

Estimating Travel Activity on Unpaved Roads for PM₁₀ Conformity

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ABSTRACT

The Federal Clean Air Act Amendments of 1990 require emission inventories be constructed for every area in nonattainment of any of six criteria pollutants, including particulate matter with an aerodynamic diameter of less than 10 μ m (PM₁₀). An essential component in building mobile emissions inventories is an accurate estimation of vehicular traffic; in California, one particularly important source of PM₁₀ is vehicle activity on unpaved roads. To develop a statewide estimate of VMT on unpaved roads, this research expands upon a pilot study developed to estimate VMT on unpaved roads for two counties in the San Joaquin Valley. Research to date indicates that the current method used by the California Air Resources Board (CARB) overestimates annual VMT on unpaved roads, particularly VMT attributable to agricultural harvest activities. The pilot study results using the new methodology produced 29% less VMT on unpaved roads in San Joaquin County than calculated by the current method and 40% less in Fresno County.

INTRODUCTION

Roughly 19 of California's 58 counties are in nonattainment with federal PM₁₀ standards and 52 of California's counties are in nonattainment with California's PM₁₀ standards¹ (CARB 2001, CARB 2001a). A large portion of the PM₁₀, particularly in regions such as the San Joaquin Valley, is generally thought to come from fugitive dust created from vehicle travel on unpaved roads, paved roads with unpaved shoulders, and from agricultural field activities (Moosmuller 1998). In fact, according to recent emission inventory calculations, nearly 27% of total PM₁₀ from all sources in the San Joaquin Valley have been attributed to unpaved roads (CARB 1997).

Previous research on PM₁₀ has focused more on estimating better pollutant emission factors (*e.g.*, *e.g.*, Dyck and Stukel 1976, Claiborn *et al* 1995, USEPA 1995, Kantamaneni 1996) rather than refining estimates of source activities (*i.e.*, the VMT generated on unpaved roads). The current method used by the California Air Resources Board (CARB) to estimate PM₁₀ source activity on unpaved roads is based on surveys given to traffic engineers in 1976 and 1979. The traffic engineers were asked to estimate daily vehicle travel on unpaved roads. Their average response was 10 vehicle passes per unpaved road per day (CARB 1997a). Daily PM₁₀ emission loads from unpaved roads then are calculated as the product of an emission's factor (2.27 lbs.

¹ Only Lake County is in attainment with California's PM₁₀ standards. The remaining five counties are unclassified.

PM₁₀/VMT), an activity factor (10 daily passes), and the miles of unpaved road in the state. The limitations of this method are many, including fairly old estimates and the lack of spatial and temporal variability.

In this paper we present a new statistical framework to produce more robust estimates of the type and amount of vehicle activity on unpaved roads in California. Since a relatively large amount of travel is expected to occur within a short period of time because of seasonal harvesting, the new framework involves specification of distinct harvest and non-harvest VMT models.

DATA

To estimate the models we rely on a wide range of data including GIS land-use and road coverages, field and crop characteristics derived from a survey of California growers, and traffic counts conducted on unpaved roads. Our data come from several sources including the California Department of Water Resources (DWR), the California Department of Transportation (Caltrans), and, California County Agricultural Commissioners' Offices (CACs).

The land-use coverages, provided by the DWR, contain several classes and subclasses of land-use (*e.g.*, agricultural, urban, native) for most counties in the state (DWR 1993). The proportion of each township-range-section location (TRS) dedicated to each land-use is calculated by overlaying each land-use coverage with the Public Land Survey System (PLSS) grid and dividing each TRS into 50 x 50 meter squares. Each micro square is then assigned a 0 or 1 value for each possible land use, according to the DWR coverage. The values are then separately averaged across each TRS to obtain the proportions of land-use. This provides us with an estimate of the amounts of acreage in each land-use. For the harvest VMT estimation, agricultural lands are further divided into crop categories representative of specific areas.

