecting of specimens will provide more opportunities for the paleontological community to gain new samples and data for research.

An efficient protocol for contacting paleontologists and the appraisal, removal, and storage of fossil remains will increase an operator's confidence in contacting institutions for future finds. Having established regional contact lists or retained a qualified paleontologist or paleo-consultant will provide an expeditious response to new finds at a landfill, and will prove beneficial to the research community and improve compliance with the mandates of CEQA, and State requirements.

If sites are determined to have high paleontologic potential, there may be a need for trained monitors, working under the direction of a professional paleontologist to monitor excavation. Monitoring would reduce the response time for evaluation and recovery. Appraisal of the site before excavation begins would provide insight into the needed frequency of on-site visits by paleo monitors. The use of on-site monitors should reduce the delay resulting from recovery of fossil vertebrate specimens following their discovery. A standard protocol will allow operators to resume excavation, possibly while fossil evaluation and recovery are being conducted.

The discovery of fossils resulting from landfill excavations in California is proving to be very rewarding. Several landfills, primarily in southern California, are yielding tremendous assemblages of Pliocene and Pleistocene vertebrates. Fairmead Landfill in Madera County is currently providing an outstanding fossil vertebrate assemblage, ranking foremost in central California. Other California landfills are providing a broad range of fossil marine vertebrates, and invertebrates continental vertebrates and land plants.

It is through the development of a cooperative relationship between current landfill operators, and the paleontologists for the respective regions that significant collections of fossils from the site have been recovered.

Analysis

There are 186 permitted operating landfills in the state of California. They extend from the Oregon-California border to the California-Mexico border, and from just inland of the California coast to the eastern slopes of the Sierra Nevada.

Of the landfills currently operating within California, approximately 28, sites, to date, are known to have yielded fossils that were recovered by paleontologists as a result of permit requirements. These landfills have yielded a variety of marine and continental vertebrates and plants. Table 1 lists all of the fossil-bearing landfills known to this author in California and the approximate numbers and species retrieved at each landfill. A listing of major representative species at each landfill is included when available. However, this listing is very incomplete.

Table 1.
Landfills In California
And
Number of Species Encountered
(Estimated)

Landfill Name	**County**	**Number of Species, Specimens Recovered**	**Activity**	**Partial listing Species/Type, Age**
1. **Altamont**	Alameda			**Marine Invertebrates:** **Cretaceous** Ammonoids
2**. Arvin**	Kern	32	Landfill	**Vertebrates**: **Rancholabrean** Microtus, Neotoma, Canidae, Dipodomys, Thomomys, Squamata, Horses, Hyla, Leporidae
3. **Bee Canyon LF**	Orange	21	Landfill	**Vertebrates Mammalia** Cetacean vertebrae, humerus, bone fragments. **Pisces**: Carcharodon (shark) teeth, Teleost bones, scales. **Invertebrates**: *Pelecypoda; Arca (Anadara), Ostrea, Pecten, Lyropecten magnolia, Clementia, Chione, Macoma,* **Echinoidea** *Scutella fairbanksi,* **Gastropod***a; Rapana vaqueroensis imperialis, Terebra Santana, Voluta sp., Turretella inezana.* **Oligocene to Pliocene**
4**. Bena** (site only)	Kern			Shark teeth
5**. Buena Vista LF**.	Calaveras			**Invertebrates:** ammonites Cretaceous Type locality

