California State Parks

Estimating the State Fuel Tax Paid on Gasoline Used in the Off-Highway Operation of Vehicles for Recreation

Survey Results

September 2006

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Survey Results

September 2006

Prepared for
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1. Executive Summary

This report presents the results of the data collected by ICF International under the California State Parks Off-Highway Vehicle Fuel Tax Transfer project. The purpose of this project is to provide data to assist the Department of Transportation and the Off-Highway Motor Vehicle Recreation Division in making estimates of the amount of fuel[1] used for off-highway vehicle (OHV) recreation on public lands in California. The purpose for such estimates is to facilitate decisions regarding transfers of fuel tax funds to the Off-Highway Vehicle Trust Fund. The secondary purpose is to provide estimates of geographic and types of recreational use. The methodology employed entailed two types of surveys:

- Random digit dial telephone surveys of over 15,000 California households during the period July to December 2003 to estimate the percentage of households that own an OHV, the percent of households that engage in off-highway vehicle recreation, and to determine the population of non-registered off-highway vehicles
- Written diaries by over 15,000 California vehicle owners during the period April 2004 to March 2005 to determine the amount of recreational fuel use for off-highway recreation in California on public lands

The results of both surveys were extrapolated to the entire population of California on- and off-highway vehicles. Table 1-1 illustrates preliminary results of gallons of gasoline used off-highway by California vehicles as determined by the ICF International surveys compared to the existing tax transfer model developed from a 1990 survey done by Tyler and Associates[2].

Using the current California gasoline tax rate of $0.18 per gallon, estimated tax revenues that would be transferred to State Parks are shown in Table 1-2. As seen in Table 1-2, there is a major decline in estimated fuel tax revenue based upon the new survey data obtained by this project. The difference is due to several factors. The largest factor results from the estimation of non-registered off-highway vehicles. In the existing tax transfer model, the number of registered green or red sticker vehicles is multiplied by a correction factor to determine the number of non-registered vehicles, based upon the survey completed in 1990.

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[1] "Motor vehicle fuel" as defined in the California Revenue and Taxation Code Section 7326 means gasoline and aviation gasoline. It does not include jet fuel, diesel fuel, kerosene, liquefied petroleum gas, natural gas in liquid or gaseous form, alcohol, or racing fuel.

[2] Tyler and Associates, "A Study to Determine Fuel Tax Attributable to Off-Highway and Street Licensed Vehicles Used for Recreation Off-Highway," November 1990.

Table 1-1. Estimated Gallons of Gasoline Used for Off-Highway Recreation on Public Lands in California from April 2004 to March 2005

Vehicle Type	ICF Survey			Existing Model
	Mean	Lower Bound	Upper Bound	
Street Licensed Vehicles	124,747,354	99,641,983	149,852,724	79,741,098
Green or Red Sticker Vehicles	20,014,590	17,081,031	22,948,148	34,439,819
Non-Registered Vehicles[a]	6,207,327	4,196,151	8,218,502	201,808,816
Total Gallons[b]	150,969,270	125,613,201	176,325,339	315,989,733

[a] Non-registered refers to off-highway vehicles that are not currently registered with a green or red sticker but could be used for recreational driving

[b] The totals given for the lower and upper bounds for all three vehicle types do not equal the total gallons given at the bottom of the table. This is because it is statistically much more likely that if one value is either very low or very high, then the other two values will not be as extreme.

Table 1-2. Estimated Fuel Tax Revenues for Off-Highway Recreation

ICF Survey			Existing Model[a]
Mean	Lower Bound	Upper Bound	
$27,174,469	$22,610,376	$31,738,561	$56,878,152

[a] The actual tax revenue transferred was $56,775,626 due to a correction in December 2004 related to a November 2004 over-transfer.

As shown in Table 1-3, for every one registered off-highway motorcycle the existing model estimates there are 5.9 non-registered off-highway motorcycles. While this may have been the case in 1990, the present day ICF International survey shows there are currently only 0.62 non-registered off-highway motorcycles for every one registered off-highway motorcycle.

Table 1-3. Non-Registered to Registered Ratios

Vehicle Type	Tyler Survey	ICF Survey
Motorcycles	5.90	0.62
ATVs	2.50	0.51
4 Wheel Vehicles[a]	7.60	2.77
Snowmobiles	7.00	0.45
Other[b]	0.066	0.013

[a] 4 Wheel vehicles include dune buggies, sand and desert rails, unlicensed street vehicles, motorized golf carts and other 4 wheeled vehicles. In the 1990 Study, unlicensed street vehicles were in the "Other" category.

[b] The ratio for Other is taken as the number of non-registered non-street licensed other divided by the total number of all registered non-street licensed vehicles. In the 1990 Study, Tyler & Associates chose what they considered a conservative number of 19 non-registered non-street licensed others to every one registered non-street licensed because the study did not produce data on any registered Others.

The significant differences in non-registered to registered ratios shown in Table 1-3 account for most of the difference in estimated gallons of fuel used by non-registered off-

highway vehicles as illustrated in Table 1-1. The existing model does not accurately account for non-registered vehicles becoming registered between the time of the 1990 Study and the present. Since 1990, significant enforcement at State Vehicular Recreation Areas (SVRAs), county parks, as well as US Forest Service and Bureau of Land Management lands has resulted in an increase in vehicle registration, forcing many non-registered vehicle owners to register their vehicles. When this occurs in a model with fixed non-registered to registered vehicle ratios, instead of subtracting a motorcycle from the non-registered vehicle counts and adding one to the registered vehicle counts, one motorcycle gets added to the registered counts and then the existing model estimates that another 5.9 non-registered motorcycles erroneously appear. This inflates the non-registered counts when they should be decreasing. In order to avoid this problem, surveys need to be done every few years to provide new non-registered to registered OHV ratios.

Three other factors create some differences in the estimated gallons used and the estimation of related fuel taxes: (1) poor classification of vehicle types in the existing DMV model used as input to the existing fuel tax transfer model, (2) the estimation of fuel used by non-registered vehicles, and (3) the purpose for which 4WD trucks and SUVs are purchased, a dramatic change since 1990.

(1) The existing DMV program which was written to provide inputs to the existing fuel tax model does not provide accurate vehicle counts due to poor classifications of vehicle types as shown in Table 1-4. This discrepancy is because the existing DMV program, which determines whether a vehicle is a 2WD or a 4WD vehicle, is vastly out of date. In addition, DMV did not purchase a motorcycle VIN decoder[3] to interpret whether an off-highway vehicle is a motorcycle or an ATV until 2003. As shown in Table 1-4, the actual counts of 4WD street licensed vehicles and the counts of off-highway motorcycles and ATVs are drastically different from what DMV is providing for the existing fuel tax transfer model. The misclassification of off-highway motorcycles and ATVs by the existing model also dramatically increases the estimation of non-registered vehicles because the existing model estimates there are 5.9 non-registered motorcycles for every one registered while it only estimates there are 2.5 non-registered ATVs for every one registered ATV. This misclassification results in an estimation of an additional 1.2 million non-registered vehicles that do not exist because most ATVs have been classified as

[3] A VIN decoder interprets the vehicle identification number (VIN) to provide various vehicle information including make, model, body type and model year. Without this, vehicle type determination has been left to the vehicle owner or DMV clerk when registering the vehicle.

motorcycles by the existing DMV program. The misclassification by the existing DMV program of 2WD and 4WD street licensed vehicles also affects fuel use. Generally 4WD vehicles are used more off-highway than 2WD vehicles and therefore have higher off-highway fuel use per month than 2WD vehicles. While correctly classifying 4WD vehicles as 4WD vehicles increases gallons of fuel used and, therefore, tax revenues, it does not make up for the drastic loss in estimated tax revenues caused by the over-estimation of non-registered vehicles.

Table 1-4. Comparison of Vehicle Counts between Existing Tax Transfer Model and Actual DMV Data[a]

Vehicle Type	Model Inputs	Actual DMV
Cars	14,887,946	14,221,617
2WD Vehicles	***9,320,229***	***7,817,512***
4WD Vehicles	***649,985***	***3,205,250***
Street Licensed Motorcycles	537,329	559,377
Street Licensed Other	442,280	277,540
Off-Highway Motorcycles	***656,816***	***335,169***
ATVs	***57,448***	***335,897***
4 Wheel Vehicles	18,478	19,329
Snowmobiles	18,894	18,502
Off-Highway Other	2,435	2,168

[a] DMV Vehicle counts and model inputs for October 2004.

(2) In addition, the existing tax transfer model assumes that non-registered OHVs use as much fuel per month per vehicle type as registered OHVs. In the current ICF International survey, annual fuel usage per vehicle of a non-registered OHV is estimated to be 62% less than that of a registered OHV.

(3) Finally, street licensed 4WD vehicles purchased today are used differently than in 1990. In 1990, when a 4WD vehicle was purchased, the 1990 Study found that approximately 36% were used for off-road driving, while the ICF International Study found that only 11% of 4WD vehicles are used for off-highway recreation today.

All these factors together result in a decline in the estimate of fuel used for off-highway recreation on public lands in California.

2. Introduction

Taxes are imposed by the State on motor vehicle fuel sold in California. In accordance with the California Revenue and Taxation Code[4], the gasoline taxes collected that are attributable to motor vehicles being used for off-highway recreation are transferred to the Off-Highway Vehicle Trust Fund (OHVTF) on a monthly basis. Those tax revenues are only associated with the off-highway operation of registered and non-registered[5] off-highway vehicles (OHVs), the off-highway operation of street licensed motor vehicles (SLVs) for recreation, and the off-highway operation of street-licensed motor vehicles while being used to gain access to any form of recreation, whether or not that form of recreation involves the use of a motor vehicle. This project is only concerned with the afore-mentioned operation of motor vehicles while they are being used off-highway on public lands in California. This project does not address use of motor vehicles in sanctioned competition events on public lands unless the vehicles are required to be DMV-registered to compete.

The primary objective of this project is to provide estimates of the amount of fuel used for off-highway vehicle (OHV) recreation on public lands in California to assist decision makers. A second task is to develop a dynamic Model for the California Department of Transportation (Caltrans) to use in determining the monthly transfer of fuel tax funds that are estimated to be attributable to the taxes imposed on the distribution of gasoline used in the off-highway operation of vehicles on public land for recreation. A third objective is to document the geographic destinations of the vehicle operators and their associated recreational activities once they get there.

The data used to estimate recreational fuel use was gathered through two surveys of California households. The first was a random-digit dial telephone survey of California households of the vehicles they owned and the types of off-highway recreation they participated in during the prior year. Further details of this survey can be found in Section 4. The second survey encompassed fuel use log books in which participants recorded fuel use, recreational activity and the recreational area in which they recreated off-highway on public lands using their vehicle. Further details on this survey can be found in Section 5. The results of both surveys

[4] California Revenue and Taxation Code sections 8101(a), 8352.6, 8352.7, and 8352.8.

[5] A non-registered OHV is defined as a vehicle required to be registered as an off-highway vehicle pursuant to Section 38010 of the California Vehicle Code, but which is not so registered. Note that there are numerous exemptions to the registration requirement (e.g. implements of husbandry (Vehicle Code Section 38010(b)(2)).

are discussed in Section 6. Lessons learned and recommendations are discussed in Section 7. The new Fuel Tax Transfer Model will be documented under a separate cover.

2.1. Definitions and Background Information

The following definitions will be used throughout this document:

Off-Road: The general public and many publications often use the term "off-road" to describe motorized recreational activities occurring off paved highways. For this project, off-road and off-highway are used interchangeably.

Off-Highway Recreation: California Vehicle Code (CVC) §38001 defines off-highway recreation, summarized as follows: Off-highway recreation applies to any motor vehicle being operated on lands, roads, or trails that are open and accessible to the general public and may include fire trails, logging roads, service roads (regardless of their surface composition), or other roughly graded roads and trails upon which vehicular travel by the public is permitted. Street-licensed vehicles that are being driven off-highway for recreational driving and/or to access 'end' recreational activities such as hunting, camping, fishing, hiking, boating, and mountain biking can use these same 'surfaces'. This project is not concerned with the off-highway use of vehicles not involving recreation.

Off-Highway vs. On-Highway: There is potential for confusion in the public's mind regarding the definition of a "highway" (or what is "on-highway" vs. "off-highway"). Since the term highway can denote specific roads in California (e.g. "Highway 395"), taken literally, some people may not consider a city street or a freeway as a highway. Many county roads are not paved yet they are legal highways. Several US Forest Service roads are paved yet they are not legal highways. Recognizing this potential for confusion, for the purposes of this project, off-highway routes are unpaved, gravel or dirt roads, trails, and open areas without roads or trails, or on snow covered areas. Off-highway starts where the pavement ends. All snowmobile use is considered off-highway for this study.

The Off-Highway Vehicle Trust Fund: The OHVTF is administered by the Off-Highway Motor Vehicle Recreation (OHMVR) Division of the Department of Parks and Recreation (DPR) and is devoted to used for the acquisition, development, and maintenance of off-highway recreation facilities and opportunities as well as the protection of natural and cultural resources associated with off-highway recreation. Fuel taxes currently represent the primary source of

income to the OHVTF. Fuel taxes represented approximately 84% of OHVTF income in Fiscal Year 2004/2005.

Data Estimates: Since data regarding monthly off-highway recreation usage patterns and the number of non-registered OHVs is not readily available, it has been necessary for the State to estimate those numbers through independent sources. The most recent source has been a 1990 Study entitled "A Study to Determine the Fuel Tax Attributable to Off-Highway and Street Licensed Vehicles Used for Recreation Off-Highway" (hereafter referenced as "1990 Study"). The 1990 Study included a telephone survey to determine the incidence of vehicle ownership statewide and a panel survey of vehicle owners who were recruited to record actual gasoline usage as it occurred.[6]. The 1990 Study and existing fuel tax transfer model are discussed in Section 3.

Non-Registered OHVs: State law requires OHVs used on public lands to be either street licensed or registered with DMV. Based upon the existing Fuel Tax Transfer Model, in October 2004, 64% of fuel tax income to the OHVTF was generated from non-registered OHVs (see Section 3). Significant efforts were made in the late1990s to enforce registration at State Vehicular Recreation Areas (SVRAs). Non-registered OHVs include all vehicles that can be used for recreational driving and have either never been registered or their registration has lapsed.[7]

Gasoline Sales and Use: For the purposes of this project, all gasoline purchases must occur in California, by residents of California, and the gasoline usage must occur on public land in California. While State law does not actually specify that off-highway recreation gasoline usage must occur in California, it does not permit the transfer of gasoline tax revenues derived from out-of-state visitors purchasing gasoline in California.

DMV Registration Data: Since the existing Fuel Tax Transfer Model utilizes monthly Department of Motor Vehicle (DMV) registration data, the following status of DMV's data shall be noted:

- OHVs may be: 1) registered with a Green Sticker or a Red Sticker, 2) issued a transportation on highway permit only, 3) issued title only, 4) currently registered in

[6] Since the time of the 1990 Study, California's population increased 14%, off-highway vehicle registrations increased 60%, and street-licensed four-wheel drive vehicle registrations increased 1,342%.

[7] For purposes of this study, vehicles with a non-operational permit are considered registered.

another state, 5) registered in California to a person from another state, or 6) legally non-registered if they are being used exclusively on private property, for farming, etc.

- DMV decoding software for street-licensed vehicles used to determine drive train has not been updated since 1990. DMV uses this software to determine the number of registered four-wheel drive (4WD) street-licensed vehicles. DMV reported 649,985 4WDs in 2004 whereas ICF International's subcontractor Robert Cenzer Consulting conservatively identified 3,205,250 registered 4WDs for 2004.

- OHV classifications recorded in DMV's database are somewhat suspect since the OHV classifications reported are subject to the interpretation of the licensing agent (dealer), the vehicle's owner, or the DMV Technician involved with the transaction. DMV reported 656,816 off-highway motorcycles and 57,448 off-highway ATVs, whereas the ICF International found 338,169 off-highway motorcycles and 335,897 off-highway ATVs in 2004. The Motorcycle Industry Council estimated that there were 330,600 off-highway motorcycles in 2003 and that ATV sales during the last 10 years would confirm an equal number of ATVs for that year.[8]

- Non-renewal data is available to a limited extent for OHVs that were registered, but failed to renew their registration. After 5 years this data is usually purged from the database.

"Red Stickers" (Seasonal Restrictions for Some OHVs): In December, 1998, the California Air Resources Board (CARB) implemented new regulations restricting the use of wheeled OHVs (specifically ATVs and dirt bikes) that did not meet CARB's new OHV exhaust emission standards. OHVs that were not in compliance were to be issued a Red Sticker (instead of a Green Sticker) and their use restricted to specific days of the year and specific areas of the State depending on the overall CARB air quality attainment for that geographic area. There is no seasonal or regional restriction if an OHV is being operated in a sanctioned competition event. The delay between the 1998 regulation implementation and the 2003 program implementation was due to computer re-programming issues at DMV and the resulting misidentifying of compliant and non-compliant OHVs. DMV began issuing Red Stickers in 2003 to OHVs built in 2003 and later and more OHV law enforcement agencies began enforcing the

[8] Conversation with Tom Yager of the Motorcycle Industry Council, December 5, 2004.

regulation. Those OHVs built before 2003 were grandfathered into the Green Sticker program regardless of emissions. Therefore, the reduced use of vehicles with Red Stickers could not be studied during this project.

Closed Course Competition Events: Most closed course competition occurs on private land, although there are a modest number of closed courses on public lands (e.g. Hollister Hills SVRA and Porterville OHV Park). Although not "legally" required, promoters of closed course events on public lands may require the competition vehicles to have a valid/current DMV registration plate/sticker. Many competition events are conducted on public lands but they are not always considered a closed course as defined in CVC Section 38014[9]. The OHVTF is not entitled to gasoline tax revenue from vehicles that are legally not required to be registered.

Motor Vehicle Fuel: "Motor vehicle fuel" as defined in the California Revenue and Taxation Code Section 7326 means gasoline and aviation gasoline. It does not include jet fuel, diesel fuel, kerosene, liquefied petroleum gas, natural gas in liquid or gaseous form, alcohol, or racing fuel.

[9] CVC 38014: As used in this division, "closed course" includes, but is not limited to, a speedway, racetrack, or a prescribed and defined route of travel on or off a highway that is closed to all motor vehicles other than those of participants. A closed course is one which is not available at any time for vehicular access by the general public.

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3. 1990 Survey and Existing Fuel Tax Transfer Model

The existing Fuel Tax Transfer Model, which calculates the amount of fuel tax funds from the Motor Vehicle Fuel Account (MVFA) that should be transferred on a monthly basis to the Off-Highway Vehicle Fund (OHVF), is derived from two surveys carried out by Tyler and Associates in the 1989 to 1990 timeframe.[10] The first survey was a random probability telephone survey of 12,156 California telephone-owning households. The second was a survey of approximately 2,800 vehicle owners on their fuel usage when recreating off-highway in California. The details of these two surveys and their results are described in the following subsections as well as details on the Existing Fuel Tax Transfer Model.

3.1. Statewide Probability Sample Study

Tyler and Associates used Bartels Research to interview 12,156 California telephone-owning households during February through May 1989. Bartels used a telephone number sample produced by Survey Sampling Inc. It included both households with listed numbers and those with unlisted numbers in the proper proportions. Interviews were conducted in 53 of 58 California counties in proportion to each county's contribution to the State's total population. Five counties (Alpine, Mono, Modoc, Sierra, and Trinity) were not interviewed because they represented no more than one-tenth of one-percent of the State's total population. However, as shown in Table 3-1, those five counties represent some of the highest OHV counts per household in the State and could have higher off-highway use than counties with lower OHV counts per household.

The interview questionnaire included information on the vehicles owned by the household and whether they participated in off-road recreational driving in California. This information was used to provide data that could be projected to the entire California population on:

- The proportion of vehicles used for off-highway recreational driving
- The proportion of various types of vehicles owned and used for recreation
- The ratio between registered and non-registered off-highway vehicles required to be registered, both overall and by vehicle type

[10] Tyler and Associates, "A Study to Determine Fuel Tax Attributable to Off-Highway and Street Licensed Vehicles Used for Recreation Off-Highway," November 1990.

Table 3-1. Non-Street Licensed Off Highway Vehicles per Household

County	Households[a]	OHVs[b]	OHVs/HH[c]
Alameda	530,115	13,837	0.026
Alpine	**495**	**187**	**0.378**
Amador	13,154	2,564	0.195
Butte	81,379	9,283	0.114
Calaveras	17,163	2,981	0.174
Colusa	6,169	1,349	0.219
Contra Costa	351,134	16,207	0.046
Del Norte	9,265	599	0.065
El Dorado	61,104	10,695	0.175
Fresno	258,332	15,215	0.059
Glenn	9,275	2,111	0.228
Humboldt	51,844	6,014	0.116
Imperial	40,496	6,065	0.150
Inyo	7,751	1,416	0.183
Kern	214,263	21,004	0.098
Kings	35,178	3,610	0.103
Lake	24,145	2,977	0.123
Lassen	9,775	2,385	0.244
Los Angeles	3,155,195	102,920	0.033
Madera	37,245	4,171	0.112
Marin	101,467	2,336	0.023
Mariposa	6,776	1,082	0.160
Mendocino	33,720	4,770	0.141
Merced	65,974	5,651	0.086
Modoc	**3,813**	**641**	**0.168**
Mono	**5,308**	**1,686**	**0.318**
Monterey	123,932	7,172	0.058
Napa	46,512	3,781	0.081
Nevada	38,022	6,360	0.167
Orange	951,827	52,476	0.055
Placer	102,236	14,312	0.140
Plumas	9,208	3,055	0.332
Riverside	531,450	61,271	0.115
Sacramento	468,674	21,144	0.045
San Benito	16,626	3,039	0.183
San Bernardino	539,046	58,237	0.108
San Diego	1,015,541	76,394	0.075
San Francisco	337,530	1,339	0.004
San Joaquin	189,512	13,750	0.073
San Luis Obispo	95,608	9,408	0.098
San Mateo	256,480	7,095	0.028
Santa Barbara	138,406	7,174	0.052
Santa Clara	576,594	19,547	0.034
Santa Cruz	91,965	6,014	0.065
Shasta	64,930	10,955	0.169
Sierra	**1,532**	**424**	**0.277**
Siskiyou	18,765	2,377	0.127
Solano	134,082	8,070	0.060
Sonoma	175,921	12,286	0.070
Stanislaus	150,649	13,811	0.092
Sutter	27,667	3,739	0.135
Tehama	21,384	3,528	0.165
Trinity	**5,633**	**955**	**0.170**
Tulare	113,003	11,166	0.099
Tuolumne	21,318	2,959	0.139
Ventura	251,090	21,876	0.087
Yolo	61,880	3,764	0.061
Yuba	20,768	2,663	0.128
Total	11,728,326	711,897	0.061

[a] Number of households, Dept of Finance, 2000 Census

[b] Non-street licensed registered off-highway vehicles -- Dept of Motor Vehicles, October 2004.

[c] Calculated OHVs per household

[d] **Bolded** counties were not included in the 1990 Statewide Probability Sample Study.

Of the 12,156 households interviewed, 10,650 households were identified as owning vehicles in California and were interviewed in-depth concerning all the vehicles owned by the household and about those that were used for off-highway recreational driving purposes. Tables 3-2 and 3-3 show the results of the study. Table 3-4 shows off-highway recreational use by vehicle type.

Table 3-2. Statewide Probability Sample Off-Highway Driving Results

	Households	Percent
Completed Household Interview	12,156	100.0%
Households that do not own street licensed vehicle	1,506	12.4%
Households that own street licensed or non-street licensed vehicles	10,650	87.6%
Households that did not drive any vehicles off-highway	8.866	72.9%
Households that drove vehicles off-highway	1,784	14.7%
Households that drove off-highway for recreation in California	1,726	14.2%
Drove on public land only	1,082	8.9%
Drove on private land only	103	0.8%
Drove on both public and private lands	541	4.5%

Note: Questions relating to driving off-highway related to the prior year. All households surveyed that had a non-street licensed vehicles had a least one street-licensed vehicle.

Table 3-3. Statewide Probability Sample Vehicle Ownership Results

	Households	Percent
Households that own a street-licensed vehicle	10,650	87.6%
Households that own a non-street licensed vehicle	690	5.7%

Note: The percentages relate to the total 12,156 households surveyed.

Table 3-4. Statewide Probability Sample Results by Vehicle Type

Vehicle Type	Households[a]	Vehicles[b]	Used Off-Highway[c]	Percent[d]
Street Licensed Vehicles				
4WD Pickups, SUVs, Vans	1,877	2,185	789	36.11%
2WD Pickups, SUVs, Vans[e]	2,913	3,401	473	13.91%
Motorcycles	757	952	211	22.16%
Cars	9,649	15,514	439	2.83%
Other	247	255	50	19.61%
Non-Street Licensed Vehicles				
Motorcycles	434	678	510	75.2%
4 Wheel Vehicles[f]	109	131	85	64.9%
ATVs	220	361	182	50.4%
Snowmobiles	13	17	12	70.6%
Other	19	22	16	72.7%

[a] Number of households surveyed that owned by vehicle type
[b] Total number of vehicles owned by vehicle type
[c] Number of vehicles used off-highway on public lands in California in the past 12 months
[d] Percent of vehicles used off-highway on public lands in California in the past 12 months
[e] Includes street-licensed dune buggies and Baja bugs
[f] Includes dune buggies and other 4 wheeled vehicles

In addition to determining the percentage of vehicles engaging in off-highway recreation during the prior year, the Tyler Statewide Probability Sample was also used to determine the ratios of non-registered to registered OHVs. This would then be used to determine the amount of non-registered OHVs in California from the registered populations determined from the DMV data. For every vehicle identified as non-street licensed in the probability sample, Tyler attempted to verify whether or not it was registered by checking the owner's name and address against the total listed registered vehicles as provided by DMV in their off-highway vehicle registration database. The results of that identification process are shown in Table 3-5.

Table 3-5. Non-Registered to Registered Ratios

Vehicle Type	Total Vehicles	Green Sticker		Unable to Determine[a]	Correction Factor (Unregistered/ Registered)
		Registered	Non-Registered		
Motorcycles	678	76	445	157	5.9
4 Wheel Vehicles	131	11	84	36	7.6
ATVs	361	71	180	110	2.5
Snowmobiles	17	1	7	9	7.0
Other	22	0	19	3	19.0[b]

[a] Some respondents did not provide adequate name and address information to verify whether the vehicle was registered or not. These vehicles were excluded from the correction factor calculation

[b] Tyler was unable to determine this factor due to lack of data so they provided what they considered a conservative value.

Tyler goes on to say that the above correction factors are not to be viewed as permanent or static, but that they have verified that there are substantial numbers of non-registered OHVs throughout California. This finding led to increased enforcement at State Vehicular Recreation Areas (SVRAs), county parks, as well as US Forest Service and Bureau of Land Management lands in order to capture non-registered vehicles operating on public areas where registration is required.

3.2. The Fuel Usage Study

Tyler surveyed approximately 2,800 households on their fuel use when operating their vehicle off-highway for recreation within California. The same households were tracked over the full course of a year in 1989. A total of 8,343 fuel use interviews were completed within the 10 vehicle categories studied during the course of four quarterly waves. Tyler used a randomly selected list of approximately 16,000 names and address from DMV for the 10 vehicle categories. In addition, all the known off-highway recreational drivers from the probability sample who had provided adequate information to allow contacting them were added to the five categories of street licensed drivers according to a proportional random selection procedure.

That procedure assigned owners of specific types of vehicles to a category in the proportion determined from the prior 12 months off-highway use. Telephone numbers for all vehicle owners were then determined and they were contacted by telephone to recruit them for participation in the fuel usage panels. Vehicles owned by businesses and other non-private use entities were excluded from the study. The initial set of participants were first contacted in April 1989 and asked about their previous three months off-highway recreational fuel usage and that they would be contacted every three months concerning their off-highway recreational fuel usage during the prior three months. The same panel of drivers was then also interviewed in July and November of 1989 and January 1990 regarding their previous three months' off-highway recreational fuel usage. At the conclusion of waves 1, 2, and 3, each respondent was sent a reminder postcard that both alerted him/her that they would be contacted three months later and a fuel log form for them to record their off-highway fuel consumption in the interim. At the conclusion of wave 3, State Parks sent each respondent its newly published "Guide to Off-Highway Vehicle Areas of California", which had been initially promised to participants during recruitment as an incentive to participate. Participation in the fuel usage panel is shown in Table 3-6.

Table 3-6. Fuel Usage Panel – Completed Interviews

Vehicle Type	Wave 1	Wave 2	Wave 3	Wave 4	Total
Street Licensed Vehicles					
4WD Pickups, SUVs, Vans	272	210	170	145	797
2WD Pickups, SUVs, Vans	275	213	175	144	807
Motorcycles	243	207	153	121	724
Cars	248	205	165	122	740
Other	246	204	175	145	770
Total	1,248	1,039	838	677	3,838
Non-Street Licensed Vehicles					
Motorcycles	290	212	170	140	812
4 Wheel Vehicles	317	249	220	182	968
ATVs	300	220	187	157	864
Snowmobiles	356	265	236	204	1,061
Other	279	207	167	147	800
Total	1,542	1,153	980	830	4,505
All Vehicles					
Grand Total	2,826	2,192	1,818	1,507	8,343

As stated above, the 1990 Study included street licensed vehicles found in the statewide probability sample that drove off-highway in the prior year. It then corrected the fuel use reported by this group by the percent of off-highway use reported for the prior year which might

or might not reflect fuel use for the current year. In addition, he used the same people for all 4 waves. Significant fall-out of participants occurred during the waves as shown in Table 3.6. Furthermore, the 1990 Study assumed the same fuel use for non-registered OHVs as for registered OHVs. Fuel use rates are shown in Tables 3-7 and 3-8.

Table 3-7. Average Monthly Fuel Usage for Street Licensed Vehicles (Gallons per Month)

Month	4WD	2WD	MCs	Cars	Other
January	3.102	0.775	0.687	0.039	0.262
February	2.876	0.661	0.651	0.051	0.754
March	3.107	0.804	0.884	0.043	0.245
April	1.287	0.304	0.261	0.035	0.384
May	1.085	0.345	0.307	0.029	0.384
June	1.452	0.573	0.344	0.025	0.384
July	1.898	0.183	0.971	0.017	1.110
August	2.121	0.275	0.790	0.014	1.110
September	2.316	0.170	0.869	0.008	1.110
October	1.228	0.473	0.309	0.111	1.311
November	1.568	0.357	0.338	0.034	0.718
December	1.661	0.472	0.268	0.043	0.764
Annual Total	23.701	5.392	6.679	0.449	8.536

4WD = 4 wheel drive pick-ups, SUVs and Vans
2WD = 2 wheel drive pick-ups, SUVs and Vans
MC = On-highway motorcycles

Table 3-8. Average Monthly Fuel Usage for Non-Street Licensed Vehicles (Gallons per Month)

Month	MCs	4WVs	ATVs	Snow	Other
January	4.950	8.514	3.679	12.369	7.309
February	4.575	6.991	3.232	11.244	6.034
March	5.041	7.145	3.462	7.626	5.979
April	4.169	3.830	1.614	0.472	2.788
May	4.137	2.835	1.569	0.138	3.137
June	3.301	2.660	1.867	0.047	2.637
July	2.457	2.163	1.840	0.000	1.988
August	2.406	2.192	1.587	0.000	2.539
September	3.283	2.766	1.447	0.000	2.133
October	2.439	3.779	2.536	0.099	3.264
November	4.080	8.095	2.676	0.300	4.646
December	3.522	5.259	2.787	2.654	4.614
Annual Total	44.360	56.229	28.296	34.949	47.068

MC = off-highway motorcycles
4WV = Dune buggies and other 4 wheeled vehicles
Snow = Snowmobiles

3.3. Existing Tax Transfer Model

Using the data collected during the Tyler Fuel Usage Study, the non-registered to registered correction factors determined during the Tyler Statewide Probability Study and DMV estimated counts of street licensed and non-street licensed vehicles by vehicle type, the existing tax model predicts an annual revenue of $56.88 million using DMV estimated vehicle counts for the 2004/2005 fiscal year[11] and a tax rate of $0.18 per gallon. Table 3−9 shows the breakdown of revenue by street licensed vehicles (SLVs), registered non-street licensed vehicles (OHV Reg) and non-registered non-street licensed vehicles (OHV Non-Reg). As is evident from that table, 64 percent of the income comes from non-registered non-street licensed vehicles.

Table 3-9. Existing Tax Transfer Model Income Projection for 2004/2005

Vehicle Type	Vehicles[a] (Millions)	Gallons (Millions)	Tax Revenue (Millions)	Percent of Revenue
SLVs	25.75	79.74	$14.35	25%
OHV Reg	0.79	34.44	$6.20	11%
OHV Non-Reg	4.53	201,81	$36.33	64%
Total	31.06	315.99	$56.88	100%

[a] Average vehicle counts over the 2004/2005 fiscal year.

Based upon the vehicle counts above, for every one registered OHV, the model predicts there are 5.86 non-registered OHVs. This is a significant source of revenue under the Existing Fuel Tax Transfer Model. Further details of the model inputs and tax revenues for selected classes of vehicles are shown in Table 3-10.

Table 3-10. Selected Details of the Existing Tax Transfer Model Income Projections for 2004/2005

Vehicle Type	Vehicles[a] (Thousands)	Gallons (Millions)	Tax Revenue (Millions)	Percent of Revenue
2WD SLVs	9,291	50.33	$9.06	15.9%
4WD SLVs	647	15.41	$2.77	4.9%
OH Motorcycles (Reg)	686	30.80	$5.54	9.7%
OH Motorcycles (Non-Reg)	4,047	181.71	$32.71	57.5%
ATVs (Reg)	59	1.69	$0.30	0.5%
ATVs (Non_Reg)	148	4.21	$0.76	1.3%

[a] Average vehicle counts over the 2004/2005 fiscal year.

As can be seen from the table above, over 57% of the tax revenue comes from non-registered off-highway (OH) motorcycles. This is driven by the high non-registered to registered ratio (5.9) and the fact that existing tax transfer model assumes the same fuel rate for non-

[11] California State Parks fiscal year is July 1st to June 30th. The Existing Fuel Tax Transfer Model uses data three months prior so that the fuel use data is from April through March.

registered motorcycles as for registered ones. This is further compounded by DMV misclassifying most ATVs as motorcycles and the fact that the model does not adjust for non-registered vehicles becoming registered.

3.4. DMV Data Inconsistencies

As part of the current ICF International Study, the data obtained from Department of Motor Vehicles (DMV) was reviewed. Robert Cenzer Consulting analyzed the DMV registration files using SAS on DMV's Teale Data Center mainframe and SAS, Excel and others on a personal computer. Robert Cenzer has worked with the California Energy Commission for almost 15 years developing guide files to assign vehicles to vehicle classes by make, model and vintage. He has created original analysis and routines to identify operational status, commercial versus personal ownership, fleet ownership, and four-wheel drive vehicles. He has done significant research on vehicle identification numbers (VINs) to determine vehicle types.

