



DYED DIESEL EDUCATION AND ENFORCEMENT

Final Report 578

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16. Abstract <p>The Internal Revenue Service and the state of Arizona allow diesel used for farm, construction, or other off-road use to be purchased tax-free. This tax-free diesel must be dyed red to identify it as off-road diesel and fuel suppliers must report their sales of dyed diesel on a monthly basis. The on-road use of dyed diesel deprives Arizona of highway tax revenue and in August, 2002, the Arizona Department of Transportation initiated federally funded education and enforcement efforts to decrease inappropriate (i.e., on-road) use of dyed diesel. Using data collected during a project by the Arizona Department of Transportation, this study examines the effect of education and enforcement efforts on dyed diesel violations. Education and enforcement efforts were found to have a statistically significant effect on reducing dyed diesel violations in pickup trucks.</p>					
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>					<u>LENGTH</u>				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
<u>AREA</u>					<u>AREA</u>				
in ²	square inches	645.2	square millimeters	mm ²	mm ²	square millimeters	0.0016	square inches	in ²
ft ²	square feet	0.093	square meters	m ²	m ²	square meters	10.764	square feet	ft ²
yd ²	square yards	0.836	square meters	m ²	m ²	square meters	1.195	square yards	yd ²
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi ²	square miles	2.59	square kilometers	km ²	km ²	square kilometers	0.386	square miles	mi ²
<u>VOLUME</u>					<u>VOLUME</u>				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft ³	cubic feet	0.028	cubic meters	m ³	m ³	cubic meters	35.315	cubic feet	ft ³
yd ³	cubic yards	0.765	cubic meters	m ³	m ³	cubic meters	1.308	cubic yards	yd ³
NOTE: Volumes greater than 1000L shall be shown in m ³ .									
<u>MASS</u>					<u>MASS</u>				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")	mg (or "t")	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
<u>TEMPERATURE (exact)</u>					<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<u>ILLUMINATION</u>					<u>ILLUMINATION</u>				
fc	foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
<u>FORCE AND PRESSURE OR STRESS</u>					<u>FORCE AND PRESSURE OR STRESS</u>				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

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LIST OF ACRONYMS

ADOT	Arizona Department of Transportation
FHWA	Federal Highway Administration
IRS	Internal Revenue Service
MVD	Motor Vehicle Division
U.S.	United States
U.S.C.	United States Code
A.R.S.	Arizona Revised Statutes

EXECUTIVE SUMMARY

The Internal Revenue Service and the state of Arizona allow diesel used for farm, construction, or other off-road use to be purchased tax-free. This tax-free diesel must be dyed red to identify it as off-road diesel and fuel suppliers must report their acquisitions and dispositions of dyed diesel on a monthly basis. The on-road use of dyed diesel deprives the state of highway tax revenue and in August 2002, the Arizona Department of Transportation (ADOT) initiated federally funded education and enforcement efforts to decrease inappropriate (i.e., on-road) use of dyed diesel. These efforts have included dissemination of program information to stakeholders via a web site, distribution of brochures, presentations at industry conferences, and on-road enforcement activities. Such efforts have resulted in increased program awareness, the identification of over 300 violations, and the collection of taxes and penalties. Often, tax administration agencies rely heavily on tax/penalty assessment data to measure the success of compliance initiatives, even though their ultimate objective is to enhance voluntary compliance with the laws. This is due to the difficulty in measuring the impact of such initiatives on voluntary compliance levels. This study attempts to reliably estimate the compliance impact of ADOT's dyed diesel education/enforcement efforts.

The research project analyzed data collected from almost 4,000 vehicles at on-road fuel inspection details across Arizona. The details were designed to focus on diesel-powered trucks in rural areas, and samples were drawn from the tanks of all diesel-powered vehicles stopped. In addition to standard detail procedures (e.g., sampling fuel tanks and citing violators), enforcement officers recorded other data relevant to the detail such as date, time, location, and the number and types of vehicles that were inspected. Two details were conducted at each of the detail sites, and changes in compliance levels from the first to the second details were analyzed. In both the initial and follow-up details, pickup trucks were the most frequently offending vehicle type.

Based on the data collected at the enforcement details, we can conclude that the education and enforcement efforts had a statistically significant effect on decreasing the on-road use of dyed diesel in pickup trucks. The study determined that there was an overall 76 percent reduction in pickup truck violation rates at the second details 8 weeks later. From this it is reasonable to infer that the previous enforcement detail had a substantial impact on compliance. The education and enforcement efforts also reduced the on-road use of dyed diesel in larger trucks, but too few samples were collected on larger trucks and other diesel-powered vehicle types (e.g., passenger vehicles, buses, and recreational vehicles) to accurately estimate the effect of education and enforcement efforts on the dyed diesel use in these vehicles. Based solely on the reduction of on-road dyed diesel use in pickup trucks, it is estimated that the dyed diesel education and enforcement program increases Arizona's diesel tax revenue by more than \$1 million per year, in addition to the taxes/penalties collected from identified violators.

The following actions are recommended to improve the effectiveness of dyed diesel education and enforcement efforts:

- Establish permanent funding for the dyed diesel education and enforcement program.

The data suggest that almost \$1 million in diesel tax revenue would be lost each year without enforcement, and the education and enforcement team has demonstrated the ability to reduce dyed diesel violations by more than 75 percent. Given that the current Tax Evasion Unit budget is \$375,000 per year and 50 percent of the budget is directed at dyed diesel fuel compliance, the dyed diesel education and enforcement program would cost \$187,500 per year.

- Expand the education and enforcement scope of work.