Roadway network characteristics are developed using a GIS coverage provided by Caltrans containing records of all known roads by service class within each county. In the coverage, unpaved roads are designated as service class 4 and class 5. There are two limitations to directly using these data to compute total unpaved road miles. First, class 4 also includes residential and unimproved roads, while class 5 includes hiking trails as well as unpaved four-wheel drive vehicle roads; and second, the original roadway network coverage was created without significant field verification and many roads, particularly in urban areas have been paved since the time the coverage was created. By overlaying the land-use coverage with the roadway network coverage and conducting field verification to eliminate clearly inactive roads we are able to refine the list of class 4 and class 5 roads to unpaved active private and unpaved active public roads. Since the GIS coverage also includes records of paved roads, we can estimate the paved road density in each TRS location.

Lists of growers in California counties are obtained from CACs databases, providing information on field acreage, field location, and the agricultural commodities grown at each location. Furthermore, the databases provide grower contact information enabling us to use a survey instrument to gather additional crop-specific data. The survey information is used to compute observed values of harvest VMT (both in-bound and out-bound) for each crop and each field

included in the survey. Field locations are identified by TRS locations, allowing field and crop characteristics to be associated with the land-use coverage.

Using these data, we constructed two models for estimating VMT. The first model is designed to estimate VMT associated with agricultural harvests (Harvest VMT Model). The second model is designed to estimate VMT associated with all other activities on unpaved roads (Non-Harvest VMT Model).

