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Comment Letter I29 June 20, 2017 Ms. Ashley Smith Land Use & Environmental Planner Planning & Development Services 5510 Overland Avenue, Suite 310 San Diego, CA 92123 RE: Harmony Grove Village South; PDS2015-GPA-15-002, PDS2015-SP-15-002, PDS2015-REZ-15-003, PDS2015-TM-5600, PDS2015-MUP-15-008, PDS2015-ER-15-08-006. Dear Ms. Smith: My comments focus principally on the sections of the documents dealing with air quality and green house gases. I will leave my neighbors to comment on the other sections of the document. I am a resident of Elfin Forest / Harmony Grove and have lived in the community for more than 20 years. But before commenting on the specifics of the DEIR, I would like to provide a brief history of the property in question. The County Board of Supervisors, with the support of Elfin Forest/Harmony Grove, adopted The Harmony Grove Village Specific Plan in February 2007. The plan was developed as part of the ongoing 2020 planning process. Elfin Forest / Harmony Grove community accepted the up-zone of Harmony Grove Village project to accommodate the county's need to grow, described by the county as the community's "fair share" of that growth. In exchange, the county established a land use pattern for the Harmony Grove area with a village core with single-family residential homes that decrease in density the further the location from the core. This was codified in the Specific Plan. At the time this agreement was struck, the property being proposed for the Harmony Grove Village South project area was zoned for between 20 and 27 homes per the Department of Planning and Land Use (DPLU). The 20 to 27 units was entirely consistent with the agreed upon land use pattern and one the community believed was not subject to further change. In March of 2007, in response to SunCal Companies Extended Initial Study/Information (GP\GPA 05-004) requesting up-zoning of the same parcels to approximately 170 units, DPLU found it to be inadequate for several reasons including the project's lack of secondary access in the event of fire and consistency with the General Plan stating: The Harmony Grove Village Specific Plan was recently approved by the Board of Supervisors. This project establishes a land use pattern for the Harmony Grove area with a Village Core surrounded by single-family residential development that I29-1	**Response to Comment I29-1** The County acknowledges these introductory comments; however, they do not raise an issue concerning the environmental analysis or adequacy of the EIR. Please see the responses below to specific comments.

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Comment Letter I29 decreases in density as distance from the Village Core increases. In addition, the project site is adjacent to the east of the approved Equestrian Ranch. It does not appear that the design of Harmony Grove Meadows has taken into account these recently approved land uses. Ultimately the request was denied, and was strongly opposed by the neighboring communities, the San Dieguito Planning Group, and County Staff. In December of 2010 Preferred Bank, an out of town bank which had become owner of the land as a result of bankruptcy, initiated the process to up-zone the same property, again requesting that it be zoned to yield 170 homes. The community opposed this request for several reasons primary among them fire safety and its violation of the agreed land use pattern for Harmony Grove as codified in The Harmony Grove Village Specific Plan. The up-zone was ultimately granted through Property Specific Request SD7 in April 2011 and finalized as part of the 2011 General Plan Update at the conclusion of the 2020 planning process, over the objections of the community and other stakeholders. The 2014 Cocos fire devastated the region, burning 1,995 acres from San Marcos to Escondido. It destroyed 40 structures, the majority in Harmony Grove. Most of the homes burned in Harmony Grove were on Country Club Drive south of Harmony Grove Road adjacent to the proposed site of Harmony Grove Village South. During the fire, residents of San Elijo Hills, the community bordering Elfin / Forest Harmony Grove to the North West, faced gridlock traffic on San Elijo Road with evacuation times of an hour and a half or more. This gridlock also meant that residents of Elfin Forest could not evacuate out Elfin Forest Road to the northwest. Many residents of San Elijo were forced to take Elfin Forest Road to Harmony Grove Road to evacuate through Elfin Forest / Harmony Grove, joining evacuating residents of those communities, many with horse trailers, down the same 2-lane road. Fortunately home construction of Harmony Grove Village (748 homes) had not begun, avoiding even more traffic joining in what was an already fraught situation. Unfortunately, the Cocos fire confirmed the concerns raised by county staff and the community with regards to fire safety each time an up-zone request has been made for this site. The current request if granted would increase the density by more than 1,800 % over what it had been zoned in early 2011. I29-1 COMMENTS WITH REGARDS TO AIR QUALITY Temperature: The EIR understates air quality impacts by using average daily temperatures, out of date temperature data from a cooler period, and it does not account for the expected temperature rise during the project's usable life. Section 2.6.1.1 states: I29-2	**Response to Comment I29-2** The information provided in Subchapter 2.6, *Air Quality*, Section 2.6.1.1 is intended to provide context for the existing meteorological setting. To clarify, the temperatures given are annual average minimum and maximum values. Regarding the statement that data are based on information through 1979, the data used actually incorporate records up to 2010. Regarding daytime temperatures, please note that this information is not the basis of the model, which is based on climate zones (Climate Zone 13, appropriate for Escondido). CEQA requires that Project analyses address effects resulting from the Project against a baseline focused on existing conditions. Projecting future conditions, and providing analysis against that future condition, does not meet the legal requirements of CEQA. Regardless, the temperatures do not affect the quantity of emissions generated by the Project which would still fall below the significance thresholds as identified in Tables 2.6-6 through 2.6-8.

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> The annual average temperature in the Project area is approximately 55 degrees Fahrenheit during the winter and approximately 74 degrees F during the summer. Total precipitation in the Project area averages approximately 16.2 inches annually. Precipitation occurs mostly during the winter and relatively infrequently during the summer (Western Regional Climate Center 2012).

Per the DEIR, the source of pollution is predominately from vehicle sources and the majority of the vehicle traffic, both during construction and operationally, will be during daylight hours. Daytime temperatures, not the average daily temperatures, should be used in any calculations to determine the impacts of pollution from the proposed project. Construction is typically limited to daylight hours and most residential traffic; parcel delivery, service calls, school traffic and most commutes, will be during daytime hours. Summer daytime temperatures in Escondido typically are in the 80's and 90's with days of 100 degrees F or more are not uncommon. The DEIR acknowledges the impacts of temperature on air pollution in appendix J, which it states in section 1.2.1 (bolding added for emphasis):

I29-2

> Although global climate change is anticipated to affect all areas of the globe, there are numerous implications of direct importance to California. **Statewide average temperatures are anticipated to increase by between 3 and 10.5°F by 2100.** Some climate models indicate that this warming may be greater in the summer than in the winter. This could result in widespread adverse impacts to ecosystem health, agricultural production, water use and supply, and energy demand. Increased temperatures could reduce the Sierra Nevada snowpack and put additional strain on the state's water supply. **In addition, increased temperatures would be conducive to the formation of air pollutants, resulting in poor air quality.**

Furthermore, the Western Regional Climate Center data for Escondido is based on records from the period, 12/01/1893 to 03/31/1979, which is clearly noted with the data. Temperatures have increased considerably since 1979; in fact, San Diego has set new records for the last several years in a row. Already this May, Escondido experienced temperatures more associated with August than what is expected during spring. By using temperatures that do not comport with the current reality or representative of when the pollutants are introduced into the environment, the analysis understates the impacts of air pollution due to the proposed project.