The dyed diesel education and enforcement team has demonstrated their effectiveness in significantly reducing the rate of dyed diesel violations in areas where on-road details are conducted. Such efforts increase diesel tax revenues by more than \$1 million per year, but current efforts fail to capture another estimated \$500,000 in lost diesel tax revenue through continued violations. Since the IRS does not conduct on-road details, it is imperative that ADOT maintain a visible presence in all areas of the state. At a minimum, the team should be staffed at a level allowing at least one on-road team to be conducting details throughout the year. This increased staffing level (i.e., two full-time enforcement officers and related costs) would cost approximately \$165,000 per year.

- Enhance the accuracy of data collected via the fuel supplier reporting system.

The project attempted to analyze data relating to the quantities and destinations of dyed diesel distributed in Arizona. Fuel suppliers are required to report the detailed information regarding dyed diesel they acquire and distribute, including information relating to the destination of each load distributed. The available data were incomplete due to supplier reporting deficiencies, and the detailed data that is available is not filed or retained electronically. The integrity of the data could be improved by instituting quality controls within the report processing system, and by developing an electronic filing system to facilitate reporting and data analysis. Currently, information technology vendors provide turnkey tax reporting and payment systems at no upfront cost to government agencies in exchange for a percentage of the tax revenue collected by the system.

INTRODUCTION

Federal and state laws and regulations allow diesel used for farm, construction, educational, or off-road use to be purchased tax-free. This tax-free diesel must be dyed red to identify it for non-taxable use and fuel suppliers must report their acquisitions and distributions of dyed diesel on a monthly basis. Because the retail price of diesel includes a federal tax of 24.4 cents per gallon, and a state tax of either 26 cents or 18 cents per gallon, there is motivation to use dyed diesel for taxable purposes (i.e., on-road use). The on-road use of dyed diesel deprives the federal and state governments of substantial tax revenue. In 1994, the Federal Highway Administration (FHWA) estimated that, nationwide, the combined federal and state fuel tax evasion losses approached \$3 billion annually.¹ Adjusting for inflation using the Consumer Price Index, this loss would be about \$4 billion annually in 2006.

The importance and magnitude of this loss has been the focus of research by scholars and practitioners alike. This focus sharpened in the early 1990s with accounts in trade publications of fuel tax evasion schemes which were related to organized crime. These reports were followed by linkages drawn between these schemes and the strategies designed to thwart them.²

By the mid-1990s, the transportation field began to focus on fuel tax revenue losses³ and the effects of fuel tax enforcement efforts.⁴ Some reports have focused on state and regional topics but, in general, the topic of fuel tax evasion has received little attention since the turn of the century.⁵

¹ U.S. Department of Transportation, Federal Highway Administration, *1998 Motor Fuel Tax Evasion Summary*.

² Federation of Tax Administrators. (1993). *Up and Down the Chain: Moving the Point of Taxation on Diesel Fuel*. Washington, DC: Author.

³ Moehring, M. (1993). "A Billion Here, a Billion There or the Cost of Motor Fuel Tax Fraud." *AASHTO Quarterly Magazine*, 72, 3, 16-19.

⁴ General Accounting Office. (1992). *Tax Administration: Status of Efforts to Curb Motor Fuel Tax Evasion*. Washington, DC: Author; Federal Highway Administration. (1993). *The Joint Federal/State Motor Fuel Tax Compliance Project – Fiscal Year 1992 Status Report*. Washington, DC: Author; Baluch, S.J. (1996). "Revenue Enhancement Through Increased Motor Fuel Tax Enforcement." *Transportation Research Record*, 1558, 67-73.

⁵ Irby, M.S., & Crabtree, J.D. (1994). *Alleviation of Fuel Tax Evasion in Kentucky*. Frankfort, KY: Kentucky Transportation Cabinet; Eger, R.J., III, Knudson, D.A., Marlowe, J., & Verbos, A.K. (2003). "Agricultural Off-Road Fuel Tax: Midwestern Comparative Analysis and Assessment." *Transportation Research Record*, 1839, 74-80.

Since this same time period, the Internal Revenue Service (IRS) has had a dyed diesel enforcement program, though it has been focused on inspections at fuel terminals and on trucks parked at business locations or job sites. The IRS does not have authority to stop traffic in order to conduct on-road inspections. In August 2002, ADOT initiated federally-funded education and on-road enforcement efforts to decrease the use of dyed diesel for the purpose of tax evasion. Under the program, MVD Enforcement Officers conduct on-road details during which all diesel powered vehicles are required to stop for a fuel inspection.

Both the IRS and ADOT assess penalties and taxes for identified violations, and data relating to such assessments is available. Frequently, tax administration agencies rely heavily on such tax/penalty assessment data to measure the success of compliance initiatives, even though their ultimate objective is to enhance voluntary compliance with the laws. This is due to the difficulty in measuring the impact of such initiatives on voluntary compliance levels.

This study attempts to identify reliable measures of the compliance impact of ADOT's dyed diesel education and enforcement efforts on the use of dyed diesel for on-highway travel. The field experiment design included the collection of data during "pairs" of enforcement details conducted at locations across the state at intervals of approximately 8 weeks.

Federal Laws and Regulations

Title 26 of the Internal Revenue Code regulates the use of dyed diesel.⁶ Dyed diesel cannot be possessed or sold by anyone who knows or has reason to know that the dyed diesel will be used to evade the highway user tax. The penalty for violating this law is either \$1,000 or \$10 for each gallon of dyed diesel involved, whichever is greater. Business entities and their officers, employees, and agents who are found guilty of violating this law are jointly and severally liable for the penalty. That is, everyone who is financially liable for a violation is completely responsible for the entire amount until it is paid in full.

