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EVALUATION OF POWER SYSTEMS RESEARCH (PSR) NONROAD POPULATION DATA BASE

REVISED DRAFT REPORT

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TABLES

ACRONYMS AND ABBREVIATIONS

AAMA	American Automobile Manufacturers Association
BAH	Booz-Allen and Hamilton, Inc.
DOE	United States Department of Energy
EEA	Energy and Environmental Analysis, Inc.
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration
IMA	International Marine Holdings
ITA	International Truck Association
NEVES	Nonroad Engine and Vehicle Emissions Study
OEM	original equipment manufacturer
OMS	Office of Mobile Sources
OPEI	Outdoor Power Equipment Institute
NMMA	National Marine Manufacturers Association
PPEMA	Portable Power Equipment Manufacturers Association
PSR	Power Systems Research
SIC	Standard Industrial Classification

CHAPTER I
INTRODUCTION

Recent growth of the nonroad sector, as well as the design and operation characteristics unique to nonroad applications, have increased the contribution of nonroad engines to air emissions inventories. In addition, relative to other mobile sources, nonroad engines are generally less regulated. To assist States in the State Implementation Plan (SIP) inventory development process, the Environmental Protection Agency's (EPA's) Office of Mobile Sources (OMS) is developing a nonroad emissions model (NONROAD). This nonroad model will enable States to evaluate potential control options to determine the effect of these strategies on controlling nonroad emissions. The OMS is evaluating potential sources of population data for use in NONROAD. The purpose of this report is to analyze the nonroad engine/equipment population methodology developed by Power Systems Research (PSR).

In order to estimate emissions from nonroad engines, base year populations for nonroad equipment types must first be established. According to EPA inventory guidance, the following equation is used to estimate emissions for a specific nonroad engine application:

$$M_i = N \times HRS \times HP \times LF \times EF_i \qquad \textbf{(Eq. 1)}$$

Where:

	M_i	=	mass of emissions of i^{th} pollutant during inventory period
	N	=	source population
	HRS	=	annual hours of use
	HP	=	average rated horsepower
	LF	=	typical load factor
	EF_i	=	average emissions of i^{th} pollutant per unit of use (e.g., grams per horsepower-hour)

Power Systems Research is an established leader in global market research of nonroad engine applications. They have developed the *North American Engine PartsLink Data Base* (hereafter referred to as *PartsLink*), which estimates engine replacement rates and parts consumption profiles for the U.S. This information is generally used by equipment manufacturers and suppliers for product planning purposes. As a component of *PartsLink*, PSR has developed annual nonroad engine populations by application, horsepower (hp), engine type (i.e., spark-ignition or compression-ignition), and the number of strokes per engine cycle (2 or 4). An earlier version of this population data base was one of the principal sources of information for 1990 nonroad emissions inventories developed for the *Nonroad Engine and Vehicle Emissions Study (NEVES*) (EPA, 1991).

Engine applications are typically classified according to equipment categories, or market segments, so that applications with similar engine characteristics and use patterns

can be analyzed on a collective basis. The following are the nonroad equipment segments defined by PSR:

- Agriculture
- Construction
- General Industrial
- Lawn and Garden
- Marine
- Material Handling
- Pumps and Compressors
- Recreational Products
- Welders and Generators

Although the NEVES relied on PSR data, in some cases, the NEVES equipment categories are different from the most recent *PartsLink* market segments. For example, airport service equipment was classified as a distinct equipment category for the NEVES, while PSR includes these applications in the general industrial market segment. Table I-1 provides a listing of the nonroad applications included within each general market segment of PSR's data base.

This report discusses the methods used to develop the most current PSR data base. In general, PSR estimates engine populations using the following procedure: 1) determine the number of engines sold for a specific year, accounting for imports and exports; 2) obtain data on mean engine life, average annual hours of use, load factor, and horsepower; 3) develop an attrition curve that relates the percent of units remaining in service to the percent of expected life not yet consumed; 4) determine the number of engines still in service for each model year population (i.e., engines placed in service during the same year) according to the attrition curve; 5) sum up the number of engines operating for each appropriate year to arrive at a total population for the year in question; and 6) allocate national populations to a county level using economic surrogate data.

To evaluate the methodology used by PSR, Chapter II examines these steps in more detail. Limitations inherent in PSR's methodology, as well as recommendations for improving the data base, are discussed in Chapter III. Chapter IV lists the references used for preparing this report.

Both the EPA and Pechan would like to acknowledge PSR for their contributions and cooperation in preparing this report. However, it is important to note that Pechan was not able to obtain the underlying data that PSR uses to develop annual nonroad populations. Much of the data, including the equations that form the basis of their methods, are proprietary, and could not be obtained from PSR. As such, this evaluation is by necessity more qualitative than quantitative.

Table I-1. PSR Nonroad Engine Applications

Segment/ Application Code	Application	Segment/ Application Code	Application
AGRICULTURE		***GENERAL INDUSTRIAL***	
98	2-Wheel Tractors	81	Aircraft Support Equipment
55	Agricultural Mowers	26	Chippers/Grinders
45	Agricultural Tractors	77	Concrete/Industrial Saws
49	Balers	34	Crushing/Processing Equipment
47	Combines	20	Locomotive
44	Irrigation Sets	12	Oil Field Equipment
46	Other Agricultural Equipment	74	Other General Industrial Equipment
69	Sprayers	80	Railway Maintenance
48	Swathers	14	Refrigeration/AC
CONSTRUCTION		21	Scrubbers/Sweepers
37	Bore/Drill Rigs	62	Specialty Vehicles/Carts
57	Cement and Mortar Mixers	23	Surfacing Equipment
27	Cranes	15	Tactical Military Equipment
31	Crawler Dozers	***LAWN & GARDEN***	
97	Crawler Loaders	70	Chainsaws >4 HP
60	Dumpers/Tenders	67	Commercial Turf Equipment
28	Excavators	88	Front Mowers
24	Forest Equipment	63	Lawn & Garden Tractors
30	Graders	65	Lawn Mowers
68	Off-Highway Tractors	66	Leaf Blowers/Vacuums
40	Off-Highway Trucks	76	Other Lawn & Garden Equipment
36	Other Construction Equipment	82	Rear Engine Riding Mowers
41	Pavers	96	Shredders <5 HP
35	Paving Equipment	56	Snowblowers
61	Plate Compactors	59	Tillers >5 HP
39	Rollers	53	Trimmers/Edgers/Brush Cutters
84	Rough Terrain Forklifts	75	Wood Splitters
32	Rubber Tired Dozers	***MARINE***	
33	Rubber Tired Loaders	51	Marine Commercial
29	Scrapers	99	Outboard Engines
38	Skid Steer Loaders	50	Powerboats
95	Tampers/Rammers	79	Sailboat Auxiliary
43	Tractors/Loaders/Backhoes		
42	Trenchers		
13	Underground Mine Equipment		

Table I-1 (continued)