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Comment Letter I29 Additionally, in spite of the acknowledgement in appendix J that the temperatures in California are expected to rise between 3 and 10.5°F by 2100, the analysis does nothing to address the impacts of this temperature rise, even though this timeframe is well within the usable life of the project. By failing to do so, it does not address the full negative impacts of the projects air pollutants on the surrounding communities. At a minimum, one would expect a best-case scenario and worst case one based on the 3 and 10.5°F range. This would inform what mitigation is needed and the best forms of mitigation to address the impacts of air pollution generated by the project throughout its life. I29-2 Mitigation plans: Even with these shortcomings in the analysis, the DEIR still finds that the project would result in a significant and unavoidable impacts to the region's air quality. Even so, the developer does not propose a mitigation plan to ameliorate any of those impacts. Instead, they claim that the impacts will be reduced when the RAQs are updated as stated in appendix H sec. 4.1.4: The Proposed Project would not conform with the RAQS and SIP and would result in a significant and unavoidable impacts. These significant impacts will be reduced to less than significant when the RAQs are updated. Yet they offer no rationale why the 2011 General Plan Update and SANDAGs growth projections, which the RAQS are based, need updating. The 2011 General Plan Update took years to develop and 10s of millions of dollars to develop and is still considered an accurate reflection of San Diego County's housing needs. Similarly SANDAGs projections remain accurate. Individual pocket zoning request are not sufficient reason to update these plans. In affect the developer is asking the county to undercut the very laws it has a duty to enforce. This is not a mitigation plan but a scheme to transfer the cost of the increased air pollution of the proposed development to the taxpayers of San Diego County. I29-3 COMMENTS WITH REGARDS TO GREENHOUSE GASES Amortized construction emissions over 20 years: The DEIR's analysis of construction related emissions represent those impacts in a misleading manner that has nothing to do with how carbon dioxide actually behaves in the environment. The DEIR states in the executive summary of appendix J: The Project-related construction activities are estimated to generate approximately 3,682 metric tons (MT) of carbon dioxide equivalent (CO2e). Construction emissions are amortized over 20 years, such that the proposed construction activities would contribute an average of I29-4	**Response to Comment I29-3** The County concurs with the statement that the EIR and the Appendix H technical report find a temporary significant impact relative to consistency with the Regional Air Quality Strategy (RAQS), but does not agree that this constitutes a significant impact to the region's air quality. The conclusion in the EIR on page 2.6-7 (emphasis added), is that: ***…the Project would not result in a significant air quality impact with regards to construction- and operational-related emissions of ozone precursors or criteria air pollutants. Therefore it is unlikely that the additional units from the Project would interfere with the SDAPCD's goals for improving air quality in the SDAB.*** *Regardless, because the Project is proposing an increase in housing units beyond what was included for the site in the RAQS, consistent with the County guidelines,* ***impacts associated with conformance to regional air quality plans would be potentially significant. (Impact AQ-1a)*** The analysis makes it clear that Project implementation is not expected to delay the ability of the region to attain California air quality goals. In fact, the impact is not related to air quality exceedances, but to plan conformance. The actual air quality effects are detailed in EIR Subchapter 2.6, *Air Quality*, Section 2.6.2.2, *Conformance to Federal and State Ambient Air Quality Standards*, which expressly addresses existing and projected air quality violations, and measures impacts against the County thresholds. No existing or future Project-related exceedance was identified. This is relevant to the mitigation proposed for the RAQS planning document impact. Because the impact is not related to the environmental effects of the Project, but is rather a "paper" inconsistency, the impact requires a "paper" mitigation measure. This would be accomplished through ensuring that the appropriate RAQS update incorporates the proposed change to the General Plan assumptions (see Mitigation Measure M-AQ-1a). The update would bring both plans into conformance. Again, no mitigation relative to actual emissions is required.

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	Response to Comment I29-4 All references to amortization are now removed from Subchapter 2.7; and the topic is no longer relevant. Please note that with the current Project net-zero commitment (and in accordance with Mitigation Measures M-GHG-1 and M-GHG-2 addressed in the subchapter), the Applicant will make one purchase to offset the full amount of construction-related GHG emissions before construction occurs (e.g., at final map or grading permits), followed by purchase of credits to offset of the full amount of operation-related GHG emissions prior to Project occupation. As a point of information, however, the amortization of the construction GHG emissions as addressed in the DEIR was consistent with prior County guidance. ~~As noted at the bottom of Table 2.7-2, the amortization of the construction GHG emissions is consistent with County guidance.~~ The use of 20 years is actually somewhat conservative because some agencies amortize over a 30-year period (e.g., the City of San Diego prior to adopting their 2016 Climate Action Plan, and the South Coast Air Quality Management District). Please also note that with the current Project commitment to attain net neutrality (net zero) for carbon emissions and consistent with mitigation specified in the Final EIR, the Applicant will make one purchase to offset the full amount of construction-related GHG emissions before construction occurs (e.g., at final map or first grading permit), followed by purchase of credits to offset the full amount of operation-related GHG emissions prior to Project occupation. The County's Climate Action Plan has been reviewed and addressed as appropriate in Project greenhouse gas discussions. Please note that subsequent to public review of the Project DEIR, confirmatory review was undertaken of the Project's GHG analysis. This is addressed in Subchapter 2.7, *Greenhouse Gas Emissions*, of the FEIR. Please see the conservative commitment by the Applicant to attain net zero GHG emissions through credit purchase identified for both construction and operational phases through mitigation measures M-GHG-1 and M-GHG-2. The Greenhouse Gas Emissions EIR section and supporting information were recirculated from February to April 2018 for public review.

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> 184 MT per year of CO2e emissions. The Project-related operational and amortized construction GHG emissions are estimated to generate approximately 5,272 MT CO_2e per year.

Carbon Dioxide does not take a period of years transform into something harmful; the impacts of CO2 begin from the time they are released into the environment. Amortizing construction air pollutants this way misleads the public as to the true cost of those pollutants and it does so in detrimental ways. It encourages the use of low cost high carbon emitting equipment and construction techniques. It promotes extensive grading as opposed to the incorporation of a site's natural features into project design, this hides the true environmental cost of these tradeoffs from the public by not presenting a true baseline to compare against alternatives as required by CEQA. The courts have consistently rejected practices that mislead the public as to the reality of the impacts and subvert full consideration of actual environmental impacts in the preparation of EIRs. Additionally, this approach is not permissible, as it has not been incorporated into San Diego's Carbon Action Plan (CAP).

Greenhouse gas analysis, efficiency metric:

The DEIR's analysis of greenhouse gases is riddled with errors of logic and omission that renders its conclusion useless. While the overall approach may, when fully developed, prove workable, the analysis as executed uses data that is not consistent with the geographic location of the proposed development. The analysis method has not been incorporated into the county's Carbon Acton Plan, which precludes its use. I29-4

The developer proposes using efficiency metric to determine if the impact of the development is significant. In appendix J section 4.0 they state:

> The analysis contained herein relies upon an efficiency metric not based on the future County CAP and not based upon guidelines adopted by a public hearing process.