The current federal tax on diesel is 24.4 cents per gallon. Some uses of diesel are exempt from this tax or taxed at a reduced rate. The diesel used for these purposes is dyed red to identify it as special use diesel. This special purpose diesel must be dyed using Solvent Red 164 to standards defined by the IRS. A notice stating, "DYED DIESEL FUEL, NONTAXABLE USE ONLY, PENALTY FOR TAXABLE USE" must be provided on shipping papers to anyone who receives dyed diesel at a terminal rack and on labels on retail pumps to anyone who obtains dyed diesel at a retail pump. A seller who does not post this notice on retail pumps is presumed to know that the diesel will be used for a taxable purpose and is liable for the tax and penalty.

⁶ 26 U.S.C. 6715.

The federal tax is not imposed on diesel used in farm vehicles, state vehicles, school buses, local public transportation buses, off-road vehicles, and educational vehicles. Farm vehicles are those that are used for off-road farming purposes. Local public transportation buses are those that operate on a regular route within a metropolitan area by a government agency or under government contract. Diesel used in local public transportation buses that are not under government contract and by intercity buses is taxed at a reduced rate of 7.4 cents per gallon. Finally, diesel used in trains is taxed at a reduced rate of 4.4 cents per gallon.⁷

Federal Case Law

Federal cases provided additional insight and interpretation on issues of taxation, burden of proof, shipping and billing paperwork, and the level of knowledge required to be in violation of laws regulating the sale, possession, and use of dyed diesel.

States are exempt from the federal excise tax on diesel whether the diesel is dyed or not. If a vendor provides dyed diesel to a state, the vendor does not pay the federal excise tax when the dyed diesel is obtained at the terminal. If a vendor provides undyed diesel to a state, the vendor pays the federal excise tax when the undyed diesel is obtained at the terminal and then may apply for a refund of the excise tax.⁸ This process of excise tax payment and refund would apply to undyed diesel supplied for other nontaxable uses. A reduced refund of the federal excise tax would be allowed for undyed diesel used in trains and intercity buses.

As in all tax cases, dyed diesel tax penalties assessed by the Internal Revenue Service are presumed to be correct unless and until the taxpayer has proven the assessment to be incorrect by a preponderance of the evidence. More simply, in tax cases the taxpayer bears the burden of proof.

Federal regulations require that a notice stating, “DYED DIESEL FUEL, NONTAXABLE USE ONLY, PENALTY FOR TAXABLE USE” must be provided to anyone who receives dyed diesel and must appear on all dyed diesel shipping and billing paperwork. Two federal cases illustrate the importance of this requirement for knowing or having reason to know whether dyed diesel will be used to evade taxes. In one case, a company was penalized \$45,000 when dyed diesel was discovered in the fuel tanks of its diesel trucks and in a bulk supply tank.⁹ The notices regarding dyed diesel on the shipping and billing paperwork for the diesel delivered to this company were inconsistent and sometimes contradictory. The court completely rescinded the penalty because the notices on the paperwork did not create the knowledge needed to violate federal

⁷ U.S.C. Title 26 § 6427.

⁸ *Twenty Four Hour Fuel Oil Corp. v. United States of America, et al.*, 38 F. Supp.2d 217.

⁹ U.S.C. Title 26 § 6427.

regulations. In another case, a company was penalized \$31,000 when dyed diesel was discovered in the fuel tanks of its trucks and in a bulk supply tank.¹⁰ The notices regarding dyed diesel on the shipping and billing paperwork for the diesel delivered to this company clearly and correctly noted the type of diesel that was being delivered. Consequently, the court upheld the penalty assessed against this company.

Federal regulations provide for a penalty for the possession and use of dyed diesel by anyone who knows or has reason to know that the dyed diesel will be used for a taxable purpose. In fact, the possession or use of dyed diesel is subject to penalty *even if the appropriate tax has been paid in full*. In one case, a company received a shipment of diesel for storage and use in its diesel trucks.¹¹ The company had ordered taxable diesel and the delivered diesel was appropriately taxed. However, the delivered diesel was also dyed, and the company was fined \$31,000.

Arizona Laws and Regulations

Title 28 of the Arizona Revised Statutes contains laws governing the tax and use of motor vehicle fuel in Arizona. Fuel used by “light class” motor vehicles (those that have a declared gross vehicle weight of 26,000 pounds or less or those that have two axels or less) is taxed at a rate of 18 cents per gallon. Fuel used by “use class” motor vehicles (those that have a declared gross vehicle weight of more than 26,000 pounds or those that have more than two axels) is taxed at a rate of 26 cents per gallon.¹²

As with federal law, under Arizona law diesel fuel that is used for off-road use and special on-road use is exempt from tax and is also required to be dyed red to identify it for these special uses.¹³ Off-road light class and use class vehicles, such as farm vehicles and highway construction vehicles, are exempt from fuel tax at the time of sale.¹⁴ Fuel for school buses and local public transit buses, which are exempt from the federal excise tax on diesel fuel, is taxed at the rate of light class motor vehicles. Purchasers of dyed diesel for these types of buses must provide both the seller and the Arizona Department of Transportation with a written statement that the fuel is for a qualified use.¹⁵

¹⁰ Consolidated Edison Company of New York, Inc. v. United States of America, 34 F. Supp. 2d 160.

¹¹ Consolidated Edison Company of New York, Inc. v. United States of America, 34 F. Supp. 2d 160.

¹² 28 A.R.S. 5606.

¹³ 28 A.R.S. 5601.

¹⁴ 28 A.R.S. 5610.