Segment/ Application Code	Application
MATERIAL HANDLING	
64	Aerial Lifts
18	Forklifts
19	Other Material Handling Equipment
16	Terminal Tractors
PUMPS & COMPRESSORS	
10	Air Compressors
89	Gas Compressors
85	Hydro Power Units
58	Pressure Washers
11	Pumps
RECREATIONAL PRODUCTS	
91	All Terrain Vehicles (ATVs)
94	Golf Carts
93	Minibikes
92	Off-Road Motorcycles
71	Snowmobiles
WELDERS & GENERATORS	
9	Generator sets
73	Light Plants
25	Marine Auxiliary
17	Welders

CHAPTER II
POWER SYSTEMS RESEARCH NONROAD ENGINE POPULATION METHODOLOGY

In order to assess the quality of PSR's population data base, Pechan first reviewed PSR's *U.S. PartsLink Reference Guide, Edition 6.2* (PSR, 1995). Upon request by EPA, PSR also provided additional details concerning the following steps used to establish in-use engine populations (Zirnheldt, 1997a; Zirnheldt, 1997b; PSR, 1997):

- Establishment of a historical sales record;
- Determination of engine life and attrition rate;
- Estimation of hours of use and load factor;
- Distribution of national populations to the county level; and
- Verification of population estimates.

It should be noted that *PartsLink* also includes engine parts consumption data for specific engine applications, and develops replacement rates for various engine components. Although important to many users of the data base, the parts consumption data are not directly used for estimating populations, and therefore are not evaluated in this report.

A. Establishment of Historical Sales Record

EnginData is a proprietary engine market data base developed by PSR, which provides a continuous 18-year record of engine sales and production in North America. This data base includes all engines installed in original equipment, whether they are domestically produced or imported. *EnginData* includes engines produced for both the U.S. and Canadian markets, but only U.S. equipment data are incorporated into *PartsLink*.

Through telephone surveys, PSR contacts over 1,600 engine-driven original equipment manufacturers (OEMs) to determine their annual engine installation rates by engine make and model for each of 99 defined engine applications. All OEMs are contacted at least once per year. These data are compared with published statistics from trade associations, governmental agencies, and engine and original equipment manufacturers. Table II-1 presents a list of the sources and references used by PSR to verify their sales data. PSR recognizes that these alternate sources are not always consistent and may be of questionable accuracy, but believes that these outside sources provide a relevant benchmark to compare to their own estimates (Zirnheldt, 1997a). Due to time and resource constraints, Pechan was not able to examine these listed sources in detail, or check if other, more reliable outside sources were available. It was noted, however, that certain applications are missing from the list, including rubber-tired loaders, wood splitters, ATVs, and minibikes.

Table II-1. List of Benchmark Sources for Verifying Nonroad Equipment Sales

APPLICATION	SOURCE	APPLICATION	SOURCE
2-Wheel Tractors	Industry Survey	Other General Industrial	Industry Survey
Aerial Lifts	CIR MA35D	Other Lawn & Garden	Industry Survey
Agricultural Mowers	CIR MA35A	Other Material Handling	Industry Survey
Agricultural Tractors	CIR MA35A	Outboard Engines	NMMA
Air Compressors	CIR MA35P	Pavers	CIR MA35D
Aircraft Support	Industry Survey	Paving Equipment	Industry Survey
Balers	CIR MA35A	Personal Watercraft	NMMA
Bore/Drill Rigs	CIR MA35F	Plate Compactors	Industry Survey
Buses	AAMA	Powerboats	NMMA
Cars	Ward's	Pressure Washers	Industry Survey
Cement/Mortar Mixers	CIR MA35D	Pumps	CIR MA35P
Chainsaws	PPEMA	Rubber Tired Dozer	CIR MA35D
Chippers/Grinders	Industry Survey	Railway Maintenance	Industry Survey
Combines	CIR MA35A	Rear Engine Riding Mowers	OPEI
Commercial Turf	CIR MA35A	Refrigeration/AC	CIR M35L
Concrete/Industrial Saws	Industry Survey	Rollers	CIR MA35D
Cranes	CIR MA35D	Rough Terrain Forklifts	CIR MA35D
Crawlers	CIR MA35D	Skid Steer Loaders	CIR MA35D
Crushing/Processing Equip.	Industry Survey	Sailboat Auxiliary	IMH Annual Sailboat Report
Dumpers/Tenders	Industry Survey	Scrapers	CIR MA35D
Excavators	CIR MA35D	Scrubber/Sweeper	Industry Survey
Forest Equipment	CIR MA35D	Shredders	PPEMA
Forklifts	ITA Annual Report	Snowblowers	OPEI
Front Mowers	Industry Survey	Snowmobiles	ISMA
Gas Compressors	CIR MA35P	Specialty Vehicles/Carts	Industry Survey
Generator Sets	CIR MA36H	Sprayers	CIR MA35A
Golf Carts	Industry Survey	Surfacing Equipment	Industry Survey
Graders	CIR MA35D	Tactical Military Equipment	Industry Survey
Hydro Power Units	Industry Survey	Tampers/Rammers	Industry Survey
Irrigation Sets	Industry Survey	Terminal Tractors	Industry Survey
Lawn Mowers	OPEI	Tillers	OPEI
Leaf Blowers/Vacuums	PPEMA	Tractor/Loader/Backhoe	CIR MA35D
Lawn and Garden Tractors	OPEI	Trenchers	CIR MA35D
Locomotives	Industry Survey	Trimmer/Edger/Cutter	PPEMA
Light Plants/Signal Boards	Industry Survey	Truck Cl 1 & 2	AAMA
Marine Auxiliary	Industry Survey	Truck Cl 3 & 4	AAMA
Marine Commercial	Industry Survey	Truck Cl 5	AAMA
Motor Home Chassis	Ward's	Truck Cl 6	AAMA
Motorcycles/ATVs	Dealer News	Truck Cl 7	AAMA
Off-Highway Mining Truck	CIR MA35D	Truck Cl 8	AAMA & Industry Survey

Table II-1 (continued)

APPLICATION	SOURCE	APPLICATION	SOURCE
Off-Highway Tractors	CIR MA35D	Underground Mine Equipment	Industry Survey
Other Agricultural Equipment	Industry Survey	Welders	CIR MA36H
Other Construction	Industry Survey	Windrowers (Swathers)	CIR MA35A
Oil Field Equipment	Industry Survey		

ASSOCIATION/SOURCE KEY:

AAMA:	American Automobile Manufacturers Association
CIR:	Current Industrial Report (Department of Commerce)
IMH:	International Marine Holdings
Industry Survey:	Annual interviews with OEMs known to produce subject equipment
ISMA:	International Snowmobile Manufacturers Association
ITA:	Industrial Truck Association
NMMA:	National Marine Manufacturers Association
OPEI:	Outdoor Power Equipment Institute
PPEMA:	Portable Power Equipment Manufacturers Association

In addition to original equipment produced in North America, sales data are compiled for imported original equipment. PSR estimates import sales based on retail sales of engine-driven products according to trade associations, original equipment importer data, and import data published by the Department of Commerce (PSR, 1995).