The efficiency metric proposed has the following formula:

Efficiency Metric = Metric Tons CO2e (based 1990 levels)/ Service Population (based on 2020 projections) /year

Where service population equals population + jobs.

The DEIR calculates the efficiency metric for the project using data for unincorporated San Diego County, including 2 different greenhouse gas inventories and one using statewide data. Not all sources of greenhouse gases were included in the analysis, but those they considered relevant to land use sectors as described in appendix D in a chart titled 'California Greenhouse Gas Inventory for 1990 — by Sector and Activity'. The efficiency

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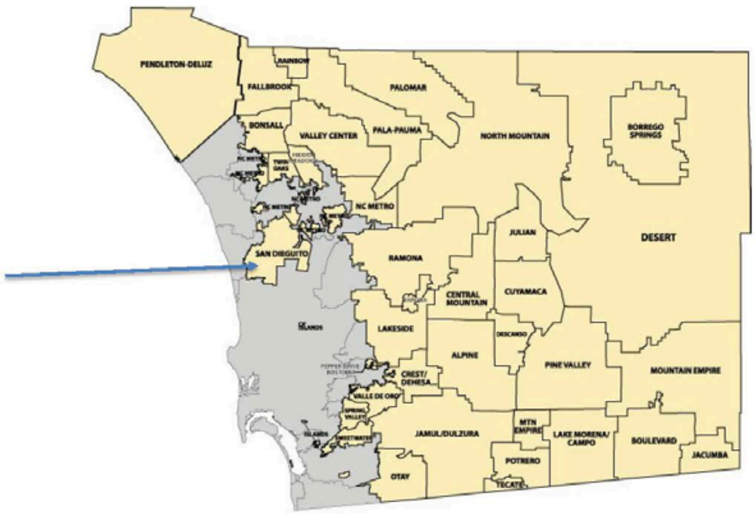
metric calculations based on San Diego County data include only carbon dioxide sources, population and jobs from unincorporated San Diego County.

While it is true the project is located in unincorporated San Diego County, it is a small inholding of county land, known as the San Dieguito planning area, which is surrounded by the counties major urban centers. The San Dieguito planning area is described in the County General Plan as:

> The San Dieguito Community Plan Area (CPA) is a low-density estate residential area surrounded by the rapidly urbanizing areas of North San Diego County. To the west lie the coastal cities of Encinitas, Solana Beach, and Del Mar; to the north are Carlsbad and San Marcos; to the east Escondido; and on the south, the City of San Diego.

Below is a map showing the location and relative size of the San Dieguito planning area relative to the rest of unincorporated San Diego County.

Unincorporated San Diego County



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Comment Letter I29 As the map shows, the proposed project is located within San Diego County's costal urban core, a fact further emphasized by the project's own description in the summary section of the DEIR, which states: The Proposed Project site vicinity is bordered by more intensive urban development in the cities of San Marcos and Escondido to the north and east, respectively. Palomar Medical Center is located approximately 2 miles to the north and Stone Brewery is located approximately 1.5 miles to the north as a crow flies. Both are part of the Escondido Research and Technology Center (ERTC), an industrial/commercial, employment and services locus located within 1 mile north-northeast of the Project. The ERTC is accessed by Harmony Grove Road, as are large big box uses, located at Valley Parkway and I-15 and along Auto Park Way. Two transit centers – "Nordahl Road" and "Escondido Transit Center" – are also located nearby. I29-4 The Escondido Research and Technology Center, as the name suggests, is located with in the city of Escondido, the "Nordahl Road" transit center is in the city of San Marcos, the "Escondido Transit Center" is in the city of Escondido as are the "big box uses". In fact, if a resident of the proposed project were to drive 7.88 mile, which is the average trip length for the project as described in appendix J section 5.3.1, they could not reach unincorporated East County San Diego nor could they reach unincorporated Camp Pendleton and the jobs located there. The vast majority of residents of the proposed project will work in the surrounding urban coastal core of San Diego as the DEIR summary suggests. The majority of student age children will attend schools in Escondido. Thus, it makes no sense to use the unincorporated county as the basis for the Greenhouse gas analysis. The analysis treats the development from a Greenhouse gas perspective as if it is being built on the shores of Lake Henshaw or the middle of the Anza Borrego desert, which is completely disconnected from the project's geographic reality. And thus, the efficiency metric calculations, regardless of which unincorporated greenhouse gas inventory is used, are meaningless. CEQA Guideline 15064.7(c)A requires a threshold of significance must be based on substantial evidence. I29-5 Applying the same logic used in the DEIR to calculate the efficiency metric with data that reflects the proposed development's location within San Diego County's coastal urban core, yields the following: the numbers are conservatively based on the data set that yielded the most favorable result for the project in their analysis (2011 GP Update EIR, University of San Diego's Energy Policy Initiatives Center (EPIC) GHG inventory for San Diego County and the EDD long term job forecast). This yields a 1990 CO_2e inventory for	**Response to Comment I29-5** As opposed to the GHG emissions inventory, which is based on land uses within the unincorporated County, the trip distance used for residences of the Project is based on the geographical proximity of employment centers, amenities, etc. that the residents would use. The suggested efficiency metric in the comment (which is based on San Diego County's coastal urban core) is not an appropriate approach for a project located in the unincorporated County.

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Comment Letter I29 San Diego County's coastal urban core of 18,588,537 MT CO_2e and a 2020 service population of 4,581,984 that produces an efficiency metric of 4.06. Applying the 5.2 % reduction as the DEIR does to account for project completion in 2021, yields a 3.85 MT CO_2e/SP/year. Which is well below project emissions per service population value of 4.4 as presented in the DEIR. Thus by the DEIRs own proposed methodology the project has significant greenhouse gas impacts. I29-5 As the discussion above shows, the DEIRs proposed methodology for analyzing greenhouse gas significance is not fully developed, reasoned nor documented. And a documented process has not been made available to the public for review and comment as required by the 2011 General Plan Update. As such it is impermissible to be used in greenhouse gas analysis as made clear in SIERRA CLUB VS. COUNTY OF SAN DIEGO (CASE NO.: 37-2012-00101054-CU-TT-CTL), which states: The County failed to comply with the CEQA-required procedures in adopting the 2016 Guidance Document. It did not adopt the 2016 Guidance Document by "ordinance, resolution, rule, or regulation." It did undertake a public review process. Also, the County's rules (ignored by the County) require that the 2016 Guidance Document be subject to public review. I29-6 The final efficiency metric calculation in the DEIR uses statewide CO2e, population and jobs projections. But again this is impermissible as made clear in SIERRA CLUB VS. COUNTY OF SANDIEGO (CASE NO.: 37-2012-00101054-CU-TT-CTL), which states: Is the 2016 Guidance Document Supported by Substantial Evidence? No. A threshold of significance must be based on substantial evidence. See CEQA Guideline 15064.7(c). The 2016 Guidance Document fails to bridge the analytical gap with substantial evidence, and thus is not supported by substantial evidence. The 2016 Guidance Document relies on statewide service population and statewide GHG inventory to derive a "per person" limit of GHG emissions. AR 10981. It provides no data specific to San Diego County. It makes no effort to explain why the calculation of the "County Efficiency Metric" based only on statewide data is appropriate for San Diego County. I29-7	**Response to Comment I29-6** Please refer to Response to Comment I29-4. **Response to Comment I29-7** Please refer to Response to Comment I29-4.