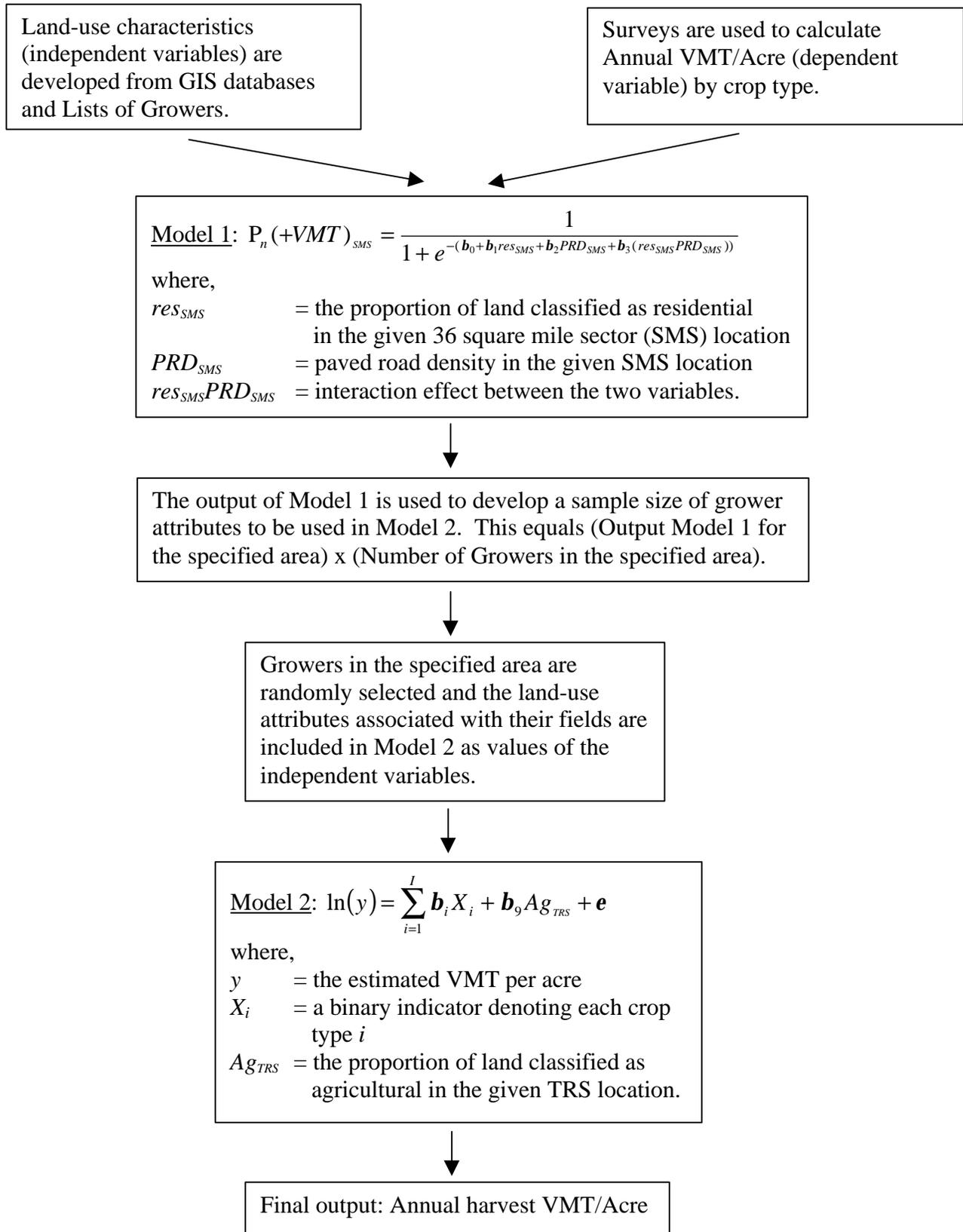
HARVEST VMT MODEL

The harvest VMT model estimates only that traffic directly related to harvest transport. It does not include such activities as land fertilization or field preparation; travel related VMT for these activities are included in the non-harvest model. The VMT that is generated on unpaved roads associated with agricultural harvests is a function of crop type, crop yields, the equipment used to haul the harvest away from the field, and of alternative transportation routes (*i.e.*, paved roads). Since harvest seasons can vary greatly by crop type, on-road vehicle counts at any one time would probably not be representative of harvest-related vehicle activity at other times.

We estimate harvest VMT using a two-step process. A given county is divided into sectors of 36 square miles and a logit model is applied to each sector to estimate the share of growers having positive VMT on unpaved roads. The logit model specification (*i.e.*, variables and estimated parameters) is based on the results of surveys sent to individual growers in which some proportion of fields were identified as not being used in any given growing season or all driving was conducted on paved roads. The application of the logit model allows us to specifically account for fields that are not generating VMT during any given growing season.

We then use a regression model, specified using information from growers who have harvest $VMT > 0$ on unpaved roads (Model 2), to estimate the harvest VMT. Model 2 is specified using the same land-use characteristics employed in Model 1, and allows the magnitude of VMT to vary by crop type, capturing any systematic differences that may exist between them.