6. **Coyote Canyon**	Orange				**Marine Invertebrates:** **e**chinoidea, sea urchins, decapod fragments, foraminifera, leaves, palm fronds
7. **Fairmead**	Madera	~32	~1000	Lateral Expansion	**Continental Vertebrates**: *Glossotherium Megalonyx, Nothrotheriops, Mammuthus columbi, Equus, Platygonus, Camelops, Hemiauchenia, Tetrameryx irvingtonensis, Capromeryx, Odocoileus, Smilodon fatalis, Homotherium, Miracinonyx, Arctodus Canus arbrusteri. Canis latrans, Vulpes, Arctodus, Taxidea taxus, Lepus, Thomomys, Spermophylus, Neotoma, Dipodomys, Peromyscus, Microtus, Clemmys marmorata* Anatidae, Passerine, snake, frog, salamander, **Pleistocene, Irvingtonian**
8. **Frank R. Bowerman** (Bee Canyon)	Orange	>35 taxa (invertebrates) >22 taxa (vertebrate) >3,000 specimens		Expansion	**Sespe Fm**. **Vertebrates** snakes, *Gerrhonotus* (alligator lizard), *Parasauromalus* sp. (guanid), birds, Opossums, shrews, hedgehogs, weasels, skunks, otters, badgers, *Sespia* (pig-like oreodont), large and small camels, rabbits, *Cuyamalagus dawsoni* (pika), Adjidaumo sp. (rodent), *Protospermophilus* sp., *Blackia* (squirrel), *Schizodontomys* sp. (gopher), florentiamyid (?), *Mookomys* sp., *Proheteromys* sp. (pocket mice), *Leidymys* (mouse). **Vaqueros Fm**. **Marine Vertebrates**: *Eurhinodelphid* (long-nose dolphin), 2 short-nose dolphins, Pachycetus (baleen whale), Squatina (angle shark), *Galeocerdo* (tiger shark*), Myliobatis* (ray).
Frank R. Bowerman (Continued**)**					**Marine Invertebrates**: *Serpula* (segmented worm), *Balanus* (barnacle), crab parts, *Arca santana*, *Arca* sp. (ark shells), *Pinna* sp., *Atrina* sp. (pen shells), *Ostrea* sp. (oyster), *Chlamys* (scallop), *Mytilus* sp. (mussel), *Diplodonta* sp. (orb clam), *Astarte* sp., (lucine clam), *Cardium* sp. (heart clam), *Clementia* sp., *Chione* sp., *Dosina* sp., (venus clams), *Macoma* sp. (tellin clam), *Tagelus* sp. (broad razor clam), *Solen* sp. (true razor clam), *Mactra* sp. (surf clam), *Panopea* sp. (geoduck clam), *Nuculana* sp. (nut clam), *Terebra santana* (drill snail), *Olivella santana* (olive snail), *Voluta* sp. (volute snail), *Nassarius* sp. (basket whelk), *Rapana vaquerosensis imperialis* (murex), *Turretella inezana* (turret snail), *architectonica* sp. (sundial snail), *Calyptraea* sp. (limpet), *Natica* sp., *Polinices (Neverita) recluzianus* (moon snail), *Tegula* sp. (turban snail), chambered nautiloid, *Scutella*

				fairbanksi (sand dollar). **Miocene** **Miocene**
9. **Highway 59**	Merced			**Marine invertebrates**
10. **Hornbrook**	Siskiyou			**Marine invertebrates** pelecypods- *Trigonium*, cephalopods: ammonites, gastropods, **Vertebrates**, Shark tooth, bone fragments. **Cretaceous**
11. **Kettleman Hills**	Kings	~27	New LF	**Marine Invertebrates**- pelecypods: *Anadara, trilineata, Macoma, Ostrea vespertina sequens, Pecten Coalingaensis, Aquipecten circularis impostor, Solen perini, Mytilus coalingensis, Trachycardium sp., Balanus sp. Gonidia sp. Mya dickersoni, Sphaerium cooperi* **g**astropods-*Littorina mariana, Calyptraea filosa, Turica caffea brevis, Neverita reclusiana, Lunatia sp., Goniobasis kettlemanensis woodring,* decapod (crab).,. cirripeda (baracle). echinoids-*Dendraster coalingensis* **Marine Vertebrates** cetacea (rib), osteichthys- *Teleostei, perciformes* (fish). **Terrestrial plants**- *Salix, Umbellaria, Plantanus paucidentata, Salix coalingensis, Umbellaria oregonensis* **Plio-Pleistocene**
12. **Mc Kittrick**	Kern			**Vertebrate** fossils comparable to type Rancho La Brea assemblage. **Pleistocene**
13. **Mountain View**	Santa Clara	~6		Vertebrates: *Camelops, Mammuthus, Equus*, **Pleistocene**
14. **Mussel Rock**	San Mateo			**Invertebrates**: pelecypods, gastropods.
15. **Mustang Hill**	Kings		Sited, Not Built	**Invertebrates**: cirripeda (barnacles), echinoidea, (urchins, sand dollars) pelecypods (clams).
16. **Ocotillo**	Imperial			**Invertebrates**: ammonoids **Cretaceous**
17. **Olinda (Alpha)**	Orange	11 fish,	Remediation	**Vertebrates**; fish: *Eclipes* sp. (cod), *Xyne grex* (herring), *Ganolytes cameo* (shad), *Decopterus* sp. (mackeral shad), *Etringus* sp. (round herring), *Lompoquia* sp. (extinct sea bass), *Isurus hastalis* (bonito shark*). Myctophidae* (deep water lantern fish), *Scorpaeonidae* (Scorpion fish), *Bathylagidae* (deep sea smelt) Hemiramphidae (Half beak) coprolites (animal droppings). **Invertebrates:** *Delectopectin, Argonauta* (cephalopoda). **Plants**: terrestrial leaves of *Salix, Persea*, (Avocado), *Platanus, Quercus*, marine algae. **Miocene**

