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Nonroad Engine Growth Estimates

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Purpose

Estimating accurate projections of future nonroad emissions inventories depends on estimations of future emission factors and future activity levels. This report focuses on the estimation of future activity levels. The purpose of this report is to document the proposed methodology for estimating growth in activity levels in the EPA NONROAD emission inventory model and to compare it to alternative methodologies.

Background

The emissions inventory for nonroad engines is a function of the emission factors and the amount of work or activity levels of these engines. Projections of future nonroad engine inventories must take into account expected changes in emission factors and activity levels. Future changes in emission factors will primarily be the result of future regulations and are discussed in separate reports (NR-009 and NR-010). Future changes in activity level will be the result of complex interactions between human population growth, changes in national and local economic factors, and changes in the markets for nonroad engines and the products they are used to produce.

Historically, EPA has often used projections of economic indicators as surrogates for growth in activity for the purpose of estimating future emissions for a wide variety of sources. When applying this approach to nonroad equipment, the underlying assumption is that engine usage is a constant proportion of earnings for a given sector. The most commonly used compilation of economic indicators is provided by the Department of Commerce's Bureau of Economic Analysis (BEA). The most recent projections were published in July, 1995[1]. BEA provides economic indicators by state or as a national average for numbers of employees, inflation adjusted national dollars of earnings, and inflation adjusted aggregate gross state products (GSP) dollars of earnings. In the past, BEA growth forecasts for major sectors of the economy (e.g., construction, farm, forestry, manufacturing, etc.) have been applied to all nonroad equipment that might be used in that sector of the economy.

However, the use of economic indicators to predict growth in nonroad activity has some drawbacks. Economic indicators may not be able to adequately predict the effects of substitution of equipment for labor in the market. Also, economic models in recent years have tended to

overestimate inflation rates. As a result of both of these factors, economic indicators may tend to under-predict growth in nonroad equipment populations and activity. Evidence that this is indeed the case can be found in an analysis done by E.H. Pechan and Associates[2] which compared BEA estimates of growth between 1990 and 1996 to estimates of actual 1990 and 1996 populations of nonroad equipment from the Power Systems Research (PSR) PartsLink database. The Pechan analysis indicated that the projected 1996 population based on the BEA growth estimate under-predicted the estimates of actual population developed by PSR in 1996 by 7.4%. Overall, the total projected BEA growth from 1990 to 1996 was 9.3%, while PSR estimated that actual nonroad equipment populations grew 18.1% over that same period.

There is a second drawback to using economic indicators that may be as important to estimation of emissions projections as the under prediction problem. Because economic indicators at best can only predict growth in broad sectors of the economy, they cannot be used to identify market trends within sectors. For example, economic indicators would not predict differential rates of growth of diesel equipment relative to gasoline equipment in nonroad applications, or changes in the horsepower distribution within nonroad applications. Because diesel and gasoline engines have very different emissions characteristics, the accurate prediction of changes in the relative distribution of different types of engines is very important to the accurate estimation of future emissions.

An alternative approach which would be able to factor in market trends would be to base growth estimates on the historical trend in growth in nonroad equipment activity. Because total activity is never directly measured, the historical trend in population must be used as a surrogate. This seems reasonable given that capital costs of nonroad equipment are high compared to operating costs, in general. As a result, owners of such equipment have a strong incentive to get the most out of the equipment they own and a disincentive to purchase new equipment that will not be fully utilized.

Although the use of historical population growth may have limitations, it is the only approach that will allow estimation of the impact of market shifts on emission projections. For these reasons, we propose to base growth projections in EPA's NONROAD emissions model on a time series analysis of historical nonroad engine populations

Methodology

We analyzed historical engine population estimates for 1989 through 1996 taken from the PSR PartsLink database, the same source used to determine 1996 baseline engine populations as described in Report No. NR-006. The PSR database contains detailed information about each engine family sold in the United States. This information could be used to segregate nonroad engines for purposes of growth estimation at by several different factors, including market sector (agricultural, construction, etc.), application type (farm tractors, combines, etc.), fuel type (gasoline, diesel, etc.), and horsepower. As a result, one could in principle estimate separate growth factors for each combination of application type and fuel type, in discrete horsepower

categories. However, there are some limitations to this approach. In many cases, equipment populations become small enough, when broken down by all of these factors, that even small errors in the PSR database would result in large errors in growth estimation. In addition, the number of individual growth rates would become unwieldy considering the number of different application types, fuel types, and horsepower categories, as well as the fact that each state would have its own unique set of growth factors.