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Comment Letter I29 Greenhouse gas analysis over the life of the project: SB 32 requires that greenhouse gases be 40 percent below 1990 levels by 2030, yet the analysis in the DEIR does not include any information beyond full build out. The project useful life extends well beyond 2030 therefore such an analysis at a minimum would inform what design features, mitigation strategies are required to ensure the project meets all applicable regulations throughout its life. For example, such analysis might determine that the proposed solar system for the project should be sized to accommodate the charging of one electric vehicle per unit. It might inform the need to have the infrastructure in place such that at least one parking space per unit could easily be adapted to accommodate electric vehicle charging. Clearly a single charging station as proposed would not accommodate even a handful of residences with electric vehicles. Electric vehicles are a major component of California's plans to meet its greenhouse gas reductions targets. I29-8 Calculation of project emissions: The project emission calculation fails to include the carbon sequestration value of the chaparral that will be removed during construction, and thus understates the total carbon impact of the project. The carbon capture value of chaparral is described in a paper published in the journal Geoderma May 1998 titled; Organic Carbon Sequestration Under Chaparral and Pine After Four Decades of Soil development. The article is included as an attachment. By not factoring the carbon capture loss in the project emissions calculations the DEIR understates the impacts of the greenhouse gases and their significant relative to the applicable laws. I29-9 CONCLUSIONS The project as described in the DEIR does not comply with the applicable air quality and greenhouse gas laws and thus the project may not be approved in its current form. The review period was too short to review in any detail the traffic impact study within appendix J and other major sections of the report. But the number of errors in logic and omission found in those sections I did review are so fundamental as to call into question the veracity of the entire report, which raises serious doubts about the project. I29-10 Thank you, Richard Murphy	**Response to Comment I29-8** The EIR addresses consistency with the goals of SB 32 in Subchapter 2.7, *Greenhouse Gas Emissions*, Section 2.7.2. Also, the County respectfully disagrees with the second point of the comment. Although the analysis has been deleted from the FEIR, there was a qualitative analysis that included post-2020 targets for horizon years 2030 and 2050 in the DEIR under the heading "Horizon Year (2030 and 2050 Analysis)." The analysis is germane to the comment, remains accurate as to conclusion, and concluded that: *…the Project would neither conflict nor interfere with the state's implementation of SB 32's target of reducing statewide GHG emissions to 40 percent below 1990 levels by 2030, or EO S-3-05's target of reducing statewide GHG emission to 80 percent below 1990 levels by 2050. This is because it would not interfere with the state's implementation of GHG emission reduction measures described in CARB's First Update to the Scoping Plan; including the state providing for 12,000 MW of renewable distributed generation by 2020, CARB's draft 2017 Climate Change Scoping Plan Update, the California Building Commission mandating net zero energy homes in the building code after 2020, existing building retrofits under AB 758, and Cap-and-Trade Regulation. CARB identified these programs to reduce emissions by 2030 to levels squarely in line with those needed in the developed world and to stay on track to reduce emissions to 80 percent below 1990 levels by 2050.* Please refer to Response to Comment I29-4 regarding carbon net neutrality (i.e., purchase of off-sets). **Response to Comment I29-9** Consistent with this comment, the final Greenhouse Gas Emissions Analysis does include sequestration analysis. A one-time loss of sequestered carbon, as well as the benefits of the Project landscaping plan (which were conservatively

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	not incorporated into the impact numbers), are addressed in the FEIR and the errata to the Appendix J. **Response to Comment I29-10** The County acknowledges these comments. Conformance of the Project with applicable air quality and greenhouse gas legislation is addressed in the EIR and responses to this letter. Please refer to those discussions. The EIR was available for review for a period exceeding the minimum time period required under CEQA law, and was extended in response to requests for time extension. It is also noted that the Greenhouse Gas Emissions section and supporting information were recirculated from February to April, 2018, as described above. The County disagrees that there are fundamental errors in logic and omission, but rather finds that the Project documents are fully sufficient and accurate to support informed review by the public and decision makers. Absent additional specific comments for which a response can be provided, this general statement does not require a further response.

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Attachment to Comment Letter I29 Comment I29-11 ResearchGate Project	**Response to Comment I29-11** This attachment onsequestration research, is addressed in Response to Comment I29-9, above.

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Attachment to Comment Letter I29 **Comment I29-11** ELSEVIER Geoderma 83 (1998) 227–242 GEODERMA Organic carbon sequestration under chaparral and pine after four decades of soil development S.A. Quideau [a,*], R.C. Graham [a,1], O.A. Chadwick [b,2], H.B. Wood [c] [a] *Department of Soil and Environmental Sciences, University of California, Riverside, CA 92521, USA* [b] *Department of Geography, University of California, Santa Barbara, CA 93106, USA* [c] *USDA-Forest Service, Pacific Southwest Research Station, 4955 Canyon Crest Drive, Riverside, CA 92507, USA* Received 26 March 1997; revised 12 November 1997; accepted 12 November 1997 **Abstract** Soils are the largest carbon reservoir of terrestrial ecosystems, and play a central role in the global carbon cycle. The large lysimeter installation at the San Dimas Experimental Forest in southern California allowed quantification of carbon storage in a biosequence of soils under chamise (*Adenostoma fasciculatum* Hook. and Arn.), hoaryleaf ceanothus (*Ceanothus crassifolius* Torr.), scrub oak (*Quercus dumosa* Nutt.), and Coulter pine (*Pinus coulteri* B. Don). After four decades of soil development, carbon sequestration in the lysimeters ranged from 4552 to 17,561 g m^{-2}. Carbon accretion in the mineral soils (0–1 m) under chaparral represented a larger percentage of total above-ground biomass (23–27%) as compared to the pine (13%). Also, contribution of the A horizon to whole soil (0–1 m) OC sequestration was higher under chaparral than under pine. Carbon accretion in the surface horizons was related to earthworm activity, which was intense under scrub oak, but absent under pine. Soils sampled in 1987 and corresponding archived fill materials were fractionated according to density and mineral particle size fractions, and analyzed for OC and N by dry combustion. Carbon and nitrogen concentrations in all mineral soil fractions can be ranked from highest to lowest by plant species: ceanothus > chamise > scrub oak > Coulter pine. Under chaparral, a greater proportion of total soil carbon was recovered in the sand fraction as compared to the pine. The C/N ratio of this sand-sized organic matter was higher under chaparral than under pine. This is indicative of fresh plant residues that may not contribute to the long-term carbon storage in soils. © 1998 Elsevier Science B.V. *Keywords:* Mediterranean ecosystems; C/N ratio; density and size fractionation * Corresponding author. Fax: +1-909-7873993; E-mail: quideau@citrus.ucr.edu [1] Fax: +1-909-7873993; E-mail: graham@citrus.ucr.edu [2] Fax: +1-805-8933146; E-mail: oac@geog.ucsb.edu 0016-7061/98/$19.00 © 1998 Elsevier Science B.V. All rights reserved. *PII* S0016-7061(97)00142-0	