18. **Prima Deshecha**	Orange	~29	327	Borrow site	**Marine Vertebrates** bony fishes*: Semicossyphus pulcher* (california sheephead), Anarrrhichthys sp. (wolf eel), cf. *Scomber* (mackerel), *Thyrsocles kreigeri, cf. Acanthocybium* sp. (wahoo), *Clupeiformes* (herring/sardine), scombridae (tuna/mackerel), Acanthomorpha, Percomorpha. sharks and batoids: *Squatina* sp. (pacific angel shark), *Cetorhinus* sp. (basking shark), *Carcharhinus sp*. (requiem shark), *Isurus* cf. *I. Oxyrhincus*, (short fin mako shark), Isurus *planus*, (hooked tooth shark), *Isurus histalis* (bonito shark juvenile), *Isurus* sp. (mako shark), *Myliobatus* sp. (horn shark), Myliobatus sp. (bat ray), *Hemipristis serra*, (snaggle-tooth shark), *Dasyatis* sp. (stingray), *Squalus* sp. (spiny dogfish shark), *Sphyrna lewini* (hammerhead shark), *Hexanchidae* (6 and 7 gill sharks). Odontoceti, Delphinidae (baleen whale and dolphin), crabs, Stomatopoda (mantis stabbing shrimp), coprolites (fossil dung), *Turretella* sp. mold (snail). **Miocene/Pliocene**
19. **Puente Hills**	Los Angeles		123 Ac. Lateral Expansion		**Marine Invertebrates**: foraminifera (49 Species), nannoplankton: 16 species. molluscs: *Acesta hamlini, Delectopecten vancouverensis, Periploma cryphia, Acila (Truncacila castrensis, Acila (Truncacila semirostra, Trachycardium* (?) sp., *Corbula gibiformis, Cuspidariidae* gen., *Felicia phrear, Malletia* sp. und, *Modiolus* sp. und. Mytilis sternbergi(?), *Mytilus* sp. und., *Nucula exigua*(?),*Nucula* sp. und., *Nuculana pernula* (?), *Nuculana* sp. und., *Ostraea* sp. und., *Pectinidae* gen.,sp und., *Thyasira flexuosa* (?), *Thyasira* sp. und., *Yoldia montereyensis* (?), *Yoldia* sp..(bivalves), Admete sp. und. *Astraea gradata*(?), *Antiplanes* sp. und., *Cancillaridae, Carinoturis, Fusiitriton oregonense, Leucosyrinx, Lirobittium rugatum*(?), *Musashia* (?), *Neptunaea, Neverita, Taranis Cancellariiadae* gen. (gastropods), *Dentalium* (scaphopod), *Lepus*(?) (barnacle), crab, *Anorthoscutum, Echinrachnius, Scutella* (sand dollars), *Brisaster townsendi* (?) (heart urchin), *Centrechinus, Paleopneustes holmani, Paleopneustes* sp. und. (sea urchins) *Mysteceti* fam.undet. (baleen whale), fish spines, scales. *Carcharodon carcharias* (great white shark), *Ganolytes* (sardine), *Diaphus* (headlightfish), *Lampanyctus* (lampfish), Myctophidae (lanternfish), *Coaloriyncus* sp. (rattail), *Merluccius* (merlucciid hake), scombridae (gen, spec, und) (Mackerel), Pleuronectidae (righteye flounder), Teleostei fam. (bony fish) fishes. **Terrestrial Plant leaves**: *Quercus hannibali (Live oak), Robinia* (black locust), *Ulmus speciosa* (elm), *Abis* (fir), *Pinus* (pine), *Acer bendirei* (maple), *Alnus*