The number of engines exported for use in equipment produced outside of North America are then subtracted from the number of domestic and imported engines. Department of Commerce records are used to estimate exports for each discrete engine application in the data base. PSR does not compare or reconcile export data with other sources, so these data are likely to be less reliable than the domestic and import data. PSR also assumes that exports are distributed proportionately among all original equipment manufacturers (e.g., if 14 percent of all tractor loader backhoes are exported in a given year, then 14 percent of John Deere tractor loader backhoes are exported in that year). While some users of the data base are interested in manufacturer distributions, knowing this distribution is not critical for estimating nonroad emissions.

In compiling *EnginData*, equipment sales and production are used interchangeably. Although the amount of equipment produced may not be equivalent to the amount of equipment sold or consumed, nonroad equipment production is an available parameter that PSR is able to track to account for engine deliveries as they move through the marketing chain. For example, for imports, PSR counts equipment as it is imported to the United States. This does not necessarily mean it has been sold at retail. PSR recognizes that if more units are imported than were actually delivered to end-users, the in-use population would be overstated. According to investigations performed by PSR, the difference between nonroad equipment production and sales (and between nonroad equipment imports and sales) in any given year does not produce significant variations in the working population estimates (Zirnheldt, 1997a).

B. Engine Life and Attrition

PSR applies a scrappage function, or attrition curve, to the sales data compiled for *EnginData* to estimate annual equipment populations. Equipment scrappage is dependent on the expected life of the installed engine, the annual hours of operation, and the average load factor. This section describes how mean engine life is estimated for each engine, and describes how the scrappage function is developed and applied. Section C discusses how estimates of average annual hours of operation and load factor are derived for each application.

1. Engine Life Calculation

Mean engine life for each engine model is determined by a mathematical computation based on field research. PSR has developed a first-order regression equation that considers the following engine-life determinants:

Cylinder material
Number of main bearings
Mean effective cylinder pressure
Cylinder bore diameter
Piston stroke
Rated engine speed
Turbo-charging
After-cooling
Engine displacement
Number of cylinders
Cylinder configuration
Cooling method

PSR explained that these variables are combined to achieve a "best-fit" against a sample of 45 known engine life-times as determined by laboratory testing (Zirnheldt, 1997a). Their mathematical model is constructed to combine these variables in a manner which most closely approximates these actual laboratory life-time values. Input from a number of engine manufacturers for engines of various types and sizes was also solicited to establish target life-time benchmarks, although the availability of life-time values from most manufacturers is fairly limited. PSR indicates that the model has predicted mean life-times within less than 5 percent error when compared with available test values from manufacturers, but no data were provided by PSR to support this claim.

2. Attrition

The scrappage curve has been developed by PSR over years of research, and represents the annual engine fleet retirement rate based on data gathered through surveys of equipment users. To account for engine attrition, it is assumed that engines are scrapped as a function of the time over which they operate and the load which they carry over that time. The attrition curve that forms the basis of PSR's model is derived from a normal distribution curve, where the mean engine life is the median of the distribution. The normal distribution curve reflects the percentage of engines placed into service which can be expected to fail after any specific time. The percentage of engines failing at each interval around the normal distribution is used to derive the cumulative percentage of failed engines. PSR's attrition curve is the reciprocal of the normal distribution, and represents

the percentage of engines remaining in service. Figure II-1 provides a representation of a typical nonroad engine attrition curve used by PSR in their scrappage model (PSR, 1995). For each engine application, PSR derives an application-specific attrition curve. Note that according to the curve, the mean lifetime expectancy is represented as the point in each engine model's life at which 50 percent of the engines originally placed in service are still in operation.

PSR conducts over 6,000 interviews per year with owners of different types of equipment to determine the variation from mean engine life expectancy which may exist in real life situations (PSR, 1995). These variations are typically associated with factors such as maintenance, engine quality, and service practices. PSR uses this information to establish the standard deviation from the mean which is needed to take into account variations. Currently, the width, or base, of the normal distribution curve reflects 2.3 standard deviations (in terms of hours) from the median value.

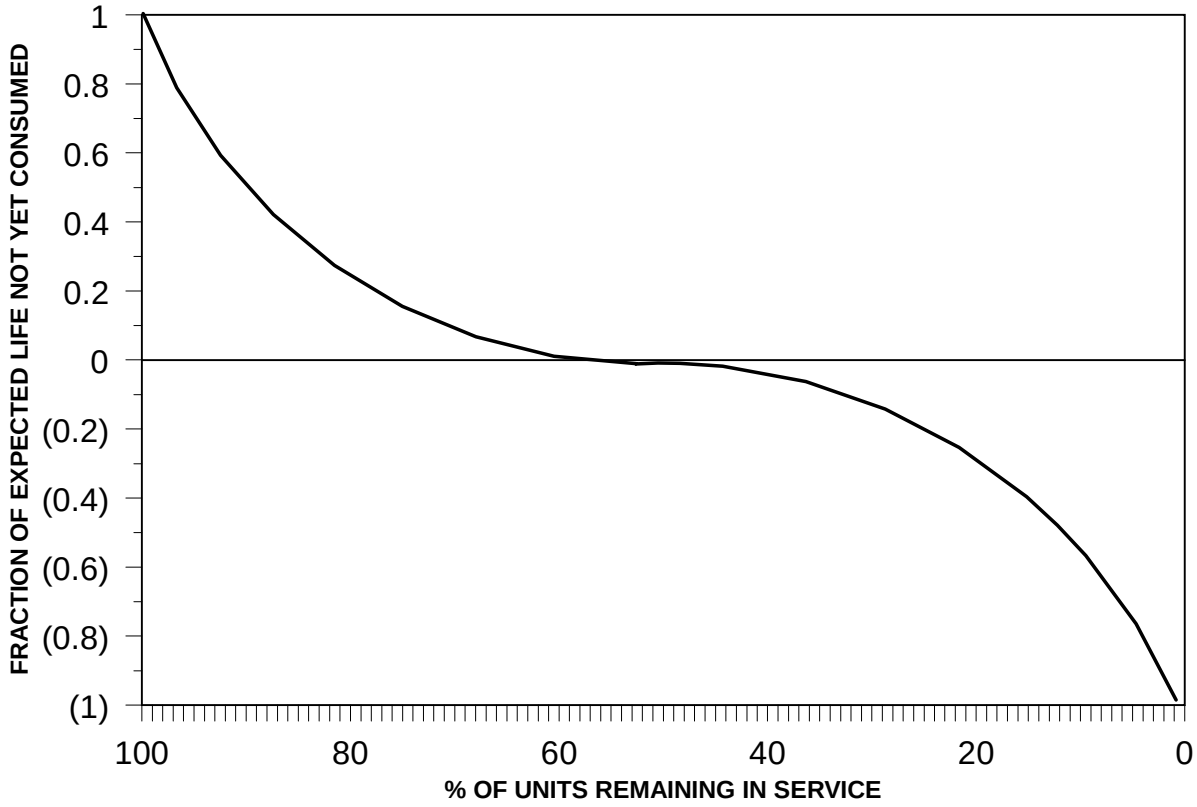
For the attrition calculation, each engine in a specific application is presumed to have operated for the average number of hours at the average load factor. The typical annual hours of use and average load factor are based on telephone surveys of equipment owners and operators. The following example illustrates how the attrition calculation is applied.