In the mid 1990s, DMV purchased VINA software for street licensed vehicles from R.L. Polk. This software decoded the first 8 characters of a vehicle's VIN to tell the make, series, model and body style of each vehicle type for 1981 and newer vehicles when the VIN codes were standardized. Prior to 1981, VIN codes were not consistent and needed specialized interpretation. Cenzer developed additional VIN decoding software to determine the vehicles that VINA couldn't decode. Since VINA does not provide information on drive train, Cenzer also developed VIN decoding software to determine whether a vehicle was two wheel drive (2WD) or four wheel drive (4WD).[12] Each year as new models are produced, new VIN decoder codes need to be written. The existing tax transfer model uses 4WD estimates based upon software developed in 1990. This software is limited to those vehicle makes and models in existence in 1990 and does not count any 4WD or AWD makes and models produced after 1990. Therefore the 4WD counts used in the Existing Tax Transfer Model are too low.

OHV classifications reported by DMV are subject to the interpretation of the licensing agent (dealer), the vehicle's owner, or the DMV Technician involved with the transaction. Therefore, the data in the DMV file has a significant amount of errors. In 2003, DMV purchased the motorcycle VINA package from R.L. Polk which provided make, model and body style information. This was then used to develop more accurate vehicle counts. It took two years of work between Cenzer and DMV to get the software to work correctly, which significantly slowed

[12] All wheel drive (AWD) vehicles are included in the 4WD counts.

progress of this project. When the software used by the existing tax transfer model was written in 1990 to discern ATVs from motorcycles, it determined that the category "All Terrain" meant motorcycles and not ATVs. ATVs were classified as 3 Wheel or 4 Wheel. In subsequent years, ATVs were listed as "All Terrain" and therefore counted by the DMV model as motorcycles instead of ATVs.

Table 3-11 shows the Existing Tax Transfer Model inputs supplied from DMV for October 1989 when the model was written and for October 2004. For a comparison, actual vehicle counts for October 2004 as determined by Cenzer are also shown.

Table 3-11. Existing Fuel Tax Transfer Model Vehicle Counts versus Actual Counts

Vehicle Type	Model Inputs		Actual
	Oct 1989	Oct 2004	Oct 2004
Cars	14,603,184	14,887,946	14,221,617
2WD SLVs	4,278,144	9,320,229	7,817,512
4WD SLVs	194,403	649,985	3,205,250
SL MC	560,839	537,329	559,377
SL Other	552,164	442,280	277,540
OH Motorcycles	207,633	656,816	338,169
ATVs	76,636	57,448	335,897
4 Wheel Vehicles	6,974	18,478	19,329
Snowmobiles	6,263	18,894	18,502
OH Other	12,998	2,435	2,168

As can be seen from Table 3-11, there was significant growth in 4WD street licensed vehicles from 1989 to 2004. Unfortunately, the DMV model inputs did not keep up with the actual growth due to the fact that the software that was used was vastly out of date. There is also a significant difference in Street Licensed Others between the DMV 2004 model inputs and actual counts. This is because the existing DMV model used for input to the existing tax transfer model classifies vehicles from 8,501 to 10,000 lbs gross vehicle weight rating (GVWR) in the SL Other category, while Cenzer include those vehicles in the SUV, truck and van categories. Cenzer's SL Other category include vehicles from 10,001 to 14,000 lbs which are mostly RVs. DMV counts of vehicles over 14,000 lbs are not included as they are too big to be used for recreational purposes. See further discussion in Section 5.

The most dramatic effect in Table 3-11 is the split between off-highway motorcycles and ATVs. The existing DMV model used for the existing Tax Transfer Model inputs was vastly out

of date and misclassified a majority of the ATVs as motorcycles. This has a significant effect on the tax revenues generated for two reasons:

1. The ratio of non-registered to registered vehicles for motorcycles is 5.9 while the ratio for ATVs is 2.5. By misclassifying ATVs as motorcycles in the registered counts, over 1.4 million additional non-registered vehicles that really don't exist even with the Tyler conversion factors shown in Table 3-4 are calculated as existing.

2. The annual average fuel usage for off-highway motorcycles is 57% higher than the average annual fuel usage for ATVs. This further artificially increases tax revenues beyond reality.

The total effect of the two factors above would result in a drop in tax revenue transferred of approximately $14.7 million if the correct DMV counts were used as shown in Table 3-12. On the other hand, 4WD street licensed vehicles used 4.4 times as much fuel per vehicle per year than 2WD vehicles based upon the 1990 Study. By correcting the classification of post 1990 4WD vehicles, there is about a $9.4 million gain as shown in Table 3-13. Using the actual registration counts developed by Cenzer plus the 1990 Study non-registered to registered ratios and average monthly fuel rates by vehicle type, projected fuel use should be approximately 29 million gallons of gasoline less for the 2004/2005 fiscal year or $5.3 million.

Table 3-12. Effect of Incorrect ATV Classifications

Vehicle Type	Vehicle Counts			Annual Gallons	Annual Tax Revenue
	Reg	Non-Reg	Total		
Existing Tax Transfer Model Inputs[a]					
Off-Highway Motorcycles	685,980	4,047,280	4,733,259	212,508,377	$38,251,508
ATVs	59,108	147,769	206,877	5,899,308	$1,061,875
Total	745,088	4,195,049	4,940,136	218,407,685	$39,313,383
Actual Registration Counts with Tyler Non-Reg to Reg Correction Factors[b]					
Off-Highway Motorcycles	338,169	1,995,197	2,333,366	103,508,120	$18,631,462
ATVs	335,897	839,743	1,175,640	33,265,895	$5,987,861
Total	674,066	2,834,940	3,509,006	136,774,015	$24,619,323
Tax Transfer Model Inputs minus Actual Registration Counts					
Difference	71,022	1,360,109	1,431,130	81,633,670	$14,694,060

[a] Average Existing Tax Transfer Inputs for 2004/2005 fiscal year.

[b] Based upon fixed vehicle counts as of October 2004.

Table 3-13. Effect of Incorrect 2WD vs. 4WD Classifications

Vehicle Type	Vehicle Counts	Annual Gallons	Annual Tax Revenue
Existing Tax Transfer Model Inputs[a]			
2WD Street Licensed	9,290,597	50,334,065	$9,060,132
4WD Street Licensed	646,753	15,407,412	$2,773,334
Total	9,937,350	65,741,477	$11,833,466
Actual Registration Counts[b]			
2WD Street Licensed	7,817,512	42,152,025	$7,587,364
4WD Street Licensed	3,205,250	75,967,630	$13,674,173
Total	11,022,762	118,119,655	$21,261,538
Actual Registration Counts minus Tax Transfer Model Inputs			
Difference	1,085,412	52,378,178	$9,428,072

[a] Average Existing Tax Transfer Inputs for 2004/2005 fiscal year.

[b] Based upon fixed vehicle counts as of October 2004.

The above analysis assumes there was no change in the ratio of non-registered to registered vehicles and that the fuel use rate of various vehicle types is the same as it was in 1990. There are several reasons why this is not true. The largest effect is that the ratio of non-registered to registered vehicles has most likely changed from 1989 to 2004. Significant enforcement at SVRAs and other public areas have forced more off-road recreational drivers to register their vehicles. Enforcement at staging areas and other areas within forests, parks and other public lands also has reduced the amount of non-registered OHV use on public lands. The largest change, however, is that now dealers who sell off-highway motorcycles, ATVs and snowmobiles offer at a nominal fee to register the vehicle with the State. As will be seen in Section 6, a reduction in these ratios can have a dramatic effect on tax revenues.

The next largest factor is that the above analysis assumes non-registered vehicles recreate at the same rate as registered vehicles. With enforcement at SVRAs and other areas, this is not the case. As will be seen in Section 6, this project estimates that non-registered OHVs recreate off-highway significantly less than registered OHVs.

The last factor is that 4WD street licensed vehicles have a significantly different use than they did in 1990. In 1990, only limited models of vehicles were 4WD and those were mostly used when it was needed to traverse rugged landscape. This population was much more likely to recreate with these vehicles off highway than the current SUV population that drives their kids to school and uses the vehicle as a commuter car. As will be seen in Section 6, the use of 4WD street licensed vehicles for off-highway recreation has decreased from 1990. Further discussion

of this reduction can be found in Sections 4, 5 and 6. As will be seen in Section 6, the above effects result in reduced fuel use for recreation that previously calculated using the Existing Tax Transfer Model.

4. Telephone Survey of California Households

Component #1 of the ICF International Study consisted of a statewide survey of California households to determine vehicle ownership, patterns of off-highway recreation, as well as the recreational preferences of vehicle owners and operators who drive off-highway in the State.

More specifically, the principle research objectives of the Component #1 survey were to:

1. Estimate how many vehicles are being used for off-highway recreation in California, distinguishing between "driving to recreate"[13] and "for the purpose of recreation".[14]

2. Estimate what types of vehicles are being used for off-highway recreation in California, distinguishing between "driving to recreate" and "for the purpose of recreation".

3. Estimate the percentage of households in California that have used at least one vehicle in the past year for off-highway recreation.

4. Establish the relationship between DMV data and the true characteristics of the fleet of vehicle types being used for off-highway recreation. This consisted of estimating in a statistically reliable manner the actual population of a) street licensed four-wheel drive vehicles and b) non-registered off-highway vehicles (OHVs)[15] in California.

5. Determine the kinds of recreational pursuits (activities) and the recreational destinations (geographically) of vehicle operators who use their vehicles off-highway on public lands in California to gain access to recreation and for the purpose of recreation.

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[13] "Driving to recreate" refers to off-highway driving that occurs because the driver wanted to access other types of recreation activities or areas. For example, some people will drive off-highway to access a lake where they engage in recreation activities, such as fishing, waterskiing, swimming, etc. In this case, the driving they do off-highway is not considered a form of recreation by itself -- it is simply a means to access other recreation areas or activities.

[14] In contrast, driving "for the purpose of recreation" refers to situations where the off-highway driving is the primary recreation activity rather than a means of accessing other activities. People who ride ATV's off-highway, for example, generally do so because they enjoy the experience of driving a vehicle in off-highway conditions.

[15] Non-registered vehicles are vehicles that are not currently registered with the Department of Motor Vehicles (DMV).

Additionally, the Component #1 survey was used to establish a pool of potential candidates that would later be recruited to participate in the fuel use log book portion of the study (Component #2).

4.1. Methodology Overview

Component #1 consisted of a Statewide survey of 15,691 California households selected using a stratified random digit dial (RDD) probability sample, with strategic over-sampling for OHV-owning households and geographic areas with above-average OHV registration status. Recruitment and interviewing was conducted by telephone between July 28 and December 10, 2003. The interviews -- which were conducted in English, Spanish, Cantonese, Mandarin, Tagalog and Vietnamese -- averaged 14.2 minutes. The following sections provide additional details about the methodologies used in the Component #1 survey, as well as the motivation for using certain techniques.

4.2. Sampling Method

Households were selected for inclusion in the Component #1 survey using a random digit dialing (RDD) method. The Statewide RDD sample was drawn by first selecting all of the active phone exchanges (first three digits in a seven digit phone number) and working blocks (the first two digits of the last four digits) that service the area of interest (California).[16] The exchanges were then stratified by County, with separate subsamples drawn from within each of the 58 county strata. Within strata, sample units were allocated to each eligible exchange in proportion to their density of known listed telephone households in the area of interest.[17] From a random start between zero and the sampling interval, working blocks were then systematically selected in proportion to their density of listed households. Once a block had been selected, a two digit number was systematically selected in the range of 00-99 to form the complete 10 digit number.[18]

[16] For example, in the telephone number 255-4200, '255' is the exchange and '42' is the block. A block is termed to be a *working* block if one or more listed telephone numbers are found in the block.

[17] A listed household is a household with a telephone number that is publicly available in a directory. Survey Sampling International (SSI) regularly obtains updated databases of directory-listed households from Telcordia and additional sources. The information is then subjected to an extensive cleaning and validation process to ensure that all exchanges are currently valid, assigned to the correct area code, and fall within the appropriate set of ZIP codes. The number of listed households is used for sample allocation, although both listed and unlisted households are eligible and included in the sample.

[18] The approach described in this paragraph is consistent with SSI's Random A selection methodology.

The RDD method ensures that listed and unlisted numbers, as well as new residents and new developments, have an opportunity to participate in the study. It is important to note, however, that RDD sampling methods have a number of known limitations and biases which, if not corrected for, will result in a sample that is not representative of California households.

4.3. RDD Limitations & Adjustments

For a sample to be representative of California households, each occupied household must have a known probability of being selected. Perhaps the most important thing to recognize about RDD samples generated using the methods described above is that they are a probability sample of *phone numbers* -- not households or people. Thus, although each phone number may have an equal (or known) probability of being selected, this does not mean each household has an equal (or known) probability of being selected for several reasons, the most important being that households vary in the number of phone numbers they have. According to the 2000 Census, less than 1.5% of households in California are without phone service, but phone service is more common among certain groups. For example, less than one percent (0.54%) of owner occupied households is without phone service, whereas close to three percent (2.68%) of renter occupied households in California are without phone service.[19] The disparities are even starker when one adds a direct measure of income to the analysis. Whereas less than one half of one percent (0.43%) of owner occupied households with family incomes above the poverty level are without telephone service in California, the corresponding figure for renter occupied households with family incomes at or below the poverty level is six percent (6.00%).[20] Of course, to the extent that family income is associated with other demographic traits, like ethnicity and age, the selection bias will be present on these traits as well. This represents one source of bias that is inherent in the RDD sampling method.

An even more important source of bias in an RDD sample is the fact that many households have more than one phone line. Since an RDD sample is a probability sample of phone numbers, a household's probability of being selected for an RDD sample is directly proportional to the number of phone lines it has. Thus, households with two phone numbers are twice as likely to be selected in an RDD sample when compared to their counterpart households that have just one phone number.

[19] Census 2000, Table H43, Summary File 3.
[20] Census 2000, Table HCT27, Summary File 3.

Although the 2000 Census does show that phone service is systematically related to socioeconomic factors and other demographic traits (like ethnicity) as discussed above, the Census does not provide data about how -- within households with phone service -- the number of phone lines is related to socioeconomic and demographic traits. It is certainly logical to expect, however, that socio-economic factors and other demographic traits (like ethnicity) are related to the number of phone lines in a household. Households with higher family incomes, Caucasian households, etc. can be expected to have a higher probability of being selected in an RDD sample when compared to other types of households. This important source of bias, and the need to adjust for it, has been recognized by dozens of important academic studies[21] and been acknowledged by Survey Sampling International (SSI), the nation's leading provider of RDD samples.[22]

To adjust for the known limitations and biases of the RDD sampling method, the Component #1 survey asked each household that participated in the survey to identify how many phone numbers service their household that are not dedicated to a fax or modem. This established the probability that each household had for selection into the sample (by county), and was used to identify and correct for the selection bias using standard weighting techniques, thereby creating a representative sample (for more on this topic, see Section 4.5).

4.4. Strategic Over-sampling

One of the key challenges facing this project was that OHV-owning households represent a small proportion of the total population of households in California. A similar study conducted in 1990,[23] for example, found that just 5.7% of California households owned an OHV.

[21] A quick review of the Internet, for example, yields dozens of published academic studies that identify the inherent bias in RDD sampling methods that is associated with multiple phone lines and then adjust for the bias through weighting according to the number of phone lines servicing each household. Examples include studies conducted by the National Institute of Justice, National Center for Injury Prevention and Control, and the Centers for Disease Control and Prevention (e.g., Patricia Tjaden and Nancy Thoennes, Violence and Threats of Violence Against Men and Women in the United States, 1994-1996), and David Vlahov, et al. Increased Use of Cigarettes, Alcohol, and Marijuana among Manhattan, New York, Residents After the September 11th Terrorist Attacks, Journal of Epidemiology: vol. 155, no. 11, 2002.

[22] Linda Piekarski, Gwen Kaplan and Jessica Prestegaard of Survey Sampling, Inc. presented a paper entitled "Telephony and Telephone Sampling" at the 1999 Conference of the American Association for Public Opinion Research in St. Petersburg, Florida. This paper discusses several of the challenges facing surveys that use RDD samples, and acknowledges the problems associated with multiple phone lines and the general need to adjust for this bias.

[23] Tyler and Associates, "A Study to Determine Fuel Tax Attributable to Off-Highway and Street Licensed Vehicles Used for Recreation Off-Highway," November 1990.

Assuming that this percentage had remained stable for the past decade, a proportional sample of 15,000 households[24] could be expected to yield just 855 OHV-owning households.

Given that OHV-owning households were of primary interest to this study, ICF International deviated from a strictly proportional sampling design by strategically over-sampling for OHV-owning households. Doing so ensured enough OHV-owning households in the Component #1 survey to reliably estimate the proportion of registered to non-registered OHVs in California and improved the reliability of the recreational pursuits and recreational destinations estimates. It also provided a sufficient number of non-registered OHV households to recruit for the Component #2 fuel use log book portion of the study. Moreover, strategically over-sampling -- rather than simply increasing the overall size of the proportional sample -- was the most efficient and cost-effective way of gathering a sufficient number of OHV-owning households.

The first method of over-sampling for OHV-owning households that was employed was to assign a disproportionately large number of interviews to counties that have a disproportionately high rate of OHV registrations. If one thinks of locating OHV-owning households as being akin to finding needles in a haystack, over-sampling in the manner described above effectively increases one's chances of finding OHV-owning households by separating the haystack into "needle rich" and "needle poor" piles and spending a disproportionate amount of resources hunting in the "needle rich" pile.

Table 4-1 presents the latest information regarding population and OHV registrations that was available from the California Department of Motor Vehicles and California Department of Finance at the time of developing the Component #1 sample. The second to the last column shows the number of registered OHVs per occupied household in each county. This figure varies from a high of 0.501 in Alpine County to a low of 0.004 in San Francisco County, with the county average being 0.104 OHVs per occupied household.

Based on this information, the 58 counties were divided into three mutually-exclusive strata. Strata 1 included counties where the estimated number of OHVs per household exceeded 0.10. Strata 2 included households where the estimated number of OHVs per household was greater than 0.05 but no greater than 0.10. Strata 3 included the remaining counties where the estimated number of OHVs per household was 0.05 or less. By strategically over-sampling for households within Strata 1, the survey yielded a greater number of OHV-

[24] The request for proposals (RFP) established a sample size of 15,000 for the Component #1 survey.

Table 4-1. Population & OHV Registrations by County

County	Total OHVs[a]	% of OHVs Statewide	Population[b]	Occupied Households	Population in Occupied Households	Persons Per Household	Persons Per OHV	OHVs Per Occupied Household[c]	Strata
ALPINE	248	0.00%	1,210	495	1,206	2.436	4.879	0.5010	1
PLUMAS	2,593	0.50%	21,000	9,208	20,803	2.259	8.099	0.2816	1
MONO	1,471	0.30%	13,250	5,308	12,966	2.443	9.007	0.2771	1
SIERRA	392	0.10%	3,500	1,532	3,468	2.264	8.929	0.2559	1
GLENN	1,885	0.30%	26,800	9,275	26,437	2.850	14.218	0.2032	1
LASSEN	1,933	0.30%	34,200	9,775	25,516	2.610	17.693	0.1977	1
COLUSA	1,124	0.20%	19,450	6,169	19,012	3.082	17.304	0.1822	1
SAN BENITO	2,734	0.50%	55,900	16,626	55,414	3.333	20.446	0.1644	1
INYO	1,199	0.20%	18,250	7,751	18,070	2.331	15.221	0.1547	1
AMADOR	2,010	0.40%	36,100	13,154	31,509	2.395	17.96	0.1528	1
MODOC	549	0.10%	9,350	3,813	8,945	2.346	17.031	0.1440	1
TEHAMA	2,913	0.50%	56,900	21,384	55,899	2.614	19.533	0.1362	1
SHASTA	8,723	1.50%	169,200	64,930	165,796	2.553	19.397	0.1343	1
NEVADA	5,082	0.90%	95,300	38,022	94,329	2.481	18.752	0.1337	1
EL DORADO	8,165	1.40%	163,600	61,104	162,532	2.660	20.037	0.1336	1
IMPERIAL	5,210	0.90%	150,800	40,496	140,007	3.457	28.944	0.1287	1
CALAVERAS	2,191	0.40%	41,700	17,163	41,268	2.404	19.032	0.1277	1
TRINITY	690	0.10%	13,100	5,633	12,866	2.284	18.986	0.1225	1
MENDOCINO	4,077	0.70%	87,700	33,720	85,507	2.536	21.511	0.1209	1
MARIPOSA	780	0.10%	17,250	6,776	15,807	2.333	22.115	0.1151	1
TUOLUMNE	2,209	0.40%	55,800	21,318	50,905	2.388	25.26	0.1036	2
SUTTER	2,823	0.50%	81,900	27,667	80,446	2.908	29.012	0.1020	2
PLACER	10,357	1.80%	264,900	102,236	261,946	2.562	25.577	0.1013	2
SISKIYOU	1,892	0.30%	44,450	18,765	43,705	2.329	23.494	0.1008	2
LAKE	2,327	0.40%	60,300	24,145	59,165	2.450	25.913	0.0964	2
HUMBOLDT	4,978	0.90%	127,700	51,844	123,433	2.381	25.653	0.0960	2
YUBA	1,833	0.30%	61,000	20,768	59,599	2.870	33.279	0.0883	2
BUTTE	7,109	1.20%	207,000	81,379	200,798	2.467	29.118	0.0874	2
RIVERSIDE	45,693	8.00%	1,644,300	531,450	1,608,917	3.027	35.986	0.0860	2
SAN BERNARDINO	44,860	7.80%	1,783,700	539,046	1,731,958	3.213	39.761	0.0832	2
MADERA	3,035	0.50%	129,700	37,245	122,573	3.291	42.735	0.0815	2
KINGS	2,828	0.50%	133,100	35,178	113,237	3.219	47.065	0.0804	2
TULARE	8,642	1.50%	379,200	113,003	373,185	3.302	43.879	0.0765	2
KERN	16,217	2.80%	687,600	214,263	655,881	3.061	42.4	0.0757	2
SAN LUIS OBISPO	7,027	1.20%	253,600	95,608	238,009	2.489	36.089	0.0735	2
STANISLAUS	10,821	1.90%	469,500	150,649	462,143	3.068	43.388	0.0718	2
NAPA	3,203	0.60%	128,000	46,512	122,684	2.638	39.963	0.0689	2
VENTURA	16,462	2.90%	780,100	251,090	767,044	3.055	47.388	0.0656	2
MERCED	4,272	0.70%	218,900	65,974	215,960	3.273	51.241	0.0648	2
SAN DIEGO	61,573	10.70%	2,918,300	1,015,541	2,816,386	2.773	47.396	0.0606	2
SONOMA	10,368	1.80%	471,000	175,921	459,128	2.610	45.428	0.0589	2
SAN JOAQUIN	10,836	1.90%	596,000	189,512	577,314	3.046	55.002	0.0572	2
SANTA CRUZ	5,094	0.90%	260,200	91,965	251,104	2.730	51.08	0.0554	2
DEL NORTE	508	0.10%	27,850	9,265	24,100	2.601	54.823	0.0548	2
YOLO	3,018	0.50%	176,300	61,880	168,470	2.723	58.416	0.0488	3
FRESNO	12,533	2.20%	826,600	258,332	808,338	3.129	65.954	0.0485	3
MONTEREY	5,873	1.00%	409,600	123,932	389,326	3.141	69.743	0.0474	3
ORANGE	45,009	7.90%	2,939,500	951,827	2,896,455	3.043	65.309	0.0473	3
SOLANO	6,332	1.10%	405,800	134,082	389,626	2.906	64.087	0.0472	3
SANTA BARBARA	5,751	1.00%	407,900	138,406	391,704	2.830	70.927	0.0416	3
CONTA COSTA	12,872	2.20%	981,600	351,134	970,263	2.763	76.259	0.0367	3
SACRAMENTO	15,906	2.80%	1,279,900	468,674	1,254,707	2.677	80.466	0.0339	3
SANTA CLARA	18,667	3.30%	1,719,600	576,594	1,688,896	2.929	92.12	0.0324	3
LOS ANGELES	83,543	14.60%	9,824,800	3,155,195	9,648,650	3.058	117.602	0.0265	3
SAN MATEO	6,398	1.10%	717,000	256,480	706,572	2.755	112.066	0.0249	3
ALAMEDA	11,705	2.00%	1,486,600	530,115	1,458,785	2.752	127.006	0.0221	3
MARIN	2,099	0.40%	249,900	101,467	238,794	2.353	119.057	0.0207	3
SAN FRANCISCO	1,214	0.20%	793,600	337,530	774,444	2.294	653.707	0.0036	3

[a] Source: Department of Motor Vehicles, May 2002

[b] Source: Department of Finance, January 2002 Population Estimates

[c] Calculated OHVs per household

owning households than could be anticipated using a sample that selected households in a proportional manner across counties.

Simply over-sampling within Strata 1, however, would not yield a sufficient number of OHV-owning households to ensure that the number of non-registered OHVs needed for the Component #2 Study was met. Accordingly, a second over-sampling strategy was employed whereby a portion (1,415) of the 15,691 interviews was dedicated to OHV-owning households. Using a second, mutually exclusive RDD sample,[25] interviewers screened for OHV-owning households. This involved asking respondents early in the survey if their household owns an OHV. If a household does not own an OHV, the interview was terminated at that point (i.e., screened-out), the data was recorded, and the interviewer dialed the next phone number in the sample. If a household reported that they did own an OHV, they were then administered the full questionnaire.

In combination, the over-sampling methods described above were the most time-efficient and cost-effective manner of obtaining a sufficient number of OHV-owning households in a way that the data could be projected to represent all California households. The major advantage of the screening method, in particular, was that it did not spend limited resources on conducting interviews with non-OHV-owning households above-and-beyond the number that was sufficient to estimate population proportions within the required levels of statistical accuracy. Moreover, because each screening interview captured whether the household owned an OHV prior to terminating the interview, these screen-out interviews (which totaled 12,264) could be combined with the 15,691 completed full interviews when estimating the proportion of households in California that own an OHV. With nearly 28,000 interviews for this purpose, ICF International was able to estimate the proportion of households in California that own an OHV within an extremely precise statistical margin of error at the 95 in 100 level of confidence (see Section 4.6).

Table 4-2 displays the *unweighted* number of interviews completed in the Component #1 survey according to the sampling plan described above, by county and distinguishing between OHV-owning households and those that did not own an OHV. Note that the frequencies in

[25] In other words, the sample for the screening over sample was drawn separately from the main RDD sample and was mutually exclusive so that phone numbers would not appear in both samples.

Table 4-2. Completed Interviews, Prior to Weighting and DMV Data Matching/Cleaning

County	Completed Interviews	Household Owned an OHV?	
		Yes	No
Alameda	342	26	316
Alpine	88	18	70
Amador	352	51	301
Butte	118	17	101
Calaveras	358	68	290
Colusa	394	48	346
Contra Costa	222	20	202
Del Norte	120	7	113
El Dorado	541	103	438
Fresno	170	22	148
Glenn	260	41	219
Humboldt	122	21	101
Imperial	375	79	296
Inyo	347	36	311
Kern	188	37	151
Kings	117	9	108
Lake	119	15	104
Lassen	376	67	309
Los Angeles	1,605	170	1,435
Madera	116	13	103
Marin	117	4	113
Mariposa	132	23	109
Mendocino	154	46	108
Merced	114	13	101
Modoc	246	41	205
Mono	289	40	249
Monterey	109	8	101
Napa	118	13	105
Nevada	389	74	315
Orange	604	65	539
Placer	208	99	109
Plumas	251	54	197
Riverside	559	107	452
Sacramento	304	29	275
San Benito	358	49	309
San Bernardino	415	111	304
San Diego	796	166	630
San Francisco	212	10	202
San Joaquin	214	37	177
San Luis Obispo	130	24	106
San Mateo	200	12	188
Santa Barbara	110	12	98
Santa Clara	395	34	361
Santa Cruz	122	17	105
Shasta	462	111	351
Sierra	261	51	210
Siskiyou	138	29	109
Solano	123	11	112
Sonoma	176	31	145
Stanislaus	134	29	105
Sutter	165	31	134
Tehama	355	62	293
Trinity	172	31	141
Tulare	163	22	141
Tuolumne	145	36	109
Ventura	276	43	233
Yolo	105	7	98
Yuba	140	7	133
Totals	**15,691**	**2,457**	**13,234**

Table 4-2 for OHV-owning households were subsequently adjusted slightly based on matching of the Component #1 survey data to DMV registration data (see Section 4.14).[26]

4.5. Methods for Weighting of the Statistical Analyses of Telephone Responses

4.5.1. Introduction

In this section, the formulae and statistical weights used for the statistical analyses of the telephone survey responses are presented. The telephone survey consisted of a main survey and a screening survey. For the main survey, a stratified random sample without replacement of 14,276 residential telephone numbers was selected using random digit dialing and each respondent household was asked all the survey questions. The stratification was by county, and the sampling rate differed by county, such that households in rural counties with higher OHV registration rates had a higher selection probability (to increase the numbers of OHV-owning households in the survey). For the screening survey, an independent stratified random sample without replacement of 13,679 residential telephone numbers was selected using random digit dialing. Just as for the main survey, the stratification was by county, and the sampling rate differed by county. For the screening survey, each household was asked whether or not they owned an OHV. If they answered No, then no further questions were asked and these 12,264 respondents are the “screen-outs”. In particular, note that the screen-outs were not asked about the number of land line telephone numbers for the household. If they answered Yes, then they were asked the remaining survey questions. A total of 1,415 respondents answered Yes, giving a total of 14,276 + 1,415 = 15,691 respondents that were asked all the survey questions. We shall call these 15,691 respondents the “combined” survey.

In Section 4.5.2, we present the main mathematical formulae for the estimated proportions, means, variances, and confidence intervals. The “proportions” are the fractions or percentages of California households with some characteristic, e.g., the percentage of households that own a street-licensed vehicle. The “means” are averages of numerical values, such as the mean number of street-licensed vehicles owned by a household. For each estimated proportion or mean we also calculate the variance, which measures the uncertainty of the estimate, and a 95% confidence interval, which is a range of values that will include the California proportion or mean 95% of the time.

[26] In limited cases, for example, an OHV was subsequently determined to be a street-licensed vehicle based on DMV data for the vehicle.

For all the survey questions except the one about OHV ownership, we analyzed the combined survey using what we refer to as the "Indirect method" to estimate the proportions of California households with a characteristic (e.g., own a street-licensed vehicle) or mean values (e.g., mean number of street-licensed vehicles per household). In the indirect method, the first step was to estimate the numbers of telephone lines (more precisely, land line telephone numbers) in each county for OHV-owning households and for non-OHV-owning households. To do this, we estimated the number of residential telephone lines in the county by taking the total number of households in the county (from California Department of Finance data) and multiplying by the harmonic mean number of telephone lines per household from the main survey. We estimated the county proportions of OHV-owning and non-OHV-owning households from the county's surveyed households in the main and screening survey, including the screen-outs (a total of 27,955 responses). The estimated number of telephone lines in each county for OHV-owning households is the estimated number of telephone lines in the county multiplied by the estimated proportion of OHV-owning households. The estimated number of telephone lines in each county for non-OHV-owning households is the estimated number of telephone lines in the county multiplied by the estimated proportion of non-OHV-owning households:.

Telephone lines in county =

No. of Households × Harmonic mean no. of telephone lines per household

Telephone lines for OHV-owning households in county =

Telephone lines in county × Proportion of OHV-owning households in county

In the second step of the indirect method, these estimated numbers of telephone lines were used to estimate sampling weights that re-weight the combined survey to account for the different sampling rates in different counties and the different numbers of telephone lines (since households with more telephone lines are more likely to be sampled). The raw set of 15,691 responses in the combined survey do not represent the California residential population because of a) the over-sampling of counties with greater OHV registration rates, b) the over-sampling of OHV owners from the screening sample (non-OHV-owning households were screened out), and c) the over-sampling of households with more telephone lines. In effect, the weighting scheme in the indirect method tilts the survey responses so that they represent the California population. To explain the process in simple terms, first assume every household has exactly one telephone line. Suppose there are R responding OHV-owning households in the county, totaling, for example, 1 percent of the estimated T households and T telephones for all

OHV-owning households in the county. Each of those R responses is, in effect, equal to T/R or 100 households in California. The 100 times the response of a given household when summed over all survey respondents would give results for all households in California. More generally, if a household has more than one telephone line, it is more likely to be selected. A household with t telephone lines has t times the probability of being selected, so those responses are down-weighted by dividing by t. The sampling weight for an OHV-owning household is T/(Rt), where T is the estimated number of telephone lines owned by OHV-owning households in the county, R is the number of surveyed OHV-owning households in the county, and t is the household number of telephone lines. Each response from an OHV-owning household in the county is, in effect, counted T/(Rt) times. A similar weighting applies to the non-OHV-owning households.

For the question about OHV-ownership, the "Direct method" was used to adjust the 27,955 responses of the entire main and screening surveys including the screen-outs. In this case the sampling weights only adjust for the over-sampling of counties with greater OHV registration rates and the analysis does not account for different numbers of telephones per household. We call this method the Direct method because the screen-out responses are included in the survey sample. In the Indirect method the survey sample excludes the screen-outs, but their responses are used indirectly as part of the sampling weight calculation.

Section 4.5.2 presents the formulae for estimating means and proportions and estimating their variances and confidence intervals. Section 4.5.3 presents in detail the approach used to estimate the numbers of telephone lines by county for OHV owners and non-owners, which were used to calculate the sampling weights for the Indirect method. Section 4.5.4 presents a mathematical derivation of the mean and variance formulae that were listed in Section 4.5.2. Section 4.5.5 presents the formulae for estimating ratios of means and their uncertainties, which are generalizations of the formulae for estimating means. A typical example of a ratio of means is the percentage of OHV motorcycles used for recreation, which by definition is equal to the mean number of OHV motorcycles owned and used for recreation per household divided by the mean number of OHV motorcycles owned per household (multiplied by 100%). Another important set of ratios, discussed later in Section 5.11, are the non-registered-to-registered correction factors, defined as the number of non-registered off-highway vehicles in a vehicle class divided by the number of registered off-highway vehicles in the same vehicle class. Finally, in Section 4.5.6 we discuss the treatment of missing values for the responses.

4.5.2. Main Formulae

In this section we present without proof the formulae used to calculate survey sampling weights, means, proportions, variances and confidence intervals. These formulae use the estimated numbers of telephone numbers for OHV-owning and non-OHV-owning households in each county, to be derived in Section 4.5.3. Section 4.5.4 gives details of the statistical theory justifying the formulae presented in this section.

We assume that in both the main and screening surveys, for each county a random sample of telephone numbers was selected. In the very unlikely case that the same household could have been selected twice, one was eliminated. For each county we know the total number of residential households, H(county). For a given survey question, assume we have a total of n(county, owner) responses among the OHV-owning households in that county. Assume we have a total of n(county, non-owner) responses among the non-OHV-owning households in that county. The numbers n(county, owner) and n(county, non-owner) include all responders in the main survey and all the responders in the screening survey that were OHV-owning households and so were not screened out. The analysis re-weights the responses to adjust for the over-sampling in some counties and to adjust for the numbers of telephone lines in each responding household, because households with more telephone lines are more likely to be selected. For questions relating to whether or not they own an OHV or the number of OHVs owned, the screened-out responses can also be directly incorporated into the analysis to increase the precision. However this improved precision comes at the expense of additional bias because the weighting adjustment for the different numbers of telephones cannot be applied to the screen-outs (who did not report the household number of telephone lines).