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Comment I29-11

1. Introduction

Soil organic matter (SOM) is a key attribute of soil quality in that it mediates many of the processes controlling the capacity of a soil to perform successfully with respect to specific conservation and management objectives (Doran and Parkin, 1994). Furthermore, soils are a substantial carbon reservoir and are estimated to store 1400×10^{15} g C on a global scale; this is approximately twice the amount stored in either the living biomass or the atmosphere (Schlesinger, 1977; Post et al., 1990). A central difficulty in quantification of the global C cycle is SOM heterogeneity, which has been conceptualized in mathematical modeling as a series of pools with different turnover rates, ranging from seasonal to millennial (e.g., Parton et al., 1987; Trumbore, 1993). Identification of analytical organic fractions corresponding to the dynamic pools of these models is a prerequisite to better understanding the role of SOM in overall soil quality and the global carbon cycle.

A wide variety of extraction methods has been employed to recover organic substances from soils, including the use of alkaline hydrolysis, followed by acidification, to separate the classical humic and fulvic acid fractions (Stevenson, 1994). However, there appears to be limited significance of these fractions to the turnover rates of different SOM pools. Physical fractionation of soil according to mineral particle sizes has proven to be the most promising separation method proposed so far (Christensen, 1992). Results from incubation studies and radiocarbon dating have demonstrated differences in turnover rate of SOM associated with different size fractions, with turnover rate typically decreasing with decreasing particle size (Anderson and Paul, 1984; Christensen, 1987). The physical fractionation approach has been successfully applied in studies of SOM decrease after cultivation of prairie soils in Canada and the US midwest (Anderson et al., 1981; Tiessen and Stewart, 1983; Zhang et al., 1988). Effects of cropping on SOM decrease following deforestation have also been documented (Cerri et al., 1985; Skjemstad et al., 1990). Cultivation typically induces a massive loss of the light, sand-associated organic matter, with a smaller loss in the fine silt and coarse clay fractions. In contrast to the net release of carbon to the atmosphere resulting from the expansion of agricultural lands, forests may represent an important sink for anthropogenically produced carbon (Post et al., 1990; Grace et al., 1995). However, SOM accretion in different particle size fractions during the early stages of soil development following afforestation are poorly documented.

The lysimeter installation at the San Dimas Experimental Forest (SDEF) in southern California presented the opportunity to study changes in organic carbon (OC) storage in imposed soil–vegetation systems four decades after planting. These large lysimeters were filled with homogeneous soil material of low OC content (0.2%), and have been under virtual monocultures of native woody species since 1946. Past research at the San Dimas lysimeter installation has

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Attachment to Comment Letter I29 **Comment I29-11**	

addressed the influence of chaparral and Coulter pine (*Pinus coulteri* B. Don) vegetation on soil morphological development (Graham and Wood, 1991), aggregate stability (Graham et al., 1995), soil OC, N, and exchangeable cations (Ulery et al., 1995), mineralogy (Tice et al., 1996), and base cation weathering (Quideau et al., 1996). Our objectives in this study were to assess (1) changes in C and N storage in the total soil–vegetation systems, and (2) changes in soil OC and N storage in particle size fractions as a function of vegetation type.

2. Methods and materials

2.1. Study area

The SDEF is located in the San Gabriel Mountains, 56 km northeast of Los Angeles. The lysimeter installation is centered in the SDEF at an elevation of 830 m, in an area known as Tanbark Flat (Mooney and Parsons, 1973). Native vegetation of the SDEF is mainly composed of mixed chaparral, which includes chamise (*Adenostoma fasciculatum* Hook. and Arn.), ceanothus (*Ceanothus* spp.), manzanita (*Arctostaphylos* spp.), scrub oak (*Quercus dumosa* Nutt.), and birch-leaf mountain mahogany (*Cercocarpus betuloides* Nutt.). The climate is typically mediterranean with warm, dry summers, and mild, wet winters. The mean annual temperature is 14.3°C, with August and January means of 22.2 and 8.0°C, respectively. The mean annual precipitation is 678 mm (Dunn et al., 1988).

History of the lysimeter installation has been described in detail elsewhere (Colman and Hamilton, 1947; Graham and Wood, 1991; Graham et al., 1995; Ulery et al., 1995; Tice et al., 1996), and is highlighted here. The large (5.3 by 5.3 m horizontally and 2.1 m deep) unconfined lysimeters were filled in 1937 with a brown (7.5YR 5/4 dry) fine sandy loam derived on site from the weathering of diorite. To insure homogeneity, the soil material was sieved (< 19 mm diameter) and thoroughly mixed prior to filling. In addition, each successive 7.5-cm-thick fill layer was chopped with a flat-bladed spade to reduce boundary effects with the underlying layer. Analysis at the time showed an extreme range in soil density through the lysimeters of less than 2% (Colman and Hamilton, 1947).

Following a 3-yr settling period, a 5% slope to the south was imposed on the surface of the lysimeters. Monocultures of chamise, ceanothus (*Ceanothus crassifolius* Torr.), scrub oak, and Coulter pine were established in 1946, either with seeds or 1-year-old seedlings. A single planting of each species was done on a 17 by 24 m area including an unconfined lysimeter and surrounding buffer strips to eliminate edge effects (Colman and Hamilton, 1947). By 1955, all lysimeters supported pure stands and had complete litter covers (Patric, 1961). In July 1960, the chamise and ceanothus stands were burned to the ground by a

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wild fire, leaving only charred stems and a 1-cm-thick ash layer (Zinke, 1977). The oak and pine stands were less affected, with only spotty burning of the litter under the oak. By 1972, vegetation on all lysimeters was again vigorous and in virtually pure stands as originally planted (Patric, 1974, unpubl. data). Except for scattered grass in the pine lysimeter, these conditions have prevailed to the present without further disturbance (Milone, 1994).

2.2. Field and laboratory methods

Above-ground biomass at each lysimeter was determined in summer 1993 as reported by Milone (1994). Because the lysimeters occupy small areas (28 m^2) and are irreplaceable resources, destructive sampling of vegetation was restricted to the buffer strips surrounding the lysimeters. Allometric equations relating stem diameter to total and foliage biomass were developed for each vegetation type (Milone, 1994). Stem diameters were then measured for all plants within each lysimeter, and estimated biomass values were extrapolated to a hectare basis. Litter biomass was estimated from cores of known volume (227 cm^3) taken in triplicate at each lysimeter. Wood, foliage, and litter samples were dried to constant weight at 70°C, ground in a Wiley mill, and analyzed for total OC and N by dry combustion using a Carlo Erba analyzer. Above-ground biomass at planting was assumed negligible relative to that of the 47-year-old vegetation, and accumulation in above-ground biomass was equated to OC and N contents as measured in 1993.