Assume that 500 units of a specific type of equipment were placed into operation six years ago, that the annual hours of operation are 600, the load factor is 50 percent, and the engines have a mean expected lifetime of 2,000 hours. For a 70 horsepower (hp) engine, using the above annual use and load estimates, 21,000 hp hours per year will be consumed. After a period of six years, each of the 500 engines is assumed to have operated 126,000 hp hours, which translates into 90 percent of expected engine life (i.e., 70 hp x 2,000 hrs = 140,000 hp hours). Therefore, 10 percent of engine life remains (i.e., has not been consumed). Applying the attrition curve to this value results in an estimate of 72 percent of the 500 engines still in service, or 360 engines. To estimate a total population for each application, these calculations are performed for engines that were placed into service as many years back as twice the expected equipment life, and are then summed to provide total units in operation by model year.

3. Differences Between Equipment and Engine Life

The life of the engine and the life of the equipment may not always be consistent. This is especially true with lawn and garden applications and recreational vehicles, whose engines are often operated and maintained in such a manner that the engines are still operable after the equipment becomes unusable and is scrapped. When PSR determines that equipment life is shorter than engine life, the equipment life becomes the determining factor in the engine lifetime for that application. PSR provided an example of a 3.5 hp walk-behind lawnmower that has an equipment life of 600 hours, and an engine lifetime of 720 hours. For this application, the equipment lifetime will take precedence over the engine lifetime in the attrition calculation. PSR's model is set up to recognize lifetime differences of greater than 15 percent as the threshold for determining when the equipment rather than the engine life will be used.

Figure II- 1. PSR's Typical Attrition Curve



C. Activity Data Estimates

As discussed in the previous section, the average annual hours of use and the load factor for each engine application are critical components for calculating in-use populations. The load factor is defined as the average operating level in a given application as a percent of the manufacturers maximum horsepower rating.

1. Annual Owner Survey

PSR conducts an annual survey of owners of various types of nonroad equipment. The survey requests the following information:

- Equipment specifications (e.g., engine make and model, application, rated horsepower, age of equipment);
- Hours of operation per year;
- Operating cost data;
- Owner assessment of equipment condition; and
- Fuel consumption.

Load factor estimates are not obtained directly through the survey, but are calculated based upon the amount of fuel consumed, the hours of operation per year, the fuel

consumption rating of the engine, and the maximum rated engine horsepower. Using a ratio based on the rated fuel consumption at full load (hp) may overstate the load factor for engines that operate a significant amount of time below the rated horsepower. One investigator indicates that the relationship of fuel consumption to engine load is nonlinear; therefore, a simple ratio may not accurately reflect the load factor (Duleep, 1997).

In compiling responses to these surveys, PSR does not distinguish among the different types of consumers within specific applications. For example, it has been established that lawn and garden equipment is used by commercial operators for a substantially greater numbers of hours per year than homeowners. To the extent possible, PSR incorporates information for a sufficient sample of users to reflect the average annual hours of use across all variations. The limitations associated with this approach are discussed further in Chapter III.

Equipment manufacturers are also contacted on an annual basis to obtain estimates (or actual data, when available) of the average hours per year their equipment is used by customers in the field, and the typical average load factor for their equipment. However, PSR has found that only a limited number of OEMs have well-documented estimates for these variables (Zirnheldt, 1997a).

2. Annual Variations In Activity Data

The annual hours of operation for nonroad equipment are influenced by fluctuations in the economy, and are likely to increase during years when the economy is strong, and products/services which rely on nonroad equipment are in demand. This is especially true for commercial applications. In addition, PSR has observed that engine load tends to decrease when fuel prices decline. PSR believes that when fuel is relatively less expensive, consumers purchase higher rated engines, which are typically operated less efficiently (i.e., lower load relative to maximum engine hp rating). As such, hours of use (and other activity data) for nonroad equipment do not remain constant from year to year.

In PSR's data base, however, the average annual use and load factor for a specific application used in 1996 is the same as the average annual use and load factor for the same engine in 1992, so that in their model the annual use and load data do not vary by year. They do make adjustments to the annual use and load factor data as information indicates that these factors have changed significantly for a particular engine application (and that value would be used until another significant change is observed; PSR did not define "significant," [Zirnheldt, 1997a].) PSR acknowledges that this may be a limitation, but explains that they do not believe the differences to be significant enough to justify the cost and complexity of accounting for these variations for each separate year.

D. Geographical Distribution

The discussion up to this point has focused on national nonroad engine population estimates. This section describes the methods for developing county populations. PSR uses a "top-down" approach to estimate county populations, and therefore the uncertainty associated with these county estimates is greater than that associated with the national populations. However, PSR notes that they do not develop these estimates in order to obtain precise counts of equipment populations in individual counties (Zirnheldt, 1997b).

County populations are estimated by PSR to assist the engine parts and service distribution organizations, who are typically assigned territories composed of several counties. The county allocation enables an estimate of the market in a multi-county territory. As the number of counties included in a territory is increased, PSR states that the representativeness of the data tends to improve.

To estimate county-level engine/equipment populations, PSR applies surrogate county indicators to their national nonroad population estimates. Because of proprietary claims by PSR, it was not possible to determine the specific surrogate county indicators PSR uses for each equipment type. PSR did provide a list of 12 indicators which it has determined to correlate with local equipment use. These 12 indicators are:

- Total employment;
- Agricultural services revenues;
- Fishing revenues;
- Mining revenues;
- Oil and gas revenues;
- Construction revenues;
- Metal manufacturing revenues;
- Machinery manufacturing revenues;
- Trucking revenues;
- Wholesale distribution revenues;
- Retail food revenues; and
- Auto dealer revenues.

PSR states it has tested combinations of more than 600 indicators in determining that these 12 provide the best multi-variate correlation models with PSR's 99 applications. For each application, a unique set of constants are applied to one or more of the 12 indicators to establish the proportion of the population at the county level (Zirnheldt, 1997a).

For the 12 indicators, PSR uses data from *County Business Patterns,* an annual publication by the U.S. Census Bureau. However, PSR only obtains updates to these data every 5 years. (PSR believes that the level of error within their county estimates exceeds the annual differences reported in *County Business Patterns* data, Zirnheldt, 1997b.) This publication, which includes employment, payroll, and the number of establishments for each county in the United States, does not contain revenue data. PSR estimates county-level revenues by multiplying census data representing average national revenues per establishment within each employment size category (e.g., 1 to 5 employees), by the number of establishments in each county within each employment size category (PSR, 1997).

State-level populations are not derived directly by PSR. State populations are determined by simply adding the county populations within a state. State-level indicators (which are summations of the county-level indicators) have been incorporated into *PartsLink* to allow for faster processing when a single state is selected by the user as the geographic unit. As already noted, State-level populations are considered by PSR to be more representative than for a smaller collection of counties or a single county.