There are three types of questions. Type 1 is a quantitative question such as the number of OHVs owned. Type 2 is a question with a Yes/No answer, such as whether or not the household owns an OHV. For Type 2 questions, if we define the variable z by z = 1 if Yes and z = 0 if No, then the mean value of z is the proportion of Yes answers so that we can calculate the estimated proportion for the State, and its confidence interval, using the same formulae as for Type 1 questions. Type 3 is a categorical question with several possible answers such as the type of OHV vehicle owned (e.g., snowmobile). We can also make the individual categories in Type 3 questions quantitative by considering each possible answer as a Yes/No, so that if “Ans” is one answer then define z by z = 1 if the answer is “Ans” and z = 0 if another response is given. The mean value of z is the proportion of “Ans” responses. (Of course one cannot define

the mean answer to the Type 3 question as a whole, such as the mean type of OHV vehicle owned). Therefore in this discussion we will treat every question as a quantitative one (Type 1).

Indirect Method

We shall first present the formulae for the analyses of the main survey plus the non-screened-out responders from the screening survey. This is the combined survey with 15,691 responding households. The screen-outs are indirectly used in these calculations since their responses are used to give the estimated fractions of OHV-owning households, which are, in turn, used to calculate the sampling weights.

Let z(u, c, A) be the response for the u'th household in county c among the subgroup A, where A is either "owner" (i.e., an OHV-owning household) or "non-owner" (i.e., a non-OHV-owning household). Thus each county is subdivided into two subgroups, for owners and non-owners of OHVs. We will treat the combination of county and subgroup as a stratum for these analyses. The estimated (weighted) mean response is

$$\text{Mean response} = \hat{Z} = \sum_c \sum_A \sum_u z(u, c, A) \times w(u, c, A) \,/\, \sum_c \sum_A \sum_u w(u, c, A)$$

where each triple sum is over all sampled households (u), counties (c), and subgroups (A) and where w(u, c, A) is the sampling weight. $\sum_c$, $\sum_A$, and $\sum_u$ are sums over counties, subgroups, and households, respectively. The sampling weights were chosen so that the mean response is an approximately unbiased estimate of the mean value of z for the entire set of California households. The sampling weight is

$$w(u, c, A) = N(\text{county}, A) \,/\, \{n(\text{county}, A) \times \text{Telephones}\,(u, c, A)\}$$

where N(county, A) is the number of residential telephones in subgroup A of county c, n(county, A) is the number of sampled households in subgroup A of county c, excluding the screen-outs, and Telephones (u, c, A) is the number of telephone lines in household u, county c, subgroup A. The value of N(county, A) was not known in advance of the surveys, but was estimated from the surveys, as discussed in the Section 4.5.3.

Since the sampling weights w appear in both the numerator and denominator sums for the mean response, they can all be multiplied by a single constant without changing any of the results. It is convenient to choose the constant so that the sum of the adjusted weights over the sample equals the sample size, 15,691. In this case the weighted sum in the numerator can be regarded as the adjusted total across the surveyed households in the combined survey. The

average adjusted weight will equal 1, which would be the sampling weight for all households if a simple random sample had been used, so that every household was equally likely to be selected.

Some respondents did not answer the question about the number of telephone lines. For calculating the weights for these households, the number of telephone lines was estimated by the sample mean number of lines for the same county.

As shown in Section 4.5.4, the estimated variance of the mean response is given by the formula:

Var = Estimated Variance (Mean response)

$$= \sum_c \sum_A n(c, A) \times \{1 - f(c, A)\} / \{n(c, A) - 1\} \times \sum_u \{e(u, c, A) - \bar{e}(c, A)\}^2 + V$$

where f(c, A) is the sampling fraction:

$$f(c, A) = n(c, A) / N(c, A)$$

e(u, c, A) is an error term, with stratum mean $\bar{e}(c, A)$:

$$e(u, c, A) = w(u, c, A) \times \{z(u, c, A) - \hat{Z}\} / \sum_c \sum_A \sum_u w(u, c, A)$$

$$\bar{e}(c, A) = \sum_u e(u, c, A) / n(c, A)$$

V is a correction term to account for the uncertainty of the estimated sampling weights:

$$V = \left\{1/\left\{\sum_c \sum_A \sum_u w(u,c,A)\right\}^2\right\} \times \sum_c \text{Var}(\text{PropOHV}(c)) \times$$

$$\left\{\frac{\sum_{\text{owner}} (z(u,c,\text{owner}) - \hat{Z})\, w(u,c,\text{owner})}{\text{PropOHV}(c)} - \frac{\sum_{\text{non-owner}} (z(u,c,\text{non-owner}) - \hat{Z})\, w(u,c,\text{non-owner})}{1 - \text{PropOHV}(c)}\right\}^2,$$

where PropOHV(c) is the estimated proportion of OHV-owning households in county c.

$$\text{PropOHV}(c) = h(c) / \text{nall}(c) \text{ and}$$

$$\text{Var}(\text{PropOHV}(c)) = \{H(c) - \text{nall}(c)\}\, \text{PropOHV}(c)\, \{1 - \text{PropOHV}(c)\} / \{(\text{nall}(c) - 1)\, H(c)\}$$

where h(c) is the total number of surveyed OHV-owning households in county c including the screen-outs, nall(c) is the total number of surveyed households in county c including the screen-outs, and H(c) is the California total number of residential households in county c.

An approximate 95% confidence interval for the mean response is given by:

95% Confidence interval = $\hat{Z} \pm t \sqrt{Var}$

where t is the 97.5th percentile of a Student's t distribution with S – C degrees of freedom, S is the total number of complete responses to the given question, and C is the total number of county / subgroup strata, i.e., C is twice the number of counties. The value of t was very close to 1.96 since the sample sizes were relatively large.

Direct Method

As a special case of the Indirect method, if we put z = 1 for households owning OHV's and z = 0 for other households, then $\hat{Z}$ estimates the Statewide proportion of OHV-owning households. However, this estimate is unreliable because the unknown sampling weights are themselves estimated from the surveyed county proportions of OHV-owning households.

A simpler and better estimate of the Statewide proportion of OHV-owning households is obtained directly from the estimated county proportions:

Estimated California proportion of OHV-owning households

= PropOHV(CA) = $\sum_c H(c)\ PropOHV(c) / \sum_c H(c)$

Estimated Variance of PropOHV(CA)

= $\sum_c [H(c)]^2\ [Var\ \{PropOHV(c)\}]^2 / [\sum_c H(c)]^2$

An approximate 95% confidence interval for the mean response is given by:

95% Confidence interval = $\hat{Z} \pm t \sqrt{Var}$

where t is the 97.5th percentile of a Student's t distribution with S – C degrees of freedom, where S = 27,955 and C = 58, since there were 27,955 households in the main and screening surveys (including screen-outs) and 58 county strata for the Direct method analyses.

The improved estimate of the OHV ownership proportion does not adjust for the relatively slight biases of different numbers of telephone lines per household, but would be expected to be less biased and have a more accurate estimated variance since the sampling weights are known exactly for this Direct approach. For the telephone survey data the difference between the two estimated proportions was quite small (5.77 ± 0.33% based on the Indirect

estimate, $\hat{Z}$, and 6.01 ± 0.33% based on the Direct estimate); the variance estimates were almost identical.

The Direct method could also have been used to estimate means and proportions for other survey questions about the number of OHVs owned (overall or by vehicle type), since the answers to those questions are also known for the screen-outs. However, since both methods gave very similar results we chose to use the indirect method for all analyses except for estimating the overall proportion of OHV-owning households.

An important issue is the definition of an OHV-owning household. Households were asked Question 4 (See Component 1 Questionnaire in Appendix A), which asks whether or not they own an OHV. They were also asked for details about their OHVs and street-licensed vehicles. In the vast majority of cases these answers were consistent, but in a few cases (about 100) the respondent said Yes to Question 4 but we found out later on, usually based on the comparisons with DMV registration data, that all the so-called off-highway vehicles that they listed were not OHVs. One possible approach would have been to define an OHV-owner based on their detailed responses about the OHV vehicles, so that a responder who actually had no OHVs would be treated as a non-OHV-owner. The problems with that approach are:

- There may be a bias because not all households reporting OHVs could be found in the DMV database, so that these corrections could only be made for some households.
- In the screening study, the screen-outs, who said they did not own an OHV, were not asked any further questions, so those responses to Question 4 could not be checked against the vehicle information.
- The survey weights were estimated using various numbers that included the proportions of OHV-owners by county, which in turn were based on the answers to Question 4 rather than actual ownership.

For these reasons, OHV-ownership was defined based on the response to Question 4 for the purposes of defining the strata and calculating survey weights. The responses to Question 4 were also used to estimate the statewide proportion of OHV-owning households by the preferred "Direct method," as described above.

4.5.3. Estimating the Numbers of Telephone Lines

Our initial approach took into account the possibility of different telephone line ownership rates for OHV-owning and non-OHV-owning households in each county. We found that overall

the telephone ownership rates were very slightly higher for OHV-owning households. However, in several counties there were very small numbers of OHV owners in the survey and substantial variability in the numbers of telephone lines, leading to inconsistent, unreliable results: estimates of OHV ownership differed significantly between the smaller main sample and the larger screening sample and were inconsistent with registration data. It appears that in general, by adjusting for differential telephone line ownership rates, the reduction in bias was more than offset by an increase in variance. Therefore in our final approach for estimating the numbers of telephone lines we decided to assume equal average telephone line ownership rates for OHV owners and non-owners within each county.

Step 1. Estimate number of telephone lines in each county

An unbiased estimate of the number of households in the county is

Estimated Households (county) =

$$\{\text{Telephones (county)} / n \text{ (county)}\} \times \Sigma_u [1 / \text{Telephones (u)}]$$

assuming n(county) telephone lines were selected in that county, excluding the screen-outs, and household u in the combined sample has Telephones (u) land telephone lines. The unbiasedness follows from Theorem 1 given below in Section 4.5.4, applied to a single stratum (L = 1) consisting of all telephone lines in a single county by substituting

X_{hi} = 1 / Telephone lines in household u, assuming telephone line i is in household u.[27]

This assumes that the number of telephone lines in the county is known. Although in fact the number of telephone lines is not known, the number of households is known so we can invert this equation to give:

Estimated Telephones (county) =

$$\text{Households (county)} \times n \text{ (county)} / \Sigma_u [1 / \text{Telephones (u)}]$$

In other words, the estimated number of telephone lines equals the total number of households in the county divided by the sample mean of the reciprocal of the number of telephone lines per household. Equivalently, the number of households in the county is multiplied by the harmonic mean number of telephone lines per household.

[27] The sum of X_{hi} across all telephone lines equals the total number of households with at least one telephone line. Households without telephone lines are ignored for this calculation.

For this calculation, the data from the screened-out responders in the screening survey could not be used since the numbers of telephone lines for those households were not obtained. The values of n(county) and the sum of the reciprocals of the numbers of telephone lines were both based on the combined survey, i.e., the main survey together with the OHV owners from the screening survey. Including the OHV owners from the screening survey increases the bias because of possible differences between telephone line ownership for OHV-owning and non-OHV-owning households, but reduces the variance because of the larger sample size.

An additional complication was that a few households did not answer the question about the number of household telephone lines. For these telephone line calculations and for the calculations of the household sampling weights, we replaced the missing numbers of household telephone lines by the mean number of lines for the given county.

Step 2. Estimate fractions of OHV-owning households in each county

The screened-out non-OHV-owners from the screening survey were not asked about the numbers of telephone lines. One approach for estimating the fractions of OHV owning households in each county would be to treat the county as a single stratum and apply Theorem 2 in Section 4.5.4 to only the main survey responders in that county, which would unbiasedly adjust for differences in the numbers of telephone lines per household. However, that approach uses a much smaller sample, and, hence, has a much higher variance, than the selected approach that uses all the main and screening survey respondents including the screen-outs. Call this set of 27,955 respondents (14,276 from the main survey and 13,679 from the screening survey) the “full” survey. The selected approach treats all these respondents as being a stratified random sample of households (rather than being a stratified random sample of telephone lines), giving results expected to be slightly biased but much more precise.

To estimate the fraction of OHV owners from the full survey, we simply took the fraction of OHV-owning households in the sample:

Fraction OHV-owners (county) = PropOHV(county)

= # OHV-owning households in full survey / # households in full survey

= h(county) / nall(county)

Step 3. Estimate numbers of telephone lines in OHV-owning and non-OHV-owning households in each county

The results from Steps 1 and 2 are combined:

N(county, owner) = Estimated Telephones in OHV-owning households

= Estimated Telephones (county) × Fraction OHV-owners (county)

N(county, non-owner) = Estimated Telephones in non-OHV-owning households

= Estimated Telephones (county) × {1 - Fraction OHV-owners (county)}

4.5.4. Estimating Means and Totals

In this section we derive the formulae presented earlier in Section 4.5.2. Statistical theory for estimating means and totals using stratified simple random samples is given in standard textbooks on survey sampling theory. Our analyses use three theorems about estimating totals and ratios which are presented following the establishment of some notation. Readers uninterested in the detailed mathematical theory should skip this section.

Assume we divide the population into L strata. Stratum h has N_h members. A sample of size n_h is selected from stratum h at random without replacement. The values of variables X and Y on the i'th unit from stratum h are denoted by X_{hi} and Y_{hi}. The population stratum totals, means and variances and the overall totals are given by:

$$\text{Stratum population totals}: X_h = \sum_{i=1}^{N_h} X_{hi}, Y_h = \sum_{i-1}^{N_h} Y_{hi}$$

$$\text{Stratum population means}: \overline{X}_h = X_h / N_h, \overline{Y}_h = Y_h / N_h$$

$$\text{Stratum population variances}: S_{xh}^2 = \sum_{i=1}^{N_h} (X_{hi} - \overline{X}_h)^2 / (N_h - 1), S_{yh}^2 = \sum_{i=1}^{N_h} (Y_{hi} - \overline{Y}_h)^2 / (N_h - 1)$$

$$\text{Overall totals}: N = \sum_{h=1}^{L} N_h, X = \sum_{h=1}^{L} X_h, Y = \sum_{h=1}^{L} Y_h$$

The corresponding stratum sample estimates are given by:

$$\text{Stratum sample totals}: x_h = \sum_{i=1}^{n_h} X_{hi}, y_h = \sum_{i=1}^{n_h} Y_{hi}$$

$$\text{Stratum sample means}: \bar{x}_h = x_h / n_h, \bar{y}_h = y_h / n_h$$

$$\text{Stratum sample variances}: s_{xh}^2 = \sum_{i=1}^{n_h} (X_{hi} - \bar{x}_h)^2 / (n_h - 1), s_{yh}^2 = \sum_{i=1}^{n_h} (Y_{hi} - \bar{y}_h)^2 / (n_h - 1)$$

(Here we use the standard notation that the population has been reordered so that the first n_h units in stratum h were in the random sample.)

Theorem 1. (Results 5.1, 5.2, 5.3, 5.4, and 5.5 of Govindarajulu (1999)[28]).

Assume the values of N_h are known. An unbiased estimate of the population total X is given by

$$\hat{X} = \sum_{h=1}^{L} N_h \bar{x}_h$$

The variance of this estimate is given by

$$\text{Variance}\,(\hat{X}) = \sum_{h=1}^{L} N_h (N_h - n_h) S_{xh}^2 / n_h$$

An unbiased estimate of the variance is given by

$$\text{Estimated Variance}\,(\hat{X}) = \sum_{h=1}^{L} N_h (N_h - n_h) s_{xh}^2 / n_h$$

Theorem 2. (Remark 6.4 and Result 6.5 of Govindarajulu (1999)).

Assume the values of N_h are known. An approximately unbiased estimate of the population ratio R = Y/X is given by the combined estimated ratio

$$\hat{R} = \hat{Y} / \hat{X} = \sum_{h=1}^{L} N_h \bar{y}_h / \sum_{h=1}^{L} N_h \bar{x}_h$$

The variance of this estimated ratio is approximately given by

$$\text{Variance}\,(\hat{R}) = \sum_{h=1}^{L} N_h (N_h - n_h) S_{eh}^2 / n_h$$

where

$$S_{eh}^2 = \sum_{i=1}^{N_h} (E_{hi} - \bar{E}_h)^2 / (N_h - 1)$$

$$E_{hi} = (Y_{hi} - R X_{hi}) / X$$

$$\bar{E}_h = \sum_{i=1}^{N_h} E_{hi} / N_h$$

An approximately unbiased estimate of the variance is given by

[28] Govindarajulu, Zakkula, 1999. *Elements of sampling theory and methods.* Prentice Hall, New Jersey.

$$\text{Estimated Variance } (\hat{R}) = \sum_{h=1}^{L} N_h (N_h - n_h) s_{dh}^2 / n_h$$

where

$$s_{dh}^2 = \sum_{i=1}^{n_h} (D_{hi} - \bar{d}_h)^2 / (n_h - 1)$$

$$D_{hi} = (Y_{hi} - \hat{R} X_{hi}) / \hat{X}$$

$$\bar{d}_h = \sum_{i=1}^{n_h} D_{hi} / n_h$$

Theorem 3. Taylor Series.

Assume the values of N_h are unknown but are estimated by $\hat{N}_h$, independently of the X's and Y's. An approximately unbiased estimate of the population ratio R = Y/X is given by the combined estimated ratio

$$\hat{R} = \hat{Y} / \hat{X} = \sum_{h=1}^{L} \hat{N}_h \bar{y}_h / \sum_{h=1}^{L} \hat{N}_h \bar{x}_h$$

An approximately unbiased estimate of the variance of the estimated ratio is given by

$$\text{Estimated Variance } (\hat{R}) = \sum_{h=1}^{L} \hat{N}_h (\hat{N}_h - n_h) s_{dh}^2 / n_h + V$$

where

$$s_{dh}^2 = \sum_{i=1}^{n_h} (D_{hi} - \bar{d}_h)^2 / (n_h - 1)$$

$$D_{hi} = (Y_{hi} - \hat{R} X_{hi}) / \hat{X}$$

$$\bar{d}_h = \sum_{i=1}^{n_h} D_{hi} / n_h$$

$$V = Var\left(\sum_{h=1}^{L} \hat{N}_h (\bar{y}_h - \hat{R} \bar{x}_h) / \hat{X} \right)$$

In the last equation for V, only the terms $\hat{N}_h$ are treated as uncertain; the other terms $\bar{y}_h, \bar{x}_h,$ and $\hat{R}$ are treated as known. The proof of Theorem 3 is an extension of the standard proof of Theorem 2 using Taylor's theorem to approximate $\hat{R}$ as a linear combination of $\bar{y}_h, \bar{x}_h,$ and $\hat{N}_h$. For this linear combination, the coefficients of $\bar{y}_h, \bar{x}_h,$ and $\hat{N}_h$ are the partial

derivatives of *R* with respect to $\overline{Y}_h, \overline{X}_h,$ and N_h. As in Theorem 2, the first term in the estimated variance is obtained by partially differentiating the ratio *R* with respect to $\overline{Y}_h$ and with respect to $\overline{X}_h$. The second term, V, is the variance of the sum across strata of $\hat{N}_h$ times the partial derivative of *R* with respect to N_h. The independence assumption avoids the need for extra terms to account for the covariances between the Y, X terms and the $\hat{N}_h$ term.

Estimating the mean response

The formulae given in Section 4.5.2 for estimating the mean response to the telephone survey follow from applying Theorem 3 to the telephone survey "combined" data as discussed below.

Let stratum h be the combination of county c and subgroup A. The population is the set of California residential land telephone lines.[29] The sample size n_h is random and not fixed in advance, since the OHV ownership status of a respondent is not known before they are questioned. Therefore Theorem 3 does not directly apply because we did not have a stratified random sample from the set of OHV-owners' telephone lines in each county and the set of non-OHV-owners' telephone lines in each county. However, the mean and variance formulae in Theorem 3 can be applied conditionally on the observed sample sizes, n_h, and the argument given at the end of this section explains why the same formulae estimate the unconditional mean and variance. We will therefore treat the n_h as fixed values.

Unit i in stratum h is the i'th selected telephone line from that stratum. Assume this unit is from household u, so that u depends upon i. Define X_{hi} and Y_{hi} by

X_{hi} = 1 / Telephones (u, c, A)

Y_{hi} = z(u, c , A) / Telephones (u, c, A)

X and Y are the sums of X_{hi} and Y_{hi} across all telephone lines in California. Therefore

$X = \sum_c \sum_A \sum_u \sum_{\text{telephones in u}}$ 1 / Telephones (u, c, A) = $\sum_c \sum_A \sum_u 1$

= Total number of households in California

[29] Since the telephone survey was only of households with land telephone lines, the estimated means and proportions apply only to residences with one or more land telephone lines. On common-sense grounds, it is not unreasonable to assume that residences with other telephone lines (e.g. mobile telephones only) would behave similarly, but the relatively few residences without any telephone lines might be expected to respond differently.

$Y = \sum_c \sum_A \sum_u \sum_{\text{telephones in u}} z(u, c, A) / \text{Telephones}(u, c, A) = \sum_c \sum_A \sum_u z(u, c, A)$

= Total of z across all households in California

Therefore the unknown ratio R = Y/X is the arithmetic mean of z across all households in California, i.e., the true mean response.

The estimated, weighted mean response is given by

$$\hat{Z} = \hat{R} = \hat{Y} / \hat{X} = \sum_{h=1}^{L} \hat{N}_h \bar{y}_h / \sum_{h=1}^{L} \hat{N}_h \bar{x}_h$$

For the numerator, we have

$$\sum_{h=1}^{L} \hat{N}_h \bar{y}_h = \sum_{h=1}^{L} (\hat{N}_h / n_h) \sum_{i=1}^{n_h} y_{hi} = \sum_{h=1}^{L} (\hat{N}_h / n_h) \sum_{i=1}^{n_h} z(u, c, A) / \text{Telephones}(u, c, A)$$

$$= \sum_{h=1}^{L} \sum_{i=1}^{n_h} z(u, c, A) \times w(u, c, A) = \sum_c \sum_A \sum_u z(u, c, A) \times w(u, c, A)$$

using the definition of the sampling weight w(u, c, A) given in Section 4.5.2:

w(u, c, A) = N(county, A) / {n(county, A) × Telephones (u, c, A)}

For the denominator, we have

$$\sum_{h=1}^{L} \hat{N}_h \bar{x}_h = \sum_{h=1}^{L} (\hat{N}_h / n_h) \sum_{i=1}^{n_h} x_{hi} = \sum_{h=1}^{L} (\hat{N}_h / n_h) \sum_{i=1}^{n_h} 1 / \text{Telephones}(u, c, A)$$

$$= \sum_{h=1}^{L} \sum_{i=1}^{n_h} w(u, c, A) = \sum_c \sum_A \sum_u w(u, c, A)$$

Therefore

Mean response = $\hat{Z}$ = $\sum_c \sum_A \sum_u z(u, c, A)\, w(u, c, A) / \sum_c \sum_A \sum_u w(u, c, A)$

The estimated variance is also obtained from Theorem 3.

$$\text{Estimated Variance } (\hat{Z}) = \sum_{h=1}^{L} \hat{N}_h(\hat{N}_h - n_h)s_{dh}^2 / n_h + V$$

where

$$s_{dh}^2 = \sum_{i=1}^{n_h} (D_{hi} - \bar{d}_h)^2 / (n_h - 1)$$

$$D_{hi} = (Y_{hi} - \hat{R}X_{hi}) / \hat{X} = (\text{z(u, c, A)} - \hat{Z}) / \{\text{Telephones (u, c, A)}\ \hat{X}\} = \text{e(u, c, A)}\ n_h/\hat{N}_h$$

$$\bar{d}_h = \sum_{i=1}^{n_h} D_{hi} / n_h$$

$$V = Var\left(\sum_{h=1}^{L} \hat{N}_h(\bar{y}_h - \hat{R}\bar{x}_h) / \hat{X} \right)$$

Other than the calculation of V, the formula for Var given in Section 4.5.2 easily follows. The calculation of V is given next.

Calculation of Variance Correction Term, V

The application of Theorem 3 to estimate the variance of the mean response assumes that the numbers of telephone lines in the strata are estimated independently of Y and X. However, as shown in Step 3 of Section 4.5.3, the estimated populations in the strata are given by:

$$\hat{N}_h = \text{Estimated Telephones (county)} \times \text{PropOHV(county)},$$
if stratum h is the OHV - owners in the county, and

$$\hat{N}_h = \text{Estimated Telephones (county)} \times \{1 - \text{PropOHV(county)}\},$$
if stratum h is the non - OHV - owners in the county.

The value of Estimated Telephones (county) is estimated from the numbers of telephone lines in each surveyed household. The value of PropOHV (county) is the estimated proportion of OHV-owning households in the county, which is estimated from the main survey and screening survey, including screen-outs. Since both these values are to some extent associated with Y and X, violating the independence assumption, the correction term V does not fully adjust for the uncertainty of the sampling weights, but should provide a correction term that is a reasonable first order approximation for most survey questions. The correction term itself was usually relatively small.

From Theorem 3 and the last two equations,

$$V = Var\left(\sum_{h=1}^{L} \hat{N}_h(\bar{y}_h - \hat{R}\bar{x}_h)/\hat{X}\right) = Var\left(\sum_c A(c) \times \text{PropOHV(c)} + \text{Constant}\right)/\hat{X}^2$$
$$= \sum_c A(c)^2 Var(\text{PropOHV(c)})/\hat{X}^2$$

where

$$A(c) = \text{Estimated Telephones(c)} \times (\bar{y}_{c,owner} - \hat{R}\bar{x}_{c,owner} - \bar{y}_{c,non-owner} + \hat{R}\bar{x}_{c,non-owner})$$

and

$$\text{Constant} = \text{Estimated Telephones(c)} \times (\bar{y}_{c,non-owner} - \hat{R}\bar{x}_{c,non-owner})$$

(Recall that in the equation for V from Theorem 3, only the terms $\hat{N}_h$ are treated as uncertain; the other terms $\bar{y}_h, \bar{x}_h,$ and $\hat{R}$ are treated as known.)

We can now simplify A(c) as:

$$A(c) = \text{Estimated Telephones(c)} \times (\bar{y}_{c,owner} - \hat{R}\bar{x}_{c,owner} - \bar{y}_{c,non-owner} + \hat{R}\bar{x}_{c,non-owner})$$
$$= \sum_i (y_{c,owner,i} - \hat{R}x_{c,owner,i})/n_{c,owner} \times \text{Estimated Telephones(c)}$$
$$- \sum_i (y_{c,non-owner,i} - \hat{R}x_{c,non-owner,i})/n_{c,non-owner} \times \text{Estimated Telephones(c)}$$
$$= \sum_i (z_{i,c,owner} - \hat{R})/n_{c,owner} \times \text{Estimated Telephones(c)}/\text{Telephones(i,c,owner)}$$
$$- \sum_i (z_{i,c,non-owner} - \hat{R})/n_{c,non-owner} \times \text{Estimated Telephones(c)}/\text{Telephones(i,c,non-owner)}$$
$$= \sum_i (z_{i,c,owner} - \hat{R}) \times \text{w(i,c,owner)}/\text{PropOHV(c)}$$
$$- \sum_i (z_{i,c,non-owner} - \hat{R}) \times \text{w(i,c,non-owner)}/\{1 - \text{PropOHV(c)}\}$$

The last equation for A(c) follows from the definition of the estimated sampling weights. Finally, the estimated variance of PropOHV = h(c) / nall(c) for county c is given by

Var (PropOHV(c)) = {H(c) – nall(c)} PropOHV(c) {1 – PropOHV(c)}
/ {(nall(c) – 1) H(c)}

which follows from Theorem 1, taking L = 1 stratum and letting

X_{hi} = 1 if household i is an OHV-owning household; = 0 otherwise.

The formula for V given in Section 4.5.3 easily follows from the above calculations.

Estimating the Unconditional Mean and Variance

The above theory assumes that the stratum sample sizes, n_h, are fixed and not random. However the stratum sample sizes are the numbers of sampled OHV owners and non-owners in each county, which were not chosen in advance; only the total number sampled per county was chosen. We can ignore the very small probability of selecting one or fewer telephone lines in a stratum, so that all the mean and variance equations are well-defined.

Since each and every set of n_h telephone lines from stratum h has the same probability of being selected, all of the above theory is still valid for the conditional mean and variance given the stratum sample sizes. Therefore, the estimated mean response, $\hat{Z}$, is an approximately unbiased estimate of the population mean Z given all the stratum sample sizes. The estimated variance of the mean response,

"Var" = Estimated Variance (Mean response)

$$= \sum_c \sum_A n(c, A) \{1 - f(c, A)\} / \{n(c, A) - 1\} \times \sum_u \{e(u, c, A) - \bar{e}(c, A)\}^2 + V$$

is a function of the survey data and the random stratum sample sizes n(c, owner) and n(c, non-owner). From the above theory, "Var" is an approximately unbiased estimate of the variance of $\hat{Z}$ given all the stratum sample sizes. Mathematically,

$$E(\hat{Z} \mid n_h \text{ for all h}) \cong Z$$
$$Var(\hat{Z} \mid n_h \text{ for all h}) \cong E(\text{"Var"} \mid n_h \text{ for all h})$$

Using well-known results about conditional means and variances,

$$E(\hat{Z}) = E_n\{E(\hat{Z} \mid n_h \text{ for all h})\} \text{ and}$$
$$Var(\hat{Z}) = E_n\{Var(\hat{Z} \mid n_h \text{ for all h})) + Var_n\{E(\hat{Z} \mid n_h \text{ for all h})\},$$

where E_n and Var_n denote the expected value and variance over the distribution of the random stratum sample sizes. The conditional mean of $\hat{Z}$ is approximately equal to the same population value, Z, for all stratum sample sizes, so its expected value over the distribution of the stratum sample sizes is approximately Z and its variance over the distribution of the stratum sample sizes is approximately zero. Mathematically,

$$E(\hat{Z}) = E_n\{E(\hat{Z} \mid n_h \text{ for all h})\} \cong E_n(Z) = Z, \text{and}$$
$$Var(\hat{Z}) = E_n\{Var(\hat{Z} \mid n_h \text{ for all h})) + Var_n\{E(\hat{Z} \mid n_h \text{ for all h})\}$$
$$\cong E_n\{E("Var" \mid n_h \text{ for all h})\} + Var_n(Z) \cong E("Var").$$

Therefore, unconditionally on the random stratum sample sizes, the estimated mean response, $\hat{Z}$, is approximately unbiased, and "Var" is an approximately unbiased estimate of the variance of the estimated mean.

4.5.5. Estimating Ratios

This section presents the formulae for estimating ratios of means and their uncertainties. A typical example of a ratio of means is the California percentage of owned OHV motorcycles used for recreation. By definition, this fraction equals

California fraction of OHV motorcycles owned and used for recreation
= Total number of OHV motorcycles owned and used for recreation /
Total number of OHV motorcycles owned
= {Total number of OHV motorcycles owned and used for recreation /
Total Households} / {Total number of OHV motorcycles owned /
Total Households}

= {Mean number of OHV motorcycles owned and used for recreation per
Household} / {Mean number of OHV motorcycles owned per Household}.

Thus the California fraction of owned OHV motorcycles used for recreation is expressible as the ratio of two population means, the population mean number of owned OHV motorcycles used for recreation and the population mean number of owned OHV motorcycles. The sample estimate is the corresponding ratio of the estimated weighted mean responses from the survey.

In general, the estimated ratio equals

Mean ratio = $\hat{S} = \sum_c \sum_A \sum_u z(u, c, A)\, w(u, c, A) / \sum_c \sum_A \sum_u t(u, c, A) \times w(u, c, A)$

where z(u,c,A) and t(u,c,A) are the observed numbers for household u, county c and the owner/non-owner subset A for the numerator and denominator variables (e.g., number of owned OHV motorcycles used for recreation and number of owned OHV motorcycles).

To calculate the variance of the estimated ratio, exactly the same arguments from sections 4.5.2 – 4.5.4 can be applied except that X_{hi} is redefined to be

X_{hi} = t(u, c, A) / Telephones (u, c, A)

The previous formulae become a special case of the following formulae with t identically equal to one.

The estimated variance of the mean ratio is given by the formula:

Var = Estimated Variance (Mean ratio)

$$= \sum_c \sum_A n(c, A) \{1 - f(c, A)\} / \{n(c, A) - 1\} \times \sum_u \{e(u, c, A) - \bar{e}(c, A)\}^2 + V$$

f(c, A) is the sampling fraction:

f(c, A) = n(c, A) / N(c, A)

e(u, c, A) is an error term, with stratum mean $\bar{e}(c, A)$:

$$e(u, c, A) = w(u, c, A) \{z(u, c, A) - \hat{S}\, t(u, c, A)\} / \sum_c \sum_A \sum_u w(u, c, A)\, t(u, c, A)$$

$$\bar{e}(c, A) = \sum_u e(u, c, A) / n(c, A)$$

V is a correction term to account for the uncertainty of the estimated sampling weights:

$$V = \left\{1 / \left\{\sum_c \sum_A \sum_u w(u,c,A)\, t(u,c,A)\right\}^2\right\} \times \sum_c \mathrm{Var}(\mathrm{PropOHV}(c)) \times$$

$$\left\{ \frac{\sum_{\mathrm{owner}} (z(u,c,\mathrm{owner}) - \hat{S}\, t(u,c,\mathrm{owner}))\, w(u,c,\mathrm{owner})}{\mathrm{PropOHV}(c)} - \frac{\sum_{\mathrm{non-owner}} (z(u,c,\mathrm{non-owner}) - \hat{S}\, t(u,c,\mathrm{non-owner}))\, w(u,c,\mathrm{non-owner})}{1 - \mathrm{PropOHV}(c)} \right\}^2$$

4.5.6. Missing Responses

Although many of the questions were answered by all of the 15,691 respondents, there were some questions where some responses were missing. This section describes how those responses were analyzed. We assumed that the responses were missing at random, so that whether or not a response is given is statistically independent of any other information on that respondent.

For a given question, if the responses are missing at random, one way to analyze the available data is to treat the households responding to that question as a stratified random sample. All of the above equations are valid provided that all the counts, sums and weights refer only to those respondents answering the question of interest. In particular, n(county, A) is the number of households in subgroup A (OHV-owner or non-OHV-owner) of a given county that responded to the given question. Under this approach, the sampling weight will vary depending upon the question because the sampling weight is defined to be:

$$w(u, c, A) = N(\text{county}, A) / \{n(\text{county}, A) \times \text{Telephones}(u, c, A)\}$$

and n(county, A) is the number of non-missing responses to the given question.