Composite soil samples of each 7.5 cm incremental layer were taken in 1937 upon filling of the lysimeters, and archived in glass jars. In 1987, three pedons in each vegetation plot were described and sampled by morphological horizon (Graham and Wood, 1991). In each lysimeter, one pedon was sampled to a depth of 1 m, the other two were sampled to 35 cm. The soils under chamise, ceanothus, and shrub oak were classified as coarse-loamy, mixed, mesic Typic Xerorthents, while the soil under pine was a coarse-loamy, mixed, mesic Typic Haploxeralf. The 1987 soil samples and samples archived in 1937 from corresponding fill layers were sieved to remove coarse fragments (> 2 mm), and analyzed for total OC and N by dry combustion (i.e; total of 92 samples). Changes in total OC and N storage within each lysimeter soil to a depth of 1 m have been calculated by Ulery et al. (1995), by taking into account soil concentrations and volumetric changes with time.

In this study, we fractionated the following sets of soil samples: (1) the A horizons from the three pedons under each vegetation type; (2) the 80–100 cm depth intervals from the 1-m-deep pedons, and (3) the archived samples corresponding to the 1987 A horizons. Soil samples (20 g) were ultrasonically dispersed in water with a Fisher Scientific P5-50 sonicator. Preliminary work established that a 1:10 soil-to-water ratio and a sonification time of 15 min at full power efficiently dispersed the soil samples. The sand fraction (> 50 μm)

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was separated by wet sieving (Anderson et al., 1981). The remaining suspension was fractionated using a combination of sedimentation and centrifugation techniques (Genrich and Bremner, 1974) into: coarse silt (20–50 μm), medium silt (5–20 μm), fine silt (2–5 μm), and clay (< 2 μm). The sand, coarse silt, and medium silt fractions were dried to constant weight at 70°C. The fine silt and clay fractions were flocculated with 1 M KCl, dialyzed against water until free of salt, and freeze dried. Weight of the five size fractions was recorded. Recovery of the original 20 g was excellent, with an average recovery of 97.7%. All fractions were analyzed for total OC and N by dry combustion (i.e., total of 100 samples).

3. Results

3.1. Storage within the plant–soil systems

Soils (0–1 m) under the four vegetation species have accumulated from 900 to 3800 g m^{-2} of carbon since planting in 1946 (Table 1). Depending on the plant species, these values represent an increase in soil OC storage of 30 to 120% relative to the original fill material, and reflect the high sequestration potential in soils during their initial stage of development. They are five to ten times greater than those measured in older (4–240 ka) grassland soils from northern California (Chadwick et al., 1994).

Total N accretion in the lysimeters ranged from 95 to 231 g m^{-2}, and was highest for the oak (Table 1). Assuming no significant loss from the plant–soil

Table 1
Changes in OC and N storage (g m^{-2}) at the four lysimeters since planting in 1946

	Above-ground biomass[a]		Litter[b]	Soil[c]	Total[d]
	wood	foliage		(0–1 m)	
OC					
Pine	13,729	1250	518	2030	17,527
Oak	12,009	1302	490	3760	17,561
Ceanothus	4808	602	408	1398	7216
Chamise	2750	578	322	902	4552
N					
Pine	27	22	14	44	107
Oak	75	33	11	112	231
Ceanothus	53	13	8	119	193
Chamise	13	13	10	59	95

[a] As sampled in 1993 (from Milone, 1994).
[b] As sampled in 1994.
[c] As sampled in 1987 (from Ulery et al., 1995).
[d] Includes wood, foliage, litter, and soil (0–1 m).

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system, N accumulation for the oak lysimeter corresponds to a mean annual atmospheric deposition rate of 4.7 g m^{-2} yr^{-1} (i.e., as estimated since the construction of the lysimeter installation in 1937), and illustrates the high level of N pollutants in the Los Angeles air basin. While annual wet N deposition at the Tanbark Flats monitoring station, located 200 m south of the lysimeter installation, was 0.4 g m^{-2} yr^{-1} (Young et al., 1988), dry deposition loads may be several-fold greater; based on branch washing techniques, dry N deposition to the canopy of *C. crassifolius* growing within the San Dimas Experimental Forest was estimated at 2.0 to 3.5 g m^{-2} yr^{-1} (Bytnerowicz and Fenn, 1996).

In addition to differences in total accumulation and storage, the four plant species exhibited differences in OC and N distribution within the plant–soil systems (Table 1). In particular, the soil under ceanothus, a notable N_2 fixer, accumulated more N than the soil under oak. Assuming that the difference in N accumulation between oak and ceanothus reflects symbiotic fixation, this would correspond to a mean fixation rate of 1.4 g m^{-2} yr^{-1}. This is higher than the 0.03 g m^{-2} yr^{-1} reported by Kummerow et al. (1978) for *C. greggii* in San Diego County, but comparable to the 1.3 g m^{-2} yr^{-1} measured for *C. cuneatus* in northern California by Delwiche et al. (1965). Also, chaparral and pine systems markedly differed in OC partitioning between above-ground biomass and mineral soil (Fig. 1). For chaparral, OC accretion in the mineral soil (0–1 m) equated 23 to 27% of OC accumulation above-ground (including vegetation and litter), as compared to 13% for pine.

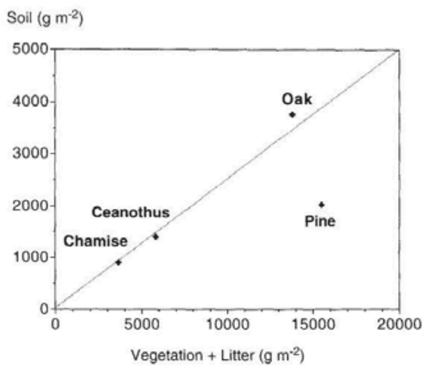

Fig. 1. Accumulation of organic carbon (OC) in the mineral soils (0–1 m) as a function of OC sequestration above-ground (litter + foliage + wood biomass).

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Table 2
Thickness, total OC concentrations, and changes in OC storage in the 1987-sampled A and C horizons under the four vegetation types. OC concentrations in the A horizons are the mean values for three pedons and standard errors are indicated in parentheses

	Thickness (cm)		OC concentration (wt%)		Change in OC storage ($g\ m^{-2}$)	
	A horizon	C Horizon (80–100 cm)	A horizon	C horizon (80–100 cm)	A horizon	C horizon (80–100 cm)
Pine	1	20	1.59 (0.31)	0.23	190	30
Oak	7	20	3.25 (0.08)	0.18	2890	−90
Ceanothus	2	20	6.58 (1.23)	0.16	1370	−160
Chamise	1	20	4.42 (0.35)	0.17	580	−70

Carbon concentration in the A horizons was higher under chamise and ceanothus than under pine (Table 2). Additionally, when the thickness of the A horizon was taken into account, OC accumulation under oak ($g\ m^{-2}$) was markedly greater than under pine. As reported by Graham and Wood (1991), the 1987 soils lacked any apparent morphological development below the 20- to 25-cm depth, and designated C horizons were sampled in 15- to 20-cm intervals. Under the three chaparral species, OC concentration in the final 20 cm increment (80–100 cm depth) was lower than the 0.2 wt% OC present in the original fill material, indicating a loss by decomposition or leaching since filling of the lysimeters (Table 2). In contrast, there was an increase in OC concentration at the 80–100 cm depth under the pine stand. These results further illustrate the difference between chaparral and pine vegetation. While the majority of OC accumulated near the soil surface under chaparral (Fig. 2), 90% of the OC accumulation under pine occurred below the 1 cm deep A horizon (Tables 1 and 2).