Figure 1. Harvest VMT Estimation Steps

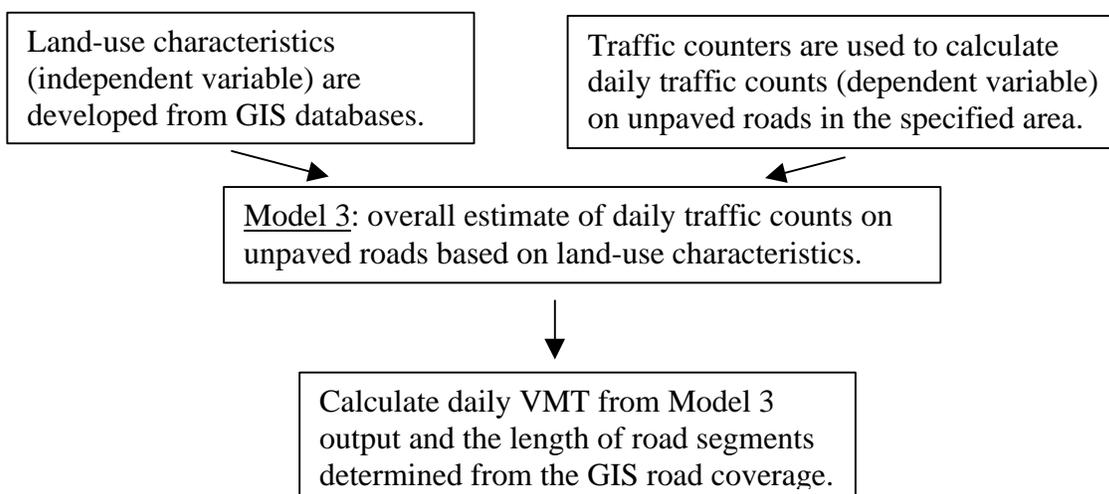


NON-HARVEST VMT

Non-harvest traffic refers to vehicular activity that can occur at any time, but that is not associated with harvest transport. In addition to vehicle activity such as recreational travel on unpaved roads, non-harvest traffic can include vehicle activity associated with non-harvest agricultural activities such as land preparation and field fertilization. Non-harvest vehicle activity is estimated by combining miles of unpaved road, observed traffic counts, adjacent land use characteristics, and precipitation statistics.

The estimation of non-harvest traffic counts on unpaved road segments uses a linear regression model in the process shown in Figure 2. The model was specified using a combination of data collected from traffic counters on unpaved roads and the land use characteristics surrounding the counter locations. With this model we estimate daily vehicle counts for each road segment. Once vehicle counts have been estimated for each road segment, total daily non-harvest VMT is calculated by multiplying the daily counts, estimated using the model, by miles of unpaved road, determined from the GIS road coverage.

Figure 2. Non-harvest VMT Estimation Steps



Daily non-harvest VMT estimations are then adjusted by the annual average number of dry days in the specified area to arrive at annual non-harvest VMT estimation. This adjustment does not suggest that VMT on unpaved roads is changed by the amount or rainfall. Rather, it reflects the fact that PM_{10} is reduced on days with precipitation.