To make the calculations simpler, we instead decided to use the same set of sampling weights for every question, regardless of the number of non-missing responses. For a given question, let n(county, A) be defined as the number of households in subgroup A (OHV-owner or non-OHV-owner) of a given county that responded to the given question. Let n*(county, A) be defined as the number of households in subgroup A and the given county that were included in the survey, whether or not they answered the question of interest. (n* could equally be defined as the number responding to the first question: what is your zip code?). Thus the true sampling weights are replaced by the fixed sampling weights

$$w^*(u, c, A) = N(\text{county}, A) / \{n^*(\text{county}, A) \times \text{Telephones}(u, c, A)\}$$
$$= w(u, c, A) \times n(\text{county}, A) / n^*(\text{county}, A)$$

and so,

$$w(u, c, A) = w^*(u, c, A) \times n^*(\text{county}, A) / n(\text{county}, A)$$

If (100 × p)% of the values are missing at random, then each of the n*(county, A) respondents independently has a probability p of not responding, so that the expected value of n(county, A) equals n*(county, A) × p for every stratum. Therefore the expected value of the fixed sampling weight w*(u, c, A) equals p times the expected value of the true sampling weight w(u, c, A). If every w(u, c, A) term is replaced by w*(u, c, A), then the estimated mean response and its estimated variance will still be approximately unbiased for the true mean response and the true variance of the estimated mean. (Since each sampling weight appears in both the numerator and denominator of the mean and variance formulae, the p factors will cancel).

This simple analysis shows that the previous formulae for estimated means, ratios, and their variances are still approximately correct even if the sampling weights or the given question are not adjusted for the missing responses.

4.6. Component 1 Questionnaire

A questionnaire is a measurement tool. Just as a scale measures weight and a ruler measures length, questions in a survey are meant to measure behaviors, opinions and other characteristics of a respondent and/or their household. One of the challenges for any survey, therefore, is to include questions that produce valid[30] and reliable[31] measures of the behaviors, opinions and other characteristics of interest. Since there are many possible sources of measurement error (priming effects, position order effects, wording effects, response category effects, etc.),[32] the ICF team of ICF International, True North Research and University of California Davis took great care in designing the Component #1 survey to avoid and/or minimize these potential sources of error. This was especially true when developing measures for key concepts including off-highway driving and driving in public areas. As shown in the Component #1 questionnaire (see Appendix A), all key concepts were carefully defined for respondents.[33] The ICF team worked closely with State Parks, Caltrans, and members of the OHV Stakeholders Roundtable in drafting, refining and finalizing the survey instrument for the Component #1 Study.

4.7. Language Translation

From a methodological perspective, it was important to translate the Component #1 questionnaire into languages for which there was a substantial percentage of California households that did not have at least one adult who speaks English well. Of course, it was cost prohibitive and statistically unnecessary to translate the questionnaire into each of the more than 150 languages spoken by California residents. An in-depth review of 2000 Census data revealed that among all individuals over the age of 5 in California, 8% speak Spanish and don't also speak English "well", 2% speak an Asian language and don't also speak English "well", and

[30] Validity refers to the degree to which a question actually measures the underlying attitude or construct that it was designed to measure.

[31] Reliability refers to the degree to which the observed results for a survey question are free of measurement errors and thus accurately measure the true value among the survey participants.

[32] For a discussion of possible sources of measurement error in surveys, see Howard Schuman and Howard Presser, *Questions & Answers in Attitude Surveys*, Sage Publications: Thousand Oaks, 1996.

[33] Rather than simply leaving it up to the respondent to understand what qualifies as *public land*, for example, the questionnaire presented respondents with each of the various types of public lands and asked whether they had driven off-highway on each type (see Question 11).

less than 1% speak another language and don't also speak English well.[34] Accordingly, once the Component #1 questionnaire was finalized, the instrument was professionally translated into Spanish and the four most commonly spoken Asian languages: Cantonese, Mandarin, Tagalog and Vietnamese.[35]

4.8. CATI & Pre-Test

Once finalized and translated, the questionnaire was CATI (Computer Assisted Telephone Interviewing) programmed to assist the live interviewers in correctly navigating the skip patterns and recording answers, and to enable answers from prior questions to be automatically piped into subsequent questions or answers, where appropriate. The CATI system also ensured that the appropriate number of callbacks were made for each number at the appropriate times.

Once the CATI was tested internally, the survey was pre-tested with a sample of 30 California households prior to actually fielding the study to ensure that respondents could easily understand the point of each question, the response options matched what respondents wanted to answer, and that the skip patterns and CATI logic were correct. Minor adjustments were made to the interviewing instructions based on the pre-test.[36]

4.9. Interviewer Training

Prior to fielding, Dr. McLarney of True North Research attended a training session with interviewing staff and supervisors of Mountains West Research Center to explain the purpose of the study, clarify the meaning of all of the questions asked in the survey, and prepare them for the types of answers they can expect and how to record them appropriately. Each interviewer also conducted several practice interviews with a supervisor and Dr. McLarney to ensure that they understood how to conduct the interviews appropriately.

4.10. Quality Control

In addition to CATI programming the instrument, conducting the pre-test and training interviewers, there were a number of quality control procedures during data collection to identify and correct for any problems that arose. The procedures included direct and remote supervisor

[34] Census 2000, Summary File 3, Table QT-P17.

[35] It should be noted that these were the only Asian languages that were spoken by at least one percent of the California population (Census 2000, Summary File 3, Table QT-P16).

[36] Some respondents reported jet skis or other watercraft as an OHV. In these cases, interviewers were instructed to clarify that OHVs do not include watercraft.

monitoring of interviewing as it occurred. Supervisors listened to calls with a headset and also walked the floor to monitor interviews as they occurred. Each interviewer was rated by a Supervisor on a monitoring form each night, to ensure they were following procedures and conducting the interviews in a professional manner. Random supervisor callbacks were conducted on 10 percent of interviews to confirm that the interview was conducted correctly. Daily progress reports regarding the disposition of calls made the previous night and to-date and weekly monitoring of the sample characteristics to ensure that the sample matched the profile established for the study were additional quality control procedures. One of the advantages of using a CATI system was that it automatically generated the data file. This not only reduced the opportunity for "human error" associated with a second keypunching phase typical of non-CATI surveys, it also allowed True North Research to receive weekly data files from the data collection facility during the data collection period so that the sample characteristics and answers to the survey could be closely monitored.

4.11. Data Collection

Component #1 interviews were conducted via telephone between July 28 and December 10, 2003. Phone calls were conducted in the evenings (5PM to 9PM) during weekdays and between 10AM and 5PM on weekends. Five attempts to complete an interview were made for each phone number identified in the sample unless a completed interview had already occurred, the person refused to participate, or the number was determined to be an invalid phone number. The timing of follow-up calls was rotated to avoid systematically calling a household at a specific time that may conflict with their daily routine. This minimized the chances that the interview would not be completed due to "bad timing".

Table 4-3 presents the disposition of all calls made during the Component #1 fielding period. Note that the frequencies shown in the table reflect the number of dialings -- not the number of unique phone numbers called. The Main column corresponds to the Main Sample which included OHV-owning households as well as households that did not own an OHV. The Screening column reflects the dialings that were made as part of the mutually exclusive effort to over sample for just OHV-owning households (see Section 4.4).

Table 4-3. Call Disposition

Call Disposition	Dialings	
	Main	Screening
No Answer	351,766	565,607
Busy Signal	30,241	47,403
Not Available	31,862	35,532
Callback	3,298	2,280
Non-working/Disconnected	57,966	40,013
Business/Non-Residential	9,391	10,691
Language Barrier	7,099	5,896
Fax/Data Line	11,012	10,770
Refusal - Soft	30,520	39,541
Refusal - DNC & Hard	10,062	14,464
Respondent Terminate	1,397	157
Interviewer Terminate	112	79
Not Qualified/Over Quota	56	79
Non-Qualified - Non-OHV Household	-	12,264
Complete - Non-OHV Household	13,234	-
Complete - OHV Household	1,042	1,415
Total Completed Interviews	14,276	1,415

4.12. Incentives

No incentives were used to encourage participation in the Component #1 survey, although vehicle-owning households were informed of the cash incentives associated with the Component #2 survey at the conclusion of the interview as a way to encourage participation in that survey.

4.13. Data Processing

As noted above, True North Research received weekly data files from the data collection facility beginning the first week of interviewing so that potential problems with the data could be identified early and adjusted for. Data processing and cleaning at this stage consisted of checking each of the variables identified in the survey for completeness and distribution, examining whether there were any logical inconsistencies between the values shown for specific variables, and producing cross-tabulations and descriptive statistics. If needed, callbacks to specific households were conducted to clarify an answer. Once data collection was complete, True North Research recoded variables and derived new variables, as needed, based on the clean data file.

4.14. Determination of Non-Registered Off-Highway Vehicles

The telephone survey resulted in 2,431 households owning a total of 4,898 OHVs.[37] In addition, 4 households that did not report that they owned an OHV in the telephone survey, but purchased one between the time of the telephone survey and the fuel use log survey and reported on that vehicle. The names and addresses of the OHV owning households were compiled and sent to Robert Cenzer to find the households in the DMV OHV dataset. Cenzer used the first letter of the person's name and the zip code for the first data cut. He then sorted by last name and matched the records if the name and zip code matched. He then compiled a list of OHVs owned by the household and sent it back to ICF International for matching to the telephone survey. If the name and address could not be found in the DMV OHV data set, the street licensed motorcycle DMV data set was reviewed and if found, a list of street licensed motorcycles for the household was generated. If still no match, the street licensed vehicle data set was searched for the person's name and zip and a list of street licensed vehicles was generated for those found. The reverse telephone directory was used to correct misspellings of names and address where possible. DMV did not provide the off-highway vehicle data set until October 2004, so the survey done in the later half of 2003 had to be compared against the October 2004, April 2005 and October 2005 file passes. A file pass is when DMV takes a snapshot of its registration databases and sends it to Cenzer for analysis. While this presented some mismatch in the time period analyzed, registered vehicles are kept in the DMV database for a period of 5 years if not renewed. Thus using the later file passes produced the necessary information needed for the analysis.

The file passes were used to generate a list of vehicles for the found households. The OHVs described during the telephone interviews for those households were matched using the following matching parameters:

Exact Match (E). If the vehicle type and model year matched that claimed by the interview respondent, it was considered an exact match.

Near Match (N). If the vehicle type was the same, but the model year was within 3 years of the one claimed by the interview respondent, it was considered a near match and the

[37] Twenty six households were removed in the cleaning process because they did not actually own an OHV.

same vehicle. This is because many people cannot remember the model year of their off-highway vehicles exactly.

Replacement Vehicle (R). If the vehicle found in the DMV datasets was more than 3 years newer than the vehicle claimed, and the vehicle claimed could not be found, the new vehicle was considered a replacement vehicle for the one not found. In some cases a different type of vehicle replaced the old one, such as the person claimed they had a 1993 ATV and we found a 2000 registered motorcycle in the DMV database but no 1993 ATV.

Mistaken Type (M). If the interview respondent claimed they had a motorcycle and we did not find a motorcycle but found an ATV of the same or near model year, we considered this scenario a mistaken identity. Because we spoke to someone in the household that may have not been the owner of the vehicle, there may be confusion about vehicle types. This was also true for claimed ATVs and found motorcycles. The largest confusion was in two categories, "Extreme 4x4" and "Off-Road Cart". The Extreme 4x4 vehicle type was found by searching the DMV data to be a number of possibilities. It was originally defined as an off-road (non-street licensed) truck or SUV, but many confused this with street licensed 4WD trucks and SUVs as well as with ATVs. The "Off-Road Cart" vehicle type was found in many cases to be either a dune buggy or an ATV. It was intended to capture off-road golf carts. In these cases, the correct vehicle type was used and the match code set to Mistaken Type.

Duplicate (D). In a number of cases where the interview respondent had responded that they had an Extreme 4x4 or a non-street licensed Other of a given model year during the non-street licensed portion of the interview, a street licensed 4WD truck or SUV was also mentioned of the same model year during the street licensed part of the interview. In some cases the people even told us the Extreme 4x4 was an SUV or pick-up truck. While it is possible that people could own a non-street licensed vehicle and a street licensed vehicle of the same model year, the occurrence of this was much too frequent to assume it was a coincidence. In this case the vehicle not found in the DMV data set was eliminated and the one found was counted. In most cases the Extreme 4x4 turned out to be a street licensed truck or SUV.

Verified Non-Registered (V). A vehicle was considered verified non-registered if the household was found in the DMV database as owning a street licensed or non-street licensed vehicle, but the vehicle in question could not be found under the above matching parameters. In this case the vehicle was assumed non-registered.

Added Vehicles (A). If we found additional vehicles in the DMV datasets registered to the household but weren't discussed during the interview, we added them to the household list if they were model year 2004 or older. We excluded vehicles newer than 2004 because they would not have existed at the time of the interviews.

In some cases the matched vehicle was not currently registered at the time of the interview but still existed in the DMV datasets. Generally DMV keeps vehicles that were once registered but their registrations have lapsed for a period of about 5 years. If the vehicle had a lapsed registration of the time of the interview, it was considered non-registered. The other case which was found was that the vehicle was registered as non-operation. A permitted non-operational vehicle was considered registered.

Households that could not be found in the DMV data base were ignored in calculation of registered versus non-registered vehicles. There were several reasons for why households could not be found. These included:

Bad Address (B). Some interviewees did not provide last name or address information and others provided incomplete information. In these cases, we could not find them in the DMV data sets and they were ignored in determination of registered or non-registered vehicles.

Other possible reasons for the household not showing up in the DMV data sets include:

- The name or address was misspelled
- We were given an incorrect name and address
- The person that owned the vehicles lived at a different address or had a different name than the person that answered the phone
- The person only owned out of state vehicles
- All the person's vehicles (including street vehicles) are unregistered

We first tried to find the person in the reverse telephone directory and correct misspellings and incorrect information. If we still could not find the household, it was ignored. The only one of the above reasons that would guarantee them to be non-registered is the last one which is the least likely.

In addition, we rejected vehicles for two reasons:

Closed Course Vehicle (C). The interview respondent indicated that this vehicle was used for close course competition only. Since State Parks does not get tax revenues for vehicles that would not need to be registered, such as race vehicles used in closed course competition, these vehicles were also not counted in the non-registered vehicle determinations.

Rejected Vehicle (J). Vehicles that were obviously not recreational vehicles such as dump trucks, farm tractors, semi trucks, property maintenance vehicles and construction equipment were also rejected from the counts.

With the added vehicles, there were 5,204 suspected non-street licensed vehicles. Of those 176 turned out to be street-licensed vehicles, 192 were determined to be closed course vehicles and 37 were rejected as not recreational vehicles. The remaining 4,799 were matched as shown in Table 4-4.

Table 4-4. DMV Matching

Match	Vehicles
Exact	895
Near	578
Replacement	334
Mistaken	40
Added	306
Verified NR	1,141
Bad	370
Not Found	1,135
Total	4,799

Because of the very long delay (over 2 years) between the interviews and the resolution of DMV OHV data to do the matching discussed above, ICF International realized that call-backs to selected households would be neither cost-effective nor meaningful other than providing limited anecdotal data. The DMV data provided useful information on whether households had registered vehicles. Since it was unlikely households would admit to having non-registered vehicles, particularly if they reported fuel use during the fuel use log book survey, and since most people would have a very selective memory two years back as to their vehicle ownership and registration status, it was decided not to do call backs to question people about non-registered vehicles.

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5. Fuel Use Log Book Survey

Component #2 of the ICF International Study consisted of a fuel use log book survey of 15,809 vehicles in California selected in a random manner using a stratified probability sample from the DMV vehicle registration database.[38] Non-registered OHVs were sampled from all households identified in Component #1 that were determined to own a non-registered OHV.

The principal research objectives of the Component #2 survey were to:

- Derive the average monthly gasoline consumption for each type of vehicle being used for off-highway recreation in California on public lands, distinguishing between "driving to recreate" and "for the purpose of recreation".
- "Estimate the recreational activities (pursuits) that vehicle operators engage in while driving off-highway in California on public lands to access recreation or for the purpose of recreating.
- Identify the recreational destinations (geographically) that vehicle operators visit while driving off-highway in California on public lands to access recreation or for the purpose of recreating.
- Collect all of the above information using a sampling plan that will allow the data to be generalized (projected) to the entire fleet of vehicles in California in a statistically reliable manner.

5.1. Methodology Overview

Component #2 of the study consisted of a fuel use log book survey of 15,809 vehicles in California selected in a random manner using a stratified probability sample from the Component #1 survey and from the DMV vehicle registration database. Surveys were administered in six consecutive, two month periods (waves) beginning in April 1, 2004 and ending one year later on March 31, 2005. For a selected vehicle, respondents were asked to provide information about the vehicle and record the off-highway driving activity of that vehicle for a two-month period. Of particular interest was the distance traveled off-highway, the amount

[38] The first wave of vehicles was selected from households that participated in the Component #1 survey. The remaining five waves were selected from the DMV database. All non-registered OHVs were recruited during the Component #1 survey.

of fuel consumed, as well as the nature and location of recreational activities associated with the off-highway driving. The log book was designed to collect the information needed to populate the Dynamic Fuel Tax Model.

The following sections provide additional details about the methodologies used in the Component #2 survey, as well as the motivation for using certain techniques.

5.2. Vehicle Types Surveyed

In order to better define vehicle types used in the survey, 11 street licensed vehicle types replaced the 5 defined in the 1990 Study. This provides further refinement to the dynamic tax model to be developed. The new street licensed (SL) vehicle types are shown in Table 5-1 and compared with the previous 1990 Study vehicle types.

Table 5-1. Street Licensed Vehicle Types

ICF Study	1990 Study
Car 2WD Car 4WD	Regular
SUV 2WD Truck 2WD Van 2WD	2WD
SUV 4WD Truck 4WD Van 4WD	4WD
Street MC Dual Sport MC	Motorcycle
Other	Other

There are two additional differences in the definitions above between the ICF International Study vehicle types and the 1990 Study. First, street-licensed dune buggies and Baja bugs were placed in the 2WD category in the 1990 Study. In the ICF International Study they are placed in the SL Other category. Also in the 1990 Study, Tyler included vehicles with a gross vehicle weight rating (GVWR) of 8,501 to 10,000 lbs in the SL Other category, while ICF International included those vehicles in the SUV, Truck and Van categories. Vehicles between 10,001 and 14,000 lbs GVWR were included in the SL Other category in the ICF International Study. Vehicles over 14,000 lbs GVWR are too heavy to be recreational vehicles and thus are not included in the vehicle counts.

The nine non-motorcycle street licensed vehicle types in Table 5-1 were matched to 25 DMV vehicle types as shown in Table 5-2. DMV categories included in each street licensed

motorcycle vehicle type are shown in Table 5-3. ICF International kept the 5 non-street licensed (NSL) vehicle types, namely Motorcycle, ATV, 4 Wheel Vehicle, Snowmobile and Other. DMV categories included in each non-street licensed vehicle type are shown in Table 5-4. While not an actual DMV category, go carts were mapped to the NSL Other vehicle type. Tyler had mapped unlicensed street vehicles in the NSL Other category, while ICF International included them in the 4 Wheel Vehicle category along with dune buggies, sand rails and off-road carts. The mappings described in Tables 5-2 through 5-4 were used to generate lists of vehicles for sampling.

Table 5-2. Street Licensed Vehicle DMV Mapping

Study Vehicle Types	DMV Vehicle Classes
Car	Car – Subcompact Car – Compact Car – Midsize Car – Large Car – Sport Cross Utility – Small – Car
SUV	Cross Utility – Small – Truck Cross Utility – Midsize Sport Utility – Compact Sport Utility – Midsize Sport Utility – Large Sport Utility – 8,501-10,000 GVWR
Van	Van – Compact Van – Standard Van – 8,501-10,000 GVWR
Truck	Pickup – Compact Pickup – Standard Pickup – 8,501-10,000 GVWR
Other	GVWR 3 Truck
Not Included	GVWR 4 Truck GVWR 5 Truck GVWR 6 Truck GVWR 7 Truck GVWR 8 Truck Neighborhood Electric Car

Table 5-3. Street Licensed Motorcycle DMV Mapping

Vehicle Type	DMV Vehicle Classification
Dual Sport Motorcycle	All Terrain Dirt Enduro Mini Moto Cross Mini Road Trail Moto Cross Racer Road Trail Trail Trail Dirt
Street Motorcycle	Mini Bike Mini Cycle Road Street Moped Motor Cycles Other Motor Scooter

Table 5-4. Non-Street Licensed Vehicle DMV Mapping

Vehicle Type	DMV Vehicle Classification
Motorcycle	Dirt Enduro Mini Bike Mini Cycle Mini Moto Cross Mini Road Trail Moped Motor Cycles Other Motor Scooter Moto Cross Racer Road Street Road Trail Trail Trail Dirt
ATV	3 Wheel Vehicle 4 Wheel Vehicle All Terrain
4 Wheel	Dune Buggy Golf Cart Pickup[a] Sport Utility[a]
Snowmobile	Snow Mobile
Other	Amphibious Utility Vehicles Varied

[a] Vehicles without a street license

5.3. Sample Distribution by Vehicle Type

As discussed in Section 4.4, the sampling design is in many respects the most important stage of the Component #1 survey. This is also true for the Component #2 fuel use log book survey. The accuracy and reliability of the fuel use estimates produced by the Dynamic Model will ultimately depend on whether the vehicles and households that participate in the Component #2 Study allow for the data to be weighted and expanded to accurately represent the fleet of vehicles operating in California.

ICF International conducted extensive analyses of the data presented in the 1990 Study produced by Tyler, and together with the vehicle counts from the Component #1 survey, identified the most efficient means of distributing the log books by vehicle type so as to "yield the highest degree of statistical accuracy". Based on this data and the assumptions outlined in Section 5.11, ICF International determined the distribution shown in Table 5-5 would produce the most accurate estimate of the fuel used off-highway on public lands for recreation in a year given the size of each group, the frequency and variance of fuel used by each group for off-highway recreation, and the other constraints of this study.[39]

It is important to recognize the distribution of log books shown in Table 5-5 is optimal if one assumes the ratio of non-registered to registered OHVs and fuel rates per month by vehicle type reported in the 1990 Study are correct today. For the reasons explained in detail in Section 3.4, there are compelling reasons to believe the 1990 Study correction factors overestimate the current population of non-registered OHVs and that the recreational fuel usage of 4WD street-licensed vehicles is too high. Unfortunately accurate vehicle counts, correct fuel use rates, and corrected non-registered to registered ratios were not available at the time the sampling plan was designed. In addition, due to the limited response to the pre-recruitment letters (as a result of State Parks initially not allowing us to use their letterhead [see Section 5.5.1]), the distribution of log book mailings was more dictated by the responses to the invitation letters than the ideal sampling plan. This led to some increased margin of error from less than 10% to slightly over 15%.

Given the pre-recruiting, sample maintenance, and follow-up procedures that are discussed in Section 5.5 as well as the financial incentives offered to participants discussed in

[39] The additional constraints include ensuring enough vehicles of types that comprise a low proportion of the overall fleet, the need to estimate fuel consumption for registered and non-registered OHVs separately, and that all non-registered OHVs must be recruited from the Component #1 data.

Section 5.6, ICF International expected to collect completed log books from approximately 50% of households that were selected for the sample. Thus, to complete 15,000 diaries, ICF International mailed approximately 30,000 log books.

Table 5-5. Initial Log Book Sampling Plan

Vehicle Type	Sampling Plan
Car 2WD	1,982
Car 4WD	385
SUV 2WD	666
SUV 4WD	3,766
Truck 2WD	1,602
Truck 4WD	3,185
Van 2WD	942
Van 4WD	577
Street MC	244
Dual Sport MC	50
SL Other	338
Motorcycle-Reg	628
ATV-Reg	80
4 Wheel - Reg	46
Snowmobile - Reg	35
Other - Reg	3
Motorcycle-Non-Reg	189
ATV-Non-Reg	98
4 Wheel - Non-Reg	153
Snowmobile - Non-Reg	18
Other - Non-Reg	13
Total	15,000

5.4. Sample Selection

With the exception of the sample for the first wave, all street-licensed vehicles were selected for participation in the study from the DMV vehicle registration database. The database was first stratified by vehicle type into the groups shown in Table 5-5. Because the geographic location of each vehicle, the make, model and model year can all be expected to influence the frequency of off-highway use and/or the fuel economy of the vehicle, the sample was further stratified prior to selecting specific vehicles to ensure the sample reflected the diversity of the entire fleet of vehicles operating in California within each vehicle category. Within each strata,

vehicles were selected at random.[40] The number of vehicles selected from each strata was proportional to the strata size. Once a vehicle had been selected from a single household, all other vehicles in the household were no longer eligible to be selected. Vehicles owned by businesses and other non-private use entities were excluded from the study.

Because non-registered OHVs are, by definition, not included in the DMV vehicle registration database, non-registered OHVs were sampled from households identified in Component #1 as owning a non-registered OHV. As noted previously, all households identified during the Component #1 survey were invited at the conclusion of the interview to opt-in to the Component #2 Study and were made aware of the attractive financial incentives to participate. Because of the high level of interest in participating in the Component #2 survey among participants in the Component #1 survey, there was a sufficiently large number of vehicles to allow ICF International to produce the sample for the first wave of interviewing for the Component #2 survey from households that participated in the Component #1 survey. Because of the limited sample size to work from, non-registered vehicles were sent log books for up to three waves. All registered vehicles were only sent log books for one wave.

5.5. Recruiting, Data Collection & Sample Maintenance

A sampling method may work in theory, but not work well in practice. This is often the case with mail-based surveys. Indeed, one of the biggest challenges this study faced was ensuring that once the sampling method had been identified, the actual participation rates and log book returns were consistent with the sampling plan. Being able to control the sampling method and administration of the sample at the outset of the study and throughout data collection was thus critical to being able to recognize and adjust for the many possible sources of response bias inherent in mail-based log book surveys. Without the mechanisms in place to closely administer and monitor the sample, the data and the projections produced by the Dynamic Fuel Tax Model would likely be incorrect.

The method used in the 1990 Study was to sample vehicles from the DMV vehicle registration database and then mail fuel logs to these households. Administration of the sample design was thereafter limited to a second and third mailing of fuel logs. The principal flaw in this

[40] This was an important step, as it made sure that the vehicles that participated in the log book study were representative of their respective vehicle categories. Otherwise, the sample may have included too many vehicles of one type, which could bias the results. For example, if too many vehicles with better fuel economy were selected for the 2WD category, then the study (and the Dynamic Model) would underestimate the amount of fuel consumed off-highway.

approach is that there is no way to directly control or administer the sample. Fuel logs are mailed-out, and there is no way to directly follow-up with a household, answer questions, encourage participation, or collect their data. If the household does not respond, the only follow-up method is indirect: mail another fuel log or letter. This can lead to low participation rates and pronounced response bias.

Accordingly, ICF International employed a three-stage Recruiting, Data Collection and Sample Maintenance process that provided far more control over the initial sampling of vehicles and households for each data collection wave, provided higher response rates and less response bias, and allowed ICF International to directly control the administration of the sample.

5.5.1. Pre-recruit

The first stage involved pre-recruiting 151,215 street licensed vehicle households and 9,863 non-street licensed vehicle households for participation in the study by sending a letter with a return form. The letter invited them to participate in the study, made clear the attractive financial incentives for doing so, and asked them to fill-out and return the postage pre-paid return form if they were willing to participate (see Pre-Recruiting Invitation Letters and Return Form in Appendix B). The Return Form contained several questions, the most important of which inquired as to the household's phone number. Households that owned non-registered OHVs were not included in Stage 1 since they had been pre-recruited during the Component #1 survey.[41]

There were several iterations of the invitation letter which are shown in Appendix B. During the first four invitation letter mailings, State Parks would not allow ICF International to use their letterhead because of the substantial incentives being offered. The first letter resulted in very low response rates mostly because people did not think the survey was valid. Several major changes were made in subsequent mailings that somewhat increased participation. First ICF International got State Parks to put a reference to the study on their website and included that website link in the letter (see Appendix B). Second, the letter stated that the incentives were not coming from the State of California General Fund. Finally, that we wanted people to respond whether they recreate off highway or not and that they would be entered into the sweepstakes drawing just for returning a log book even if they didn't recreate off-highway. The

[41] Wave 1 and all non-registered OHVs were pre-recruited from the Component 1 survey. They were randomly selected from the Component 1 respondents that provided names and addresses based upon the sampling plan discussed in Section 5.4.

final change came in the last invitation letter mailing in which State Parks allowed us to use their letterhead and it was signed by the Director of California State Parks. This led to over 50% higher return rate over the ICF International invitation letters.

5.5.2. Household Selection

The returned forms were then processed to create a pool of vehicles that were eligible to be selected for participation in the Component #2 survey. Log books were then mailed to each selected household for each wave at the appropriate time based upon the sampling plan discussed in Section 5.3.

5.5.3. Data Collection & Follow-up

Once the log books had been mailed to households, ICF International established an 800-phone line that participants could call should they have any questions about the study (See Section 5.10). At the conclusion of the data collection wave, Mountains West Research Center attempted to contact via phone all households that did not return a log book to encourage them to return the log book, allow them to report their log book information over the phone, or determine that they did not collect the information and then recruit them for the next wave if appropriate. Mountains West Research Center made at least five calls per household, as needed.

The principal advantage of the approach outlined above was that respondents who failed to return a log book could be contacted directly via phone to encourage their participation, collect the data over the phone, or be personally recruited for the next wave. This had the effect of increasing response rates and the reliability of the data collected. Follow-up calls were conducted in the evenings (5PM to 9PM) during weekdays and between 10AM and 5PM on weekends. If needed, at least five attempts were made to complete a follow-up. The timing of follow-up calls was rotated to avoid systematically calling the household at a specific time that may have conflicted with their daily routines. This minimized the chances that the household would not be contacted due to "bad timing".

Because some respondents preferred to have the data collected via phone rather than mailing in their log book, or simply forgot to mail the log book, the person making the follow-up call had a CATI-based interview ready so that all of the information was collected and recorded appropriately. The CATI program was thoroughly reviewed and tested by True North Research prior to fielding.

Follow-up calls were also used to resolve issues that arose when keypunching the data from returned log books. If, for example, the log book did not provide sufficiently clear information on a key variable, a callback was conducted to identify the appropriate information.

5.6. Incentives

Substantial incentives were provided to participants in the study in the form of a sweepstakes drawing. Each of the six waves had a $5,000 prize plus five $1,000 prizes. In addition there was a $25,000 grand prize awarded at the end of the study. Households that returned a completed fuel use log book or read their log book over the telephone were entered into a sweepstakes drawing. Entries were randomly selected without regard to the type of vehicle they drove or whether or not they recreated off-highway during the log book period. A total of $85,000 in cash prize awards was given to participants of the study.

5.7. Data Collection Waves

Fuel use log books were sent to households that were recruited from the Component 1 survey or responded to the invitation letter with a completed return form over a one year period. Log books were sent in six 2-month waves starting in April 2004. Because of the urgency to get the survey started, Wave 1 was taken entirely from the Component 1 survey participants. It was weighted differently (as discussed in Section 5.11) than the randomly selected registered DMV households. Waves 2 through 6 used non-registered vehicles from the Component 1 survey (also weighted differently than the DMV sample) and registered street-licensed and non-street licensed vehicles from the DMV sample that showed interest in participating via a completed Return Form. Unfortunately, Wave 2 had significantly fewer participants due to the low initial response to the initial invite letter. The low response in Wave 2 was compensated for in Wave 6. 27,296 fuel use log books were sent to households during the six waves as shown in Table 5-6. Over 15,000 were completed and returned as shown in Table 5-7. Responses from these log books were used to develop the results found in Section 6.

5.8. Log Book Design

The log book was designed to measure fuel use by off-highway drivers in California by Drs. Ken Kurani and Tom Turrentine of University of California, Davis. Drs. Kurani and Turrentine are experienced researchers in travel behavior and fuel use. They have worked with log book design since 1994. This fuel use log book survey was particularly challenging for reasons listed below. However, iterative design and real world testing led to a practical and reliable log book instrument.

Table 5-6. Fuel Use Log Books Sent to Participants

Vehicle Type	Reporting Waves						
	1	2	3	4	5	6	Total
Car 2WD	788	294	380	321	441	530	2,754
Car 4WD	208	104	127	68	366	165	1,038
SUV 2WD	142	175	148	117	117	192	891
SUV 4WD	841	897	1,146	782	1,198	1,283	6,147
Truck 2WD	787	252	342	220	297	449	2,347
Truck 4WD	1,352	647	758	568	194	1,059	4,578
Van 2WD	250	149	204	156	201	279	1,239
Van 4WD	81	102	114	73	9	155	534
Street MC	119	58	79	156	90	102	604
Dual Sport MC	33	13	11	19	14	45	135
SL Other	52	31	25	22	37	110	277
Motorcycle-Reg	52	187	173	182	181	230	1,005
ATV-Reg	43	47	54	103	45	65	357
4 Wheel - Reg	5	23	17	19	13	17	94
Snowmobile - Reg	20	18	12	16	15	21	102
Other - Reg	2	-	-	-	-	-	2
Motorcycle-Non-Reg	198	200	300	383	342	416	1,839
ATV-Non-Reg	79	140	200	485	455	554	1,913
4 Wheel - Non-Reg	100	112	115	272	241	242	1,082
Snowmobile - Non-Reg	25	25	25	52	48	46	221
Other - Non-Reg	20	19	20	29	26	23	137
Totals	5,197	3,493	4,250	4,043	4,330	5,983	27,296

Table 5-7. Completed Fuel Use Log Books Returned

Vehicle Type	Reporting Waves						
	1	2	3	4	5	6	Total
Car 2WD	467	177	253	224	319	362	1,802
Car 4WD	114	65	82	61	274	116	712
SUV 2WD	69	121	92	86	81	131	580
SUV 4WD	493	515	730	582	800	859	3,979
Truck 2WD	432	143	232	157	193	287	1,444
Truck 4WD	727	371	456	385	136	671	2,746
Van 2WD	123	84	108	111	132	166	724
Van 4WD	33	60	66	48	5	96	308
Street MC	63	45	56	124	64	73	425
Dual Sport MC	19	7	7	20	16	31	100
SL Other	23	20	17	16	33	72	181
Motorcycle-Reg	63	165	157	196	187	200	968
ATV-Reg	51	63	87	209	133	133	676
4 Wheel - Reg	8	17	10	15	15	15	80
Snowmobile - Reg	19	17	14	34	28	29	141
Other - Reg	1	1	1	-	-	-	3
Motorcycle-Non-Reg	40	40	55	81	53	45	314
ATV-Non-Reg	18	30	50	123	88	98	407
4 Wheel - Non-Reg	23	15	16	43	33	24	154
Snowmobile - Non-Reg	7	7	7	9	7	4	41
Other - Non-Reg	1	2	1	7	6	7	24
Totals	2,794	1,965	2,497	2,531	2,603	3,419	15,809

Design goals were to make the log book simple but also engaging. The log book was used to measure fuel use by an owner in a designated vehicle over a two-month period. To discourage false log book entries but obtain a high rate of return, sweepstake incentives were used to reward returning log books, regardless of whether a fuel use event had occurred during the log book wave period.

The fuel use log book presented many challenges. First, the log book was intended to measure intermittent use of a designated vehicle over a long period (usually travel log books measure repetitive behaviors over a few days). Second, the log book was to cover behavior, which took place often in remote locations, often during vacation periods (when log book users are focused on new activities). Third, the log book had to be clear to a wide range of off-highway vehicle users, including snowmobilers, dirt bikers, jeep users, sand rails, and ATVs as well as other drivers who are using normal street vehicles off-highway to access recreational activities such as camping, hiking, fishing, and mountaineering. Further challenges were to define clearly for users when they were on a qualifying road (and non-road) surface. Finally, many off-road type vehicles do not have fuel gauges and thus the design had to offer alternative means to record and calculate fuel use for a measured fuel use event. Vehicles also use different types of fuels.