¹⁵ 28 A.R.S. 5649.

The seller pays the fuel tax before it is actually sold at the retail level. Retail diesel fuel pumps must have a decal that states if the retail price includes the 26 cent per gallon tax, the 18 cent per gallon tax, or if no tax is included in the price per gallon. Purchasers of diesel fuel for use outside the state may obtain a refund of Arizona tax from the Arizona Department of Transportation.¹⁶ Purchasers of diesel fuel for a light class motor vehicle who use a pump that includes the use class tax may obtain a refund of the difference between the use class tax and the light use class tax from the seller at the time of purchase.¹⁷ The seller may in turn apply for a refund of that pre-paid tax from the Arizona Department of Transportation.

Anyone who obtains dyed diesel at a terminal rack, bulk tank, or retail pump must also receive a notice that states, “DYED DIESEL FUEL, NONTAXABLE USE ONLY, PENALTY FOR TAXABLE USE” and this notice must be provided at the time of sale. In addition, the notice must appear on shipping papers, bills of lading, and invoices reflecting the sale of dyed diesel.¹⁸

Arizona law applies to both buyers and sellers of dyed diesel. Arizona prohibits the sale or possession of dyed diesel by anyone who knows or has reason to know that the dyed diesel is or will be used to evade the use tax. Arizona also prohibits the dilution of dyed diesel to evade the tax. Businesses, and any officer, employee, or agent who willfully participates in the violation of Arizona dyed diesel law is jointly and severally liable for penalties of \$1,000 or \$10 per gallon of dyed diesel involved (whichever is greater) for each violation.¹⁹ That is, each business and individual found guilty of violating dyed diesel laws is equally and fully responsible for the entire penalty until it is paid in full.

Arizona laws allow dyed diesel to be used in vehicles that do not operate on public roads. Examples of these vehicles include earth-moving equipment used in mining and farm tractors, to the extent that these vehicles do not travel on public roads. It is a Class 1 misdemeanor (the most serious of misdemeanors) for anyone to violate Arizona laws regarding dyed diesel or to knowingly aid and abet someone else who violates Arizona laws regarding dyed diesel. However, it is not a crime to use dyed diesel on Arizona highways if that diesel was purchased outside Arizona in a jurisdiction that allows the use of dyed diesel on highways or to use dyed diesel on Arizona highways in ways that comply with Internal Revenue laws, such as in a school bus.²⁰

¹⁶ 28 A.R.S. 5612.

¹⁷ 28 A.R.S. 5605.

¹⁸ 28 A.R.S. 5646.

¹⁹ 28 A.R.S. 5647.

²⁰ 28 A.R.S. 5645.

The Arizona Department of Transportation's education and enforcement program includes on-road enforcement activities and other efforts to educate the public about dyed diesel laws. Brochures containing information on the program are produced and distributed to petroleum, trucking, and other industry groups, and are also available on ADOT's web site. Enforcement officers conduct on-road fuel inspection details, during which they sample the contents of fuel tanks, document violations, and educate drivers relative to fuel tax laws and the compliance program.

This study attempts to identify reliable measures of the compliance impact of ADOT's dyed diesel education and enforcement efforts, and data collected during the study's field experiment answer the following research questions:

- What are reliable measures of effectiveness for dyed diesel education and enforcement efforts?
- How effective are ADOT dyed diesel education and enforcement efforts?
- What opportunities exist to improve the effectiveness of education and enforcement efforts?
- What strategies should be adopted to improve the effectiveness of education and enforcement efforts?

RESEARCH METHOD

Data collected during routine dyed diesel inspection details were used to answer the research questions. The inspection details were conducted in rural rather than urban locations to isolate the effect of education and enforcement efforts, and to focus on areas that do not have public transportation and thus increased use of private vehicles (see Table 1).

Table 1. Enforcement detail locations.

Town	Population ^a	Drive ^b
Holbrook	4,917	88.5%
Marana	13,556	92.6%
Page	6,809	90.0%
Quartzsite	3,354	75.6%
Tacna	555	88.4%
Thatcher	4,022	87.1%

^a2000 U.S. Census

^bTo work alone or carpool in car, truck, or van

Participants

Participants in this study were 35 individuals (33 men and 2 women) who were driving diesel-powered vehicles and who stopped at the inspection details. The age of participants ranged from 22 to 101 years, with an average age of 49 years. Among the participants, 22 were Arizona residents and 13 were residents of other states. Participant vehicle types were recorded as passenger, pickup truck, semi tractor, or recreational vehicle. During Detail 1, a total of 1,928 vehicles were inspected. During Detail 2, a total of 2,006 vehicles were inspected (see Table 2).

Table 2. Vehicle inspections.

Vehicle Type	Detail 1 <i>N</i> = 1,928	Detail 2 <i>N</i> = 2,006
Passenger	0.41	0.20
Pickup	57.52	56.43
Semi Tractor	38.80	40.08
RV	3.27	3.29
Total	100.00	100.00

All values are percentages.

RV = Recreational vehicle

Measures

Enforcement detail officers recorded the number of diesel vehicles that stopped at each detail and how many dyed diesel violations were discovered at each detail.

Procedure

The enforcement data were collected during six pairs of enforcement details conducted between late 2004 and mid-2005 (see Table 3). Each enforcement detail began in the morning and ended in the afternoon of the same day. The first details lasted for an average duration of 9 hours and 43 minutes, and the second enforcement details lasted for an average duration of 9 hours and 10 minutes. Each pair of enforcement details were separated by an average interval of 58 days.

Table 3. Enforcement detail schedule.