					(alder), *Celtis* (?) (hackberry), *Populus pliotremuloides* (aspen), *Salix laevigatoides* (willow), grasses, seaweed, fern. **Miocene/Pliocene**
20. **Santiago Canyon**	Orange	~5	6	Improvements	**Marine Invertebrates**: *Subprionocyclus* sp. ammonites), crustaceans, clams. crabs, mollusks, pelcypods, gastropods, petrified wood, **Marine Vertebrates**: Plesiosaur and hadrosaur bone fragments **Terrestrial plants**: leaves and stems. **Cretaceous.**
21. **Santiago Canyon**	Orange	87	1500	SW/SE Borrow Areas	**Continental Invertebrates:** insects **Marine Vertebrates:** *Carcharhinus* sp. (reef shark), *Rhinoptera* sp. (eagle ray), teleostei, (bony fishes) **Sespe/Vaqueros Formations, undifferentiated** **Continental Vertebrates** *Gopherus pansa, Zerobates laticunea* (tortoises), *Gerrhonotus*(?) (alligator lizard), *Tomarctus* (?) sp., *Tomarctus canavus* (large dogs), *Cuyamalagus dawsoni* (pika), *Tamias* (?) sp. (chipmunk), *Protospermophilus* sp. (squirrel), Petauristidae (flying squirrels), *Pseudotheridomys* sp. (mouse-like rodent), *P. cuyamensis*, *Cupidinimus* sp., cf. *C. lindsayi*, *Mookomys*, *Proheteromys* (pocket mouse), *Schizodontomys* sp. (gopher), *Leidymys* (mouse), *Paciculus* sp. cf. *P. montanus*, (mouse), *Tanymykter* b*rachydontus* (larger advanced camel), *Michenia agatensis* (?) (smaller advanced camel), *Merychyus arenarum* (small advanced oreodont, *Machaeromeryx tragulus* (?) (small hornless deer), *Blastomeryx (Pseudoblastomeryx) advena* (?)(medium-sized hornless deer), *Blastomeryx (Problastomeryx* (?) sp. (large hornless deer), *Menoceras barbouri* (small two-horned rhinoceros, *Parahippus pawariensis*, *Anchitherium clarencei* (large primitive 3-toed horse) **Topanga Formation** **Marine Invertebrates:** corals, *Dosinia* sp. (clam), *Anadara* sp. (ark clam), *Trachycardium* sp. (cockle), *Panope* sp. (goeduck), *Pectinidae* (scallops), Pholadidae (rock-boring clams), *teredo* (?) (shipworm), *Squilloidea* (mantis shrimp) **Marine Vertebrates:** (Chondrichthys-sharks, rays)*Heterodontus* (horn shark), *Carcharocles megalodon* (giant great white shark), *Isurus hastalis* (mako shark), *Isurus planus* (mako shark), *Mustelus* sp. (smooth hound), *Triakis* sp. (leopard shark), *Carcharhinus* sp.(reef shark), *Galeocerdo aduncus* (tiger shark), *Galeorhinus* sp. (soupfin shark), *Himipristis serra* (snaggletooth shark), *Rhizoprionodon*