3.2. Distribution with particle size

Carbon concentrations in particle size fractions of the original fill material showed marked differences, ranging from 0.06 to 0.96% OC (Fig. 3a and Fig. 4). Concentrations increased with decreasing particle size, and reached a maximum in the clay fraction. The distribution of OC among size separates, calculated by taking into account particle size distribution (58% sand, 12% coarse silt, 12% medium silt, 7% fine silt, 11% clay), basically followed the same trend as OC concentration; OC content (as percent of < 2 mm soil content) increased with decreasing particle size (Fig. 3b). One exception was in the coarse silt, which contained significantly less OC than sand. This was due to the small coarse silt content in the soil, only 20% of the sand content.

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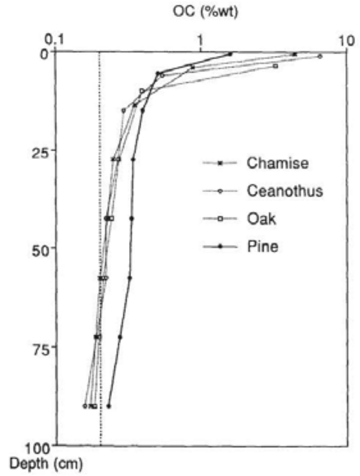

Fig. 2. Organic carbon (OC) concentration (%) as a function of depth under the four vegetation types. The dashed line indicates OC concentration (0.2%) in original fill material. Note log scale for OC concentration.

Carbon concentrations in the 1987-sampled A horizons were 4 to 90 times greater than those of the fill material, depending on the particle size fraction (Fig. 3a). In contrast to the original fill material, carbon enrichment increased with increasing particle size, which led to a shift in OC distribution from the fill material. In 1987, the sand fractions contained 32 to 54% of total OC (Fig. 3b). This OC pool includes undecomposed and only slightly decomposed plant residues (Christensen, 1992), and reflects the dominant influence of litter-derived materials in the sampled A horizons. In contrast to these surface horizons, OC concentrations in the size fractions at the 80 to 100 cm depth exhibited up to a 40% loss in OC as compared to the original fill material (Fig. 4). The sand and coarse silt fractions under pine were an exception and displayed a small enrichment in OC.

In all size separates from the A horizons, OC concentrations decreased in the following order: ceanothus > chamise > oak > pine, indicating that there was no interaction between vegetation and particle size (Fig. 3a). In contrast, an

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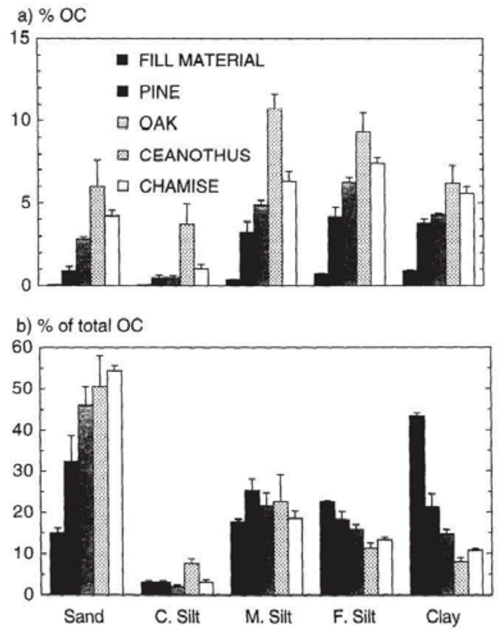

Fig. 3. The organic carbon (OC) in particle size fractions of the original fill material and of the A horizons under the four vegetation types expressed as (a) concentration (%) and (b) distribution (as % of total OC). Error bars indicate one standard error from the mean ($n = 3$–4).

interaction was apparent between vegetation and particle size for carbon distribution (Fig. 3b). In particular, the sand fraction contained more OC under the three chaparral species than under pine, while the opposite was true for the silt and clay fractions.

The C/N ratio in the original fill material decreased with decreasing particle size, from a high of 14.1 in the sand to 8.9 in the clay (Fig. 5). This supports the concept of lower mineralization rate for OC with decreasing particle size (Christensen, 1987). The deep (80–100 cm) samples collected in 1987 under the

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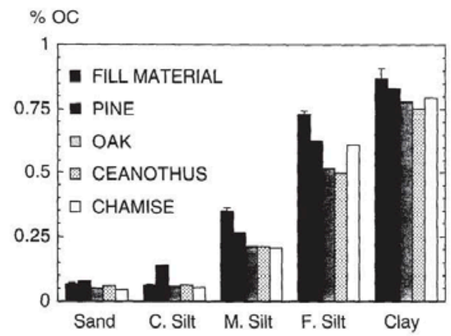

Fig. 4. The organic carbon (OC) concentration (%) in particle size fractions of the C horizons (80–100 cm) under the four vegetation types. Organic C concentrations in the original fill material are given as a reference (error bars indicate one standard error from the mean, $n = 4$).

three chaparral species had C/N ratios close to, but in general slightly higher than that of the fill material in all particle size fractions. This was particularly true for the sand and coarse silt fractions under pine vegetation (Fig. 5). These data suggest that higher OC input through root turnover was responsible for the greater SOM sequestration at depth under pine than under chaparral. In the

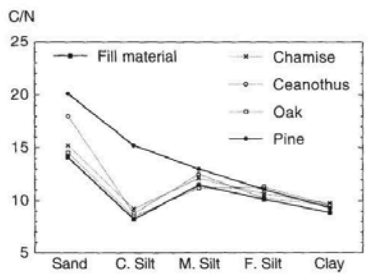

Fig. 5. C/N ratios in particle size fractions of the original fill material and of the C horizons (80–100 cm) under the four vegetation types.

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Table 3
C/N ratios in foliage, litter, and A horizons at the pine, oak, ceanothus, and chamise lysimeters. Standard errors are indicated in parentheses ($n = 3$)

	Foliage[a]	Litter[b]	A horizon[c]			
			sand	silt	clay	total
Pine	57	(Oi1) 72.5 (6.6) (Oi2) 46.6 (1.4) (Oe) 30.3 (1.6)	21.4 (1.3)	16.4 (0.9)	11.1 (0.7)	16.1 (1.4)
Oak	39	44.6 (3.9)	36.0 (5.9)	16.8 (0.7)	10.1 (0.2)	19.5 (1.2)
Ceanothus	46	46.9 (2.7)	27.3 (5.5)	17.7 (0.5)	10.8 (1.3)	20.3 (2.3)
Chamise	44	32.9 (1.4)	36.9 (4.9)	19.7 (1.4)	12.4 (1.9)	24.3 (2.8)

[a] As sampled in 1993 (from Milone, 1994).
[b] As sampled in 1994.
[c] As sampled in 1987.