Site	Date	Detail 1			Date	Detail 2		
		Start ¹	End ¹	Time ²		Start ¹	End ¹	Time ²
Holbrook	03-25-05	0630	1600	09:30	06-01-05	0630	1600	09:30
Marana	12-16-04	0700	1600	09:00	02-10-05	0645	1345	07:00
Page	01-24-05	0630	1700	10:30	03-21-05	0630	1700	10:30
Quarzsie	12-09-04	0700	1630	09:30	02-03-05	0630	1630	10:00
Tacna	02-02-05	0600	1540	09:40	03-29-05	0600	1600	10:00
Thatcher	02-08-05	0700	1710	10:10	04-05-05	0630	1430	08:00

¹24-hour time in Hour Hour Minute Minute (HHMM).

²Duration in Hour Hour:Minute Minute (HH:MM).

RESULTS

The enforcement detail inspections and discovered violations were analyzed to determine the effectiveness of the dyed diesel education and enforcement efforts. The number of inspections and violations were converted to percentages of their respective totals to facilitate direct comparisons. The number of violations was also converted to rates per 100 inspections to control for the varying number of inspections of each vehicle type.

Inspections

During Detail 1, a total of 1,928 vehicles were inspected (see Table 4). The most frequently inspected vehicles were pickup trucks (1,109), followed by semi tractors (748). During Detail 2, a total of 2,006 vehicles were inspected (see Table 5). Again, the most frequently inspected vehicles were pickup trucks (1,132), followed by semi tractors (794).

Table 4. Detail 1 inspections ($N = 1,928$).

Site	Vehicle Type			
	Passenger	Pickup	Semi	RV
Holbrook	0.05	12.60	8.66	0.10
Marana	0.16	5.71	1.87	0.05
Page	0.10	6.59	9.44	0.16
Quarzsie	0.10	11.31	13.12	1.82
Tacna	0.00	7.42	2.44	0.41
Thatcher	0.00	13.90	3.27	0.72

All values are percentages.

Table 5. Detail 2 inspections ($N = 2,006$).

Site	Vehicle Type			
	Passenger	Pickup	Semi	RV
Holbrook	0.05	13.21	8.23	0.10
Marana	0.00	4.29	0.45	0.00
Page	0.00	6.62	7.58	0.35
Quarzsie	0.10	17.45	13.96	1.73
Tacna	0.00	8.03	5.73	1.10
Thatcher	0.05	6.83	4.14	0.00

All values are percentages.

Violations

During Detail 1, a total of 25 violations were discovered (see Table 6). The most frequently violating vehicles were pickup trucks (23), followed by semi tractors (1), and recreational vehicles (1). During Detail 2, a total of 10 violations were discovered (see

Table 7). The most frequently violating vehicles were pickup trucks (7), followed by recreational vehicles (2), and semi tractors (1).

Table 6. Detail 1 violations ($N = 25$).

Site	Vehicle Type			
	Passenger	Pickup	Semi	RV
Holbrook	0.00	16.00	4.00	0.00
Marana	0.00	16.00	0.00	0.00
Page	0.00	16.00	0.00	0.00
Quarzsie	0.00	12.00	0.00	0.00
Tacna	0.00	12.00	0.00	4.00
Thatcher	0.00	20.00	0.00	0.00

All values are percentages.

Table 7. Detail 2 violations ($N = 10$).

Site	Vehicle Type			
	Passenger	Pickup	Semi	RV
Holbrook	0.00	20.00	0.00	0.00
Marana	0.00	0.00	0.00	0.00
Page	0.00	10.00	0.00	0.00
Quarzsie	0.00	20.00	0.00	10.00
Tacna	0.00	20.00	10.00	10.00
Thatcher	0.00	0.00	0.00	0.00

All values are percentages.

Violation Rates

During Detail 1, violation rates ranged from 0.00% to 12.50% (see Table 8). The only vehicle type to have violations at all six sites was pickup trucks. During Detail 2, no vehicle type was found to be in violation at all six sites (see Table 9).

Table 8. Detail 1 violation rates.

Site	Vehicle Type			
	Passenger	Pickup	Semi	RV
Holbrook	0.60	1.65	0.00	0.00
Marana	0.00	3.64	0.00	0.00
Page	0.00	3.15	0.00	0.00
Quarzsie	0.00	1.38	0.00	0.10
Tacna	0.00	2.10	0.10	12.50
Thatcher	0.00	1.87	0.00	0.00

All values are percentages.

Table 9. Detail 2 violation rates.

Site	Vehicle Type			
	Passenger	Pickup	Semi	RV
Holbrook	0.60	0.75	0.00	0.00
Marana	0.00	0.00	0.00	0.00
Page	0.00	0.75	0.00	0.00
Quarzsie	0.00	0.57	0.00	2.86
Tacna	0.87	1.24	0.00	4.55
Thatcher	0.00	0.00	0.00	0.00

All values are percentages.

Table 10 contains the mean comparisons of violation rates between Detail 1 and Detail 2 for each vehicle type in each of the six locations. The only mean difference that rose to statistical significance was that for pickup trucks.

Table 10. Violation rates ($N = 6$).

Vehicle Type	Detail 1	Detail 2
Passenger	0.00	0.00
Pickup*	2.30	0.55
Semi	0.10	0.15
RV	2.08	1.24

$p = .013$

RV = Recreational vehicle

The statistical magnitude of the reduction in violation rates for pickup trucks and the statistical significance of this reduction is noteworthy. Between Detail 1 and Detail 2, the violation rate for pickup trucks decreased by 76 percent, and there is a 98.7 percent probability that this reduction is not due to random chance. Rather, this reduction is almost certainly due to the compliance impact of Detail 1.