					sp. (sharpnose shark), *Sphyrna* sp. (hammerhead shark) *Squalus* sp.(dogfish), *Dasyatis* sp. (diamond stingray), *Gymnura* sp. (butterfly ray), *Myliobatis* sp. (bat ray), *Mobula* sp. (devil ray), *Rhinoptera* sp.(eagle ray) Teleostei (bony fishes): *Sphyraena* sp. (barracuda*) Semicassyphus* sp. (california sheephead wrasse), *Diodon* sp. (porcupine fish), *Prionurus* sp. (surgeon fish), *Naso*(?) sp. (surgeon fish). Reptiles: *Crocodylus (Thecahcampsa)* sp. (Marine crocodile). **Marine Mammals**: *Allodesmus* sp. (primitive sea lion), *Neotherium* sp. (primitive walrus), *Copomys* sp. (mouse),*" Squalodon" errabundus* (shark-toothed whale), Cetotheriidae (primitive baleen whale), *Paleoparadoxia* n.sp. (primitive sirenian-like mammal), *Desmostylus hesperus* (advanced sirenian-like mammal).
22. **San Timoteo**	San Bernardino			Lateral Expansion	**Continental Vertebrates**: *Mammuthus* sp (mammoth), *Mammut americanum* (american mastadon) Camelops (camel), *Hemiauchenia* (possible extinct llama), *Equus* sp. cf. *E. Scotti* (possibly scott's horse), *Equus* sp. (small horse), *Equus* Sp. (extinct horse), *Odocoileus* sp. possible carnivore, Spermophilus Sp. (squirrel), *Thomomys bottae* (botta's pocket gopher), *Dipodomys* sp. (kangaroo rat), *Perognathus* sp. (deer mouse), *Neotoma* (wood rat), *Microtus* sp. (meadow vole), *Silvilagus* sp. (Cotton tailed rabbit), *Lepus* sp. (jackrabbit), Fam. Soricidae (shrew), Fam. Icteridae (blackbird), Fam. Corvidae (crow), *Zenedia astatica* (white-winged dove), Callipepla (quail), Crotalus sp. (rattlesnake), cf. *Masticophis* sp. or *Coluber* sp. coach whip or racer snake), *Phrynosoma* sp. (probable horned toad), Order. Anura (frog or toad). **Invertebrates:** *Succinea* sp. (freshwater snail), Fam. Limacidae (slug) Pelecypoda (clams), Order ostracoda. **Continental Plants:** Abies(?) (fir?), *Magnolia grandiflora* (magnolia), *Platanus* sp. (?) (sycamore), *Quercus chrysolepis* (oak), *Salix* sp. (willow), cf. Washingtonia sp. (fan palm).
23. **Simi Valley**	Ventura	~37	10,000	Expansion	**Continental Vertebrates**: Chelonia, Iguanidae, *Parasauromalus*, Glyptosaurini, Melanosauri*ni*, *Tinosaurus*, *Paracontogenys sp. (*lizards*), Paleoxantusia sp., P allisoni*, *Crypholestes, Sespidectes singularis*, *Proterixoides davisi*, *Centetodon* sp. cf. *C. aztecus*, *Batodonoides powayensis* (insectivores), Omomyidae, *Dyseolemur*