The basic log book content was determined in meetings with a small group of the OHV Stakeholders Roundtable, who helped flesh out the basic questions and identify potential problems. From these initial ideas, a draft set of instructions; definitions and a "day" of use for the log book were developed and circulated among the Stakeholders, and then redrafted with their input. The log books used for the fuel use study included the following information and a sample log book can be found in Appendix C:

- Date vehicle used off-highway, i.e., the date of this data record.
- Location of off-highway driving: “area’s common name” and the name of the county and nearest city and street names (where applicable)
- Up to three types of recreation activities that were pursued during the recorded day.
- The amount of gasoline used when they traveled off-highway for that day.
- Distance traveled off-highway that day (or for that location and date). This data will be collected for vehicles that have odometers.

- Hours the vehicle was used off-highway throughout the day (less stopping time). This data will be collected for vehicles that do not have odometers.
- Whether the fuel used this day was purchased in California
- (Dependent on type of vehicle) Whether or not a trailer was towed off-highway by this vehicle.
- Type of terrain (sand, hills, desert) and type of use (easy, moderate, hard/racing).
- Type of fuel used that day (racing fuel, gasoline, two-stroke (gas-oil mix), or diesel.[42])

5.9. Log Book Pilot Test

The fuel use log "booklet" was designed to record several days of off-highway driving by the widest range of users. The booklet was circulated for testing and review by a wider range of users, including snowmobilers, dirt bikers, hikers, and others recommended by the OHV Stakeholders Roundtable members. This test sample was encouraged to try using the log book on their next trip off-highway, to mark up the log book with questions and suggestions. We called several testers who answered questions in an unexpected way.

Finally, Drs. Kurani and Turrentine visited Hollister Hills, a California State Vehicular Recreation Area, and handed out log books to motorcycle and ATV riders and jeep and truck users who used the log book that day and were then interviewed at the end of the day about the log book, to gather their impression of its legitimacy, clarity and ease of use. We interviewed them to check if their written responses were congruent with our goals. Returned log books and interviews were rewarded with a modest cash incentive. Additionally, more log books were handed out to be returned in the mail after a few weeks of additional travel events.

As a result of this pilot test, problems with the log books had been reduced and most log books were completed without error. Based on final feedback from interviews and returned log books, a final iteration was developed and printed for the first distribution of log books to the project sample. Still, given the complexities of the log books, a "hotline" was established for help with the log books (See Section 5.10), but as is recorded about the hotline, the log book design worked well; users described it as straight forward and understandable and for the most part engaging. Considering the complexities of this log book, the final log book which was used for all waves of this study can be considered a success.

[42] Racing and diesel fuel use are not considered vehicle motor fuels per Section 7326 of the Revenue and Taxation Code.

5.10. Telephone Helpline

The objective of the telephone helpline was to increase survey participation and accuracy of participant responses by providing answers to questions generated by the survey mailings. Each participant received (at least) two separate mailings: an invitation to participate in the survey and the fuel use log book.

Helpline calls prompted by the invitations fell into two categories, those that were directly related to filling out the return form and others that were more general. Callers with difficultly filling out the return form were more often non-English speakers. These callers requested assistance with the response bubbles for the phone numbers or understanding the decision tree of the return form. Invitation recipients also needed assistance substituting an appropriate alternative vehicle, if they had sold the car that was named on the return form.

Callers with questions of a general nature wanted to know who we were; what was our objective; and what we would do with the information. Some callers were suspicious that the survey was commercial in origin; others were concerned about the cost to tax payers; and others felt the data would be used to restrict motorized access to public land. Still others were primarily concerned with how we had obtained information about them.

These concerns were addressed by providing the following information. They were told that the State was mandated by law to periodically survey the use patterns of public roads in California. The purpose of these surveys was to determine the correct allocation of public funds for the maintenance of the roads. Because this is a random sample, you may be asked to provide information about a car that is never driven off-road. Because this is a survey being conducted by the State, the DMV provided vehicle information to ICF International, the company contracted to conduct the survey for the State. This particular survey was being conducted by California State Parks and Recreation for the maintenance of roads and areas under their jurisdiction. Restriction was not the goal. Correct allocation of funds to the various parks was the goal. A sweepstake drawing is the most economical way to encourage respondents to finish surveys. Many of these calls dropped off when we were able to use the State Park letterhead on the invitation.

Typical fuel use log book calls were: 1) Invitees had lost, or never received a return envelope; 2) Invitees had to substitute a vehicle for the one designated by ICF International; 3) The invitee was unable to drive vehicle because of injury or weather or travel; 4) The invitees wanted to know if we will use this information to restrict their access to parks; 5) How can the

State afford this? 6) Is it too late to mail this in? and, 7) Why do you want information about a car that can't be driven off-road? Don't you want to know about the vehicle that I do drive off-road?

5.11. Methods for Weighting and Statistical Analyses of the Fuel Use Log Book Responses

5.11.1. Introduction

In Section 4.5 we described the statistical methods and weights used to analyze the responses in the Component 1 telephone survey data. In Component 2, fuel use log books were obtained from a sample of vehicle owners. Each vehicle owner provided information on "gallons used per recreational day," more precisely defined as the gallons of fuel used for recreation (driving to recreation or driving for recreation) on public lands in California in each recreational day during a two month "wave" or "period." Only one vehicle was sampled per household, but some vehicles were sampled for more than one wave. This section describes the statistical methods used to weight and analyze the Component 2 gallons used per month data. (Other fuel use log book information such as gallons used for specific activities can be analyzed in a similar manner). The methodology is based on the methodology and telephone survey weights in Section 4.5 which will be referred to frequently.

Vehicle samples for the Component 2 survey were drawn in two ways. For wave 1, April and May 2004, all households were sampled from the Component 1 telephone survey responders that said they were willing to participate in the Component 2 survey. For waves 2 through 6, June 2004 to March 2005, the non-registered off-highway vehicles (OHVs) were also selected from the Component 1 responders that said they were willing to participate in the Component 2 survey and had an off-highway vehicle that could not be found in the DMV registration database. We shall refer to both these groups of vehicles as the "household-selected" vehicles. For waves 2 through 6, registered OHVs and street-licensed vehicles (SLVs) were selected randomly from DMV registration lists. We shall refer to those vehicles as the "DMV-selected" vehicles.

Vehicles were grouped into 21 vehicle classes described in Section 5.2. The sampling of the household-selected vehicles from the telephone survey households was not an exact probability sample but was chosen as randomly as possible to meet several constraints:

- Households were willing to participate in the fuel use log book survey, i.e., they responded positively to the participation question in the telephone survey.

- The total numbers of vehicles in each of the 21 vehicle classes should be close to the target values identified in the sample design (as described in Section 5.4)
- Only one vehicle was sampled per household. If the household had more than one vehicle of a given class, then the log book vehicle was selected at random.
- For each vehicle class and county, the number of log books sent was approximately proportional to the number of vehicles in that class and county. For this calculation of the number of vehicles by class and county, each household was weighted using the telephone survey weights, as presented in Section 4.5.
- The household completed and submitted their fuel use log book.

Since the telephone survey was intentionally biased towards OHV-owning households in rural areas, and since the wave 1 (and wave 2-6 non-registered OHV) Component 2 survey was a random sample of households from the telephone survey, the responses needed to be properly weighted to adjust for this bias, as described below. The crucial statistical issue is that because these vehicles were selected using the telephone survey responses, these samples were really samples of telephone lines, rather than of households or vehicles. Separately for each vehicle class, we treated the data as a stratified random sample of telephone lines from strata defined by the county, OHV ownership, and vehicle class ownership.

In waves 2 through 6, the DMV-selected SLVs and registered OHVs were selected randomly from DMV lists. For each vehicle class, the number of invitation letters sent for each county was proportional to the number of those vehicles in that county, as estimated from the telephone survey. In this case the statistical analysis is different and much simpler since for each vehicle class, we had a stratified random sample of vehicles, where the strata were the counties.

The primary goal of these analyses was to estimate monthly, bi-monthly, and annual gallons used for driving to or for off-highway recreation on public lands in California. For the rest of this section, we will refer to this as “gallons used,” without the cumbersome explanatory clause.

The first step, detailed in Section 5.11.2, was to estimate the numbers of vehicles by vehicle class and county as well as total counts by vehicle class for all counties. Although these estimates were initially based on the telephone survey data, the final set of estimates for the registered OHVs and for the SLVs were based on the DMV counts developed by Cenzer for this

project. For the non-registered OHVs, vehicle counts were estimated by multiplying the counts for the registered OHVs by suitable correction factors estimated from the telephone survey using the methods for estimating ratios and their uncertainty that were described in Section 4.5.5. For 4-wheel vehicles, ATVs, snowmobiles, and motorcycles, the correction factor equals the weighted sum of the household numbers of non-registered vehicles of each class divided by the weighted sum of the household numbers of registered vehicles of that class. The weights are the Component 1 household weights given in Section 4.5.2. For each county, and for the California total, the estimated count for non-registered vehicles is obtained by multiplying the vehicle class count for registered vehicles by this correction factor. Because there were few vehicles in the OHV Other category, the correction factor for the OHV Other category was the weighted sum of the household numbers of non-registered OHV Other vehicles divided by the weighted sum of the household total numbers of all registered OHVs:

For class T = 4-wheel vehicles, ATVs, snowmobiles, or motorcycles,

Non-registered OHVs of class T

= Registered OHVs of class T $\times$ Correction Factor

Correction Factor = $\sum_c \sum_A \sum_u R(u, c, A)\, w(u, c, A) / \sum_c \sum_A \sum_u N(u, c, A)\, w(u, c, A)$

where R(u,c,A) and N(u,c,A) are the observed numbers of registered and non-registered class T vehicles for household u, county c and the owner/non-owner subset A, and w(u, c, A) is the telephone survey weight.

Non-registered Other OHVs = Registered Other OHVs $\times$ Correction Factor

Correction Factor = $\sum_c \sum_A \sum_u O(u, c, A)\, w(u, c, A) / \sum_c \sum_A \sum_u All(u, c, A)\, w(u, c, A)$

where O(u,c,A) and All(u,c,A) are, respectively, the observed numbers of registered OHV Other and of All non-registered OHVs for household u, county c and the owner/non-owner subset A, and w(u, c, A) is the telephone survey weight.

The correction factors and their 95% confidence intervals are presented in Section 5.11.2. We assumed that the only source of error in the vehicle counts was due to the uncertainties in the correction factors due to the random variation in the telephone survey.

The detailed analysis of the household-selected vehicles is presented in Section 5.11.3. For all 21 vehicles classes in wave 1, for the non-registered OHV ATVs, motorcycles,

snowmobiles, and 4-wheel vehicles in waves 2 through 6, and for the OHV Other vehicles in waves 2 through 6[43], we used a weighted analysis of the telephone survey data to calculate the gallons used per vehicle. For each vehicle class and month (or wave), the gallons used per vehicle was estimated as the ratio of the weighted average gallons used per California household to the weighted average number of vehicles per California household. The gallons used was then estimated by multiplying the gallons used per vehicle by the number of vehicles in California in the vehicle class. Since the household-selected vehicles were treated as a stratified random sample of telephone lines, the sampling weights for these weighted averages are defined for each of the 15,691 sampled telephone lines, i.e., for each household. However, we show in Section 5.11.3 how these sampling weights were converted into vehicle statistical weights.

Separately for each vehicle class, we treated the household-selected vehicles as a stratified random sample of telephone lines from strata defined by the county, OHV ownership, and vehicle class ownership. The first two stratification variables are exactly as in Section 4.5, where we described the analyses of the telephone survey data. The extra vehicle class ownership stratification adjusts for the necessary bias of the log book survey towards households that owned vehicles of the given vehicle class. The log book households were necessarily drawn from the households that own at least one vehicle of the given vehicle class, but those households that do not own any such vehicles obviously used zero gallons of fuel.

In Section 5.11.4, we will describe the analysis of the DMV-selected vehicles, which applies in waves 2 through 6 for the 11 street-licensed vehicle classes and four of the five registered OHV vehicle classes. (The small number of registered and non-registered Other OHVs was treated as a single vehicle class selected from the telephone survey). For each county, vehicle class and month (or wave), the gallons used per vehicle was estimated as the arithmetic average gallons of fuel used per vehicle in that county. To estimate the gallons used per vehicle for the entire state, a weighted average of the county average gallons per vehicle was calculated, where the county weight is the total number of vehicles in the county and vehicle class. Counties without log book data are excluded from this weighted average, under the assumption that the counties with data are representative of the counties without data. (The analyses of the household-selected vehicles was also based on this assumption). Finally, the

[43] The registered and non-registered Other OHVs were combined into one group for calculating gallons used per vehicle because there was limited data on this vehicle category.

gallons used per vehicle class and month (or wave) was estimated by multiplying the gallons used per vehicle by the number of vehicles in the vehicle class:

Gallons used per vehicle in class T =

Σ_c Gallons used per vehicle in class T, county c $\times$ Vehicles (c) / Σ_c Vehicles (c)

where Vehicles (c) is the total number of vehicles of class T in county c, both sums are across only those counties with log book data for class T in the wave of interest, and

Gallons used per vehicle in class T, county c =

$\Sigma_{\text{log book vehicles in county c, class T}}$ Gallons used / No. of log book vehicles in county c, class T.

Section 5.11.5 describes how we used those results to estimate total fuel use summed over the year and/or the vehicle classes, the corresponding gallons used per vehicle, and their margins of error.

5.11.2. Vehicle Counts

Table 5-8 presents the total State vehicle counts in each of the 21 vehicle classes, based on the DMV registration data. For the street-licensed and registered OHV classes, these are the sums of the county totals provided by Cenzer. For the non-registered OHV classes, these estimates were made by applying correction factors to the counts for registered OHVs, as shown in the formulae presented in Section 5.11.1.

For OHV class T = 4-wheel vehicles, ATVs, snowmobiles, or motorcycles:

Non-registered OHVs of class T = Registered OHVs of class T $\times$ Correction Factor

Correction Factor = $\sum_c \sum_A \sum_u R(u, c, A) \times w(u, c, A) / \sum_c \sum_A \sum_u N(u, c, A) \times w(u, c, A)$

where R(u,c,A) and N(u,c,A) are the observed numbers of registered and non-registered class T vehicles for household u, county c and the owner/non-owner subset A, and w(u, c, A) is the telephone survey weight.

For OHV Others:

Non-registered Other OHVs = All Registered OHVs $\times$ Correction Factor

Correction Factor = $\sum_c \sum_A \sum_u O(u, c, A) \times w(u, c, A) / \sum_c \sum_A \sum_u All(u, c, A) \times w(u, c, A)$

where O(u,c,A) and All(u,c,A) are, respectively, the observed numbers of non-registered OHV Other and of All registered OHVs for household u, county c and the owner/non-owner subset A, and w(u, c, A) is the telephone survey weight.

Table 5-8. Vehicle Counts by Vehicle Class

Vehicle Type	Vehicles
Car 2WD	13,874,265
Car 4WD	347,352
SUV 2WD	1,912,732
SUV 4WD	2,176,385
Truck 2WD	3,716,946
Truck 4WD	991,787
Van 2WD	2,187,834
Van 4WD	37,078
Dual Sport Motorcycle	46,696
Street Motorcycles	512,681
Street Licensed Other	277,540
Total Street Licensed	26,081,296
Reg Motorcycles	338,169
Reg ATV	335,897
Reg 4 Wheel Vehicles	19,329
Reg Snowmobiles	18,502
Reg Other	2,168
Total Reg OHVs	714,065
Non-Reg Motorcycles	209,725
Non-Reg ATVs	171,803
Non-Reg 4 Wheel Vehicles	53,561
Non-Reg Snowmobiles	8,354
Non-Reg Other	9,344
Total Non-Reg OHVs	452,787
Total All Vehicles	27,248,148

The estimated correction factors and their 95% confidence intervals are presented in the Table 5-9. The 95% confidence interval is between the lower bound and the upper bound. This equals the correction factor plus or minus the margin of error (%).

Table 5-9. Correction Factors

Vehicle Type	Correction Factor	Margin of Error (%)	Lower Bound	Upper Bound
Motorcycles	0.6202	18.814	0.5035	0.7369
ATVs	0.5115	19.695	0.4107	0.6122
4 Wheel Vehicles	2.7710	41.166	1.6303	3.9117
Snowmobiles	0.4515	82.868	0.0774	0.8257
Other	0.0131	66.453	0.0044	0.0218

Each of these correction factors is a ratio estimate, i.e., the weighted sum over households of non-registered OHVs divided by the weighted sum over households of registered OHVs. The estimated correction factors and their uncertainty estimates were computed using the formulae in Section 4.5.5. These weighted sums were summed across all telephone survey households where the numbers of registered OHVs (for the denominator) and non-registered OHVs (for the numerator) were both not missing. For all households with one or more OHVs that were found in the DMV registration database, the numbers of registered and non-registered vehicles of each of the five OHV vehicle types were easily calculated from the survey responses (either number could be zero). For households with zero OHVs, the numbers of registered and non-registered OHVs in each vehicle class are zero. For households with one or more OHVs that were not found in the DMV registration database, the numbers of registered and non-registered OHVs of class T are missing if they have more than one class T vehicle (since it is unknown whether or not those vehicles were registered), but are zero if they do not have any class T vehicles. Note that telephone survey households with zero registered and zero non-registered OHVs of class T do not contribute to the correction factor ratio but they are an important part of the variance calculation for the correction factor.

5.11.3. Analysis of Log Book Responses Drawn From the Telephone Survey

As described in Section 5.11.1, the wave 1 log book households and all the non-registered OHV log book households were drawn from the telephone survey responders. The registered OHV Other vehicles were combined with the non-registered OHV Other vehicles, as described later. An exact calculation of the sampling probabilities is not tractable because of the complex process under which households / vehicles were selected to meet various constraints, in addition to the varying response rates. Instead, we assumed that the survey could be treated as being approximately a stratified random sample of telephone lines from strata defined by the county, OHV ownership, and vehicle class ownership. The first two stratification variables are exactly as in Section 4.5, and adjust for the biases towards households with more telephones,

OHV-owning households, and counties with higher OHV ownership rates. The additional vehicle class ownership stratification accounts for the fact that the log book survey was necessarily biased towards households that own at least one vehicle of the given vehicle class, since households without those vehicles would be excluded. The telephone survey households were divided into four groups.

(1) Households with unknown numbers of class C vehicles (i.e., for OHV vehicle classes, households that were not found in the DMV database) were treated as being randomly missing and excluded from the analysis.

(2) Households with zero class C vehicles were treated as having zero vehicles and zero gallons and all were selected with probability one.

(3) A random subsample of the households with at least one vehicle of class C was selected to be in the log book survey and was included in these analyses.

(4) The remaining households with at least one class C vehicle but not in the log book survey are also treated as being randomly missing, since the gallons used is unknown.

Since the sampling rates in each stratum vary with the vehicle class and stratum, each vehicle class was analyzed separately. For simplicity, in Section 5.11.5, where we sum estimates across vehicle classes, we assumed that the vehicle class fuel use estimates were approximately independent.

The following analyses were carried out for all 21 vehicle classes in wave 1. For waves 2 through 6, they were carried out for non-registered OHV ATVs, motorcycles, snowmobiles, and 4-wheel vehicles, and the combined class of OHV Other vehicles. For OHV Other vehicles, there were only 27 log books, of which 24 were from household-selected non-registered vehicles, two were from household-selected registered vehicles, and one was from a DMV-selected registered vehicle. Due to the small numbers of OHV Other log books, we decided to combine the registered and non-registered OHV Other vehicles into a single class for the purpose of estimating gallons per vehicle. We also decided to drop the single DMV-selected log book from the analyses rather than attempting to model it separately.

The general approach was to estimate gallons per vehicle from the telephone survey and then to estimate total gallons used by multiplying gallons per vehicle by the vehicle class counts estimated in Section 5.11.2. The estimated gallons per vehicle is a ratio estimate of

gallons per household to vehicles per household. This suggests that an alternative approach would have been to estimate total gallons used and total vehicles by simply multiplying the mean gallons per household and mean vehicles per household by the total number of households in California. We did not choose this method because we assumed that the vehicle counts from DMV registrations should be much more precise than estimated vehicle counts from a survey, especially since the responders made frequent errors about their vehicle types. Even if the estimated vehicles per household from the survey is not very reliable, it is plausible that the gallons per vehicle ratio is more reliably estimated.

In the remainder of this Section, we present the detailed steps of our analysis of the household-selected log book data. The six steps of the analysis are mathematically complicated, but follow a similar approach to the telephone survey analyses presented in Sections 4.5.3 to 4.5.5. Finally, we present the calculations of the vehicle weights and of the uncertainty of total gallons used.

Step 1. Vehicle counts for each household

Let C be the selected vehicle class. The first step was to estimate the number of vehicles in class C for each household. For the vehicle counts we used the data corrected for incorrectly classified vehicles (including vehicles reported as OHVs in the telephone survey that should have been treated as street-licensed), duplicate vehicles (e.g., reported both as OHVs and street-licensed vehicles), additional or replacement vehicles used for the log book survey, and additional or replacement vehicles found in the DMV registration database (See Section 4.14). If a street-licensed vehicle of class C in the log book survey was not in any of the vehicle classes reported in the telephone survey, this was treated as an extra vehicle in class C and not a replacement vehicle. The justification for this approach is that the analysis of gallons used was based on the log book responses and so the vehicle counts should reflect the numbers of vehicles at or near to the time of the log book survey, rather than the numbers of vehicles at the time of the earlier telephone survey. For the following class and household combinations, the numbers of vehicles were known directly: street-licensed classes and all households; the OHV Other class and all households; and non-street-licensed classes and those households found in the DMV database. For non-street-licensed classes and households not found in the DMV database, the numbers of registered and non-registered vehicles in the ATV, motorcycle, snowmobile and categories are zero if there are zero OHVs in that category. For non-street-licensed classes and households not found in the DMV database, the numbers of registered and non-registered vehicles in the ATV, motorcycle, snowmobile and categories are missing if

there are some OHVs in that category; if so, the household is excluded from the analysis of class C.

Step 2. Gallons used for each household

The second step was to estimate the monthly or two-month wave fuel use for class C vehicles by each household. If the number of class C vehicles is zero, then the household monthly or wave fuel use is known to be zero, even though that household did not participate in the log book survey for that vehicle class. Those households with zero vehicles and zero fuel use were treated as being part of the "fuel survey" for class C and included in these analyses. Note the distinction between the "log book survey," which are the vehicles with log books, and the "fuel survey," which includes the log book survey households plus the extra households with zero class C vehicles. The statistical analysis of the fuel use from the telephone survey households is based on the larger fuel survey.

If the number of vehicles in class C was one or more, but none of those vehicles were included in the log book survey, then that household has missing data for the fuel survey and was excluded from the analysis, since the gallons used is obviously unknown. If the number of vehicles in class C is one or more, and one of those V vehicles was included in the log book survey, then the number of vehicles equals V and the household monthly fuel use is estimated as V multiplied by the log book total gallons:

Estimated Household Fuel Use in month or wave

= No. of vehicles $\times$ Month or wave fuel use on log book vehicle (gallons).

These estimates are unbiased for the household total fuel use for class C, assuming that the log book vehicle was selected at random from the pool of V available class C vehicles. Note, however, that for simplicity, this analysis will ignore the uncertainty in the estimated household fuel use attributable to estimating household fuel use from one household vehicle only.

Households also needed to be classified as OHV-owning or non-OHV-owning households for the purposes of stratification and weighting. As discussed in Section 4.5.2, OHV-ownership was usually based on the answer to survey Question 4, paraphrased as "Do you own an off-highway vehicle?" We used this survey question rather than counting the actual OHVs owned (after any vehicle type data corrections) primarily because the stratification for the screening survey was based on this question. (The screened-out "No" responders in the screening survey were not asked the more detailed questions about vehicles owned.) The

answers to Question 4 were also used to estimate the county proportions of OHV-owning households that were needed to compute the sampling weights. For the street-licensed vehicle categories, using the answer to Question 4 to define OHV-owning households for stratification and weighting introduces no inconsistencies. For the OHV categories, in wave 1 only, there were a few households where the response to Question 4 was No, but the log book vehicle was an OHV. This could occur if the household obtained an OHV between the telephone and log book surveys or if the answer to Question 4 was incorrect. Since we chose to analyze the OHV classes using only the OHV-owning strata, any households that had a log book OHV but said they were not OHV-owners for Question 4 were treated as being OHV-owning households for the analyses of the OHV vehicle classes but were treated as being non-OHV-owning households for the analyses of the street-licensed classes. This issue arose rarely and so has little impact on the results.

Step 3. Telephone lines per stratum

The third step was to estimate the number of telephone lines in each stratum. For each combination of county and OHV owner or county and OHV non-owner, we estimated the number of telephone lines, N(county, A), in Section 4.5.3 by

N(county, OHV owner) = Estimated Telephones in OHV-owning households

= Estimated Telephones (county) × Fraction OHV-owners (county)

N(county, OHV non-owner)

= Estimated Telephones in non-OHV-owning households

= Estimated Telephones (county) × {1 - Fraction OHV-owners (county)}

For the fuel survey, the strata are defined by three variables instead of two:

- County
- A = OHV owner or OHV non-owner
- B = Class C owner or Class C non-owner.

For each county and A, let

G(county, A) = Number in county in group A and having a known number of class C vehicles

C(county, A) = Number in county in group A with at least one class C vehicle.

(These counts include households that were NOT included in the fuel survey but have known numbers of class C vehicles, i.e., households participating in the telephone survey that did not participate in the log book survey for the given vehicle class and month or wave). The ratio C/G estimates the proportion of households in the (county, A) stratum that have at least one vehicle. Therefore we can estimate the population number of telephone lines in the stratum defined by (county, A, B) by multiplying N(county, A) by C/G or 1-C/G, respectively:

Fraction Class C-owners (county, A) = C(county, A) / G(county, A)

Fraction Class C-non-owners (county, A) = 1 - C(county, A) / G(county, A)

N(county, OHV owner, Class C owner)
= Estimated Telephones in OHV-owning Class C-owning households
= Estimated Telephones (county) × Fraction OHV-owners (county)
× Fraction Class C-owners (county, OHV owner)

N(county, OHV owner, Class C non-owner)
= Estimated Telephones in OHV-owning Class C-non-owning households
= Estimated Telephones (county) × Fraction OHV-owners (county)
× Fraction Class C-non-owners (county, OHV owner)

N(county, OHV non-owner, Class C owner)
= Estimated Telephones in OHV-non-owning Class C-owning households
= Estimated Telephones (county) × Fraction OHV-non-owners (county)
× Fraction Class C-owners (county, OHV non-owner)

N(county, OHV non-owner, Class C non-owner)
= Estimated Telephones in OHV-non-owning Class C-non-owning households
= Estimated Telephones (county) × Fraction OHV-non-owners (county)
× Fraction Class C-non-owners (county, OHV non-owner)

Step 4. Sampling weights and Gallons per vehicle

The fourth step was to calculate the sampling weights. (These weights are applied to each household / telephone line and are different to the vehicle weights that are described later.) The primary goal was to estimate gallons per vehicle. This is defined as the ratio of the total gallons used by class C vehicles in California households to the total number of class C vehicles in California households. Suppose that for every household, Z* denotes the number of

gallons used divided by the number of telephone lines and T* denotes the number of vehicles divided by the number of telephone lines. The sum of Z* across all residential telephone lines in California equals the total gallons used. The sum of T* across all residential telephone lines in California equals the total number of vehicles. The ratio of these two sums is the California gallons per vehicle.

Define

N(county, A, B) = Estimated total number of telephone lines in the stratum (county, A, B), as calculated in the third step

n(county, A, B) = Sampled number of telephone lines in the stratum (county, A, B)

Since the random sampling is over telephone lines, the telephone line sampling weight in the stratum (county, A, B) is

TLSW = N(county, A, B) / n(county, A, B)

and the gallons per vehicle is estimated as the weighted sum of Z* for the sampled households / telephone lines divided by the weighted sum of T* for the sampled households / telephone lines, where the weights are TLSW.

Instead of using Z* and T* and the weights TLSW, it is more convenient to express this same ratio in terms of the gallons used and the number of vehicles.

Define

Telephones(u, county, A, B) = Number of telephone lines for household u in the stratum (county, A, B)

Sampling weight = w(u, county, A, B)
= N(county, A, B) / {n(county, A, B) × Telephones(u, county, A, B)}

z(u, county, A, B) = Gallons used by household u class C vehicles

t(u, county, A, B) = Class C vehicles owned by household u

The estimated California gallons per vehicle is easily shown to be equal to the weighted sum of z for the sampled households / telephone lines divided by the weighted sum of t for the sampled households / telephone lines, where the weights are the sampling weights, w:

Gallons per vehicle = $\hat{R}$ =

$$\sum_c \sum_A \sum_B \sum_u z(u, c, A, B) \times w(u, c, A, B) \,/\, \sum_c \sum_A \sum_B \sum_u t(u, c, A, B) \times w(u, c, A, B)$$

where the quadruple sum is over all sampled households (u), counties (c), OHV ownership subgroups (A), and class C ownership subgroups (B).

Step 5. Estimate gallons per vehicle and its uncertainty.

The fifth step was to use the sampling weights to calculate the estimated gallons per vehicle and its sampling variance. The estimated ratio $\hat{R}$ is defined above. Using the same basic proof as in Section 4.5.5, but extended to the (county, A, B) stratum definition, it can be shown that the variance of the estimated gallons per vehicle is given by the formula:

Var = Estimated Variance (Gallons per vehicle)

$$= \sum_c \sum_A \sum_B n(c, A, B) \times \{1 - f(c, A, B)\} / \{n(c, A, B) - 1\}$$
$$\times \sum_u \{e(u, c, A, B) - \bar{e}(c, A, B)\}^2 + V_1 + V_2$$

f(c, A, B) is the sampling fraction:

$$f(c, A, B) = n(c, A, B) / N(c, A, B)$$

e(u, c, A, B) is an error term, with stratum mean $\bar{e}(c, A, B)$:

$$e(u, c, A, B) = w(u, c, A, B) \times \{z(u, c, A, B) - t(u, c, A, B)\, \hat{R}\}$$
$$/ \sum_c \sum_A \sum_B \sum_u w(u, c, A, B) \times t(u, c, A, B)$$

$$\bar{e}(c, A, B) = \sum_u e(u, c, A, B) / n(c, A, B)$$

As in Section 4.5.5, V_1 is a correction term to account for the uncertainty of the estimated sampling weights because of the uncertainty of the proportions of OHV-owning households:

$$V_1 = \left\{1 / \left\{\sum_c \sum_A \sum_B \sum_u w(u,c,A,B)\, t(u,c,A,B)\right\}^2\right\} \times \sum_c \mathrm{Var}(\mathrm{PropOHV}(c)) \times$$
$$\left\{\frac{\sum_{A=\text{OHV owner}} \sum_{B,u} (z(u,c,A,B) - t(u,c,A,B)\hat{R})\, w(u,c,A,B)}{\mathrm{PropOHV}(c)} - \frac{\sum_{A=\text{OHV non-owner}} \sum_{B,u} (z(u,c,A,B) - t(u,c,A,B)\hat{R})\, w(u,c,A,B)}{1 - \mathrm{PropOHV}(c)}\right\}^2$$

where PropOHV(c) is the estimated proportion of OHV-owning households in county c.

PropOHV(c) = h(c) / nall(c), and

Var (PropOHV(c)) = (H(c) – nall(c)} PropOHV(c) {1 – PropOHV(c)}
/ {(nall(c) – 1) H(c)}

where h(c) is the total number of surveyed OHV-owning households in county c, nall(c) is the total number of surveyed households in county c including the screen-outs, and H(c) is the California total number of residential households in county c.

V_2 is an additional correction term to account for the uncertainty of the estimated sampling weights because of the uncertainty of the proportions of Class C-owning households:

$$V_2 = \left\{1/\left\{\sum_c \sum_A \sum_B \sum_u w(u,c,A,B)t(u,c,A,B)\right\}^2\right\} \times \sum_c \sum_A \mathrm{Var}(\mathrm{PropClassC}(c,A)) \times \left\{\frac{\sum_{B=\text{Class C owner}} \sum_{A,u} (z(u,c,A,B) - t(u,c,A,B)\hat{R})\, w(u,c,A,B)}{\mathrm{PropClassC}(c,A)} - \frac{\sum_{B=\text{Class C non-owner}} \sum_{A,u} (z(u,c,A,B) - t(u,c,A,B)\hat{R})\, w(u,c,A,B)}{1 - \mathrm{PropClassC}(c,A)}\right\}^2$$

where PropClassC(c, A) is the estimated proportion of Class C-owning households in county c, subgroup A:

PropClassC(c, A) = Fraction Class C owners (c, A) = C(c, A) / G(c, A), and

Var(PropClassC(c, A)) =
PropClassC(c, A) {1 – PropClassC(c, A)}/ {G(c, A) – 1}

An approximate 95% confidence interval for the estimated mean gallons per household is given by:

95% Confidence interval = $\hat{Z} \pm t \sqrt{\mathrm{Var}}$

where t is the 97.5th percentile of a Student's t distribution with S – C degrees of freedom, where S is the total number of households in the fuel survey and C is the total number of strata. The value of t was very close to 1.96 since the sample sizes were relatively large.

Step 6. Adjustments for missing strata

The sixth step deals with problems of missing strata, i.e., combinations of county, OHV-ownership and class C ownership where there were no log book vehicles. Simply using the non-

missing strata to estimate the gallons per vehicle and ignoring the missing strata could bias the results significantly. Therefore we recombined strata when necessary to reduce the possible bias.

First, consider the street-licensed vehicles. For each county, the above stratification assumes four strata, corresponding to A = OHV owner or OHV non-owner, and B = Class C owner or Class C non-owner. If for a given county / B combination there are no OHV owners in the fuel survey, then it is reasonable to assume that the fuel survey results for the non-OHV-owners can be represented by the fuel survey results for the OHV-owners.[44] Therefore we combined the (county, OHV owner, B) stratum with the (county, OHV non-owner, B) stratum to create a (county, All, B) stratum for these counties. The same treatment was applied in the rarer situation where all households in a given county / B combination are OHV owners. In effect we now have an extra stratification value

A = All

and we also need the following calculations for Step 3:

G(county, All)

= Number in county having a known number of class C vehicles

C(county, All)

= Number in county with at least one class C vehicle

Fraction Class C-owners (county, All)

= C(county, All) / G(county, All)

Fraction Class C-non-owners (county, All)

= 1 - C(county, All) / G(county, All)

N(county, All, Class C owner)

= Estimated Telephones in all Class C-owning households

= Estimated Telephones (county)

× Fraction Class C-owners (county, All)

[44] This would not be a reasonable assumption if the fuel usage by street-licensed vehicles tends to be higher or lower if the household also has an OHV. For example, having an OHV might tend to discourage off-highway driving for recreation by street-licensed vehicles, but might tend to encourage off-highway driving to recreation by street-licensed vehicles that are used to transport the OHV. However, we expect this potential bias is negligible compared to the biases caused by alternative treatments of the missing stratum.