E. Population Verification

1. County-level Verification

PSR regularly audits the reliability of their estimated populations through a detailed, randomly-selected county survey. Each type of equipment is included in a survey at least once every three years. For example, a specific equipment application and geographic territory are selected (e.g., skid-steer loaders in Baldwin County, Nebraska). A working population of skid-steer loaders in that county has been predicted by PSR's attrition model. PSR makes an effort to contact every possible commercial operator of skid-steer loaders in that territory, and a profile is developed comparing actual ownership to the predicted ownership from the model.

PSR acknowledges that it is not feasible to speak with every commercial operator of nonroad equipment in a county. Using county census data compiled by Dun and Bradstreet, all Standard Industrial Classification (SIC) codes determined to include engine-powered equipment are identified. PSR makes up to 12 attempts to contact each identified organization within each SIC code. When 85 percent of the organizations across all SIC codes have been successfully contacted in that county (and the remaining 15 percent are determined to be relatively small based on annual revenues or employees), PSR considers the contact effort complete. If the remaining 15 percent are large businesses, further contact is pursued. PSR also verifies that it has contacted at least two-thirds of all businesses within each SIC code. For equipment types that involve private users (e.g., lawn and garden), PSR also performs random sampling of individual households. PSR contacts up to 144 households per county to obtain a profile of consumer use of these applications. The total county equipment population is then projected based on the population that was actually contacted (Zirnheldt, 1997b).

If the survey application populations and predicted application populations deviate substantially (i.e., greater than 10 percent), PSR first reviews their survey methods and investigates whether a significant sector of the population has been omitted. As an additional check, PSR conducts surveys of this application in nine additional counties. For example, if the 10 percent discrepancy is consistently exceeded in all additional counties surveyed for an application, the observed variation is assumed to be due to a defect in the attrition model, most likely associated with the estimates for average annual use or load factor. If necessary, PSR will adjust these inputs on a national basis, and then recalculate the county estimates.

If the survey methodology is proven to be sound (based on the checks described above) and the totals are still significantly different, the geographic allocation methods are then reviewed and revised as needed. Changes are typically made to the weighting constants associated with the county surrogate indicators, until predicted and actual populations are within 5 percent (Zirnheldt, 1997a).

2. National-level Verification

As an additional check of their national in-use populations, PSR conducts a detailed census of all equipment in service in a typical, reasonably-populated county. This census differs from the county surveys previously described, in that every type of engine-powered

equipment is surveyed for a particular county. Each year, PSR compiles these surveys for approximately 8 to 12 counties. To date, census data for 126 counties have been compiled. The correlation of the actual census results with the economic indicators established for that county are then used to extrapolate populations for the entire nation, and these extrapolated populations are compared to the national populations estimated from their scrappage model. As with the county-level verification, if significant variations are observed, census results are reviewed and the hours of use and load factor data are re-evaluated. PSR indicated that extrapolations of these survey data typically result in estimates that are within 5 percent of the calculated national total (Zirnheldt, 1997a).

Although outside sources are used as an external check on their equipment and engine sales data, PSR typically does not compare their national in-use populations to other available population estimates. PSR believes that their methodology is a more accurate method of verifying their national nonroad equipment populations than comparing estimates to recreational vehicle or marine registration data, or other published population estimates. Registration data is known to have limitations because in some cases the registrations correspond to both active and inactive registrations, or in other cases, equipment is not registered by users even if required by law (i.e., noncompliance with registration laws results in an underestimation of the population). Other available sources of population for several nonroad equipment types, including registration data, are discussed in Chapter III.

CHAPTER III
LIMITATIONS OF PSR APPROACH AND RECOMMENDATIONS

PSR uses a "top-down" approach to estimate populations at a county level. The total national number of engines sold is estimated by first adding sales of imported engines to sales of domestic engines installed in equipment, and then subtracting the number of engines exported. Engine populations for a certain year are then derived from key activity variables which factor into the attrition calculation, including engine life, annual hours of use, load factor, and horsepower rating. After engine populations are determined on a national level, county-level populations are estimated using economic indicators. County populations are periodically checked against actual survey data for each application, and national populations are verified by extrapolating from the surveyed county populations.

Pechan believes that PSR's methods are generally sound, but there are some limitations, which perhaps not important to PSR's typical customers, may be of some significance to EPA. In several cases, PSR collects the data that could be used to overcome these limitations. For the majority of these cases, though, PSR does not see the added value to their customers in refining their present assumptions. The limitations inherent in PSR's national and county level population estimates are outlined below. Recommendations for

increasing the reliability of these components are also described. Finally, alternate population sources are briefly described.

A. Variations in Use

1. Private vs. Commercial Use

PSR does not develop separate estimates for commercial and residential use of nonroad equipment types. This distinction is especially important in the lawn and garden category, where commercial equipment has been found to have greater annual use, a shorter lifetime (i.e., greater attrition), and a higher average horsepower rating than consumer applications. PSR combines commercial and residential populations for all applicable equipment types, and the hours of use and load factor are annual average values derived from PSR's owner survey data. PSR contacts both commercial operators and homeowners so that all users are represented by the final average value. However, given the significant differences in the characteristics of commercial and residential use of lawn and garden applications, it is suggested that separate estimates be developed for each, as discussed below.

For their 1996 *PartsLink* data base, PSR estimates that there are approximately 140 million gasoline engines (both 2-stroke and 4 stroke). Of this total, about 121 million (87 percent) are installed in lawn and garden equipment. The NEVES also determined that lawn and garden applications, along with recreational marine equipment, are the largest contributors to nonroad volatile organic compound (VOC) emission inventories. Given the significant contribution of lawn and garden applications to total gasoline nonroad inventories, having an accurate value for use in EPA's NONROAD model is critical.

Trade associations have been known to track sales and differentiate between commercial and residential purchasers. Manufacturing associations such as the Portable Power Equipment Manufacturers Association (PPEMA) and Outdoor Power Equipment Institute (OPEI) have compiled data to account for variations among end-users of the equipment. Table III-1 presents data reflecting commercial and residential use obtained from a study conducted by Booz-Allen and Hamilton for the California Air Resources Board (CARB) (BAH, 1990). This study also tracked annual hours of use and load factor variations among private and commercial equipment types. These values incorporate some data compiled specifically for California, but the use patterns are mainly based on estimates derived from national trade associations (including PPEMA and OPEI), as well as engine manufacturers.