				pacificus, Macrotarsius roederi, Apatemys downsi, Unitasorex (primates), Ophidea Boidae *Leptotomus, Microparamys sp. Microparamys tricus, Microparamys sp.* und. *Namatomys* n.sp, *Paradjiadaumo n.sp, Griphomys alecer, Heliscomys* n.sp. *Simimys simplex, Simimys* n.sp. (large), Zapodidae n.gen, sp, *Pareumys* sp. aff. *P. milleri, Pareumys* sp., *Rapamys, Metanoiamys fantasma, Metanoiamys korthi* (rodents), *Miacis* sp. und. *Miacisae*, Protoreodon *annnectens tardus, Protoreodon pacificus, Protylopus robustus* (Artiodactyla) Camelidae Dichobunidae gen./sp. und. *Leptoreodon edwardsi*, *Leptoreodon stocki, , Simimeryx hudsoni, Simimeryx* n.sp., *Eohaplomys, Boavus* (Boa). **Aquatic Invertebrates**: Freshwater gastropods, pelecypods. **Middle Eocene**
24. **Sonoma Co. LF**	Sonoma		Borrow Area	**Invertebrates**: Pelecypods
25. **Tajiguas LF.**	Santa Barbara		Expansion	No specimens found, but highly sensitive formations with potential for discoveries during future project expansions.
26. **Toland Road**	Ventura	19	Expansion	**Marine Invertebrates**: Foraminifera, *Conus californicus* (cone snail), *Tegula* sp (top snail), *Mitrella* sp. (miter snail), *Modiolus* sp. (mussel), *Crepidula* (slipper shell), Fusitron sp. (rock shell), *Neptunea* sp. (whelk), *Anomia* sp. Rock scallop), Megasurcula *carpenteriana* (carpenter's turrid), *Olivella biplicata* (olive snail), *Polinices* sp. (moon snail), *Spisula* sp. (surf clam), *Trachycardium* (cockle shell), *Panope generosa* (gweduc clam), *Cerithidea* sp. (horn shell), *Pecten* sp. (scallop, *Strongylocentrus* sp. (sea urchin). Crab claw. Vertebrates: *Carcharadon carcharias* tooth (shark), teleost, (bony fish). **Pliocene**
27. **Vasco Road**	Alameda			**Invertebrates**: Pelecypods (clams)
	San Diego Co. (Misc)			
28. **San Diego Garbage Dump**		5	Landfill	**Vertebrates**: Myliobatis, Mancalla. **Blancan**
2.9. **Dump Road Site**		1	Landfill	**Vertebrate**: Artiodactyla **Eocene**

The majority of landfills with large megavertebrate assemblages are located in the southern and central California counties. The northernmost landfills containing fossils are in Calaveras, Madera, Santa Clara, and Contra Costa Counties.

Despite the lack of finds in the northern California counties north of San Francisco Bay, this absence of finds does not preclude future discoveries in these counties. Most northern California landfills are shallower and do not penetrate as deeply as the larger projects in the southern

California counties. Fossils have been found at other construction projects in northern California, however. For example a mammoth was found at a county airport project in Siskiyou County. In addition, fossils have been found in other public works projects throughout the state.

In addition to these landfills, two retaining basins, including one at Bee Canyon, near the Bee Canyon Landfill, are also recorded as possessing additional faunal assemblages.

Nature of Samples Found

The types of fossils retrieved at the majority of the California landfills have been Cenozoic continental megavertebrates (the size of dog, horse, etc.) and microvertebrates the (size of a shrew, squirrel, etc.). The specimens from the Frank R. Bowerman, Puente Hills, and Simi Valley landfill predominantly were primarily teeth and jaw fragments of small continental vertebrates. The Fairmead and Santiago Canyon landfills' specimens consisted of more numbers of large land mammals, including two species of ground sloth, Armbrusters wolf, and two species of horse.

The Frank R. Bowerman Landfill and Santiago Canyon Landfill borrow areas contain both terrestrial and marine faunal assemblages within their project boundaries. The Toland Road and Frank R. Bowerman landfill assemblages primarily contained marine invertebrates (clams, snails). In addition, the Toland Road Landfill also contained marine foraminiferal (protozoan) microfossils. The Prima Deshecha and Santiago Canyon marine faunas primarily consist of sharks, rays and fishes. The Buena Vista Landfill in Calaveras County contains a type locality for Cretaceous ammonites; shelled cephalopods similar to the now living chambered nautilus.

The Kettleman Hills, Prima Deshecha and Santiago Canyon landfills yielded larger marine mammals, such as whales, dolphins, sirenians and sea lion. Santiago, Olinda, and Puente Hills landfills yielded some terrestrial plant leaves.
The rock in many of the landfills is relatively soft and allows facilitates easy removal of the fossils from the sites and recovering the fossils from the enclosing matrix when brought to the lab for final preparation.