N(county, All, Class C non-owner)

= Estimated Telephones in all Class C-non-owning households

= Estimated Telephones (county)

× Fraction Class C-non-owners (county, All)

Another case of missing strata occurred when a county had no log book vehicles from class C so that every B was for Class C non-owners, and the (county, A, Class C owner) stratum was missing. Since the estimated ratios are found by averaging across all the non-missing strata, the estimated ratios would have been biased towards Class C non-owners, where the fuel usage is zero. To avoid this bias, we excluded all strata from counties with no log book vehicles. For similar reasons, we also planned to exclude strata from counties where every sampled household had at least one class C vehicle, so that the (county, A, Class C) non-owner) stratum was missing, although this situation did not arise.

In summary, for street-licensed vehicle classes, the possible strata for a county were therefore one of the following sets:

- No strata
- (County, All, Class C owner), (County, All, Class C non-owner)
- (County, OHV owner, Class C owner), (County, OHV non-owner, Class C owner), (County, All, Class C non-owner)
- (County, OHV owner, Class C non-owner), (County, OHV non-owner, Class C non-owner), (County, All, Class C owner)
- (County, OHV owner, Class C non-owner), (County, OHV non-owner, Class C non-owner), (County, OHV owner, Class C owner), (County, OHV owner, Class C non-owner).

For non-street-licensed vehicle classes, a different approach to missing strata was used. Temporarily ignore the problem that some OHV-owners said they were non-owners in response to Question 4. Then, all the non-OHV owners have zero class C vehicles and zero fuel usage since all class C vehicles are OHVs. Therefore all the (county, OHV non-owner, Class C owner) strata are missing. To deal with this issue, the analysis for non-street-licensed vehicle classes was restricted to the sub-population and strata of OHV-owning households. As discussed above, owners of OHV vehicles at the time of the log book survey were treated as OHV-owners for these analyses, regardless of their answer to Question 4. Furthermore, using the same

arguments as for street-licensed vehicles, counties where every fuel survey household had zero vehicles were excluded, as were counties where every fuel survey household had one or more vehicles.

Vehicle weights

First consider a street-licensed vehicle class C. To estimate total gallons used by class C vehicles per household, the above analysis gives

Mean gallons per household

= Σ Sampling Weight × Gallons (u) / Σ Sampling Weight

where

Sampling weight = w(u, county, A, B)

= N(county, A, B) / {n(county, A, B) × Telephones(u, county, A, B)}

Gallons (u) = Estimated gallons used by household u

= Vehicles (u, county, A. B) × Gallons used by log book vehicle, for households in the log book survey for class C

= 0, if the household has no class C vehicles

Each sum is over the fuel survey households, which consists of the households in the log book survey plus the households with no class C vehicles.

The estimated total gallons used in California is therefore

Total gallons =

{Σ Sampling Weight × Gallons (u) / Σ Sampling Weight} × Households

where “Households” denotes the total number of households in California. Furthermore, we can easily re-write this as a sum across all log book vehicles,

Total gallons =

{Σ Sampling Weight × Gallons (u) / Σ Sampling Weight} × Households

= {Σ* Sampling Weight × Vehicles (u, county, A, B) × Gallons used by log book vehicle / Σ Sampling Weight} × Households

where Σ* denotes the sum over the log book vehicles only, but Σ denotes the sum over the log book households and the households with zero class C vehicles in the telephone sample. Here

we used the fact that all the non-log book households in the "fuel survey" sample have zero vehicles and zero gallons used.

Similarly,

Total vehicles =

{Σ Sampling Weight × Vehicles (u, county, A, B) / Σ Sampling Weight} ×

Households = {Σ* Sampling Weight × Vehicles (u, county, A, B) /

Σ Sampling Weight} × Households

Therefore the vehicle weight is given by the equation:

Vehicle Weight = Sampling Weight × Vehicles (u, county, A. B)

× Households / Σ Sampling Weight

where

Sampling weight

= N(county, A, B) / {n(county, A, B) × Telephones(u, county, A, B)}

To obtain the estimated gallons per vehicle, you take the vehicle-weight weighted sum of the gallons used by each log book vehicle in the vehicle class and divide it by the sum of the vehicle weights, i.e., the weighted average of gallons used by log book vehicles based on the vehicle weights. In addition, the weighted sum of the gallons used estimates total gallons, and the sum of the vehicle weights estimates total vehicles. However, these last two estimates are less reliable than our recommended approach of using the gallons per vehicle ratio and applying the vehicle counts obtained directly from the DMV registration data.

For OHV vehicle classes, the same approach can be used provided that "Σ Sampling Weight" is only summed over the OHV-owning households and the number "Households" is re-interpreted as the total number of OHV-owning households, estimated as 6.01% of all California households (see Section 4.5.2). This is because the analyses for OHV vehicle classes were restricted to the sample of OHV-owning households (see Step 6).

Estimating total gallons used

For each vehicle class and month or wave, the total gallons used was estimated as the product of the estimated number of vehicles, P, and the estimated gallons per vehicle, Q.

Total gallons used = P × Q

where:

P = Total number of vehicles

Q = Gallons per vehicle

From standard theory, the variance of the total gallons used is easily calculated, assuming that P and Q are independent:

$$\text{Var (Total Gallons)} = \text{Var}(P \times Q)$$
$$= \text{Var}(P) \times E(Q)^2 + \text{Var}(Q) \times E(P)^2 + \text{Var}(P) \times \text{Var}(Q)$$

where:

E(P), E(Q) = Expected values of P and Q

Var(P), Var(Q) = Variances of P and Q

The expected values of P and Q were replaced by their estimates from Section 5.11.2 and from Step 4, and the estimated variance of Q was calculated in Step 5. The variance of P is the variance of the total number of vehicles. For the street-licensed and registered OHV vehicle classes, P is assumed to be known exactly (see Section 5.11.2) and so Var(P) = 0. For the non-registered OHV vehicle classes, P is given by

P = Total registered OHVs of class T $\times$ Correction factor (T), if T ≠ "Other,"

P = Total registered OHVs $\times$ Correction factor (T), if T = "Other."

The numbers of registered OHVs are assumed to be known exactly and the variances of the correction factors were derived and tabulated in Section 5.11.2. Thus we get

$$\text{Var}(P) = \{\text{Total registered OHVs of class T}\}^2 \times \text{Var}\{\text{Correction factor (T)}\}, \text{ if T} \neq \text{"Other,"}$$
$$= \{\text{Total registered OHVs}\}^2 \times \text{Var}\{\text{Correction factor (T)}\}, \text{ if T} = \text{"Other."}$$

5.11.4. Analysis of Fuel Log Book Responses Drawn From the DMV

For street-licensed vehicles or registered non-street-licensed vehicles in waves 2 through 6, the vehicles were selected randomly from the DMV registration database. The selection rates varied by vehicle class, county, and wave. For each vehicle class, the number of vehicles per county were initially estimated from the telephone survey, weighting the numbers of

vehicles in a household by the household telephone survey weight. Then, for each vehicle class, the number of invitation letters for each county were made approximately proportional to the total number of vehicles in that county. If the response rates had been the same for every county, then the sample would have been self-weighted so that no adjustment would have been needed for the stratification. Since the actual response rates varied by county, we chose to adjust for county differences by treating the sample to be a stratified random sample where the strata are the counties.

Define

V(c) = Number of Class C vehicles in county c

where V(c) is treated as known, with no uncertainty, since these analyses of DMV-selected vehicles are for vehicles classes of street-licensed vehicles or registered OHVs. (See Section 5.11.2). Assume that in county c, class C, there were v(c) log book vehicles, with a sample mean of g(c) gallons per vehicle and a sample variance of $S^2(c)$ gallons per vehicle squared. To account for the small vehicle population numbers for some county / vehicle class combinations, the variance of the estimated sample mean (squared standard error) is estimated as

$$\text{Varg}(c) = \text{Estimated Variance}\{g(c)\} = S^2(c)\{1 - v(c) / V(c)\} / v(c)$$

as shown in Theorem 1 of Section 4.5.4, for example. In some cases, $S^2(c)$ could not be calculated directly because only one vehicle was in the sample for that county (i.e., v(c) = 1). If so, $S^2(c)$ was replaced by the usual pooled variance estimate across the other counties,

$$\text{Pooled variance estimate} = \Sigma\, S^2(c)\{v(c) - 1\} / \Sigma\{v(c) - 1\}$$

where this sum is across all counties with v(c) >= 2. If v(c) <= 1 for all counties, then $S^2(c) = 0$ was assumed. The estimate of the gallons per vehicle is given by

$$\text{Gallons per vehicle} = G = \Sigma' V(c) \times g(c) / \Sigma' V(c)$$

where we have introduced the notation Σ' to mean a sum over those counties where there were some vehicles in the log book survey. The numerator estimates the total gallons for counties with data and the denominator estimates total vehicles for those counties. The assumption is that the results for counties with data are representative of the results for counties without data.

It easily follows from standard theory that

$$\text{Var}(G) = \text{Var (Gallons per vehicle)} = \Sigma' \{V(c)\}^2 \times \text{Varg}(c) / \{\Sigma' V(c)\}^2$$

The estimated total gallons is calculated by multiplying the total number of Class C vehicles in California by the estimated gallons per vehicle. Therefore,

Total vehicles = Σ V(c), summed over all counties

Total gallons = Total vehicles $\times$ G

Var (Total gallons) = {Total vehicles}^{2} $\times$ Var(G)

This calculation of Total gallons also gives the vehicle weights:

Total gallons = Total vehicles $\times$ G = Σ V(c) $\times$ Σ' V(c) $\times$ g(c) / Σ' V(c)

= {$\Sigma_{\text{all counties}}$ V(c)} / {$\Sigma_{\text{counties with data}}$ V(c)}

$\times$ $\Sigma_{\text{counties with data}}$ [V(c) $\times$ Σ_{vehicles} gallons used / v(c)]

Therefore,

Vehicle Weight = {$\Sigma_{\text{all counties}}$ V(c)} / {$\Sigma_{\text{counties with data}}$ V(c)} $\times$ V(c) / v(c)

assuming that the vehicle is from county c.

5.11.5. Estimating Total Fuel Usage Summed Over the Year and/or Vehicle Class

To estimate annual fuel usage by vehicle class, month or wave, total fuel usage summed over all vehicle classes, or annual fuel usage summed over all vehicle classes, the above estimates of month or wave fuel usage by vehicle class were summed over months or waves and/or vehicle classes. To estimate the variance of these totals, we assume that the terms are approximately independent (see below).

Thus

Estimated annual fuel usage for class C = A(C) =

Σ_i Estimated wave i fuel usage for class C = Σ_i X(i)

Var{(A(C)} = Σ_i Var {X(i)}

Estimated month or wave fuel usage for all vehicles = M

= Σ_C Estimated month or wave fuel usage for class C = Σ_C M(C)

Var{M} = Σ_C Var {M(C)}

Estimated annual fuel usage for all vehicles = A

$= \Sigma_i \Sigma_C$ Estimated wave i fuel usage for class C $= \Sigma_i \Sigma_C X(i, C)$

$Var\{A\} = \Sigma_i \Sigma_C Var\{X(i, C)\}$.

An approximate 95% confidence interval for the annual fuel usage for class C is given by:

95% Confidence interval $= A(C) \pm z_{0.975} \sqrt{Var\{(A(C)\}}$,

where $z_{0.975}$ is the 97.5th percentile of a standard normal distribution, approximately 1.96. The margin of error is therefore

Margin of error (%) $= z_{0.975} \sqrt{Var\{(A(C)\}} / A(C) \times 100\%$.

The confidence intervals and margins of error are calculated similarly for the other sums across vehicle classes and waves.

The independence assumption is needed to justify calculating the variance of a sum as the sum of the variances. When summing across months or waves, this assumption of independent terms is only approximately true because a) the estimated sampling weights for different waves are not independent since they are based on the same survey data (e.g., the county proportions of OHV owners), b) some vehicles were included in more than log book wave, c) for non-registered OHVs, the vehicle counts were not known exactly, because of the correction factors, but were assumed to be the same for every wave. When summing across vehicle classes, this assumption of independent terms is only approximately true because a) the estimated sampling weights for different households or vehicles are not independent, and b) in wave 1, or for non-registered OHVs, the numbers of vehicles, and the associated fuel usages, in each vehicle class for the same household are not independent. As an example of the last point, consider a household with 3 class C street-licensed vehicles, of which one was in the log book survey, and 0 class D off-highway vehicles. This household would be included in the fuel survey sample for both class C and class D. The fact that the household has no class D off-highway vehicles might influence the gallons used for the other household street-licensed vehicles in class C.

For a given sum of vehicle classes or time periods, the gallons per vehicle was estimated as the total gallons divided by the total number of vehicles. Using a Taylor series expansion, the variance of this estimate can be shown to be approximately

Var (Gallons / Vehicles) =

$$\text{Var (Gallons)} / \text{Vehicles}^2 + \text{Var(Vehicles)} \times \text{Gallons}^2 / \text{Vehicles}^4$$

5.12. Estimating Fuel Use

For any log book day in which the respondent reported fuel use (gallons of gasoline used), this was used in determining the amount of fuel used during that day of off-highway recreation. Fuel used was not counted if:

- Fuel was purchased outside of California
- Racing gasoline or diesel fuel was used
- Recreation occurred outside of California
- Recreation occurred on non-public lands
- Activity was not recreation

For those that did not report gallons of gasoline used, fuel consumption was calculated using average fuel consumption rates from the vehicles that did report fuel use. For street licensed vehicles, average miles per gallon was calculated for each vehicle type and divided into the number of miles driven off-highway during that day. For non-street licensed vehicles, average gallons per hour were calculated for each vehicle type and multiplied by the number of hours (and minutes divided by 60) that they recreated off-highway. Table 5-8 shows the average fuel consumption in miles per gallon for each street licensed vehicle type and Table 5-9 shows the average fuel consumption in gallons per hour for each non-street licensed vehicle type. Fuel consumption was missing on approximately 8% of the 9,722 recreational day entries and needed to be calculated.

Table 5-10. Average Fuel Consumption for Street Licensed Vehicles (mpg)

Vehicle Type	Mean	95% Confidence	
		Lower	Upper
Cars	8.33	6.16	10.51
SUV 2WD	3.76	3.28	4.25
SUV 4WD	5.92	5.39	6.45
2WD Trucks	6.56	5.38	7.75
4WD Trucks	6.34	5.66	7.01
Vans	7.72	5.34	10.11
Dual Sport Motorcycle	23.93	19.49	28.37
Street Motorcycle	17.17	7.08	27.26
Other	4.23	0.45	8.00

Table 5-11. Average Fuel Consumption for Non-Street Licensed Vehicles (gph)

Vehicle Type	Mean	95% Confidence	
		Lower	Upper
Motorcycle	0.68	0.63	0.73
ATV	0.81	0.70	0.92
4 Wheel Vehicle	1.27	0.81	1.73
Snowmobile	1.43	1.11	1.74
Other	0.70	0.69	0.71

5.13. Recreational Pursuits and Recreational Destinations

Log book respondents reported the common name of the area in which they recreated, the county in which the area is located, and the nearest city and the nearest paved road. Using this information, the California State Park's "Guide to California Off-Road Adventures", and other information on recreational areas, area names were confirmed and standardized to use for database analysis. In addition, counties were double checked against the other information given. Fuel use for each day was weighted as discussed in Section 5.11 and then summed by county for the people that used gasoline to recreate on public lands within California.

Log book respondents also reported up to three recreational activities for the day. Since they were not given in any particular order or ranking, fuel use was divided among the various activities during the day. If someone indicated they were recreational driving and camping and fishing, one third of the gallons used that day would be assigned to each. Again data was weighted and summed for the various activities. Wood-cutting was not considered a recreational activity.

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6. Results

In this section, results from the Component 1 and Component 2 surveys are discussed along with the effects these results will have on the Existing Fuel Tax Transfer Model. Results from this study are also compared against those from the 1990 Study.

6.1. Component 1 Results

One of the main objectives of the Component 1 survey was to estimate the percent of households that engaged in off-highway recreation and the percent of households that owned non-street licensed vehicles used for recreation. Tables 6-1 and 6-2 compare the findings from the Component 1 survey using the indirect method against those presented in the 1990 Study.

Table 6-1. Household Recreational Driving

	1990 Study		ICF Study	
	Number	Percent	Number	Percent
Completed Interviews	12,156	100.0%	15,691	100.0%
Households that do not own a street licensed vehicle or a non-street licensed vehicle	1,506	12.4%	2,187	13.9%
Households that own a street licensed or non-street licensed vehicle	10,650	87.6%	13,504	86.1%
Households that did not drive any vehicles off-road	8,866	72.9%	11,659	74.3%
Households that drive vehicles off-road	1,784	14.7%	1,845	11.8%
Households that drive off-road for recreation on public lands	1,623	13.6%	1,551	9.9%

Note: Questions relating to driving off-highway related to the prior year.

Table 6-2. Household Vehicle Ownership

	1990 Study		ICF Study	
	Number	Percent	Number	Percent
Households that own a Street Licensed Vehicle	10,650	87.6%	13,452	85.7%
Households that own a Non-Street Licensed Vehicle	690	5.7%	906	5.8%

Note: Percentages relate to the total number of completed interviews.

As can be seen from the above table, the number of households that do not own a vehicle has increased slightly over the last 14 years, while the number of households that own non-street licensed vehicles has stayed about the same. Households that drive off-highway for recreation have decreased from 13.6% ± 0.62% in 1989 to 9.9% ± 0.59% in late 2003. Using the direct method described in Section 4.5, which includes the screen-outs during the OHV

screening sample, a higher percentage of OHV ownership is estimated, but both are within the margin of error. With the screen-outs, 27,955 households were interviewed with 1,680 households indicating they owned a non-street licensed vehicle. Based upon these figures, 6.01% of all households own a non-street licensed recreational vehicle with a margin of error of 0.33%.

Another objective of the Component 1 Study was to determine whether people drove off-highway as recreation or to gain access to a recreational pursuit. Figure 6-1 shows the breakdown of survey respondents during the prior year. Over half indicated that they both drive off-highway for the fun of it and also access some other recreational pursuit. About one-third indicated that they only drive off-highway to gain access to a recreational pursuit other than off-highway driving. Somewhat different results were found in the Component 2 results discussed in Section 6.3.

Figure 6-1. Driving for Recreation or to Pursue Recreation

A further objective of Component 1 was to determine the types of recreational activities households pursue when they drive off-highway to access recreation. Figure 6-2 shows the top seven recreational preferences of those households that drove off-highway to access recreation during the prior year. These are also calculated for the Component 2 survey in Section 6.3.

The most important objective of the Component 1 Study (other than to define a pool of non-street licensed vehicles for use in the Component 2 Study) was to determine the amount of non-registered vehicles in California. Using the methodology described in Section 4.14, the ratio of non-registered to registered vehicles was determined for the five non-street licensed vehicle classes. These results are shown in Table 6-3. As can be seen, the ratio of non-registered to registered vehicles has dropped significantly from 1990. ICF International believes this is due to several reasons.

Figure 6-2. Recreation Pursuits of those Accessing Recreation

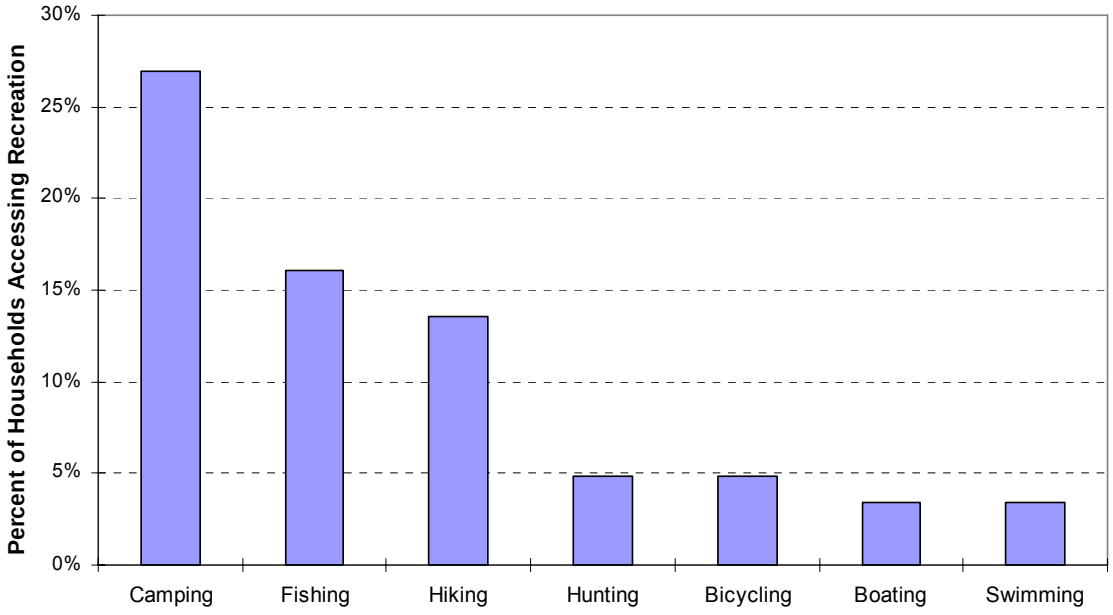


Table 6-3. Non-Registered to Registered Vehicle Ratios

Vehicle Type	1990 Study	ICF Survey
Motorcycles	5.90	0.62
ATVs	2.50	0.51
4 Wheel Vehicles[a]	7.60	2.77
Snowmobiles	7.00	0.45
Other[b]	0.066	0.013

[a] 4 Wheel vehicles include dune buggies, sand and desert rails, unlicensed street vehicles, motorized golf carts and other 4 wheeled vehicles. In the 1990 study, unlicensed street vehicles were in the "Other" category.

[b] The ratio for Other is taken as the number of non-registered non-street licensed other divided by the total number of all registered non-street licensed vehicles. In the 1990 Study, Tyler & Associates chose what they considered a conservative number of 19 non-registered non-street licensed others to every one registered non-street licensed because the study did not produce data on any registered Others.

- When new vehicles are purchased, dealers now aid purchasers in registering their vehicles with DMV. This was not the case in 1990.

- State Parks and other governmental agencies began an enforcement program after seeing the results of the 1990 Study, and set up check points within several parks and U.S. Forest Service and BLM lands to check on vehicle registration. In addition, some agencies set up amnesty programs with a DMV clerk on the

premises to register vehicles found to be non-registered so that riders could avert a large fine.

- Grantees under the State Parks program now have to enforce off-highway vehicle registration under California Public Resources Code Section 5090.53(b)(5) as part of receiving a grant to do planning, acquisition, development, maintenance, administration, operation, enforcement, restoration, and conservation of trails, trailheads, areas, and other facilities associated with the use of off-highway motor vehicles, and programs involving off-highway motor vehicle safety or education.

- Enforcement at limited access points into State Parks and other areas has increased.

Today there are significantly fewer non-registered off-highway vehicles than in 1989 when the 1990 Study was done. Table 6-4 shows a comparison of the estimated non-registered vehicles in 1989 and 2003. The major decline is in off-highway motorcycles, but there are significant declines in snowmobile and non-street licensed "other" populations as well. The "other" category, however, could be a result of counting vehicles that were unlicensed street vehicles in that category instead of the 4 wheel category where ICF International classified them.

Table 6-4. Estimated Non-Registered Off-Highway Vehicles in California

Vehicle Type	Oct 1989[a]	Oct 2004[b]
Off-Highway Motorcycles	1,225,035	209,725
ATVs	191,590	171,803
4 Wheel Vehicles	53,002	53,561
Snowmobiles	43,841	8,354
Other	246,962	9,344

[a] DMV registered counts by vehicle type for October 1989 times Tyler correction factors

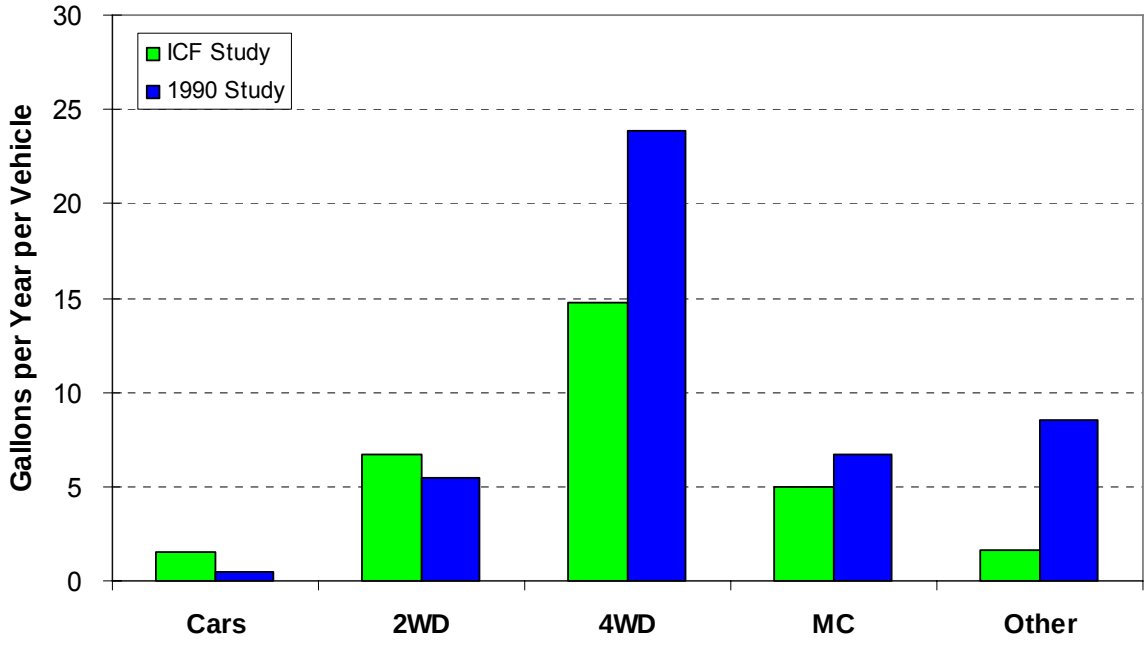
[b] DMV registered counts by vehicle type for October 2004 times ICF non-registered to registered ratios.

The large effect the new non-registered to registered vehicles has on the Existing Tax Transfer Model calculations as discussed in Section 6.4.

6.2. Component 2 Results

The main objective of Component 2 was to develop fuel use estimates by month by vehicle type that can be projected to the entire population of California vehicles to define gasoline used off-highway for recreation on public lands in California. As described in Section 5.2, ICF International defined 11 street licensed vehicle categories in comparison to the 5 categories that were used in the 1990 Study. This is because street licensed vehicles now account for 82.2% of the gallons used off-highway instead of the 25.2% that they used under the Existing Tax Transfer Model. Figure 6-3 shows a comparison of street licensed vehicle fuel consumption per vehicle per year found in the ICF International Study versus that found during the 1990 Study using the 1990 Study vehicle types (See Section 5.2 to see how these are mapped). As can be seen from this figure, average annual fuel consumption per vehicle for gasoline used off-highway in public lands in California increased slightly for cars and 2WD vehicles, while it decreased for 4WD, street licensed motorcycles and other.

Figure 6-3. Average Annual Gasoline Consumption by Street Licensed Vehicles While Recreating Off-Highway



The most significant difference above is the reduction of gasoline use by 4WD street licensed vehicles. Four wheel drive vehicles have changed significantly since 1990 and are much more commonplace. In addition, the number of different make and models of 4WD SUVs and vans has increased substantially as shown in Table 6-5.

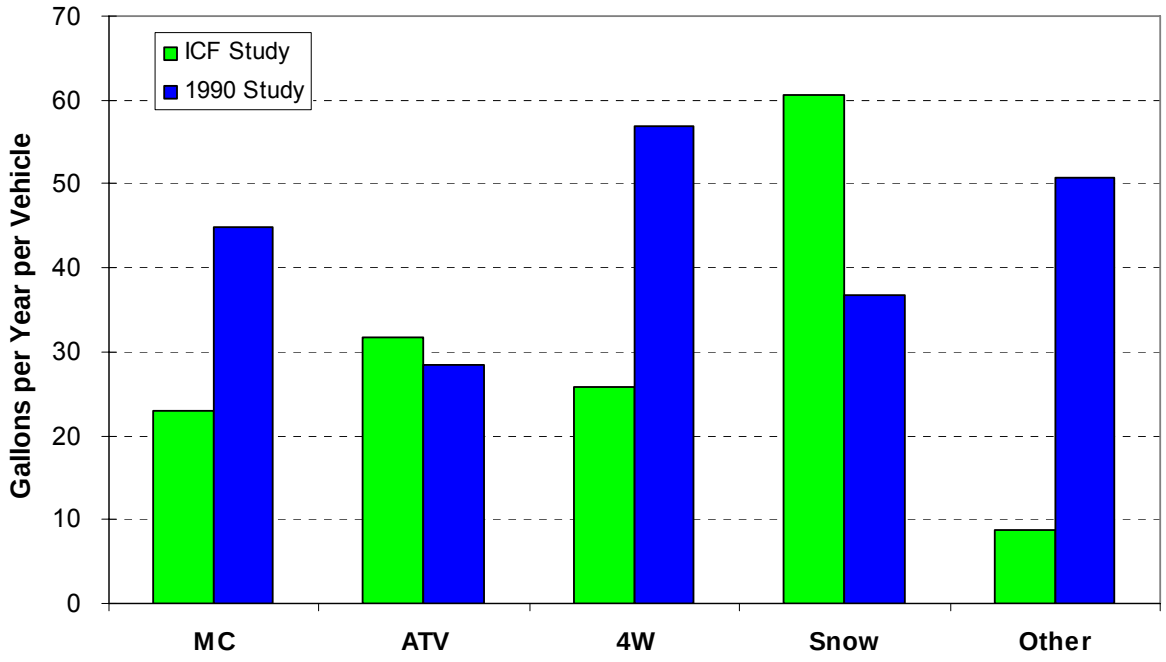
Table 6-5. Number of Distinct Models

Vehicle Type	Vehicle Models	
	1989	2003
SUVs	27	66
Trucks	18	16
Vans	2	13

The largest effect, however, is the different use of 4WD vehicles. In 1989, 4WD vehicles were used when people wanted to recreate off-highway or needed them for work. In 2003, people tend to use 4WD SUVs to commute to work and drive the kids to school, but rarely take them off-highway. The reduction in fuel use by 4WD vehicles is not surprising.

Average annual fuel consumption per vehicle for registered OHVs was also less than in 1990 except for ATVs and snowmobiles as shown in Figure 6-4. Motorcycles and 4 wheel vehicles had significantly less fuel use. Since the Existing DMV model used to generate inputs to the Existing Tax Transfer Model counted most ATVs as motorcycles, this has a large effect on the amount of fuel tax transferred.

Figure 6-4. Average Annual Gasoline Consumption by Registered Non-Street Licensed Vehicles While Recreating Off-Highway

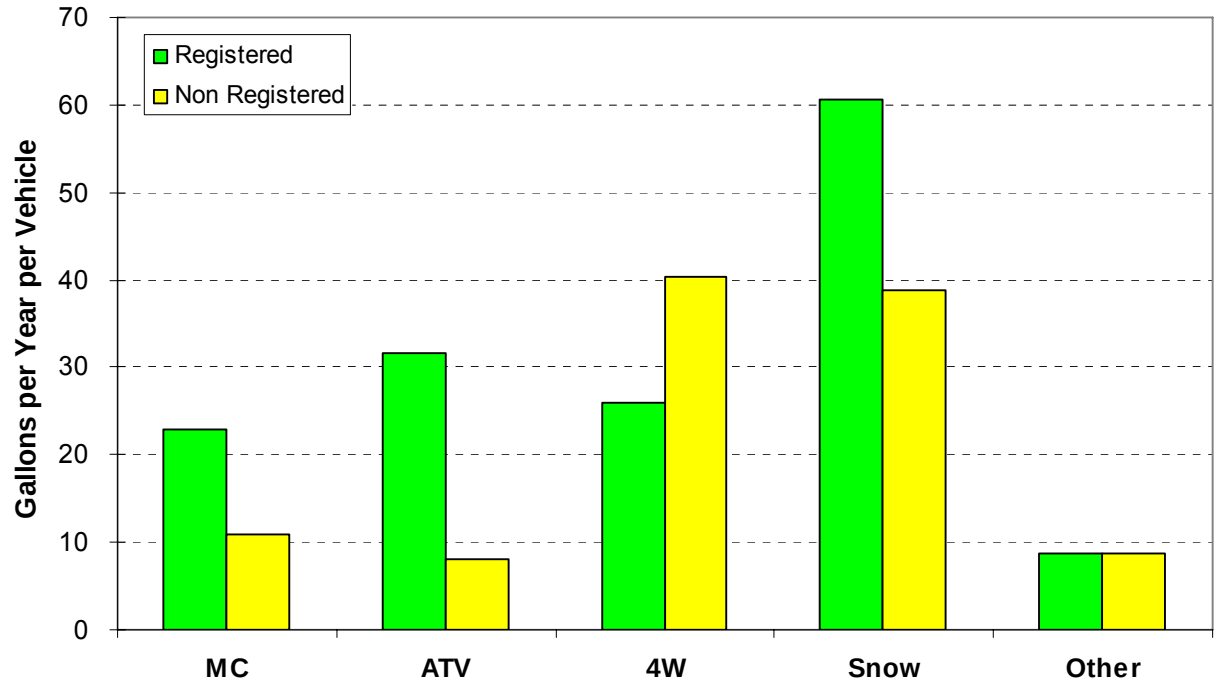


One additional point that should be mentioned is the difference in approaches between the 1990 Study and ICF International. The 1990 Study used the same respondents for each wave of the fuel use survey while ICF International used different respondents. This led to a

large drop out in subsequent waves in the 1990 Study as discussed in Section 3. In addition, when people did not send in their fuel use logs, Tyler sent them post card reminders. ICF International called the participants and allowed them to read their log books over the telephone instead of sending them in capturing a much better response rate. By using substantial incentives (the 1990 Study only promised them a free map) and the call-backs, ICF International was able to get a more representative sample that included people that did not travel off-highway and might not have sent back a log book.

Another large impact is with the non-registered, non-street licensed OHVs. Because Tyler did not survey any non-registered vehicles, he assumed that registered and non-registered OHVs consume the same amount of fuel. As can be seen in Figure 6-5, this clearly is not the case. Figure 6-5 shows the fuel use is significantly less for non-registered vehicles except for 4 wheel vehicles. Because there was not enough data to distinguish between registered and non-registered fuel use for non-street licensed Other vehicles, ICF International assumed that registered and non-registered Others had the same fuel use. This is a small category and the impact of that assumption is small.