1987-sampled A horizons, C/N ratios under all plant species were higher than in the fill material, again portraying the input of fresh plant residues (Table 3).

The C/N ratios of foliage, litter, and OC in the A horizons differed among plant species (Table 3). For pine, the C/N ratio decreased from the Oi1 to the Oi2 and Oe layers, and exhibited a further decrease in the SOM of the A horizon associated with the sand fraction. These data reflect the progressive increase in the degree of decomposition of pine needles until their incorporation into the mineral soil. In contrast, SOM associated with the sand fractions under chaparral vegetation showed a smaller decrease in C/N as compared to the foliage and litter pools. Furthermore, the C/N ratio of the sand fraction under the three chaparral species was higher than under pine, indicating a lower degree of decomposition for the plant material at its point of incorporation into the mineral soil. No consistent differences among vegetation types were apparent in the silt and clay fractions.

4. Discussion

Proportionally greater OC accretion in the mineral soil under chaparral (i.e., as percentage of OC accumulation in biomass) may be due to a proportionally greater litterfall and a more rapid litter decomposition than under the pine. In particular, litterfall for the oak lysimeter was estimated to be 3 to 4 times greater than that for the pine (Quideau et al., 1996). The percentage of above-ground biomass that becomes annual litterfall in chaparral ecosystems ranges from 6 to 14%, and is higher than the 3 to 5% range reported for coniferous forests (Gray and Schlesinger, 1981). Litterfall is also a function of the relative allocation of biomass to foliage; at the lysimeter installation, foliage made up 10 to 17% of total above-ground biomass for the three chaparral species as compared to 8% for the pine. Additionally, for the chamise and ceanothus lysimeters, the 1960

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fire may have contributed to the increase in soil OC. Fire is an integral part of chaparral ecosystems, and typically short-circuits intrasystem cycles by returning to the soil as ashfall elements and compounds of organic matter tied up in vegetation and undecomposed litter (Gray and Schlesinger, 1981).

Decomposition rates have been related to a variety of litter properties, including C/N ratio and lignin content (Schlesinger and Hasey, 1981; Horner et al., 1988). In the San Dimas vegetation systems, earthworm activity also appears to be a central determinant in litter decomposition and OC accumulation (g m^{-2}) in the A horizons. Graham and Wood (1991) reported varying degrees of earthworm activity according to chaparral species. In 1987, the soil under oak had the thickest A horizon (7 cm), comprising 95% worm casts. A similar earthworm-worked horizon was 2 cm thick under ceanothus (Table 2). Worm casts only composed 50% of the 1-cm-thick A horizon under chamise, and were absent under pine. Carbon accumulation in the A horizons increased with the increasing earthworm activity, reflected by horizon thickness and abundance of casts (Table 2).

The earthworms identified within the lysimeter installation were primarily *Aporrectodea caliginosa*, *Aporrectodea trapezoides*, and juvenile Lumbricidae (Wood and James, 1993). These species are endogeic; they live within the soil profile in temporary burrows and feed primarily on soil and associated organic matter (Bouché, 1977; Hendrix, 1995), but surface organic matter, such as leaf litter and small twigs, may also serve as a food source (Ferrière, 1980; Lee, 1985). In our study, the role of earthworms in mixing surface litter and mineral soil was evidenced by the greater proportion of total OC recovered in the sand fraction of the A horizons under chaparral vegetation as compared to pine (Fig. 3b). The wide C/N ratio of this sand-sized organic matter suggested little alteration of the litter material with incorporation into the mineral soil.

Organic matter associated with the sand fraction in soils either undergoes rapid oxidation to CO_2, or is redistributed to finer size fractions where it becomes increasingly resistant to decomposition and contributes to the long-term OC sequestration in soils (Christensen, 1987; Stevenson, 1994). However, proportionally less carbon was contained in the clay fraction of the A horizons under chaparral than under pine. These data could be due to slower mineralization processes under chaparral. Soil organic matter mineralization is slower in intra-aggregate regions than in inter-aggregate spaces, a phenomenon which has been related to the physical protection of organic matter contained within soil aggregates (Gupta and Germida, 1988; Cambardella and Elliott, 1994). Martin (1991) similarly reported much lower C mineralization from earthworm casts (3% yr^{-1}) than from non-aggregated control soils (11% yr^{-1}). Within the lysimeter installation, aggregate stability was 15% greater under scrub oak than under pine as a result of earthworm activity (Graham et al., 1995). Thus, greater aggregate stability could result in lower C mineralization rates and comparatively lower OC content of the clay fraction as compared to the soil under pine.

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An alternative hypothesis to explain the lower OC enrichment factor in the clay fraction under chaparral vegetation is a higher loss of the clay-sized organic matter through respiration processes. Based on $\delta^{13}C$ measurements, Martin et al. (1992) demonstrated that *Millsonia anomala*, a tropical geophagous earthworm, assimilated SOM associated with the finer fraction (< 20 μm). Data from our study suggest that these results may also apply to Mediterranean-type ecosystems in North America, and that earthworms at the lysimeter installation may be feeding on two distinct pools of organic materials: (1) relatively fresh plant residues contained in the litter layer; and (2) SOM associated with the clay fraction. At the lysimeter installation, the A horizons under oak and ceanothus, which were composed of earthworm casts, contained significantly ($p = 0.01$) more clay than the underlying horizons and the archived parent materials, indicating that earthworms preferentially ingested finer soil fractions (Graham and Wood, 1991).

Past research at the lysimeter installation emphasized the role of biocycling as a mechanism resulting in greater amounts of exchangeable cations under chaparral, particularly scrub oak, than under pine vegetation (Ulery et al., 1995). Biocycling was also implicated in the enhanced K fixation by A horizon vermiculite (Tice et al., 1996), and the lower release of base cations by weathering under chaparral as compared to the soil under pine (Quideau et al., 1996). This study corroborates past work in that it demonstrates a proportionally greater flux of biomass OC to the mineral soil under chaparral. However, the increase of total SOM under chaparral principally arose from the incorporation of coarse (> 50 μm), only partially decomposed organic materials, into the mineral soil. These materials contribute to OC sequestration in soils on a short-term basis, on the order of decades or less (Parton et al., 1987; Trumbore, 1993). As global climate change increases world temperatures by 0.02 to 0.05°C yr^{-1} over the next decades (Houghton et al., 1990), this fast-cycling SOM reservoir is predicted to decrease, causing a net transfer of carbon from the soil pools to the atmosphere (Trumbore et al., 1996). This scenario signifies that at the lysimeter installation, the soils under chaparral would release more CO_2 than the soil under pine. This is particularly probable since a greater proportion of total SOM is concentrated at depth under pine, and would be buffered from rapid temperature changes.

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