- Retrieval of microfossils, such as small teeth, jaw and bone fragments of rodents, marsupials, and even birds by using wet screening and heavy liquid separation techniques, has been very productive. The collection of thousands of specimens of these small vertebrates has changed the overall perspective regarding population distributions, diversity, and sizes of these animals relative to the larger mega-vertebrate species (Lander, E. Bruce, 1992) *Simi Valley Landfill Impact Mitigation Prog. 6TH Progress Report*. Jan 1, to June 30, 1992.).

New Specimens and Species

The long-term durations of the excavation activities that have transpired at these landfills have provided excellent opportunities for paleontologic researchers to gather massive quantities of fossil bearing rock from which fossil specimens representing new taxa could be collected.

- LACM Loc 5876 member, middle Sespe Fm. New species of Namatomys, *Paradjidaumo, Heliscomys, Simimys, and Simimeryx.* New genus and species of Zapodid rodent.

New, Local Faunas

Excavations at California landfills have revealed new vertebrate fossil localities and assemblages. The Simi Valley Landfill has yielded a new locality (LACM Loc. 5876) is situated stratigraphically higher in the middle member of the Sespe Formation than any previously known locality in the area. The assemblage in this locality is distinctive, with taxa more derived than those of any other assemblage from the middle Sespe. The distinctiveness of this assemblage has prompted its assignment to a new local fauna, the Simi Valley Landfill Local Fauna. This fauna is an addition to the four currently existing local faunas [(Tapo Canyon, Brea Canyon, Strathern, and Pearson Ranch Local Faunas) (Kelly, Thomas S., Lander, E Bruce). Bruce, Whistler, David P., Roeder, Mark A., Reynolds, Robert E. ,1991., PaleoBios, Vol 13,# 50, July 26, 1991)]. As mentioned, the Buena Vista Landfill in Calaveras County contains a type locality for Cretaceous ammonites.

Geographic Range Extensions

- Most of the numerous land mammal and other continental vertebrate taxa represented in the Santiago Canyon Borrow project demonstrate extended geographic range distributions. Excluding one horse species, none of these taxa was recognized previously in the undifferentiated Sespe and Vaqueros Formations or Orange County. (Lander, E. Bruce, Ph D. 1994, *Paleontologic Resource Impact Mitigation Program Final Report Santiago Canyon. LF. Southeast and Southwest Borrows, Orange Co., CA* July 1991 to April 1994).

- A nautiloid shell was found at the Frank R. Bowerman Landfill; Orange County (Vaqueros Fm., lower middle Miocene.) that demonstrated this species' geographic range is now much larger than previously known. (Raschke, Rodney, *E. Paleontological Monitoring Report, Frank R. Bowerman Landfill, Orange Co. CA,* March 5, 1997).

- The discovery of at least five specimens of a cephalopod test known as an "Argonaut" have been discovered in he Olinda Alpha Landfill. The only other specimen known is from a region in Japan.

Temporal Range Extensions

- Crocodilian found in the Sespe Fm. as the oldest from the Sespe in the Simi Valley LF. (Lander, E. Bruce, 1992 *Simi Valley LF Impact Mitigation Program. 6TH Progress Rpt*. Jan 1, to June 30, 1992.)
- Oldest land mammals from the Sespe Fm. and first reported from the lower member, (Lander, E. Bruce, 1992 *Simi Valley LF Impact Mitigation Program. 6TH Progress Rpt*. Jan 1, to June 30, 1992.)