Figure 6-5. Average Annual Gasoline Consumption for Registered and Non-Registered OHVs



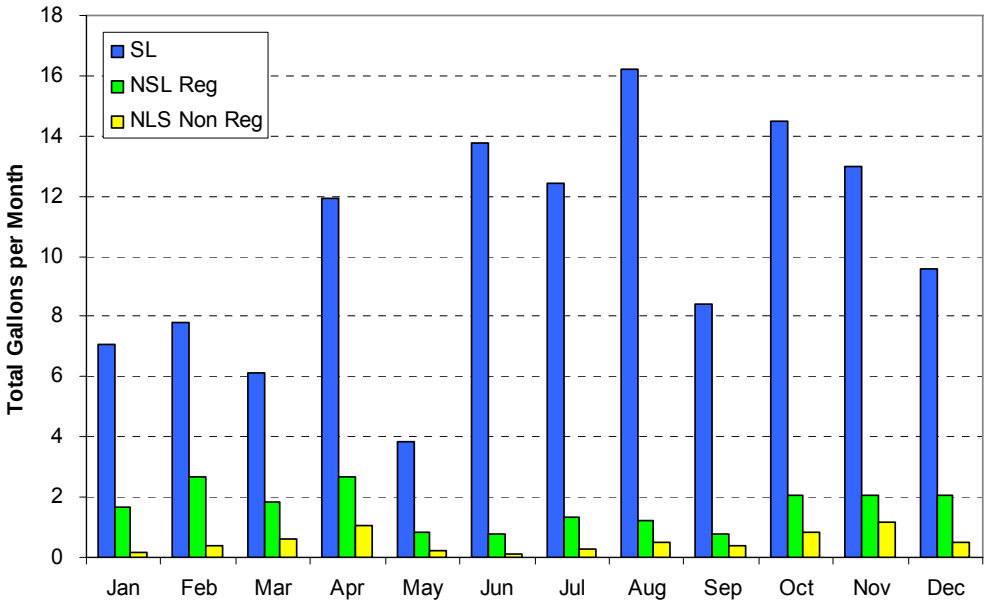
Only gasoline use for recreation in California using California gasoline could be counted in the tallies of fuel used. Fuel used in non-recreational activities, fuel used for recreation

outside of California, fuel purchased outside of California, and diesel and racing gasoline could not be counted in determining the recreational fuel use in California on public lands. Table 6-5 shows the breakdown of fuel used as reported by the log books. Average fuel use by month per vehicle is shown in Figure 6-6 for street licensed (SL) and non-street licensed (NSL) vehicles, both registered and non-registered. Detailed tables of fuel use per month by vehicle type and the margin of error can be found in Appendix D. Using October 2004 DMV counts and the fuel rates determined by the survey, annual gasoline use off-highway for recreation in California was 150,969,270 gallons with a 16.80% margin of error. Since the sampling plan was driven more by the poor response rate to the initial invitation letters, it provided a less than ideal margin of error. Had ICF International had been able to use the State letterhead from the beginning, we would have been able to identify more interested parties to send log books to which would have resulted a lower margin of error.

Table 6-6. Breakdown of Fuel Use Reported by Log Books (weighted)

Total Gallons	161,316,717
Non-Recreation Gallons	153,455
Non-California Recreation	338,784
Non-California Fuel	1,784,191
Diesel	5,550,203
Racing Gasoline	2,520,813
Remaining Gallons	150,969,270

Figure 6-6. Average Monthly Gasoline Use for Recreation



6.3. Recreational Pursuits and Destinations

Twenty-two recreational pursuits were defined in the log book. For each day of recreational off-highway vehicle use, up to three recreational pursuits could be listed. Gasoline usage for that day was divided equally among the various pursuits. As can be seen from Table 6-6, the majority of fuel used was for recreational driving. Recreational pursuits which had higher gasoline use included camping, fishing, and hunting/target practice.[45]

Table 6-7. Gallons Used in Recreational Pursuits

Recreational Pursuit	Annual Gallons of Gasoline			Percent
	Street Licensed	Non-Street Licensed	Total	
Driving for Recreation	60,872,723	21,238,911	82,111,634	54.4%
Backpacking	622,422	1,187	623,609	0.4%
Bicycling	3,459,162	655,836	4,114,997	2.7%
Non-Motorized Boating	564,835	37,711	602,546	0.4%
Camping	16,825,335	1,881,918	18,707,253	12.4%
Rock/Mountain Climbing	513,898	699,729	1,213,627	0.8%
Fishing	10,597,921	337,300	10,935,222	7.2%
Prospecting/Rock Collecting	1,491,679	23,032	1,514,711	1.0%
Hiking/Walking Pets/Running	8,330,295	471,548	8,801,843	5.8%
Horseback Riding	433,580	4,638	438,218	0.3%
Hunting/Target Practice	7,399,543	360,895	7,760,439	5.1%
Motor Boating	249,240	131,582	380,822	0.3%
Animal/Bird Watching	1,779,921	25,127	1,805,048	1.2%
Paragliding/Hang Gliding	5,115	396	5,511	0.0%
Photography/Painting	2,022,984	63,877	2,086,860	1.4%
Picnicking	2,573,085	230,194	2,803,279	1.9%
Sail Boating/Sail Boarding	-	264	264	0.0%
Skiing/Snowboarding	2,803,679	20,331	2,824,010	1.9%
Spelunking	56,071	3,315	59,386	0.0%
Snowshoeing	194,297	1,688	195,986	0.1%
Swimming	668,970	16,405	685,374	0.5%
Astronomy	236,475	5,405	241,880	0.2%
Other	3,046,124	10,628	3,056,752	2.0%
Totals	124,747,354	26,221,916	150,969,270	100.0%

Recreational gasoline use by the county in which the recreational activity occurred is shown in Table 6-7.

[45] While Table 6-6 provides interesting information, it should be noted that log book responders did not indicate a priority or the amount of gasoline attributed to each activity if they marked more than one. In this case we divided the gallons used that day equally between the various activities they reported for that day.

Table 6-8. Fuel Use by Recreational County

County	Recreational Gasoline Gallons		
	SLV	OHV	Total
Alameda	552,400	313,330	865,730
Alpine	324,061	34,903	358,964
Amador	235,678	10,182	245,860
Butte	249,124	429,415	678,539
Calaveras	20,407	13,838	34,245
Colusa	1,888,390	489,467	2,377,857
Contra Costa	284,612	-	284,612
Del Norte	348,517	1,821	350,338
El Dorado	3,154,461	1,368,298	4,522,759
Fresno	1,875,978	114,114	1,990,091
Glenn	38,553	4,946	43,498
Humboldt	4,780,825	125,323	4,906,147
Imperial	11,622,028	6,306,131	17,928,159
Inyo	965,471	5,827	971,298
Kern	13,163,822	1,791,915	14,955,737
Kings	3,677	-	3,677
Lake	343,777	28,690	372,467
Lassen	1,293,973	209,460	1,503,433
Los Angeles	17,993,473	3,292,707	21,286,180
Madera	6,050	-	6,050
Marin	369,804	-	369,804
Mariposa	3,458	-	3,458
Mendocino	39,175	-	39,175
Merced	-	-	-
Modoc	290,596	4,874	295,470
Mono	2,393,141	243,004	2,636,144
Monterey	1,316,618	-	1,316,618
Napa	136,831	128,362	265,193
Nevada	3,382,913	304,476	3,687,389
Orange	1,295,095	594,849	1,889,944
Placer	638,134	520,366	1,158,500
Plumas	890,292	557,967	1,448,259
Riverside	5,025,156	1,312,865	6,338,021
Sacramento	1,678,521	74,446	1,752,967
San Benito	1,375,415	957,387	2,332,802
San Bernardino	16,006,186	3,316,920	19,323,106
San Diego	8,909,886	617,009	9,526,895
San Francisco	-	-	-
San Joaquin	174,066	-	174,066
San Luis Obispo	2,324,309	1,438,794	3,763,103
San Mateo	553,922	-	553,922
Santa Barbara	1,200,957	5,094	1,206,051
Santa Clara	239,010	162,418	401,428
Santa Cruz	106,594	-	106,594
Shasta	781,147	436,325	1,217,472
Sierra	473,734	983	474,717
Siskiyou	1,015,074	123,722	1,138,796
Solano	46,703	28,606	75,309
Sonoma	384,659	-	384,659
Stanislaus	1,066,300	37,547	1,103,847
Sutter	23,516	-	23,516
Tehama	158,491	32,313	190,804
Trinity	865,892	40,898	906,789
Tulare	4,098,516	152,351	4,250,868
Tuolumne	8,043,018	505,410	8,548,428
Ventura	131,773	-	131,773
Yolo	78,302	4,857	83,159
Yuba	84,873	79,707	164,580
Total	124,747,354	26,221,916	150,969,270

Highest fuel use is in Los Angeles county, followed by San Bernardino, Imperial and Kern. The six areas with highest fuel use are Angeles National Forest, Imperial Sand Dunes, San Bernardino National Forest, Hungry Valley SVRA, Ocotillo Wells SVRA, and Jawbone Canyon / Dove Springs.

6.4. Revised Tax Transfer Model Calculations

Using the fuel rates discussed in Section 6.2, the non-registered to registered OHV ratios discussed in Section 6.1, and the DMV registered vehicle counts by vehicle type as determined by Cenzer following the methodology discussed in Section 5.2, the estimated recreational fuel use gallons calculated are shown in Table 6-9.

Table 6-9. Estimated Gallons of Gasoline Used for Off-Highway Recreation on Public Lands in California from April 2004 to March 2005

Vehicle Type	ICF Survey[a]			Existing Model[b]
	Mean	Lower Bound	Upper Bound	
Street Licensed Vehicles	124,747,354	99,641,983	149,852,724	79,741,098
Green or Red Sticker Vehicles	20,014,590	17,081,031	22,948,148	34,439,819
Non-Registered Vehicles[c]	6,207,327	4,196,151	8,218,502	201,808,816
Total Gallons[d]	150,969,270	125,613,201	176,325,339	315,989,733

[a] Used fixed Cenzer DMV counts as of October 2004 for entire 2004/2005 fiscal year.

[b] Existing DMV Model inputs for 2004/2005 fiscal year.

[c] Non-registered refers to off-highway vehicles that are not currently registered with a green or red sticker but could be used for recreational driving

[d] The totals given for the lower and upper bounds for all three vehicle types do not equal the total gallons given at the bottom of the table. This is because it is statistically much more likely that if one value is either very low or very high, then the other two values will not be as extreme.

As can be seen from the above table, street licensed vehicles now dominate the gallons used, followed by registered non-street licensed vehicles. The significant drop in non-registered vehicle fuel use is due to the dramatic reduction in the non-registered to registered ratios, the correct classification of ATVs and the reduced fuel use per vehicle for non-registered vehicles.

Using the current California gasoline tax rate of $0.18 per gallon, estimated tax revenues that would be transferred to State Parks are shown in Table 6-9.

Table 6-10. Estimated Fuel Tax Revenues for Off-Highway Vehicle Use

ICF Survey			Existing Model[a]
Mean	Lower Bound	Upper Bound	
$27,174,469	$22,610,376	$31,738,561	$56,878,152

[a] The actual tax revenue transferred was $56,775,626 due to a correction in December 2004 related to a November 2004 over-transfer.

The important thing to realize is that the Existing Tax Transfer Model with the 1990 Study correction factors did not account for non-registered vehicles becoming registered. Due to the various reasons discussed in Section 6.1, a significant amount of the non-registered vehicles found in 1990 were subsequently registered. When using a model with fixed non-registered to registered OHV ratios, when a non-registered vehicle becomes registered, instead of removing one from the non-registered vehicle count and adding one to the registered vehicle count, one was added to the registered vehicle count and approximately 6 more non-registered vehicles appeared because of the approximate overall non-registered to registered ratios found in the 1990 Study. These phantom non-registered vehicles times the fuel rate for registered OHVs[46] produced significant fuel use that wasn't really occurring. Regular reevaluation of non-registered to registered OHV ratios need to be done to prevent these errors.

Annual fuel use by vehicle type along with actual DMV vehicle counts as of October 2004 are shown in Table 6-10. As can be seen from this table, street licensed vehicles now consume 82.6% of the total recreational fuel use, with 2WD and 4WD SUVs and trucks using consuming over 55 percent of the recreational gallons. Registered OHVs only consume 13.3% with the largest coming from ATVs and motorcycles. Non-registered OHVs now only consume 4.1% of the total gallons with non-registered motorcycles and 4 wheel vehicles topping the list. This is a major departure from the Existing Tax Transfer Model that calculates street licensed vehicles at 25%, registered OHVs at 11%, and non-registered OHVs at 64%.

[46] Tyler assumed that the amount of fuel used per month per vehicle by registered and non-registered OHVs was the same due to lack of data.

Table 6-11. Annual Recreational Fuel Use by Vehicle Type

Vehicle Type	Vehicles	Gallons	% of Gallons
Car 2WD	13,874,265	20,892,554	13.8%
Car 4WD	347,352	654,326	0.4%
SUV 2WD	1,912,732	16,663,229	11.0%
SUV 4WD	2,176,385	31,025,372	20.6%
Truck 2WD	3,716,946	23,144,895	15.3%
Truck 4WD	991,787	16,332,160	10.8%
Van 2WD	2,187,834	12,739,512	8.4%
Van 4WD	37,078	66,408	0.0%
Dual Sport Motorcycle	46,696	2,281,294	1.5%
Street Motorcycles	512,681	486,288	0.3%
Street Licensed Other	277,540	461,316	0.3%
Total Street Licensed	26,081,296	124,747,354	82.6%
Reg Motorcycles	338,169	7,739,579	5.1%
Reg ATV	335,897	10,636,652	7.0%
Reg 4 Wheel Vehicles	19,329	499,560	0.3%
Reg Snowmobiles	18,502	1,119,668	0.7%
Reg Other	2,168	19,130	0.0%
Total Reg OHVs	714,065	20,014,590	13.3%
Non-Reg Motorcycles	209,725	2,263,927	1.5%
Non-Reg ATVs	171,803	1,377,244	0.9%
Non-Reg 4 Wheel Vehicles	53,561	2,159,281	1.4%
Non-Reg Snowmobiles	8,354	324,419	0.2%
Non-Reg Other	9,344	82,455	0.1%
Total Non-Reg OHVs	452,787	6,207,327	4.1%
Total All Vehicles	27,248,148	150,969,270	100.0%

7. Lessons Learned and Recommendations

This section discusses lessons learned as a result of this study and recommendations for improvements in future studies. In addition, recommendations for vehicle code and taxation laws to better accommodate today's off-highway vehicle use are discussed. Finally, a discussion on measurement error is included.

7.1. Lessons Learned

The ICF International Study provides a significant improvement in the data used for estimating the amount of gasoline used for recreation on public lands in California. It provides corrected non-registered vehicle counts which were vastly out of date. Because of this, significant fuel use for non-registered OHVs was being calculated erroneously by the Existing Tax Transfer Model. In addition to correcting non-registered vehicle counts, the ICF International Study determined fuel use rates for non-registered vehicles separately from registered vehicles. The previous model assumed that non-registered and registered vehicles used fuel at the same rate, while the ICF International Study found that non-registered OHV fuel use per vehicle was 51% less than registered OHV fuel use per vehicle.

The ICF International Study improved vehicle counts by vehicle type. Significant miscounting of registered ATVs as Off-Highway Motorcycles in the Existing Tax Transfer Model results in overestimation of non-registered vehicles. By correcting counts of ATVs and Off-Highway Motorcycles, this study corrects an overestimation of approximately 1.4 million vehicles currently estimated by the Existing Tax Transfer Model. In addition, 4 wheel drive street licensed vehicle counts were improved taking into account vehicle models that had been produced since 1990 when the Existing Tax Transfer Model was developed. A five-fold increase in 4WD vehicles was found over the existing model.

Further benefits of the ICF International Study resulted from targeting the categories that currently generate the most fuel tax revenue. By increasing the street-licensed vehicle categories from 5 to 11, better resolution of changes in vehicle ownership can be captured. Street licensed vehicles now account for 83% of the fuel use as opposed to the 25% predicted by the Existing Tax Transfer Model.

Finally, the ICF International Study provides data needed to estimate the recreational activities and recreational destinations of the California Off-Highway Recreation population.

Generally, off-highway driving as a form of recreation produced the highest fuel use. The other activities resulting in high fuel use (camping, fishing, hiking and hunting) all require road access. In addition, the recreational counties in which people recreate off-highway were also quantified.

While this study was a vast improvement over the 1990 Study, several improvements could be made in future studies. These are listed below:

Lesson Learned #1

OHV recreation is expanding. Expecting a model which is relevant today to be relevant in ten years is just not realistic. The last study was published 16 years ago and, as the current ICF International Study found, the data generated 16 years ago is not valid today. This has led to an overestimation of gasoline used by California vehicles when they are driven off-highway for recreation on public lands in California, primarily because of out-of-date survey data. This was particularly true with regard to the non-registered to registered OHV ratios. While the ICF International Study found non-registered vehicles current are responsible for a small portion of the total amount of fuel used for off-highway recreation, this could change if enforcement is decreased, or if registration fees are raised substantially and, as a result, the number of non-registered OHVs increases.

In addition, other fundamental shifts in vehicle use could change the tax revenues dramatically and this change must be captured. For example, the Existing Tax Transfer model's estimation of vehicle use was out of date. Today, 4WD SUVs are used differently than they were in 1990. In the future, if more SUV use is shifted to off-highway, the tax transfer model would need to reflect this.

Recommendation

Planning for a new study with regular update surveys should begin immediately. Surveys need to be completed regularly, not less than every 5 years, to provide updated input to the Fuel Tax Transfer Model on an ongoing basis.

Lesson Learned #2

The Household Telephone survey used some vehicle categories which resulted in some confusion on the part of the parties surveyed. This included the "Extreme 4x4" and "Off-Road Cart" categories. It was intended that the "Extreme 4x4" category would capture non street-licensed trucks and SUVs, however, respondents used this category for anything from a street licensed truck or SUV to an ATV. The "Off-Road Cart" category was intended to capture modified golf carts. People responded with this category for dune buggies, sand or desert rails,

go-carts, ATVs and golf carts. These two categories had to be studied record-by-record to determine the correct vehicle category.

Recommendation

Replace the "Extreme 4x4" Category with an "Unlicensed Street" category. This will capture non-street licensed cars, trucks and SUVs. In addition, the "Off-Road Cart" category should be eliminated and replaced with a "Go-Cart" category and a "Gasoline Golf Cart" category. This should reduce confusion.

Lesson Learned #3

The ICF International Study found significant errors in the classification of street-licensed drive train (2WD versus 4WD) and the classification of off-highway motorcycles versus ATVs in the Existing Tax Transfer Model input program that is run by DMV. In addition, ICF International added extra street-licensed vehicle categories to provide extra clarity in vehicle counts and fuel use differences. The new model will more accurately track changes in vehicle populations as people move from trucks to SUVs to vans. The Existing DMV model used for input to the Existing Tax Transfer Model is seriously out of date.

Recommendation

The DMV input model must be rewritten to provide more accurate vehicle counts by vehicle classification and to accurately determine drive train. The means of achieving better clarity already exists. Robert Cenzer has worked with the California Energy Commission for almost 15 years developing guide files to assign vehicles to vehicle classes by make, model, and vintage, and has also developed vehicle identification number (VIN) decoding software to determine whether a vehicle has a two-wheel drive (2WD) or four-wheel drive (4WD) drive train. He has also done significant research on VINs to determine vehicle types, particularly those before VINs were standardized. Through the ICF International Study, Cenzer worked with DMV to improve proper vehicle counts as accurate vehicle counts by vehicle type are an important input component to the Fuel Tax Transfer Model. At present, only Cenzer has been able to accurately determine drive train from the DMV data. DMV must work with Cenzer to improve vehicle counts. In the meantime, Cenzer's outputs developed during this study should be used to determine the counts of 4WD SUVs, trucks and vans as well as the number of non-street licensed motorcycles and ATVs.

Lesson Learned #4

Support from the California State Parks is essential for good response rates to written survey documents. Because ICF International could not use State Parks letterhead for the first few rounds of letters inviting people to participate in the fuel use log book survey, initial response rates were low.

Recommendation

Any new surveys secure approval ahead of time for use of Departmental logo, letterhead and web presence. Without these, confusion and mistrust ensue and response rates are low.

Lesson Learned #5

Researchers must have specific vehicle information from the telephone survey to assist finding the vehicles in the DMV data. This is used to determine whether a non-street licensed vehicle is registered or not, and used to determine the non-registered to registered vehicle ratios. In addition, DMV took two years to get their motorcycle VIN decoder working. This tool that was necessary to accurately determine the vehicle type of off-highway motorcycles and ATVs. As a result, ICF International had to send out log books without knowing whether a vehicle was registered or non-registered. Furthermore, because non-registered to registered ratios could not be determined prior to developing the sampling plan for the log book survey, the older 1990 Study ratios were initially used and affected the sampling plan.

Recommendation

The telephone survey should only be used to determine non-registered to registered vehicle ratios and to provide a pool of non-registered vehicles. This would require that only a screening survey be done. While some of the information obtained during the telephone survey was interesting, it did not lead to information to generate the new Tax Transfer Model. Much of the information gathered could have been determined in the fuel use survey and through a screening survey for non-street licensed vehicles only. By centering in on non-street licensed vehicles, more completed telephone surveys could have been accomplished which would have led to better accuracy in the non-registered to registered vehicle ratios and a larger pool of non-registered vehicle owners to which log books could be sent. In addition, by asking more vehicle information (such as make and model), finding the vehicles within the DMV database and classifying those vehicles would have been easier. Unfortunately the interviews averaged 14 minutes which test the resolve of most respondents. A shorter interview would have led to more completed interviews.

Lesson Learned #6

Trying to do the project within a 2 year period is next to impossible. Due to the original two-year length of the project, several compromises had to be made. To develop the questionnaire for the Household Telephone survey and get it approved by the stakeholders plus train the Computer Aided Telephone Interview operators took about 4 months. The Household Telephone survey took about 5 months. This left little time for data analysis or sending out letters inviting people to participate before having to begin the Component 2 survey which was a year long in itself.

Recommendation

RFPs for future studies should build in adequate time for analysis. ICF International believes this is really a 3+ year study. It is important to leave enough time to analyze the Component 1 results before beginning Component 2. The extra time required to work with stakeholders to design the questionnaire, as well as the extra time which was required to work with Cenzer to develop a VIN decoder to interpret DMV data led to significant delays in completing this study. Future studies should either be designed with more time to account for such difficulties, or not be initiated until it is clear that all needed information will be available to researchers. In addition, sufficient time must be built in to insure adequate time to interpret telephone survey results prior to developing sampling plans for log book distribution. Finally, sufficient time must be included to analyze log book data once it has been gathered.

7.2. Additional Recommendations

Two additional recommendations related to needed changes in the vehicle codes are listed below.

1. Consider changing the regulations to allow diesel fuel as a possible motor fuel for tax transfers. Many manufacturers now offer diesel trucks and the trend is increasing due to fuel prices. Many people buy diesel trucks for towing or hauling and also use them for recreation. The original idea that diesel fuel is used primarily for commercial vehicles is no longer valid.

2. Consider changing the regulations to allow to collection of fuel tax revenues for recreation on private and public lands. Generally this recreation is off-highway and therefore should go for off-highway recreation improvements and/or any repairs that might be needed to private lands as a result of OHV recreation on those lands, whether legally or illegally.

7.3. Measurement Error

Although this study discusses statistical accuracy of the survey portions of the project, it does not discuss measurement error. The difference between what is observed and the true (but unknown) value is called "measurement error". In determining the amount of fuel a vehicle uses in off-highway recreational pursuits, the ideal measurement tool would be the gallons of gasoline that the operator used when operating his/her vehicle off-highway on public lands for recreational purposes. However, short of filling up the gas tank just before recreating and then filling up again afterwards, and recording the exact amount of fuel used (from gasoline receipts), most people will use their fuel gauge to determine that value. Besides the inherent errors in fuel gauges, most people can only determine fuel level to, at best, 1/8th of the tank. In a Hummer H2, that amounts to ± 4 gallons on the starting and ending measurement. On motorcycles and other off-highway vehicles that do not have a fuel gauge, a visual inspection is how most riders determine how much fuel is left. At best, this would only have accuracy within 1/4 tank. The result of asking people how many gallons they used recreating off-highway on public lands would likely result in a very large variation of values, many of which would not be accurate. In examining the data from this study, it appeared as though one person's overestimation was compensated for by another person's underestimation. An improvement might be to have street-licensed vehicles record mileage off-highway and then determine average fuel economy for each vehicle category. The biggest challenge is to capture enough of the fleet that the fuel economy is representative of the entire fleet of a particular vehicle type. The 1990 Study was not able to do this either. Unfortunately the cost of instrumenting enough vehicles to measure fuel use could be prohibitive given the number and variety of vehicle types, sizes, engine sizes, terrains, and towing weight. Additional thought to this issue should be given in future studies.

APPENDIX A

Component 1 Questionnaire

True North RESEARCH

CA Dept. Park & Rec, OHV
Survey of California Households
July 2003

Section 1: Introduction to Study

Hi, my name is _____ and I'm calling on behalf of California State Parks. We're conducting a brief and confidential survey of California households and we'd like to get your participation.

If needed: The survey is about important issues in California – I'm NOT trying to sell anything.

If needed: The survey should take less than 10 minutes to complete.

If needed: If now is not a convenient time, can you let me know a better time so I can call back?

Section 2: Intro Questions for Sampling Purposes

This survey will ask questions about the vehicles owned by your household and how they may be used for recreation. Are you at least 18 years of age and familiar with the vehicles owned by your household?
(*If respondent states that they don't own a vehicle, assure them that we are STILL interested in their opinions and would just like to ask them a few questions*)

(*If yes, continue with interview. If 'no', then ask*):
May I please speak to someone in your household who is at least 18 years of age and familiar with the vehicles owned by your household?

If there is no one currently available that is at least 18 and familiar with the vehicles in the household, ask for an appropriate callback time.

Q1	To begin, what is the zip code at your residence? (*After typing zip code, repeat zip code back to respondent to make sure it is correct*)	
	Record 5 digit zip code	

Section 3: Vehicle Overview

Next, I'd like to ask you several questions about the vehicles in your household.

Q2	Does your household own or lease any vehicles that are licensed to be driven on the street, such as a car, SUV, truck, van, street or dual-sport motorcycle, or RV?		
	1	Yes	Ask Q3
	2	No	Skip to Q4
	98	Don't Know	Ask to speak to an adult who will know
	99	Refused	Terminate
Q3	How many **street-licensed** vehicles does your household own or lease?		
	Write total number of street-licensed vehicles		

Q4	Does your household own any vehicles that are designed to be driven only in off-road conditions and are **not** licensed to be driven on the street? Examples include dirt motorcycles, three or four-wheel all terrain vehicles (ATV's), snowmobiles, dune buggies, sand or desert rails, off-road carts, rock crawlers and extreme 4x4's that are **not** street-licensed. ***(Note: SUV's, 4x4 and all-wheel-drive vehicles that are licensed to be driven on the street should not be counted in this question. They should be counted in Question Q2)***		
	1	Yes	Ask Q5
	2	No	Skip to Section 4
	98	Don't Know	Ask to speak to an adult who will know
	99	Refused	Terminate
Q5	How many of these **off-road** only vehicles does your household own?		
	Write total number of off-road, non street-licensed vehicles		

Section 4: Off-road Driving for Recreation			
ONLY ASK Q6 IF Q2=2 AND Q4=2. OTHERWISE, START WITH Q7			
Q6	In the past 12 months, has anyone in your household driven a **rental vehicle** off-road in California? By driving off-road, I mean driving on gravel and dirt roads, gravel and dirt trails, open areas without roads or trails, and snow-packed trails and open areas. (*if unsure, ask them to answer to the best of their knowledge*)		
	1	Yes	Skip to Q9
	2	No	Skip to SECTION 9
	99	Refused	Skip to SECTION 9
Q7	In the past 12 months, has anyone in your household driven **any** of your vehicles off-road in California? By driving off-road, I mean driving on gravel and dirt roads, gravel and dirt trails, open areas without roads or trails, and snow-packed trails and open areas. (*if unsure, ask them to answer to the best of their knowledge*)		
	1	Yes	
	2	No	
	99	Refused	
Q8	In the past 12 months, has anyone in your household driven a **rented** vehicle off-road in California?		
	1	Yes	
	2	No	
	99	Refused	

ONLY ASK Q9 AND Q10 IF Q6=1, Q7=1 OR Q8=1. OTHERWISE SKIP TO INSTRUCTIONS FOR SECTION 6			
Q9	Sometimes people will drive off-road because they enjoy driving a vehicle as a form of recreation. In other words, they drive off-road for the fun of it. Has anyone in your household driven off-road in California for this reason in the past 12 months?		
	1	Yes	
	2	No	
	99	Refused	
Q10	Sometimes people will drive off-road because they want **to get** to recreation areas or activities, such as sightseeing, camping, hiking, fishing, horseback riding, or boating. In the past 12 months, has anyone in your household driven off-road in California because they wanted to get to recreation areas or activities?		
	1	Yes	
	2	No	
	99	Refused	

ONLY ASK Q11 IF Q9 =1 OR Q10=1. OTHERWISE SKIP TO INSTRUCTIONS FOR SECTION 6

Q11 There are many public areas that are open to off-road driving in California. As I read each of the following categories, please tell me if your household drove **off-road for recreation purposes** in this type of area during the past 12 months.

Here is the (first/next) area:

	Do Not Randomize – Ask in Order	Yes	No	Don't Know	Refused
A	National Parks, National Forests, Federal lands or BLM lands in California	1	2	98	99
B	State Parks or State lands in California	1	2	98	99
C	County or City lands or parks in California	1	2	98	99
D	**Public** lands or public parks that are dedicated to off-road vehicles in California, like dirt bike tracks	1	2	98	99
E	Fire roads, logging roads, or utility roads that are on **public** lands in California	1	2	98	99
F	**Public** beaches in California	1	2	98	99
G	**Public** desert lands in California	1	2	98	99
H	Any other **public lands** in California that I did not mention previously	1	2	98	99

Section 5: Recreation Areas & Activities			
ONLY ASK QUESTIONS IN THIS SECTION IF THEY ANSWERED 'YES' (=1) TO ONE OR MORE OF THE AREAS IN Q11. OTHERWISE SKIP TO INSTRUCTIONS FOR SECTION 6			
This section is a loop. Ask Questions Q12 and Q13 for the first area, then probe for up to two additional areas where they most often drove off-highway in California for recreation purposes.			
Q12	You just indicated that your household has driven off-road on public lands in California for recreation purposes. Can you tell me the specific name of the area in California where you drove off-road (next) most often last year? (*record up to three areas*)		
		Record Area Name – Confirm spelling with respondent if unsure	
Q13	Do you know what County this area is in?		
	1	Alameda	
	2	Alpine	
	3	Amador	
	4	Butte	
	5	Calaveras	
	6	Colusa	
	7	Contra Costa	
	8	Del Norte	
	9	El Dorado	
	10	Fresno	
	11	Glenn	
	12	Humboldt	
	13	Imperial	
	14	Inyo	
	15	Kern	
	16	Kings	
	17	Lake	
	18	Lassen	
	19	Los Angeles	
	20	Madera	
	21	Marin	
	22	Mariposa	
	23	Mendocino	
	24	Merced	
	25	Modoc	

26	Mono	
27	Monterey	
28	Napa	
29	Nevada	
30	Orange	
31	Placer	
32	Plumas	
33	Riverside	
34	Sacramento	
35	San Benito	
36	San Bernardino	
37	San Diego	
38	San Francisco	
39	San Joaquin	
40	San Luis Obispo	
41	San Mateo	
42	Santa Barbara	
43	Santa Clara	
44	Santa Cruz	
45	Shasta	
46	Sierra	
47	Siskiyou	
48	Solano	
49	Sonoma	
50	Stanislaus	
51	Sutter	
52	Tehama	
53	Trinity	
54	Tulare	
55	Tuolumne	
56	Ventura	
57	Yolo	
58	Yuba	
98	Don't Know	
99	Refused	

ONLY ASK QUESTION Q14 IF Q10=1. OTHERWISE SKIP TO INSTRUCTIONS FOR SECTION 6			
Q14	You indicated that your household has driven off-road in California to get to recreation areas and activities. What types of recreation activities do you most often do at these locations? (*Record up to three activities – first three mentioned*) ***If respondent answers with driving-related activities, like ATV riding, clarify***: "In this question, we're interested in non-driving recreation activities, such as hiking or fishing. What types of non-driving recreation activities do you do at these locations?"		
	1	Animal watching (birds included)	
	2	Backpacking	
	3	Bicycling (road bikes)	
	4	Bicycling (mountain bikes)	
	5	Boating/Kayaking/Canoeing/Rafting	
	6	Camping	
	7	Climbing/Bouldering/Rock Climbing/Mountain Climbing	
	8	Fishing	
	9	Gold/Silver or Stone/Rock Collecting	
	10	Hiking	
	11	Horseback Riding	
	12	Hunting	
	13	Painting	
	14	Photography/taking pictures	
	15	Picnicking	
	16	Running/Jogging	
	17	Shooting (targets/trap/skeet)	
	18	Sightseeing	
	19	Skiing (downhill)	
	20	Skiing (crosscountry)	
	21	Snowboarding	
	22	Snowshoeing	
	23	Spelunking/Caving	
	24	Swimming	
	25	Walking	
	26	Walking pets	
	27	Watersports (skiing/wakeboarding/jetskiing)	
	28	Wildlife Study/Conservation	

	29	Other	Specify:	*Write activity clearly if not on list.*
	98	Don't Know		
	99	Refused		

Section 6: Off-road Vehicles				
ONLY ASK QUESTIONS IN THIS SECTION IF Q4=1. OTHERWISE SKIP TO INSTRUCTIONS FOR SECTION 7				
You mentioned that your household owns _____ (*insert number from Q5*) off-road vehicles that are **not** street-licensed. I'd like to ask you some questions about each of these vehicles.				
This section is a loop. Ask questions Q15 through Q21 for the first off-road vehicle, then repeat the questions in sequence for each additional off-road vehicle owned by the household.				
Q15	Thinking of your (first/next) off-road vehicle: What type of vehicle is this? (*If respondent hesitates, read list*)			
	1	Dirt Motorcycle, Motocross, Enduro, Minibike		
	2	All Terrain Vehicle (ATV) – includes 3 and 4 wheel ATV's		
	3	Dune Buggy		
	4	Rock Crawler		
	5	Extreme 4x4		
	6	Desert or Sand Rail		
	7	Off-road Cart (modified golf cart)		
	8	Snowmobile		
	9	Other Vehicle	Specify:	*Note: After specifying the 'other vehicle type', confirm that this vehicle is not licensed to be driven on the street. If it is street licensed, it should be recorded with the street licensed vehicles in the next section – not in this section!*
	99	Refused		Terminate
Q16	In what year was this vehicle manufactured? (*If unsure, ask them to estimate*)			
		Write year (4 digits)		
Q17	Have you owned this vehicle for at least 12 months?			
	1	Yes		
	2	No		
	98	Don't Know		
	99	Refused		

Q18	Is this vehicle used in closed-course racing competitions? (*If yes, ask*): Is it used **only** for racing competitions? (*Note: a closed-course is ONLY used for racing or racing practice and is NEVER available for use by non-racers or the general public*)		
	1	Yes, used only for racing	
	2	Yes, but don't use only for racing	
	3	No	
	98	Don't Know	
	99	Refused	
Q19	During the past 12 months, was there ever a period of 30 consecutive days or longer where this vehicle was broken or otherwise not in working condition? (*Note: If the person has owned the vehicle for less than 12 months, ask them to respond for the period of time they have owned the vehicle*)		
	1	Yes	Ask Q20
	2	No	Skip Q20
	98	Don't Know	Skip Q20
	99	Refused	Skip Q20
Q20	For how many months was this vehicle **not** in working condition? (*Round to nearest month*)		
	1	One Month	
	2	Two Months	
	3	Three Months	
	4	Four Months	
	5	Five Months	
	6	Six Months	
	7	Seven Months	
	8	Eight Months	
	9	Nine Months	
	10	Ten Months	
	11	Eleven Months	
	12	Twelve Months	
	98	Don't Know	
	99	Refused	

ONLY ASK Q21 IF Q7=1 AND THEY ANSWERED 'YES' (=1) TO ONE OR MORE OF THE AREAS IN Q11			
Q21	Was this one of the vehicles that your household drove off-road for recreation purposes on public land in California in the past 12 months?		
	1	Yes	
	2	No	
	98	Don't Know	
	99	Refused	

Section 7: Street-Licensed Vehicles			
ONLY ASK QUESTIONS IN THIS SECTION IF Q2=1. OTHERWISE SKIP TO SECTION 8.			
You mentioned that your household owns or leases _____ (*insert number from Q3*) street-licensed vehicles. I'd like to ask you some questions about each of these vehicles.			
ONLY ASK Q22pre1 IF Q3=5 OR GREATER. OTHERWISE SKIP TO Q22.			
Q22pre1	Are any of these vehicles vintage or collector cars that you do not drive on a regular basis?		
	1	Yes	Ask Q22pre2
	2	No	Skip to Q22
	98	Don't Know	Skip to Q22
	99	Refused	Skip to Q22
Q22pre2	How many of the vehicles are vintage or collectors cars that you don't drive on a regular basis?		
		Record Number	
Ok – let's just talk about your vehicles that are NOT vintage or collector vehicles.			
The remainder of this section is a loop. Ask questions Q22 through Q26 for the first street-licensed vehicle that is not a vintage or collector vehicle, then repeat the questions in sequence for each additional street-licensed vehicle owned by the household.			