Table III-1. Residential and Commercial Use of Lawn and Garden Equipment

Lawn and Garden Application	Percent Home Use	Percent Commercial Use
Walk Behind Mowers	95	5
Front Mowers	97	3
Rear Engine Riding Mower	97	3
Lawn and Garden Tractor	97	3

Tillers	68	32
Snowblowers	90	10
Shredders	64	36
Commercial Turf Equipment	0	100
Leaf Blowers/Vacuums 2-stroke 4-stroke	 90 75	 10 25
Trimmers/Edgers/Brush Cutters 2-stroke 4-stroke	 90 79	 10 21
Chain Saws	92	8

Recommendation—PSR's owner surveys establish useage patterns with respect to certain activity variables (e.g., annual hours of use), but the survey questions do not enable a determination of the commercial/residential population splits for each application. A recent study of lawn and garden activity data revealed that the only identified sources of data for estimating these splits are the BAH study mentioned above, and the NEVES (Heiken, 1997). Since the NEVES values typically had to be back-calculated from the available documentation, Pechan recommends applying the BAH percentages shown in Table III-1 to PSR's total lawn and garden populations. It should be noted, however, that these use profiles were developed for gasoline nonroad equipment populations. No data are known to be available to explicitly define commercial and residential populations of diesel-powered equipment. In the absence of any conclusive data, all diesel-powered lawn and garden applications are assumed to be used exclusively in commercial settings (Heiken, 1997).

Once separate populations are estimated, distinctions should also be made with respect to mean engine lifetimes for commercial and residential equipment. Although PSR estimates expected engine lifetimes using their own model, average lifespans that account for these differences have been established by CARB and OPEI (BAH, 1990). The appropriate values for expected engine lifetimes (as well as annual hours of use and load factor differences reported by BAH) could then be incorporated by PSR into separate attrition calculations for these two distinct populations.

2. Use According to Equipment Age

New engines are typically operated at a higher number of hours per year relative to older engines. In other words, as engines approach retirement, annual hours of use tends to decrease. This is especially true of agricultural, construction, and industrial applications (PSR, 1997). Although PSR acknowledges this trend in useage patterns, their attrition model does not account for variations in the annual hours of use as a function of age. It is assumed that all engines in a given application operate for the average annual duration, regardless of age or condition.

Recommendation—As part of the regular survey for obtaining average use and load factor data, PSR does collect information on the age of the equipment. PSR's survey data

collected over the past number of years indicates that use does vary according to equipment age. PSR has noted that the data needed to develop an adjustment factor for age-related operation could be provided to EPA at relatively low cost. In addition, the correlation between hours of use and age of equipment has been relatively static according to PSR, so that once established, the relationship may not need to be revised in future years (e.g., this is important in considering the frequency of updates needed for input to EPA's future versions of the NONROAD model). Accounting for age-related operation may, however, result in revisions to PSR's current scrappage function, since PSR indicated that in their current model, equipment used infrequently (i.e., low hours per year) is considered to be scrapped (PSR, 1997).

3. Regional Variations in Use and Fuel Type

PSR's current methodology does not adjust the annual hours of use or load factor data to account for regional variations in the use of certain types of applications. This is important to consider for applications whose use is expected to vary considerably in certain parts of the country relative to others. For example, it is probably not reasonable to assume that existing populations of golf carts are used for the same amount of hours per year in all regions of the country.

Another limitation of PSR's methodology with respect to regional differences concerns the ratio of gasoline to diesel-fueled equipment within a certain nonroad application. The gasoline/diesel split applied to county level nonroad populations is based on the national proportion of gasoline to diesel engines. This procedure is also followed for those applications known to be fueled by compressed natural gas (CNG) and liquefied petroleum gas (LPG). Using a national ratio to estimate fuel distributions for all counties may not always hold, and PSR recognizes that this is a limitation in their methodology. For example, according to PSR, swathers are typically fueled by gasoline in northern climates, and by diesel fuel in southern climates. However, the ratio established by the national population (approximately 4:1, diesel:gasoline, for 1996) is assumed throughout the country.

Recommendation—The engine type and engine use data that PSR collects through its owner survey could be categorized into several regions of the country (e.g., southeast, northeast, southwest, etc). Responses could be tracked and regional use profiles for each application could then be calculated and compared with national averages. It appears that PSR once tracked regional variations in equipment use (EEA, 1991), although currently they do not. Where differences exist, these values could potentially be incorporated into PSR's attrition model to develop regional populations that reflect these variations in operation and fuel type. The regional load factor and annual use data could subsequently be included in EPA's NONROAD model equations (e.g., by reflecting these variations in the activity data applied to State or county-specific nonroad populations according to Equation 1 of this report).

Other sources of data may be used to estimate fuel distributions at the State level, including gasoline consumption from the Federal Highway Administration (FHWA) and diesel/distillate sales from the Department of Energy (DOE). Under Task 2 of this work assignment, these fuel consumption data were tested for their ability to project the national nonroad equipment population from 1990 to 1996. Relative to other established projection methods, the fuel use data were less accurate in predicting nonroad population growth

between 1990 and 1996. However, because of time and resource constraints, the projection methods were not compared at the individual PSR market segment-level (e.g., agriculture, construction). As such, it is possible that there may be some categories for which fuel data are a good predictor of nonroad population changes. For these categories, State-level historical fuel consumption could be used to estimate gasoline and diesel populations at the State-level. The fuel consumption data provides a method of developing State-specific gasoline-diesel fuel splits, although the proportions of gasoline to diesel equipment would not be specific to each application (i.e., they would be category-specific, due to the level of detail available from the FHWA and DOE reports). These State populations could potentially be further allocated to the county level by the application of selected county surrogate indicators. The county level allocation procedure is discussed in more detail below.

B. Allocation of National Nonroad Equipment Populations to Counties

1. PSR Approach

Although PSR does verify the accuracy of their county-level distribution by performing county surveys and comparing these actual survey results to their predicted populations, there are still some limitations associated with the derivation of county populations. Relative to other areas of their data base, PSR cautions that the county-level estimates are less defensible. As described in Chapter II, PSR estimates county-level equipment populations by applying surrogate county indicators to their national nonroad population estimates. A list of the 12 economic indicators which PSR has found to correlate with local equipment use is provided in Section D of that chapter.

Because of proprietary claims by PSR, the specific indicators that PSR uses for each equipment type were not provided. Without this information, it is difficult to make firm conclusions on potential improvements to PSR's allocation procedures. However, there are some important issues of note. For example, the list of indicators does not include population or number of single-family households, which intuitively should be better indicators for residential lawn and garden equipment and recreational vehicles than any of the indicators listed. However, as noted earlier, PSR does not distinguish between commercial and recreational lawn and garden use, so the same indicator used for commercial equipment is by default used for residential applications. It is not at all clear which indicator(s) would be used for recreational equipment—none of the 12 indicators listed is a natural choice for such an indicator.

Another concern with this list of indicators is that they are quite broad in scope—most are associated with multiple 2-digit SIC codes (e.g., wholesale distribution refers to SIC codes 50 and 51). It may be important to develop more specific indicators for individual equipment types when such distinctions can be made, and where more detailed data are available (e.g., 3-digit or 4-digit SIC code).