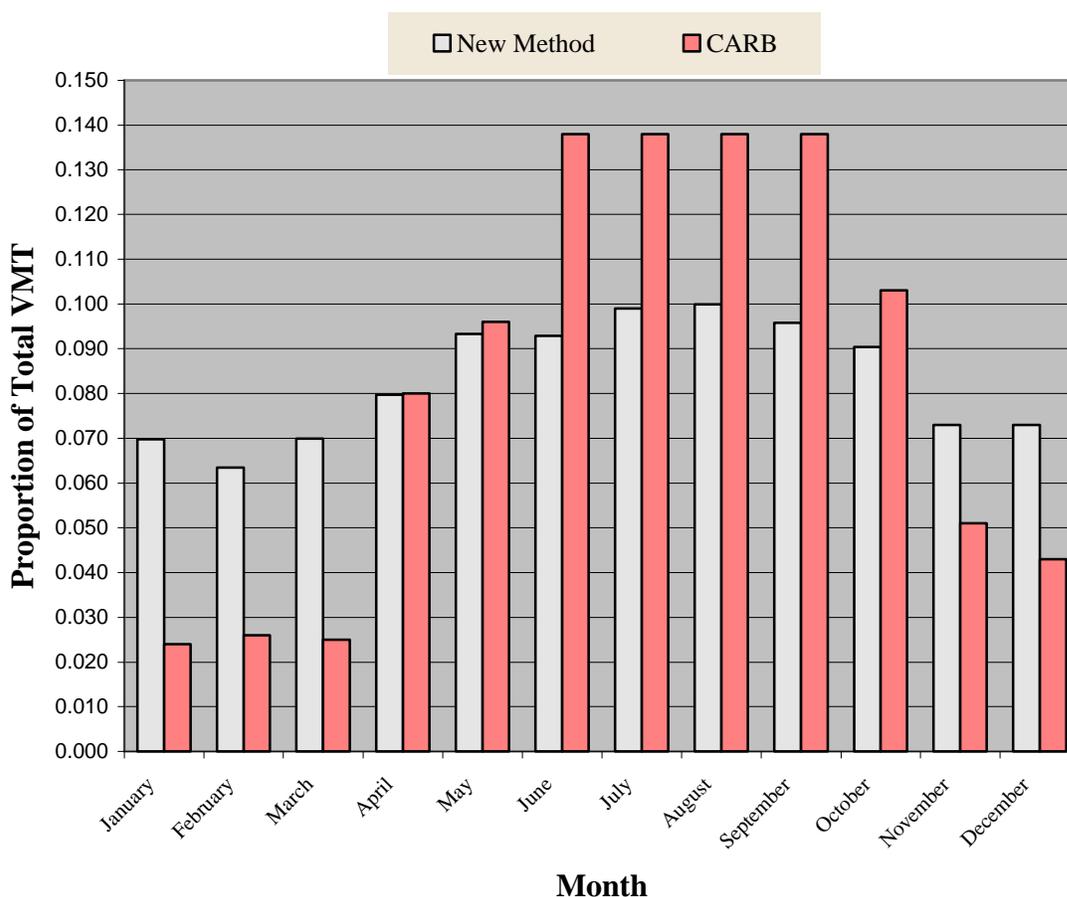
ANALYSIS

Preliminary results indicate that CARB's current method overestimates the number of vehicle miles traveled on unpaved roads in California. As mentioned previously, the method employed by CARB to estimate VMT on unpaved roads is fairly basic: countywide VMT equals a county's unpaved road mileage multiplied by 10 and summed for every day of the year (CARB 1997). For San Joaquin County, using the most recent inventory of unpaved road miles, CARB's VMT estimate is 3,732,667. For Fresno County CARB's VMT estimate is 11,580,820. By

comparison, the new estimation technique presented in this paper produces about 29% less VMT in San Joaquin County and 40% less VMT in Fresno County.

Since CARB did not differentiate between harvest and non-harvest vehicle activity, a direct comparison between the two methods is difficult. However, as an example, Figure 3 shows the monthly VMT profile for San Joaquin County estimated by the new framework as well as by CARB's method. The figure shows not only a substantial difference between annual VMT estimates, but also between the proportions of VMT per month (e.g., January).

Figure 3. Monthly Proportion of VMT, San Joaquin County



It is interesting to note the major differences between estimations made by the new method and CARB's estimations for January, February, March, June, July, August, and September. We suspect these discrepancies highlight the dominance of non-harvest VMT in estimating the county annual total. Even in the peak month of September, harvest VMT accounts for only about 4% of total VMT for that month in San Joaquin County, and just over 3% of total September VMT in Fresno County. This suggests that growers may not have the ability to significantly affect the PM₁₀ inventory. However, our method estimates only harvest transport

from the field to the nearest paved road; it does not include actual harvesting activities that take place in the fields.

CONCLUSION

In this paper, we have proposed a new methodology for estimating unpaved road VMT. The methodology consists of two separate, but interrelated modeling tracks: 1) one to estimate VMT associated with agricultural harvest activities, and 2) one to estimate VMT associated with non-harvest activities. In providing separate models for the type (harvest versus non-harvest) of vehicle activity on unpaved roads, the methodology allows us to distinguish between the relative impacts of these sources as contributors of PM₁₀.

Using the preliminary results from San Joaquin and Fresno Counties, the new methodology for estimating VMT on unpaved roads in California suggests that CARB's current method is substantially overestimating vehicular travel on these roads. In particular, it is likely that the amount of travel attributable to agricultural harvests has been overestimated. The method presented in this study provides a more statistically robust alternative for estimating vehicle activity on unpaved roads than the one currently employed by CARB.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the contributions of Joel P. Franklin, Kishore Lakshminarayanan, and Thirayoot Limanond to this study. The study is funded by the California Air Resources Board. The views reflect those of the authors alone.

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Prepared for the 2001 EPA International Emission Inventory Conference: One Atmosphere, One Inventory, Many Challenges, Denver, CO, April 30 - May 3, 2001

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KEYWORD

Air Quality
Vehicle Activity
Unpaved Roads
VMT
PM₁₀