We invite comment on whether or not we should move to that level of detail in the final version of NONROAD. For the current version, we have chosen to segregate nonroad engines by market sector and fuel type. Individual applications in the PSR database were assigned to broad market sectors as shown in Appendix A of Report No. NR-006. For example, excavators, graders, backhoes, dozers, etc. were all assigned to the Construction market sector (SCC category 2260002xxx). Total market sector populations, segregated by fuel type, were calculated for each year from 1989 through 1996. An exponential curve was fit to each of these to determine the growth rate over the period from 1989 to 1996. We also estimated the growth rate for the total of all engines of all fuel types in each market sector for purposes of comparison with BEA estimates.

Results

Table 1 compares projected annual growth rates from BEA with those derived from a historical analysis of the PSR database (actual populations are given in the Appendix). With the exception of the logging and recreational sectors, the PSR estimates are significantly higher than the BEA estimates. The PSR database also indicates very large differences in growth rates for different fuel types. In most cases, the rate of growth for diesel equipment is substantially higher than that for gasoline equipment. In the industrial and light commercial categories LPG and CNG engines also show higher than average rates of growth (categories with no growth rates for LPG or CNG had populations that were either zero or negligible; i.e. less than 0.1% of the total population for that category).

Table 1. Projected Average Annual Growth Rate Comparison

Sector	BEA	PSR				
		Total	Diesel	Gasoline	LPG	CNG
Airport Service	5.5%	8.2%	9.4%	1.4%		
Construction	1.0%	2.6%	3.6%	0.3%		
Farm	2.4%	2.8%	3.2%	2.0%		-7.7%
Industrial	1.9%	3.1%	4.4%	-3.5%	4.1%	
Lawn & Garden	1.0%	2.7%	9.6%	2.6%		
Light Commercial	1.9%	4.9%	5.5%	4.7%	14.2%	5.1%
Logging	7.4%	5.2%	-0.8%	5.9%		
Railway	-0.9%	2.7%	5.1%	1.3%		
Recreational	1.0%	0.9%	3.9%	0.9%		

It is obvious from the PSR data that a substantial shift from gasoline to diesel engines is occurring in most of the market sectors. Given the high rates of growth for diesel engines in most sectors compared to the overall sector growth rates, it is reasonable to ask whether or not these growth rates due to market shifting are sustainable. However, there is a more basic problem with the use of the fuel-specific growth rates for projecting future growth. In future years, the sum of the all of the projected fuel-specific populations will be greater than the projected total population using the total growth rate for the particular market sector. This is an unreasonable result. The total growth in any market sector should be determined by the historical total growth in that sector, not by market shifts occurring within the sector.

The best solution to this problem may be to use total market sector growth factors to determine future total populations and to create a separate input (i.e., % share of diesel, gasoline, LPG, and CNG engines) to predict changes in fuel market share. Although the current version of the model can easily handle multiple growth rates, this solution would involve model coding changes that we will not be able to complete before release of the Beta version of NONROAD, and may not be able to complete in time for the final release of this version of NONROAD. As an interim solution for the Beta release, we have two options on which we request comment. The first option would be to only incorporate the total market sector growth factors in this version of the model. Under this option, output from the Beta release of the model would not reflect market shifts in fuel use.

The second option would be to scale the individual fuel-specific growth factors so that projected total population when the individual fuel-specific populations are summed does not exceed the projected total population. This option could be implemented as follows:

1. project total population using the total growth rate and fuel-specific populations using fuel specific growth rates for each market sector out to 2020 (or some other projection year).
2. sum the fuel-specific populations for each year and calculate the fraction of those summed populations contributed by each fuel type.
3. multiply those fractions by the projected total population derived from the total growth rate to determine projected populations by each fuel type scaled to the projected total populations.

This option offers a relatively crude method for adjusting the projected fuel-specific populations, and we invite comment on more appropriate statistical analyses that might be used instead of this approach. However, under this option, Beta users would be able to see model results that do reflect estimates of changes in fuel market share. Table 2 shows the original and scaled population growth estimates by fuel type for each market sector.

We invite comment on which of the two options to incorporate into the Beta release, but caution that we may have to implement the first option in the Beta release due to time constraints.