CONCLUSIONS

The violations summarized in Table 6 suggest that pickup trucks are the highest proportion of diesel vehicles using dyed diesel in violation of relevant state and federal laws. Table 11 shows the distribution of vehicles with carriages of “pickup,” “½ ton pickup,” “¾ ton pickup,” and “1 ton pickup” among the 1,188,284 trucks registered in Arizona counties as recorded in ADOT title and registration data as of March 15, 2005.

Table 11. Registered pickups (*N* = 1,188,284).

County	Diesel		
	No	Yes	%
Low			
Pima	161,456	8,320	5.16
Santa Cruz	13,688	720	5.26
Maricopa	565,284	36,374	6.43
Apache	24,591	1,682	6.84
Pinal	46,916	3,722	7.93
Medium			
Yuma	36,728	2,989	8.14
Navajo	34,108	2,938	8.61
Coconino	34,652	3,003	8.67
Cochise	35,966	3,204	8.91
Greenlee	3,273	315	9.62
Graham	8,367	832	9.94
High			
Gila	19,174	1,968	10.26
Mohave	57,025	6,092	10.68
Yavapai	60,429	6,706	11.10
La Paz	6,972	890	12.77
Total	1,108,529	79,755	7.19

As indicated in Table 11, Maricopa county had more than four times the number of registered diesel pickup trucks than the next most populous county (Pima) yet had one of the lowest overall percentages of diesel pickup trucks. La Paz and Yavapai counties had the highest proportion of registered diesel pickup trucks. Figure 1 depicts the Arizona counties and their diesel pickup registration density levels.

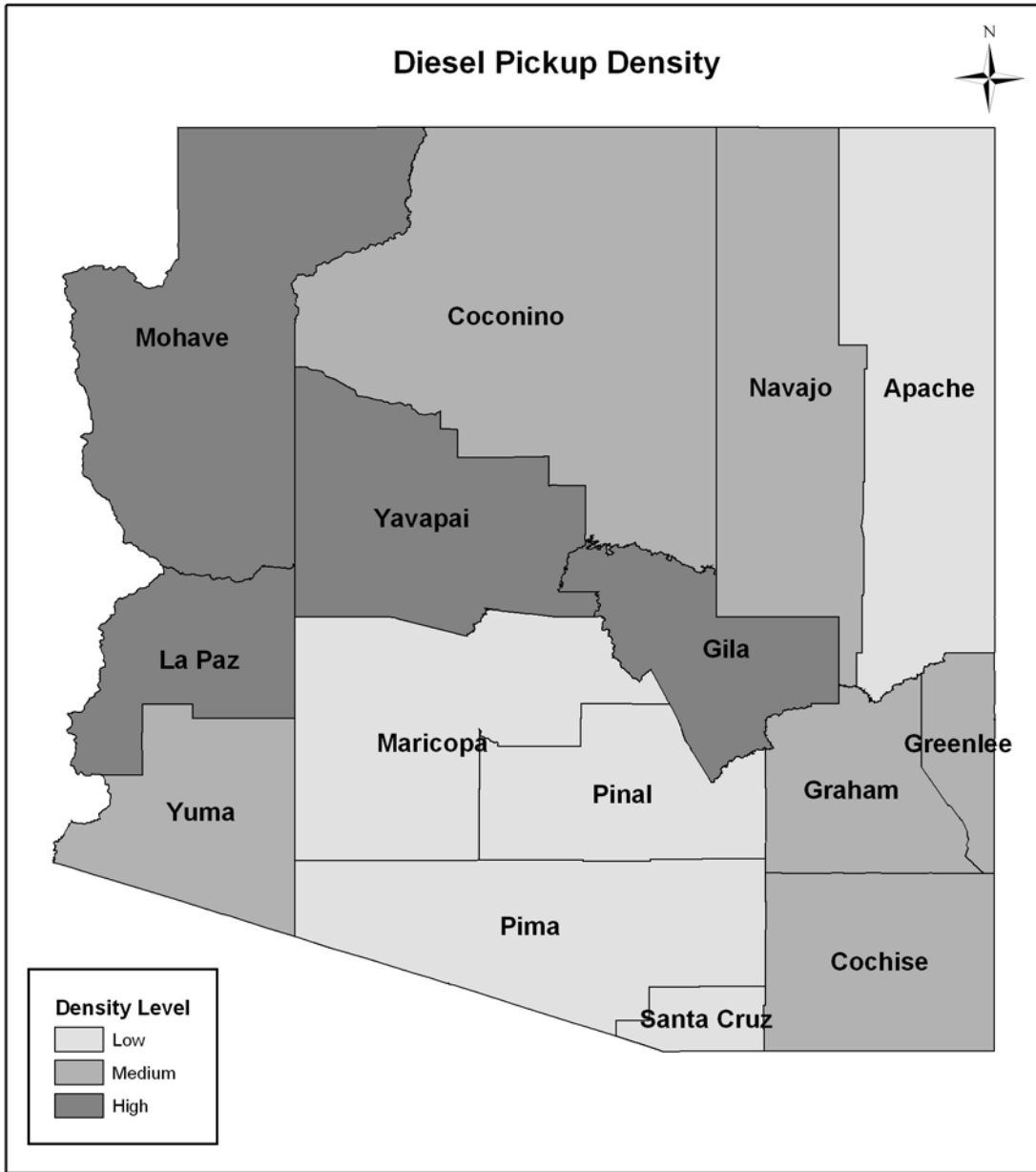


Figure 1. Diesel pickup truck registration densities.