2. Nonroad Engine and Vehicle Emission Study (NEVES) Approach

As part of the NEVES, Energy and Environmental Analysis (EEA) estimated county populations, and ultimately, nonattainment area populations, from national data (EEA, 1991). In developing its methodology, EEA estimated regression equations based on PSR

State-level data. With some notable exceptions, these regression equations were typically developed using number of employees in related industries (e.g., State-level logging equipment was regressed versus the number of employees in SIC 241–Logging). This approach uses indicators that are statistically correlated with PSR State distributions. The major concern with the EEA approach is that, with one minor exception, it is based on relationships with PSR's State estimates, which PSR has indicated are simply summations of its county estimates. Since PSR State data were used as the benchmark for EEA's regression equations, and, as noted above, the PSR allocation methods may have some shortcomings, it may be possible to improve upon the indicators developed by EEA. The one exception to using PSR State estimates was the recreational marine category. State-level registration data as reported to the U.S. Coast Guard were available and deemed more reliable than PSR data.

3. California Air Resources Board (CARB) Approach

For CARB's off-road inventory model (OFFROAD), activity indicators such as employment, fuel use, and registrations were generally used to distribute State populations to a county level (EEA, 1997). Table III-2 presents a summary of the surrogates used for each nonroad category in CARB's OFFROAD model (excluding locomotives, marine vessels, and aircraft). For several categories, county-level populations were estimated using the same indicators that were applied for the NEVES. To the extent that these listed surrogates are available nationally, some of these surrogates are likely to be good candidates for estimating county-level populations (i.e., surrogates derived for the NEVES).

Table III-2. County Surrogate Indicators Used by CARB for OFFROAD model

Nonroad Category	County Indicator or Method
Motorcycles/ATVs	Department of Motor Vehicles (DMV) county registration data
Snowmobiles	Fuel use data collected from snowmobile users by U.C. Davis (for exhaust emissions), or DMV registration data (for diurnal evaporative emissions)
Golf Carts and Specialty Vehicles	Data from publication California Golf, including addresses for golf courses/resorts in the State, as well as identification of those resorts using powered golf carts.
Construction and Mining Equipment	Construction equipment—number of construction employees from *County Business Patterns*. All construction equipment over 500 hp assigned to counties on the basis of mining employment since mining industry more likely than the construction industry to use high hp equipment. (Similar to NEVES)
Industrial Equipment	Manufacturing employment data. (Similar to NEVES)
Lawn and Garden Equipment	Multiple regression using number of single family housing units in each county along with number of employees in SIC 78 (Landscape and Horticultural Services). (Similar to NEVES)
Farm Equipment	County populations of wheel tractors (for total farming equipment populations) and grain and bean harvesters (for heavy-duty farming equipment populations) from the 1987 *Agriculture Census*.
Light Commercial Equipment[1]	Number of wholesale and retail establishments from *County Business Patterns*. (Similar to NEVES, but NEVES only used wholesale establishments)
Logging	Number of employees in SIC 24 (Lumber and Wood Products). (Similar to NEVES)
Ground Support Equipment	Directly estimated county populations for this category using data from California Federal Implementation Plan (FIP)
Pleasure Craft	County-level fuel consumption estimates developed by CARB
Transport Refrigeration Units (TRUs)	For trailer mounted units, used commercial truck and trailer registration data from DMV; for TRUs on railroad boxcars, used county's share of the total annual California locomotive emissions.

[1]In CARB model, this category includes equipment that are generally used in light manufacturing and various wholesale and retail activities, including generator sets, pumps, air compressors, gas compressors, welding machines, and pressure washers.

It is apparent, though, that for several equipment types, indicators are only available for California (e.g., golf carts, ground support equipment, and recreational marine).

4. Recommendations

Both PSR and the NEVES allocation methodology have advantages and limitations. Eleven of the twelve indicators that PSR employs are revenue-based (the twelfth is total employment). Depending on the equipment type, employment may be a better indicator than revenue, as the population of equipment is intuitively correlated more with the number of employees that use the equipment, rather than revenues from use of equipment. For several nonroad categories in the NEVES, high correlations were established using number of employees as the surrogate. One would expect that revenues would be a better indicator of total equipment activity level (e.g., hours of use and load factor), rather than equipment population. For example, changes in revenues of a manufacturing industry may result from an increase or decrease in the hours that a type of equipment is operated, rather

than an increase or decrease in the actual population of the equipment. For certain industries (e.g., the logging industry) nonroad equipment population may be best reflected by the number of production workers (as opposed to total employment). However, production worker data are typically not available for most (if any) industries at the county level.

As discussed above, PSR's indicators are very broad, are based on revenue rather than employment (with one exception), and cannot be replicated. The NEVES indicators are based on State-level PSR populations which are based on PSR's indicators. As such, Pechan recommends an alternative approach for developing county populations. The approach would involve EPA obtaining PSR's county survey data, or surveying a representative sample of counties themselves, in order to test alternative county indicators . If EPA conducted the equipment survey (in lieu of PSR providing the survey data) and developed regressions to establish correlations among the surrogates, this procedure is likely to be rather resource intensive. However, it is apparent that actual surveyed county populations would be the best measure to check the predicting ability of county surrogates. This is essentially what PSR does, but this approach would enable EPA to test other indicators not used by PSR (e.g., industry-specific employment) that may be suitable surrogates.

In lieu of county data, this approach could also be followed for any published sources of State-level data for specific equipment types. This approach would be similar to what EEA did for the NEVES, except that State estimates distinct from PSR could be used. However, these data are not likely to be available for every equipment type/category. An investigation to identify all categories with available independent State-level populations was not conducted, although one example is the State-level marine recreational populations derived from registration data (EEA, 1991).

If county or State data were not obtained, another approach would be to develop time-series regressions at the national level. Using indicators that are also available at the county level, the national historic trend in these available surrogates could be compared and tested against PSR's historical population estimates. If the national regressions indicate that a particular indicator or set of indicators provides a statistical relationship with equipment populations over time, then it would be reasonable to use that indicator to apportion the national population to counties.

Until the actual regressions are performed to test the suitableness of various economic surrogates, a recommendation of the best indicator cannot be made. For some PSR applications, Pechan has identified more specific surrogates that are available at a county level. Because of time constraints, Pechan could not make an exhaustive investigation into potential indicators for each application. The remainder of this section discusses two alternate surrogates that were identified.

For aircraft support equipment (PSR application 81), the number of aircraft take-offs and landings per airport reported in Federal Aviation Administration's (FAA's) *Air Traffic Activity* may be a better predictor of county-level populations, since these data are tracked for each separate airport. For agricultural equipment, the Department of Commerce publishes county-level farm expenditures for various types of fuel, including diesel, gasoline, natural gas, and LP gas (DOC, 1995). The *Census of Agriculture* reports State and county level statistics every fifth census year; the most recent update is for 1992. In addition,

national average prices paid for fuel by farmers are also reported in *Agricultural Statistics* (USDA, 1997). These data would enable conversion of total fuel expenditures to total gasoline, diesel, and LPG consumption by county. Fuel use could then be tested for its ability to predict county populations. Another option may be to use county-level farm employment data reported by the Department of Commerce (DOC, 1995). EEA had tested the number of employees within SIC 07-Agricultural Services, obtained from *County Business Patterns*. Although there was good correlation, the populations were over-predicted when applying this surrogate, since SIC code 07 accounts for employees in other nonfarm-related industries including veterinary services and other animal services (employees in landscape and horticultural services had already been omitted). As a result, these employment figures from the *Census of Agriculture* are a surrogate worth evaluating.