Table 2. Projected Average Annual Growth Rates with Fuel-Specific Growth Rates Scaled to PSR Total Growth Rates

Sector	BEA	PSR								
		Total	Diesel	Scaled Diesel	Gasoline	Scaled Gasoline	LPG	Scaled LPG	CNG	Scaled CNG
Airport Service	5.5%	8.2%	9.4%	8.3%	1.4%	0.8%				
Construction	1.0%	2.6%	3.6%	3.3%	0.3%	0.0%				
Farm	2.4%	2.8%	3.2%	3.1%	2.0%	1.9%			-7.7%	-8.1%
Industrial	1.9%	3.1%	4.4%	3.6%	-3.5%	-4.3%	4.1%	3.3%		
Lawn & Garden	1.0%	2.7%	9.6%	9.1%	2.6%	2.5%				
Light Commercial	1.9%	4.9%	5.5%	5.3%	4.7%	4.6%	14.2%	13.2%	5.1%	5.0%
Logging	7.4%	5.2%	-0.8%	-1.2%	5.9%	5.4%				
Railway	-0.9%	2.7%	5.1%	4.5%	1.3%	0.8%				
Recreational	1.0%	0.9%	3.9%	3.8%	0.9%	0.8%				

1. “BEA Regional Projections to 2045: Vol. 1, States”, U.S. Department of Commerce, Bureau of Economic Analysis, July 1995, available on the World Wide Web at www.bea.doc.gov/bea/ar1.htm

2. “Comparison of Methods for Projecting Nonroad Equipment Activity Levels”, E.H. Pechan and Associates, Inc., Prepared for U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, September 1997

Appendix - Engine Populations by Year, Market Sector, and Fuel Type

		1989	1990	1991	1992	1993	1994	1995	1996
Airport Service	Diesel	8,325	9,516	10,688	11,800	12,862	13,962	15,087	16,199
	Gasoline	1,904	1,699	1,583	1,548	1,617	1,701	1,851	2,042
	Total	10,229	11,215	12,271	13,348	14,479	15,663	16,938	18,241
Construction	Diesel	1,445,011	1,515,056	1,563,077	1,614,190	1,671,812	1,740,599	1,810,301	1,869,003
	Gasoline	746,147	750,523	744,661	740,852	740,747	746,487	757,411	766,264
	Total	2,191,176	2,265,603	2,307,767	2,355,077	2,412,600	2,487,185	2,567,862	2,635,454
Farm	Diesel	2,624,347	2,764,773	2,881,337	2,992,660	3,051,566	3,114,436	3,270,810	3,302,604
	Gasoline	1,200,445	1,231,311	1,258,131	1,282,338	1,306,827	1,332,163	1,355,539	1,382,342
	CNG	17,457	16,355	15,526	14,671	13,609	12,449	11,255	10,050
	Total	3,842,504	4,012,671	4,155,212	4,289,868	4,372,171	4,459,200	4,637,746	4,695,124
Industrial	Diesel	652,656	683,015	708,222	735,321	765,152	805,322	849,118	892,852
	Gasoline	176,736	177,063	172,120	165,380	153,632	150,339	148,457	140,950
	LPG	84,314	91,092	91,545	91,062	94,866	104,450	114,569	110,292
	Total	913,706	951,185	971,949	991,887	1,013,826	1,060,293	1,112,351	1,144,322
Lawn & Garden	Diesel	327,626	365,587	398,010	437,044	483,345	532,684	587,132	645,149
	Gasoline	98,583,888	102,100,138	104,940,288	107,515,906	109,594,695	112,415,996	115,937,367	119,490,009
	Total	98,911,514	102,465,725	105,338,298	107,952,950	110,078,040	112,948,680	116,524,499	120,135,158
Light Commercial	Diesel	897,686	953,629	1,008,575	1,062,662	1,120,187	1,185,848	1,254,203	1,320,233
	Gasoline	4,185,087	4,376,324	4,537,560	4,701,324	4,912,338	5,185,707	5,520,270	5,868,886
	LPG	4,128	4,849	5,603	6,508	7,489	8,588	9,849	11,128
	CNG	37,947	40,571	42,651	44,611	46,767	49,122	51,944	55,098
	Total	5,124,864	5,375,388	5,594,404	5,815,120	6,086,799	6,429,289	6,836,298	7,255,386

		1989	1990	1991	1992	1993	1994	1995	1996
Logging	Diesel	51,430	50,381	48,758	47,261	46,634	47,149	48,348	49,032
	Gasoline	337,267	366,182	395,921	427,873	449,011	471,027	492,469	511,778
	Total	388,697	416,563	444,679	475,134	495,645	518,176	540,817	560,810
Railway	Diesel	5,686	6,117	6,511	6,856	7,199	7,537	7,867	8,175
	Gasoline	10,508	11,285	11,730	11,898	11,900	11,840	11,863	11,816
	Total	16,194	17,402	18,241	18,754	19,099	19,377	19,730	19,991
Recreational	Diesel	83,258	86,988	90,304	93,758	97,433	101,342	105,559	110,169
	Gasoline	8,797,673	8,727,791	8,632,439	8,678,772	8,654,282	8,815,925	9,119,795	9,424,489
	Total	8,906,281	8,839,961	8,747,216	8,796,325	8,763,104	8,918,613	9,225,906	9,535,762