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Assessment and Standards Division
Office of Transportation and Air Quality
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Nonroad Engine Growth Estimates

Report No. NR-008b

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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 current methodology for estimating growth in activity levels in the draft NONROAD2002 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 will not be discussed here (detailed discussion of current and future emission factors in NONROAD can be found in Technical Reports NR-009B and NR-010C on the OTAQ web site, http://www.epa.gov/otaq/nonrdmdl.htm). 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). However, BEA has discontinued issuing projections of economic indicators. The last 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 under-predict growth in the national economy. 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 may be 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 have chosen 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 in NONROAD. 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.

Given those concerns, for the draft NONROAD2002 version, we have chosen to segregate nonroad engines only by market sector and fuel type. Individual applications in the PSR database were assigned to broad market sectors. 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.

For previous versions of NONROAD, we projected future populations by fitting an exponential curve to the historical populations and extrapolating from that curve to future years. In response to comments received about this approach, we reviewed the data again and concluded that extrapolating from a simple linear regression of the historical populations would give more reasonable estimates of future populations. These changes in the growth estimates are reflected in the draft NONROAD2002 model.

For oil field equipment, the PSR database indicates a sharp decline in oil field equipment population over the period from 1989 to 1996, which is potentially consistent with trends in the domestic oil production industry over that period. However, if that trend is extrapolated linearly, oil field equipment would disappear completely by 2006. Because there is no indication that domestic oil production will cease in that time-frame, we have chosen to use BEA economic estimates of gross state product from domestic oil production to estimate growth in this equipment category.

EPA has revised the method used to estimate growth for All-Terrain Vehicles as part of the rulemaking process for recreational equipment and other large spark-ignition engines.[3] The ATV population growth rates used in the draft NONROAD2002 model have been updated to reflect the expected growth in ATV populations based on historic ATV sales information and sales growth projections supplied by the Motorcycle Industry Council (MIC), an industry trade organization. The growth rates were developed separately for 2-stroke and 4-stroke ATVs. Based on the sales information from MIC, sales of ATVs have been growing substantially throughout the 1990s, averaging 25% growth per year over the last 6 years. MIC estimates that growth in sales will continue for the next few years, although at lower levels of ten percent or less, with no growth in sales projected by 2005. Combining the sales history, growth projections,

and information on equipment scrappage, we have estimated that the population of ATVs will grow significantly through 2010, and then grow at much lower levels (See Appendix A, Table 2 and Figure 1. Under the proposed ATV emission standards, 2-stroke designs are expected to be phased-out as they are converted to 4-stroke designs.) The growth rates for ATVs, as well as snowmobiles and off-road motorcycles, may be revised for the portion of the Final Large SI Rule that addresses recreational equipment if additional equipment sales data is received from the recreational equipment industry.

Results

Table 1 compares projected annual growth rates from BEA with those derived from a historical analysis of the PSR database. These growth rates are calculated as the average annual growth expected between 1996 and 2010 (the key period for State Implementation Plan (SIP) purposes) as a percentage of 1996 population (i.e., the difference between 2010 population and 1996 population divided by 14 years divided by 1996 population). The numbers that result are different than those presented in the growth technical report we released earlier because of both the move to a linear extrapolation method and a change to a more appropriate time period over which to estimate growth (the previous report used the period from 1990 to 2010).

With the exception of the recreational and railway 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).

For two fuel categories, farm CNG and industrial gasoline, the PSR database indicates a decline in population so rapid that these categories would cease to exist within the usable time-frame of the model. For these categories, we allowed the population to decline to zero and then adjusted the growth of the other fuel types within the market sector so that the sum of the fuel types continues to equal the total projected population for all subsequent years.

Table 1. Projected Average Annual Growth Rate Comparison

Sector	BEA	PSR				
		Total	Diesel	Gasoline	LPG	CNG
Construction	1.2%	2.3%	3.2%	0.2%		
Farm	2.0%	2.6%	3.0%	1.8%		-10.2%
Industrial	1.8%	2.7%	3.7%	-4.0%	3.8%	
Lawn & Garden	0.9%	2.4%	6.8%	2.4%		
Light Commercial	1.8%	4.0%	4.5%	3.8%	8.7%	4.2%
Logging	0.6%	4.5%	-1.0%	5.0%		
Railway	3.4%	2.6%	4.4%	1.4%		
Recreational	0.9%	0.7%	3.3%	0.6%		

Comments Received On Present Method to Estimate Growth

Lastly, we have received comments from stakeholders which suggest that the current national growth factors used in the NONROAD model do not accurately portray nonroad equipment/emissions growth at the regional or state levels. We recognize this as a shortcoming with the current draft model and would welcome suggestions on how to develop or obtain regional or State-specific growth factors. In addition, a stakeholder expressed concern about basing long-term growth estimates for nonroad equipment/emissions on the seven years of data from PSR. We also invite comments on using this approach and suggestions for alternatives.

References

1. "BEA Regional Projections to 2045: Vol. 1, States", U.S. Department of Commerce, Bureau of Economic Analysis, July 1995.

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 Transportation and Air Quality, Ann Arbor, MI, September 1997

3. "Control of Emissions from Unregulated Nonroad Engines," Draft Regulatory Support Document, U.S. Environmental Protection Agency, Office of Air and Radiation, EPA420-D-01-004, September 2001

Appendix A

Table 1: 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

Table 2: Projected ATV Populations by Year

Category	1970*	1990	1996	1997	1998	1999	2000	2005	2010	2020	2030
4-stroke ATVs	0	3,616,858	3,616,858	3,540,904	3,504,736	3,602,391	3,776,000	5,513,000	7,223,000	8,460,000	8,540,000
2-stroke ATVs**	0	185,912	185,912	285,374	404,730	533,380	673,000	1,457,000	2,057,000	2,424,000	2,445,000
All ATVs	0	3,802,770	3,802,770	3,826,279	3,909,465	4,135,771	4,449,000	6,970,000	9,280,000	10,884,000	10,985,000

* - The 1970 population is considered to be essentially as zero, but to avoid a divide-by-zero error the input growth index is actually set to 1, which results in 1/1000 of the 1996 population.

** - The projected population estimates for 2-stroke ATVs correspond to the current uncontrolled regulatory scenario. Under the Phase 1 standards proposed in 2001, we would expect all 2-stroke engines to be converted to 4-stroke designs.

Figure 1