Q22	Thinking of your (first/next) street-licensed vehicle: Is this vehicle a car, truck, SUV, van, motorcycle, RV or some other type of vehicle?			
	1	Car		Skip to Q24
	2	Truck		Skip to Q24
	3	SUV		Skip to Q24
	4	Van		Skip to Q24
	5	Motorcycle		Ask Q23
	6	RV/Motorhome		Skip to Q24
	7	Other Vehicle	Specify:	*Note: After specifying the 'other vehicle type', confirm that this vehicle is licensed to be driven on the street.* Skip to Q24
	99	Refused		Terminate
Q23	Is this motorcycle a dual-sport motorcycle, or is it meant for riding on paved surfaces only? (*Note: Dual-sport means that the motorcycle is designed so that it can be ridden off-road and on-road*)			
	1	Dual-sport		
	2	Not dual-sport (street only)		
	98	Don't Know		
	99	Refused		
Q24	What year was this vehicle manufactured? (*If unsure, ask them to estimate*)			
		Write year (4 digits)		
ONLY ASK Q25 IF Q22=1, 2, 3, 4, 6 OR 7. OTHERWISE SKIP TO INSTRUCTIONS PRECEDING Q26				
Q25	Is this vehicle a 2-wheel-drive, 4-wheel-drive (4x4), or all-wheel-drive (AWD) vehicle? (*Note: an all-wheel-drive (AWD) vehicle is always sending power to all four wheels. A 4x4 vehicle generally provides the driver the option of sending power to all four wheels or just two wheels*)			
	1	2-wheel-drive		
	2	4-wheel-drive (4x4)		
	3	All-wheel-drive (AWD)		
	98	Don't Know		
	99	Refused		

ONLY ASK Q26 IF Q7=1 AND THEY ANSWERED 'YES' (=1) TO ONE OR MORE OF THE AREAS IN Q11			
Q26	Was this one of the vehicles that your household drove off-road for recreation purposes on public land in California in the past 12 months?		
	1	Yes	
	2	No	
	98	Don't Know	
	99	Refused	

Section 8: Solicit Follow-up Survey & Contact Information			
ONLY ASK QUESTIONS IN THIS SECTION IF Q2=1 OR Q4=1. OTHERWISE SKIP TO SECTION 9			
Thank you so much for your participation in this important research project. We have just a few more questions.			
D1	We will be conducting a follow-up mail survey in the next year as part of this important study about off-road driving in California. If your household participates in this upcoming survey, it will be entered into a random drawing to win one $25,000 cash grand prize, one $5,000 cash prize, or one of five cash prizes totaling $1,000 each. Would your household be willing to complete this follow-up survey and be entered into the drawing? *Note: for lottery rules and odds of winning, the respondent can call 760.632.9900 and ask to have the information mailed to them.*		
	1	Yes	
	2	No	
D2	***Use this language if D1=1***: Thank you! To be able to send you the mail-survey, I need your name and mailing address. What is your first name? ***Use this language if D1=2***: Ok. I have just a few more questions. What is your first name?		
		Write first name	***Note: The name and address information is an essential part of the interview. If needed, reassure the respondent that this information will be kept strictly confidential and will only be used for the study.***
D3	What is your last name?		
		Write last name	
D4	What is the street address of your residence? (*Make sure to confirm street number, street spelling and to ask if there is an apartment or suite number*)		
		Write street address with separate fields for address #, street name, and unit #	

D5	What is the City name?		
		Write City Name	
D6	And can you repeat your zip code?		
		Write 5 digit zip code	
ONLY ASK QUESTION D7 IF Q4=1. ALL OTHERS SKIP TO SECTION 9.			
D7	Has your household been at this location for the past 12 months, or have you moved?		
	1	Been at location for 12 months or more	Skip to SECTION 9
	2	Moved within the past 12 months	Ask D8
	99	Refused	Skip to SECTION 9
D8	Can you tell me the street address of your previous residence? (*Make sure confirm street number, street spelling and to ask if there is an apartment or suite number*) ***Only use this statement if D1=1 and only if respondent asks why we need their previous address:*** When we send the follow-up survey, we will use the DMV vehicle registration database to choose one of your vehicles at random. Since you have moved in the past year, however, your DMV registrations may still be linked to your previous address.		
		Write street address with separate fields for address #, street name, and unit #	
D9	What is the City name?		
		Write City Name	
D10	And the zip code?		
		Write 5 digit zip code	

Section 9: Demographics			
Only use following introduction if Q2=2 AND Q4=2. Otherwise skip intro and go straight to D11. Thanks for your participation. I have just a few more questions for comparison purposes.			
D11	**Not** including cell phones or phone lines that are dedicated to a fax machine or computer modem, how many phone numbers does your household have?		
	1	One	
	2	Two	
	3	Three	
	4	Four	
	5	Five or More	
	99	Refused	

D12	How many adults 18 years of age or older live in your household?		
	1	One	
	2	Two	
	3	Three	
	4	Four	
	5	Five or More	
	99	Refused	
D13	How many children 17 years of age or younger live in your household?		
	1	One	
	2	Two	
	3	Three	
	4	Four	
	5	Five or More	
	6	No Children	
	99	Refused	
D14	What ethnic group do you consider yourself a part of or feel closest to? (*Read list if respondent hesitates*)		
	1	Caucasian/White	
	2	Latino/Hispanic	
	3	African-American/Black	
	3	American Indian or Alaskan Native	
	4	**Asian** -- Korean, Japanese, Chinese, Vietnamese, Filipino or other Asian	
	5	Pacific Islander	
	6	Mixed Heritage	
	7	Other	
	99	Refused	

D15	Last question. I'm going to read you several income categories. Please stop me when I reach the category that best describes your total annual household income.		
	1	Less than $25,000	
	2	$25,000 to $39,999	
	3	$40,000 to $59,999	
	4	$60,000 to $74,999	
	5	$75,000 to $99,999	
	6	$100,000 or more	
	99	Refused	

Post-Interview Items			
D16	Gender		
	1	Male	
	2	Female	
D17	Phone Number (10 digits)		
		Write Phone Number	
D18	Interview Date		
		Write Date MM/DD/YY	

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APPENDIX B

Pre-Recruiting Invitation Letters

Version 1 – Initial Invitation Letter

Version 2 – Revised Invitation Letter

Version 3 – State Parks Invitation Letter

Return Form

State Parks Website Notice

May 18, 2004

Dear Californian,

The State of California Department of Parks & Recreation is conducting an important study, and we need your assistance. The State of California Department of Parks & Recreation has contracted with ICF Consulting, an independent research firm, to conduct this study.

The study will focus on how often and where Californian's drive their vehicles in California for recreation or to access recreation areas. To get an accurate picture of recreational driving off public highways in California, we need all types of Californians to participate in this study, **whether they drive off-road or not.** Households that are selected and participate in the study will be eligible to receive $30,000 in cash prizes, including one $25,000 grand prize!*

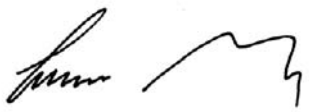
Participating in the study is easy – you need only answer a few questions about your activities and fuel use on each day that you drive your vehicle off-road, and enter this information into a diary that will be provided to you. **If you do not drive your vehicle off-road during the survey period – that is OK.** We need to know that information too and you are still eligible for the cash prizes noted above.

If you are interested in participating in the study, simply fill out the enclosed form (including your home phone number) and mail it to us in the enclosed envelope within the next few days. You phone number and other information will be used for this study only. It will not be sold to others. The postage has been pre-paid, so you do not need a stamp.

From all of the returned forms, we will select a sample of households to participate in the survey. If your household is selected to participate, we will send you a survey in the next two months with instructions on how to participate.

Thank you for your interest. We look forward to receiving your form to indicate your desire to participate in this study. If you have any questions, please call 1-866-396-7422.

Sincerely,



Louis Browning

Project Administrator

**A drawing will be held bimonthly, with all completed and returned diaries for the previous two-month period receiving one entry. In each drawing, one award of $5,000 and five awards of $1,000 each will be given. All returned diaries will also receive one entry in the Grand Prize drawing for $25,000. For complete rules and regulations for the Sweepstakes drawing, write to: Sweepstakes Rules, Box 26, 205 De Anza Blvd., San Mateo, CA 94402.*

October 27, 2004

Dear Fellow Californian,

California State Parks is conducting a very important survey to obtain an accurate picture of the recreational driving activities of Californians. We need *you*, as a Californian, to participate in this study, *whether you ever drive for recreation or not*. If you sign up, complete, and return the survey, you will be entered in a cash sweepstakes drawing (*even if you did not drive for recreation during the survey period)*. The independent research firms of ICF Consulting and True North Research are helping with this study and they are offering cash prizes of up to $30,000 for this important survey*. Please note that funding for the sweepstakes drawings **are not** coming from the State of California General Fund. For more details on this study, please see http://www.ohv.parks.ca.gov and click on "*California Fuel Use Survey Underway by ICF Consulting*".

Participating in the survey is easy – you need only answer a few questions about your driving and fuel use for a two-month period, enter the information into a log book that we will provide to you, and return the log book in a postage-paid envelope we will provide.

If you are interested in participating in the survey, simply fill out the enclosed form and mail it to us in the enclosed envelope within the next few days. The postage has been pre-paid, so you do not need a stamp.

Your telephone number and other information will be used for this study only. It will not be used again, sold to others, or divulged to anyone outside the persons involved in this specific survey.

From the returned response forms, we will select a "random sample" of households to participate in the survey. If your household is selected, we will send you a log book within the next two months with instructions on how to participate.

I'm thanking you in advance for your consideration to participate in this very significant survey for the California State Park System. I look forward to receiving your form indicating your desire to participate in the survey. If you have any questions, please call our toll-free number, 1-866-396-7422, or email us at StateParkSurvey@icfconsulting.com.

Sincerely,

Louis Browning

Fuel Usage Study Project Administrator

A drawing will be held bimonthly with all **completed and **returned** surveys for the previous two-month period receiving one entry in the sweepstakes. In each sweepstakes drawing, one award of **$5,000** and five awards of **$1,000** each will be given. Your odds of winning a $1,000 prize is approximately 1 in 600 and your chance of winning the $5,000 prize is approximately 1 in 3,000. All returned surveys will also receive one entry in the Grand Prize sweepstakes drawing for **$25,000**. Your odds of winning the Grand Prize will be approximately 1 in 15,000. For complete rules and regulations for the Sweepstakes drawing, write to: Sweepstakes Rules, Box 26, 205 De Anza Blvd., San Mateo, CA 94402.*

State of California • The Resources Agency — Arnold Schwarzenegger, *Governor*
DEPARTMENT OF PARKS AND RECREATION • P.O. Box 942896 • Sacramento, CA 94296-0001 — Ruth Coleman, *Director*

November 3, 2004

Dear Fellow Californian,

California offers a wide range of outdoor recreation opportunities and experiences. Regardless of the type of activity you enjoy, one thing is certain: California provides something for everyone. The independent research firms of ICF Consulting and True North Research are conducting a very important survey for California State Parks. We wish to determine what types of outdoor recreation Californian's enjoy and how they travel to their recreation destination(s). As an incentive to participate, ICF Consulting is offering all eligible survey participants* one opportunity to win up to a grand prize of **$25,000.00*** cash and all bi-monthly eligible participants* the opportunity to win either one of five **$1,000.00*** cash prizes or one **$5,000.00*** cash prize.

We need *you* to help California State Parks continue to provide the best recreation opportunities available to our residents. Regardless of whether you drive a vehicle to access recreation activities or not, we would like you to participate in this study. By gathering this information we will be able to develop an accurate picture of the recreational driving habits of all Californians. To sign up, please complete and return the enclosed form in the self-addressed stamped envelope. Once all forms are received by the deadline, a "random sample" will be drawn from the forms submitted and those selected will be sent a "logbook: in which to record their driving habits and fuel usage over a two-month period. A postage-paid envelope will be provided to return the logbook. Thus, there is absolutely no cost for you to participate!

Eligible participants* in the two-month survey will be entered in the cash sweepstakes drawings once they have returned their logbook by the specific deadline. **Please note: *No funds for the sweepstakes drawings are coming from California's General Fund*.** For more information on this study, please see http://www.ohv.parks.ca.gov and click on "California Fuel Use Survey Underway by ICF Consulting".

We value your help and in order to protect your privacy, please be assured that your telephone number and other information will **ONLY** be used for this study. No information will be used again, sold to others, or provided to any persons not involved in this specific survey.

I look forward to receiving your completed form indicating your willingness to participate in the survey. I wish to thank you in advance for your help in this very important project to assist California State Parks. If you have any questions, please call our contractor's toll-free number, 1-866-396-7422, or email them at StateParkSurvey@icfconsulting.com.

Sincerely,

Ruth Coleman, Director

California State Parks

A drawing will be held every two-months for all Eligible Participants. To be an Eligible Participant, you must **complete and **return** the two-month survey "LOGBOOK" provided to you, even if you had no recreational gasoline usage during that period. In each two-month sweepstakes drawing, one award of **$5,000** and five awards of **$1,000** will be given. Eligible Participants have one chance to win one of those six cash sweepstakes awards. Your odds of winning a $1,000 prize is approximately 1 in 600 and your chance of winning the $5,000 prize is approximately 1 in 3,000. **All** Eligible Participants will also receive one entry in the Grand Prize cash sweepstakes drawing for **$25,000**. Your odds of winning the Grand Prize will be approximately 1 in 15,000. For complete rules and regulations for the Sweepstakes drawing, write to: Sweepstakes Rules, Box 26, 205 De Anza Blvd., San Mateo, CA 94402.*

California Department of Parks and Recreation
Recreational Fuel Use Survey

Thank you for your interest in participating in this important study. By completing and returning this information sheet, you will be eligible to be selected for participation in the study. All households that are selected *and* that participate in this study are eligible to receive up to $30,000 in cash prizes (see cover letter for how to receive complete rules and regulations on the drawing).

Darken appropriate ovals completely with a black or blue pen or a pencil.
Like this: ● **Not** like these: ⊗ ⦸ ⊙

---

1. Do you still own this vehicle?

<Vehicle Info Label Here>

YES, still own vehicle	◡
NO, do not own vehicle	◡

If No, please select another vehicle in your household and enter its info below:

Year: _____

Make: _____
(examples: Honda, Yamaha, Ford)

Model: _____
(examples: Civic, YFM350X, Explorer)

2. Please write your 10-digit telephone number, and for each digit, fill in the appropriate bubble in the column below it. Your telephone number is for this study only and will not be sold to others.

Area Code									
(___	**___**	**___)**	**___**	**___**	**___**	**-**	**___**	**___**	**___**	**___**
□	□	□	□	□	□		□	□	□	□
◱	◱	◱	◱	◱	◱		◱	◱	◱	◱
◂	◂	◂	◂	◂	◂		◂	◂	◂	◂
▸	▸	▸	▸	▸	▸		▸	▸	▸	▸
▴	▴	▴	▴	▴	▴		▴	▴	▴	▴
▾	▾	▾	▾	▾	▾		▾	▾	▾	▾
◂◂	◂◂	◂◂	◂◂	◂◂	◂◂		◂◂	◂◂	◂◂	◂◂
▸▸	▸▸	▸▸	▸▸	▸▸	▸▸		▸▸	▸▸	▸▸	▸▸
⏮	⏮	⏮	⏮	⏮	⏮		⏮	⏮	⏮	⏮
–	–	–	–	–	–		–	–	–	–

Do not write below this point.

<Barcode Label Here>

http://www.ohv.parks.ca.gov/pages/1140/files/ICF_Consulting.doc

California Fuel Use Survey Underway by ICF Consulting

The Off-Highway Motor Vehicle Recreation Division of California State Parks is currently surveying California households to find out how much gasoline people use while recreating off-highway and where that recreation is occurring in the state. The results of this survey will be used by State Parks to provide off-highway recreational opportunities while simultaneously protecting California's precious natural resources.

California State Parks has contracted with the independent research firms of ICF Consulting and True North Research to conduct the study. As part of this study, recreational fuel use log books are being sent to randomly selected California households requesting they record the amount of gasoline used when they drive off paved roads on public land for recreational purposes, or to access recreational activities such as hiking, biking, boating, rock climbing, camping, etc.

ICF Consulting is offering a sweepstakes drawing to encourage participation among those households that are randomly selected to participate. As a participant you have nothing to lose.

California State Parks would like to encourage every household contacted by ICF Consulting to participate in the survey. As previously stated, the results of this survey will provide California State Parks the information necessary to provide quality and ecologically responsible recreation opportunities throughout California, The Golden State!

APPENDIX C

Fuel Use Log Book

Survey of Recreational Fuel Use by California Drivers

California Department of Parks and Recreation and
California Off-Highway Vehicle Stakeholders Roundtable

Dear Californian,

Thank you for participating in this important study. California Department of Parks and Recreation is conducting this study for resource planning and maintenance purposes.

This log book is designed for you to tell us the amount of gasoline you use during a **two-month period** while driving using the vehicle on the label below:

Your log book period is: **December 2004 and January 2005**
Return log book: Between **Feb 1, 2005 and Feb 29, 2005**

(vehicle label here)

If you no longer own this vehicle, please choose another vehicle in your household. If possible, choose a vehicle similar to the one listed above, cross out the vehicle information above and enter the information for the new vehicle. **ONLY RECORD FUEL USE FOR THE VEHICLE LISTED ABOVE** (or the one substituted if you no longer own that vehicle).

We provide pages for up to 15 days of recreational driving during the two months. For additional log book pages call 1-800-398-5356.

*For completing and returning this log book (**even if you do not drive for recreation using this vehicle during your two month log book period**) you will be entered in a drawing in which you could win up to $30,000 in cash prizes, including the $25,000 cash grand prize.*

Important - read the following page

Reference List of Recreation Activities

Circle here and record activity number in question D-3 for any log book days you participated in this activity.

Number	Activity
1	Driving for Recreation (see definition page 2)
2	Backpacking
3	Bicycling (mountain, road)
4	Non-motorized Boating (kayaking, canoeing, rafting)
5	Camping
6	Climbing (Rock, Bouldering, Mountaineering, Ice)
7	Fishing
8	Gold, Silver, Rock Collecting
9	Hiking, Walking, Walking Pets, Running, Jogging
10	Horseback riding
11	Hunting, target shooting
12	Motor boating, including personal watercraft, waterskiing (fuel used by watercraft not included in this study)
13	Animal Watching, Birding, Wildlife Study
14	Paragliding, Hang gliding, Base Jumping
15	Photography, Painting
16	Picnicking
17	Sail boarding, Sail boating
18	Skiing or Snowboarding (cross country, alpine, backcountry)
19	Spelunking (caving)
20	Snowshoeing
21	Swimming
22	Astronomy

Other Recreational Activity (add your own if not on list)

23 _____

24 _____

Dear Log book keeper,

Please record your fuel use only when you drive off-road on public lands for recreation or to access recreational activities.

Please review the following 4 definitions….

1. Off-road driving in this study means driving a vehicle on unpaved, gravel, or dirt roads, trails, and open areas without roads or trails, or on snow covered areas. Off-road starts where the pavement ends. All snowmobile use is considered off-road for this study.

2. Public lands include National, State and County Parks, National and State Forests, Bureau of Land Management (BLM) lands, County, and State or Federal recreation areas. Examples are forest and desert roads, jeep and dirt-bike trails, off-highway vehicle parks such as SVRAs, public dirt racetracks, and snowmobile areas.

3. Driving for recreation (activity #1 on inside front cover). Driving for recreation means the primary purpose is to enjoy driving the vehicle off-road. For example, you might drive for fun at one of the State Off-Highway Vehicle Parks, on jeep trails, dune areas, public racetracks, or snowmobile trails.

4. Driving to accessing recreational activities. When people drive to get to recreation areas or recreation activities, some part of that driving might be off-road. For example, you might drive 50 miles on a paved road, then 10 more miles on a dirt road to get to your favorite camping or fishing spot. In this log book, you would record the 10 miles you drove on the dirt road; you would **not** record the 50 miles you drove on a paved road. **View a list of recreation activities on the inside front cover.**

If these definitions don't apply to you, please read #5 and #6 on the next page.

Now read log book instructions on next page

Instructions to complete your log book

1. This log book is to record your fuel use when you drive the vehicle listed on the front cover off-road on public land for recreation or to access recreational activities. **Do not record any travel on private land or any driving that is not for recreational purposes or to access recreational activities.**
2. Take this log book on recreational off-road trips. Check fuel and reset odometer (if you have one) and fill out one set of pages for each day you use this vehicle off-road on public lands in California for recreation or to access recreational activities during the log book period. Review the sample log book day on pages 6-7. Your log book begins on page 8. There is space in this log book for up to 15 days of recreational activity during the 2 month log book period. (If you plan to drive off-road for recreational purposes or to pursue recreational activities for more than 15 days during the 2 month period, please call 1-800-398-5336 for additional pages.)
3. Please include your driving **and** that of anyone who uses the vehicle on the front cover. If you no longer have that vehicle, please correct the label on the front of the log book with the vehicle that you replaced
4. For each day that you use this vehicle off-road, mark that day on the **calendar on the inside back cover.**
5. **If you never drove this vehicle off-road on public lands in California during December 2004 and January 2005, check this box ☐ and return your log book to us February 1, 2005.**
6. **If you never drive off-road for recreation or to access recreation on public lands with the vehicle listed on the front cover, check this box ☐ and return your log book to us immediately**.

If you check the boxes under #5 or #6 above and return this log book to us, you are still eligible for the sweepstakes drawing.

Before filling out your log book, first please answer the questions below:

V1. Does this vehicle have a fuel gauge? ☐ Yes ☐ No

V2. What does the manufacturer say is the miles per gallon (MPG) for this vehicle? _____ MPG, or ☐ Manufacturer doesn't say

V3. What do you estimate is the actual off-road MPG for this vehicle when doing **easy to normal** off-road driving? (*Hard off-road driving would involve steep, difficult terrain, racing, dunes, deep snow, and using low range in some vehicles.*)

_____MPG is my estimate for easy to normal driving

V4. On any given day that you drive this vehicle off-road, would you say that you know how many gallons of fuel you used in this vehicle just for off-road driving? (Mark one box)

☐ I'm not certain how many gallons are used
☐ I'm certain to within a gallon
☐ I'm certain to within a 1/2 gallon or less.

See sample log book pages on pages 6 and 7

…..Sample Log Book Day ……

D-1 Date vehicle was used off-road on public lands

12/20/04
Month / Day / Year

(Mark this date on calendar inside back page as well)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	Hollister Hills
County (identify State or country if not in Calif.)	San Benito
Nearest town	Hollister
Nearest exit off paved road	Cienaga Rd.

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.
# 7	Fishing
#1	driving for recreation
# 9	Hiking

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) 2 1/2 gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. ___45___ mile(s) [x] No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) ___3___ hour(s)

D-7 Was the fuel used this day, purchased in California? [x] Yes [ ] No

D-8 Type of fuel used this day (mark one box)
- [x] gasoline (regardless of grade)
- [ ] racing fuel
- [ ] diesel
- [ ] two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- [x] No
- [ ] Yes, but only a short distance
- [ ] Yes, up to 1/2 of driving included towing
- [ ] Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- [ ] Primarily easy driving
- [ ] 3/4 easy, 1/4 hard and fuel demanding
- [ ] 1/2 easy, 1/2 hard and fuel demanding
- [x] 1/4 easy, 3/4 hard and fuel demanding
- [ ] Primarily tough and fuel demanding

Next page begins your two-month log book

1st Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

2nd Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

3rd Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year
(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

4th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

5th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

6th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year
(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

7th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year
(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

8th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year
(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

9th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

10th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

11th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

12th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

13th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

14th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year
(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

15th Day of Off-Road Use during Log Book Period

D-1 Date vehicle was used off-road on public lands

_____
Month / Day / Year

(Mark this date on calendar on inside back cover too.)

D-2 Describe the area your vehicle was driven off-road on public lands on **this day**.

Common name of area	
County (identify State or country if not in Calif.)	
Nearest town	
Nearest exit off a paved road?	

D-3 Describe your activities off-road today with this vehicle.

Enter numbers from list on inside cover.	Describe activity.

D-4 If you are reasonably certain of how much fuel this vehicle used off-road this day, record at right. (use fractions, such as 1/2 gallon or 5 1/2 gallons) _____gallon(s)

D-5 If this vehicle has an odometer, record miles traveled off-road this day? If no odometer, check the box and estimate your miles traveled. _____mile(s) ☐ No odometer

D-6 How many hours was this vehicle driven off-road this day? (Do not include time the vehicle was parked) _____hour(s)

D-7 Was the fuel used this day, purchased in California? ☐ Yes ☐ No

D-8 Type of fuel used this day (mark one box)
- ☐ gasoline (regardless of grade)
- ☐ racing fuel
- ☐ diesel
- ☐ two-stroke mix

D-9 Did this vehicle tow anything off-road this day? (one box)
- ☐ No
- ☐ Yes, but only a short distance
- ☐ Yes, up to 1/2 driving included towing
- ☐ Yes, most or all driving included towing

D-10 Was your off-road driving easy to normal driving or hard driving that used more fuel than normal? (hard driving includes steep, difficult trails and terrain, dunes, using low range gears, racing)
- ☐ Primarily easy driving
- ☐ 3/4 easy, 1/4 hard and fuel demanding
- ☐ 1/2 easy, 1/2 hard and fuel demanding
- ☐ 1/4 easy, 3/4 hard and fuel demanding
- ☐ Primarily tough and fuel demanding

For an additional log book pages call 1-800-398-5356.

Last Question!

In the space below, please comment on this survey.

Mark days you went off road driving in this two month period. We provide pages for up to 15 days off-road. For additional log book pages call 1-800-398-5356.

December 2004						
Sun	Mon	Tues	Weds	Thurs	Fri	Sat
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

January 2005						
Sun	Mon	Tues	Weds	Thurs	Fri	Sat
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	**Return log book**				

For help filling out this log book, please call 1-866-396-7422 or email us at StateParkSurvey@icfconsulting.com.

Please return this log book to:

True North Research/SDV-SCC
P.O. Box 231850
Encinitas, CA 92023-9891

Don't forget, unless you return this fuel use log book to us, you will not be eligible for the sweepstakes drawing in which you can win up to $30,000 in cash.

For more information on this study, see http://www.ohv.parks.ca.gov and click on **California Fuel Use Survey Underway by ICF Consulting**

Thank you for participating in this important study for California Department of Parks and Recreation.

APPENDIX D

Detailed Fuel Use Tables

Table D-1. Recreational Gasoline Gallons per Month per Vehicle for Street Licensed Vehicles

Month	Cars		SUVs		Trucks		Vans		Motorcycles		Other
	2WD	4WD	2WD	4WD	2WD	4WD	2WD	4WD	Dual Sprt	Street	
Apr 04	0.036	0.045	0.544	4.007	0.251	0.700	0.002	0.000	0.210	0.060	0.005
May 04	0.038	0.013	0.249	0.671	0.194	0.626	0.004	0.001	0.409	0.000	0.030
Jun 04	0.135	0.348	0.232	0.901	1.344	1.928	0.951	0.323	6.830	0.097	0.000
Jul 04	0.153	0.114	0.292	1.474	1.023	1.911	0.201	0.357	6.094	0.094	0.000
Aug 04	0.379	0.290	0.655	1.396	0.756	1.835	0.606	0.000	11.683	0.089	0.000
Sep 04	0.081	0.262	0.953	1.078	0.388	1.210	0.127	0.215	2.006	0.031	0.000
Oct 04	0.261	0.175	2.032	0.886	0.331	2.232	0.536	0.046	7.398	0.060	0.000
Nov 04	0.139	0.047	1.609	0.657	0.180	1.784	1.783	0.023	4.168	0.023	0.000
Dec 04	0.034	0.192	0.899	1.092	0.760	1.396	0.224	0.464	4.433	0.011	0.149
Jan 05	0.123	0.256	0.434	0.554	0.429	0.669	0.386	0.000	3.550	0.000	0.000
Feb 05	0.081	0.093	0.388	0.776	0.327	1.180	0.618	0.309	1.246	0.320	0.882
Mar 05	0.044	0.048	0.425	0.762	0.244	0.998	0.384	0.053	0.829	0.164	0.595

Table D-2. Margin of Error in Recreational Gasoline Gallons per Month per Vehicle for Street Licensed Vehicles

Month	Cars		SUVs		Trucks		Vans		Motorcycles		Other
	2WD	4WD	2WD	4WD	2WD	4WD	2WD	4WD	Dual Sprt	Street	
Apr 04	0.051	0.050	1.034	6.112	0.292	6.112	0.004	0.005	3.364	0.271	0.028
May 04	0.081	0.049	0.480	0.695	0.346	0.695	42.237	0.018	6.896	0.000	0.260
Jun 04	0.072	0.693	0.248	0.323	1.359	0.323	28.591	0.303	15.682	0.195	0.000
Jul 04	0.179	0.185	0.270	1.011	1.108	1.011	71.410	0.290	14.428	0.337	0.000
Aug 04	0.586	0.581	0.083	0.656	0.844	0.656	50.325	0.000	27.583	0.000	0.000
Sep 04	0.150	0.364	0.114	0.535	0.351	0.535	51.511	0.338	3.473	0.000	0.000
Oct 04	0.311	0.353	2.818	0.390	0.319	0.390	31.583	0.109	1.518	0.101	0.000
Nov 04	0.303	0.140	2.580	0.382	0.268	0.382	63.175	0.058	4.363	0.055	0.000
Dec 04	0.039	0.147	0.870	0.565	0.710	0.565	63.779	0.000	6.512	0.018	0.051
Jan 05	0.235	0.244	0.520	0.217	0.510	0.217	32.946	0.000	4.851	0.000	0.000
Feb 05	0.087	0.131	0.343	0.272	0.292	0.272	38.263	0.612	3.828	0.549	1.125
Mar 05	0.071	0.064	0.574	0.261	0.292	0.261	50.211	0.121	0.831	0.314	1.086

Table D-3. Recreational Gasoline Gallons per Month per Vehicle for Non-Street Licensed Vehicles

Month	Motorcycles		ATVs		4 Wheel Vehicles		Snowmobiles		Other	
	Reg	Non-Reg	Reg	Non-Reg	Reg	Non-Reg	Reg	Non-Reg	Reg	Non-Reg
Apr 04	3.541	3.888	4.336	0.730	0.265	1.353	1.418	4.623	0.000	0.000
May 04	0.757	0.236	1.768	0.185	0.265	2.443	0.445	0.228	0.000	0.000
Jun 04	1.605	0.013	0.640	0.016	0.086	1.722	0.000	0.000	1.631	1.631
Jul 04	1.924	0.025	1.979	0.201	0.000	4.647	0.000	0.000	0.000	0.000
Aug 04	0.882	0.026	2.700	1.180	0.035	5.141	0.000	0.000	0.969	0.969
Sep 04	0.777	0.109	1.622	1.995	0.000	0.023	0.000	0.000	0.000	0.000
Oct 04	2.873	1.265	2.850	0.702	5.741	8.420	0.255	0.853	0.000	0.000
Nov 04	2.624	1.620	3.250	0.486	1.780	11.677	2.358	11.866	0.000	0.000
Dec 04	2.183	0.610	2.815	0.210	3.987	4.036	17.350	16.626	0.003	0.003
Jan 05	1.749	0.205	2.388	0.245	1.897	0.853	13.311	4.638	0.000	0.000
Feb 05	2.175	1.338	4.286	0.156	4.219	0.000	21.543	0.000	6.221	6.221
Mar 05	1.796	1.459	3.032	1.911	7.569	0.000	3.837	0.000	0.000	0.000

Table D-4. Margin of Error in Recreational Gasoline Gallons per Month per Vehicle for Non-Street Licensed Vehicles

Month	Motorcycles		ATVs		4 Wheel Vehicles		Snowmobiles		Other	
	Reg	Non-Reg	Reg	Non-Reg	Reg	Non-Reg	Reg	Non-Reg	Reg	Non-Reg
Apr 04	4.967	4.529	1.998	1.251	0.556	1.251	2.358	2.980	0.000	0.000
May 04	1.196	0.392	1.203	0.381	0.556	0.381	0.949	0.398	0.000	0.000
Jun 04	0.525	0.026	0.588	0.020	0.246	0.020	0.000	0.000	0.740	0.740
Jul 04	1.619	0.040	0.712	0.155	0.000	0.155	0.000	0.000	0.000	0.000
Aug 04	0.391	0.029	1.292	1.720	0.000	1.720	0.000	0.000	1.961	1.961
Sep 04	0.310	0.145	1.057	3.642	0.000	3.642	0.000	0.000	0.000	0.000
Oct 04	0.956	2.121	1.415	0.639	5.535	0.639	0.252	1.817	0.000	0.000
Nov 04	0.763	2.450	1.760	0.538	2.146	0.538	3.642	10.588	0.000	0.000
Dec 04	0.802	0.210	2.047	0.348	5.063	0.348	15.153	12.637	0.006	0.006
Jan 05	0.525	0.102	1.126	0.479	1.730	0.479	6.489	6.895	0.000	0.000
Feb 05	0.778	1.131	2.179	0.136	3.485	0.136	12.058	0.000	4.855	4.855
Mar 05	0.884	1.408	1.634	0.663	11.400	0.663	4.548	0.000	0.000	0.000

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