- *Batodonoides*, *Eohaplomys*: youngest known records of these two genera. (Lander, E. Bruce, 1992 *Simi Valley LF Impact Mitigation Program. 6TH Progress Rpt*. Jan 1, to June 30, 1992.)
- Many of the Taxa from the Santiago Canyon Landfill, particularly the rodents, represent temporal range extensions, not being reported previously as part of the early Hemmingfordian North American Land Mammal Age. A marine crocodile (*Thecachampsa)* is the first found in the Topanga Formation as are the bony fish *Naso* (?), two sharks, *Rhizoprionodon* and *Sphyrna* and a ray, *Rhinoptera. Copemys* is the first record of a rodent from the Topanga Fm. This record has allowed correlation of the late Hemmingsfordian and Barstowian North American land mammal age and the Temblorian Provincial Molluscan Stage. (Lander, E. Bruce) Bruce, 1994, Paleontologic *Resource Impact Mitigation Program Final Report Santiago Canyon. LF. Southeast and Southwest Borrows, Orange Co., CA* July 1991 to April 1994).
- A Didelphid marsupial from Frank R. Bowerman Landfill is a new discovery for this area, and it also extends the age range of this taxon upward into the Miocene. Raschke, Rodney, *E., 1997 Paleontological Monitoring Report, Frank R. Bowerman Landfill, Orange Co. CA,* March 5, 1997.

From this very small sampling of the most current discoveries reported for landfill excavations, the importance of a comprehensive paleontological recovery and coordination plan is instrumental as part of a Statewide policy in dealing with landfill operations.

Many of the organizations involved in these projects operate on minimal budgets for facilities and support staff. Preparation of fossils is often in crowded facilities lacking adequate space for preparation, poor heating and air conditioning, lighting, support equipment such as computers and other records storage facilities. Specimens are sometimes prepared outside in parking lots or any other available space.

Storage facilities for larger specimens are often crowded or becoming so; inadequately set up to store the materials safely and securely. Some facilities are overflowing and materials are being stored outside, exposed to the elements that can damage them or to potential vandalism. Little funding is available to develop and establish efficient data storage systems, relying on the ingenuity of staff and volunteers to create databases and other equipment as needed. The ideal facilities are few and far available.

Such a plan, under legislated mandate, would provide potential for a financial resource from which participating consultants, museums and other institutions could draw funds for curatorial activities involving landfill related specimens

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The current status of a statewide policy through the California Integrated Waste Management Board primarily is dependent upon the compliance of operators with the requirement of the CEQA. This requirement does not provide for a statewide "network" or listing of contact individuals or institutions with whom operators can confer, especially new operators or project proponents and consultants unfamiliar with the CEQA process or the Permitting process of the CIWMB. It also does not provide a financial resource from which funding could be garnered for data storage and retrieval of the growing body of information being created from these discoveries.

Photographs of Fossils in Fairmead Landfill, Madera County

View of Fairmead Landfill module with three fossil localities. Major excavation in light area of aranaceous material upper left-center. Second site at far left (west). Third site where photo was taken, south slope of module.

Camel Jaw found in south slope of module, Fairmead Landfill, Madera Co.

Tail vertebral bones of early Camel, south excavation site, Fairmead Landfill

Mammoth tusk found in north excavation site, Fairmead LF.

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Repositories for Retrieved Fossils

Many of the paleontological resources recovered from these landfills are being stored at institutions in the respective local areas. Some of the landfills have retained specimens at their offices.
Most of the specimens recovered from the Fairmead landfill have been retained at:
University of California Museum of Paleontology
University of California, Berkeley campus.

Museum of Paleontology
University of California
1101 Valley Life Sciences Building
Berkeley, CA 94720-4780

Voice: (510) 642-1821
FAX: (510) 642-1822
E-mail: ucmpwebmaster@uclink.berkeley.edu

Some specimens from the Fairmead Landfill have been retained in a small display in the administrative offices of the:
Fairmead Landfill
Avenue 22 at Road 19
Chowchilla, CA.

Specimens from San Bernardino County are stored at:
San Bernardino County Museum
2024 Orange Tree Lane
Redlands CA 92374-4560 USA

Specimens from the Orange County vicinity are stored at facilities of:
Orange County Natural History Museum
28373 Alicia Parkway
Laguna Niguel, California 92677.
949-831-3287.

Specimens from Los Angeles County are stored at facilities of:
Natural History Museum of Los Angeles County
900 Exposition Blvd.
Los Angeles, CA 90007
(213) 763-DIN0

Specimens from the San Diego area are stored at:

San Diego Natural History Museum
1788 El Prado, Balboa Park
P.O. Box 121390
San Diego, CA 92112-1390
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