The amount of revenue lost to dyed diesel violations in pickup trucks can be computed based on known and estimated values applied to the following formula:

$$\left(\frac{ViolationRate(AnnualMileage)}{MilesPerGallon} \right) TaxRate$$

The known values are the relevant federal and state diesel tax rates for pickups of 24.4 cents and 18 cents per gallon, respectively, which sum to 42.4 cents per gallon in the *TaxRate* operand. Based on evidence (e.g., odometer readings, registration records, and ADOT MVD inspection records) collected during dyed diesel violation investigations, the annual miles traveled by the 79,755 diesel pickup trucks registered in Arizona can be estimated to be 23,000 each, for a total *AnnualMileage* of 1,834,365,000 in the numerator.

Of all the diesel pickup trucks represented in Table 11, the single most common vehicle make and model is a ¾ ton Ford pickup truck (e.g., the F-250 series). However, vehicles in excess of 8,500 pounds (including Ford F-250 pickups) are exempt from official fuel efficiency ratings. Thus, there are no official fuel efficiency ratings for the most common diesel pickup registered in Arizona to provide the basis for the estimated average miles per gallon. Instead, evidence (e.g., driver statements, fuel and mileage logs, etc.) collected during dyed diesel violation investigations indicates that the average fuel efficiency of diesel pickups stopped during the enforcement details was 11 miles per gallon and serves as *MilesPerGallon* in the denominator.

The study's baseline level of dyed diesel compliance was the level observed during the First Detail (Detail 1), even though that compliance level reflects the impact of pre-study IRS and ADOT educational/enforcement efforts. In other words, it is likely that the baseline First Detail compliance would have been lower if not for pre-study IRS/ADOT education and enforcement activities. The changes in compliance from the First to the Second Detail reflects the compliance impacts of the First Detail. The amount of lost revenue at the First Detail (Detail 1) compliance level is computed as follows: During Detail 1, a total of 1,109 diesel pickup trucks were inspected and 23 were found to contain dyed diesel. If this *ViolationRate* of 0.020739 is applied to the *AnnualMileage*, the resulting annual lost revenue is estimated to be \$1,466,381.

The amount of lost revenue based upon compliance levels during the Second Detail (Detail 2) can be estimated from the number of inspections and violations in Detail 2. During Detail 2, a total of 1,132 diesel pickup trucks were inspected and 7 were found to contain dyed diesel. As with the preceding calculation, if this *ViolationRate* of 0.006184 is applied to the *AnnualMileage*, the estimated annual lost revenue would be \$437,249.

Thus, the estimated annual increase in tax revenues resulting from the “First Detail” is estimated to be \$1,029,132, in addition to the \$151,412 in average annual collections of taxes and penalties from identified violators. This figure addresses an important point raised in a 1995 ADOT report on fuel tax evasion regarding the lack of a reliable estimate of the return on fuel tax enforcement efforts. This report, produced before ADOT initiated fuel tax education and enforcement activities, noted the complete lack of any reliable estimate of any enforcement measure.²¹ This estimate could be affected by a number of factors. The estimate could be too low if there are more violators of the law, if the number of registered diesel powered vehicles is understated, if the annual mileage of diesel pickup trucks is higher than 23,000, or if the fuel efficiency of these vehicles is less than 11 miles per gallon. The estimate could be too high if the opposite of any of these factors is true.

The interaction of the semi tractor sample size and violation rate change prevented any statistically significant findings from emerging. Thus, an accurate estimate of tax revenue associated with inappropriate fuel use and enforcement efforts for these vehicles cannot be reliably determined.

²¹ Arizona Department of Transportation, *Fuel Tax Evasion*, September 1995.

RECOMMENDATIONS

The results of this study suggest that more than 2 percent of diesel-powered pickup trucks illegally use dyed diesel on Arizona roadways. Although the study could not statistically quantify violation rates and lost tax revenue for larger trucks, the available data suggest that substantial tax losses do result. Although education and enforcement efforts reduced the rate of pick-up related violations by more than 75 percent, the financial incentive to evade fuel taxes remains. Continued education and enforcement efforts are required in order to promote voluntary compliance. The data suggest that almost \$1.5 million in diesel tax revenue would be lost each year without enforcement, and the education and enforcement team has demonstrated the ability to reduce dyed diesel violations by more than 75 percent. Given that the current Tax Evasion Unit budget is \$375,000 per year and 50 percent of the budget is directed at dyed diesel fuel compliance, the cost of the dyed diesel education and enforcement program is \$187,500 per year. It is recommended that:

- The Arizona Department of Transportation establish permanent internal funding for the dyed diesel education and enforcement program.

Despite the fact that the team's enforcement efforts increase diesel tax revenues by more than \$1 million per year, current efforts fail to capture another estimated \$500,000 in lost diesel tax revenue through continued violations. Currently, ADOT has only one fuel inspection team. Occasional staff unavailability due to court appearances, training, leave, or other activities sometimes prevents the team from operating on-road details for periods of time. At a minimum, the team should be staffed at a level allowing at least one on-road team to be conducting details throughout the year. This increased staffing level (i.e., two full-time enforcement officers and related costs) would cost approximately \$165,000 per year. Accordingly, it is recommended that:

- The Arizona Department of Transportation expand the education and enforcement scope of work.

Dyed diesel education and enforcement efforts are hampered by the lack of complete and accurate blending, shipment, and sale data. Fuel suppliers are required to report the number of gallons of dyed diesel that are blended, shipped, and sold, but because there are no tax payments associated with these reports, there is little motivation to file timely, complete, and accurate reports. Currently, information technology vendors provide turnkey tax reporting and payment systems at no upfront cost to government agencies in exchange for a percentage of the tax revenue collected by the system. Thus, it is recommended that:

- The Arizona Department of Transportation implement an automated system that allows fuel suppliers to track and report their blending, shipment, and sale of dyed diesel.

Discussion

This research has examined the effectiveness of dyed diesel education and enforcement efforts in Arizona. Federal and state laws and regulations allow diesel used for farm, construction, educational, or off-road use to be purchased tax-free. This tax-free diesel must be dyed red to identify it for non-taxable use and fuel suppliers must report their sales of dyed diesel on a monthly basis. The current education and enforcement efforts result in the collection of taxes and penalties, but the ultimate goal of the education and enforcement program is to decrease the inappropriate use of dyed diesel.

This research analyzed data collected from almost 4,000 vehicles at dyed diesel enforcement details across Arizona. The enforcement details were designed to focus on diesel-powered pickup trucks in rural areas, but diesel fuel was sampled from the tanks of all diesel-powered vehicles that stopped at the enforcement details. In addition to standard enforcement detail procedures (e.g., sampling fuel and citing violators), enforcement officers recorded other data relevant to the detail such as date, time, location, and the number and types of vehicles that were inspected. In both the initial and follow-up enforcement details, pickup trucks were the most frequently offending vehicle type.

Based on the data collected at the enforcement details, the education and enforcement efforts had a statistically significant effect on decreasing the on-road use of dyed diesel in pickup trucks. The education and enforcement efforts also reduced the on-road use of dyed diesel in commercial trucks, but too few data were collected on commercial trucks and other diesel-powered vehicle types (e.g., passenger vehicles, buses, and recreational vehicles) to accurately estimate the effect of education and enforcement efforts on the use of dyed diesel in those vehicles. Based solely on the reduction of on-road dyed diesel use in pickup trucks, it is estimated that the dyed diesel education and enforcement program increases diesel tax revenue by more than \$1 million per year.

The first research question addressed reliable measures of effectiveness for dyed diesel education and enforcement efforts. The results of this study suggest that violation rates found at the same location, at the same time of day, and at an interval of not more than 60 days provide a robust measure of education and enforcement effectiveness. Other measures may also be valid, but the measure used in this study controls for a variety of relevant factors that could influence measurement validity. The results of this study also suggest that the interaction of location and vehicle type may influence the validity of this measurement approach. Because the study was designed to focus on diesel powered pickup trucks in rural areas, diesel powered commercial trucks may have been underrepresented. This underrepresentation is likely to have impacted the apparent validity of this measure on those vehicles.

The second research question addressed the effectiveness of dyed diesel education and enforcement efforts on reducing violations. The results of this study suggest that the dyed diesel education and enforcement team is highly effective in reducing on-road use

of dyed diesel. After 2 months beyond initial enforcement details in six locations across the state, on-road use of dyed diesel in pickup trucks was reduced by more than 75 percent. In addition to the fines and taxes collected from enforcement efforts, the decrease in dyed diesel use results in an estimated tax revenue increase of more than \$1 million per year. This estimate is probably low because the research design focused on diesel-powered pickup trucks at the exclusion of diesel powered commercial trucks.

The third research question addressed opportunities to improve the effectiveness of dyed diesel education and enforcement efforts. The results of this study suggest several opportunities for the Arizona Department of Transportation to improve the effectiveness of dyed diesel education and enforcement efforts. At the most fundamental level, the education and enforcement program could be more fully institutionalized into the ADOT mission through permanent internal funding. In addition, the demonstrated effectiveness of the education and enforcement team suggests that their scope of work could be expanded. The results of this study suggest that the opportunity exists to collect up to an additional \$500,000 per year through increased education and enforcement efforts. Moreover, the amount of additional collected tax revenue could be even greater if specialized education and enforcement efforts were developed for different vehicle types (e.g., pickups versus commercial trucks). And finally, while the intuition and experience of the education and enforcement team is reflected in its effectiveness, additional resources (especially fuel supplier report data) could be leveraged in education and enforcement efforts.

The opportunities to improve the effectiveness of dyed diesel education and enforcement efforts can be capitalized upon through a variety of strategies. The institutionalization of the education and enforcement program can be most directly accomplished through the establishment of permanent funding that is independent of grant funds provided by the Internal Revenue Service or other agencies. Based on the analyses reported here, this effort would yield a net return of more than \$650,000 per year (see Table 12). This is a benefit/cost ratio of 2.7. That is, for each dollar invested, \$2.70 is gained.

Table 12. Permanent funding.

Cost	\$375,000
Revenue Gain	\$1,029,132
Net Return	\$654,132

Concurrently, the dyed diesel education and enforcement team’s scope of work and grant funding could be expanded to provide continuous enforcement efforts and to include efforts currently deployed by Internal Revenue Service. Current budget amounts and the results of these analyses suggest that this effort would produce a net benefit of \$272,240 (see Table 13). This is a benefit/cost ratio of 2.6. That is, for each dollar invested, \$2.60 is gained.

Table 13. Expanded enforcement.

Cost	\$165,000
Revenue Gain	\$437,249
Net Benefit	\$272,249

Finally, an automated fuel supplier reporting system could be implemented to increase compliance with dyed diesel reporting and to provide the education and enforcement team with the basis for more sophisticated tactics. Although the exact return on this effort cannot be known until it is implemented, because there would be no upfront cost and the continuing cost would be a percentage of the tax collected, the net benefit must be positive. Conservatively then, the net benefit of the recommendations suggested here is almost \$1 million per year. Together, these education and enforcement efforts should maximize compliance with dyed diesel laws and revenue collection in Arizona.