C. Alternate Sources of In-use Population

PSR indicates that their estimates of engine sales are checked against data available from various trade associations and industry representatives. They have also provided details about how they verify county-level in-use populations determined by their scrappage model with actual county survey results (Zirnheldt, 1997a). However, PSR does not compare their national populations with other outside sources of populations. PSR asserts that the majority of alternate in-use population data that they have examined are not based on estimation methodologies of comparable quality.

This section first discusses issues related to PSR's current in-use population estimates. Alternate sources of nonroad populations are also briefly discussed. These alternate sources are especially important in cases where there were no population estimates available from PSR, or in cases where the PSR data are thought to be less reliable. Methodologies distinct from PSR's for estimating in-use populations are presented in more detail in the Task 1B report under this work assignment.

1. Consistency Issues Related to PSR's Current Data Base

Pechan identified those PSR applications for which no gas or diesel-powered populations are available from PSR's 1996 data base. It seems likely that the following nonroad equipment have associated diesel or gasoline populations and are relevant to the nonroad model:

- Wood Splitter (PSR application 75);
- Minibikes (PSR application 93); and
- Crawler Loaders (PSR application 97).

PSR's current 1990 population estimates were briefly examined for reasonableness and consistency with 1990 NEVES populations. PSR populations were used to develop Inventory A of the 1990 NEVES. In general, concordance between the two data sets (i.e., PSR and NEVES) was relatively good, but there are a few notable discrepancies. For 1990, the NEVES estimated 48,990 minibikes and 502,181 wood splitters; the current PSR data base does not have 1990 populations reported for these applications (i.e., the applications are not included in the data base). It appears that crawler loaders were not included in the NEVES. If it is established that populations of these nonroad equipment types are in operation (i.e., the populations are not "0"), alternative sources of data will need to be

considered. It may be possible that populations for these applications have been incorporated into other equipment types, but that was not confirmed by PSR.

For leaf blowers and vacuums, PSR estimates a total 1990 population (i.e., both gasoline and diesel) of 3.6 million, while NEVES only estimates 2.8 million. This large discrepancy (800,000) in the 1990 base year value is questionable since the NEVES was based on PSR data. There is also a large difference in the total number of rear engine riding mowers in 1990 reported by PSR, and reported by the NEVES. PSR reports approximately 2 million, while the NEVES estimates a population of 0.8 million.

As an additional check, trends in PSR populations from 1990 to 1996 were also analyzed. When comparing PSR leaf blower/vacuum populations between 1990 and 1996, the total population decreases by 17 percent. (There is an increase in the diesel population, but diesel applications are less than 0.1 percent of total). It seems counterintuitive that populations of leaf blowers and vacuums, which appear to be more prevalent in both commercial and residential settings, have decreased from 1990 to 1996. If the NEVES 1990 population is compared to PSR's 1996 population, the population increases by 11 percent.

PSR acknowledges that they will periodically update historical estimates, but will usually not change estimates more than five years prior to the current year. However, one would not anticipate that variations in populations predicted by the attrition model would be that great from year to year. These historical anomalies in populations for leaf blowers/vacuums and rear engine riding mowers diminishes the level of certainty associated with PSR's estimates for lawn and garden applications. Pechan recommends that an alternate source be considered for deriving lawn and garden equipment populations in EPA's model (alternate sources are described in more detail in the Task 1B report.)

2 Comparison of PSR Population Estimates with Alternative Estimates

Due to time constraints and data availability, the following discussion does not address all PSR applications or market segments. Where national in-use population data were identified for a general nonroad category, the source of the data and the basis for the estimates are described. Population estimates are then compared with PSR populations for a specified year, but a critical comparison to determine the most representative estimate was generally not conducted. It is important to note that prior investigations have established that available in-use population estimates (especially from trade associations) are typically based on simplistic assumptions of engine scrappage and engine life (EEA, 1997), and in these cases the populations are judged to be less defensible than PSR's estimates.

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Agriculture

The United States Department of Agriculture compiles on-farm machinery and equipment inventories for select farm applications, and reports these populations in *Agricultural Statistics* (USDA, 1997). These data are derived directly from the Department of Commerce's *Census of Agriculture.* These populations are only available for a few of the applications included within PSR's agricultural market segment, and only two are considered in making comparisons to PSR data (Table III-3).

Table III-3. Comparison of Farm Equipment Population Estimates

	In-Service Population	
Farm Equipment	**USDA (1992)**	**PSR (1990)**
Wheel Tractors	4,305,000	2,333,034
2-wheel tractors	NA	10,693
Ag. Tractors	NA	2,322,341
Combines	569,000	271,313

USDA's estimates are much higher than PSR's for the select equipment types. This is not entirely unexpected since the *Census of Agriculture* tends to include equipment that is no longer in operation in their total equipment counts. The USDA acknowledges that survey respondents are not consistent in their reporting practices; some farmers report both in-use and retired equipment, whereas other respondents only report equipment that is operable (DOC, 1995). Because of these known shortcomings in USDA's survey methodology, Pechan considers the PSR data to be more representative than the USDA estimates for the nonroad farm category.

Lawn and Garden

It should be noted that for CARB's OFFROAD model, in-use populations from PSR were not used as the basis for estimating emissions from the lawn and garden nonroad category (EEA, 1997). Because of the many questions concerning PSR's lawn and garden estimates, two established trade associations (PPEMA and OPEI) representing manufacturers of these applications were contacted to determine if they have alternate in-use population estimates. Both of these organizations supplied sales data for estimating in-service populations potentially affected by emission standards for select nonroad spark-ignition engines. These standards were promulgated on July 3, 1995. However, in-use populations were not readily available from the documentation of the regulatory impact analysis for the spark-ignition engine rulemaking (EPA, 1994).

PPEMA represents manufacturers of chainsaws, leaf blowers/vacuums, shredders, and trimmers. OPEI represents manufacturers of lawn mowers, lawn/garden tractors, rear engine riders, and snowblowers. Both associations indicated that they have not compiled any current in-use populations against which to check PSR populations for these applications.

Snowmobiles: Recreational Equipment

The International Snowmobile Manufacturing Association (ISMA) estimates U.S. snowmobile populations based on active registrations. Because of the increased enforcement efforts and improved tracking of snowmobile registrations by States, ISMA believes the number of snowmobiles registered in 1996 is an accurate count of the in-use population. For registration purposes, the 1996 annual snowmobile season runs from June 1996 to June 1997. Although the estimates are not directly comparable because of temporal discrepancies, ISMA estimates a 1996 working population of 1,421,177, while PSR estimates a 1996 population of only 793,881. It is ISMA's belief that these estimates are

representative of the number of snowmobiles in operation (ISMA, 1997). However, since ISMA is not applying any type of scrappage function to their populations, PSR populations are more defensible than ISMA estimates. Although not directly relevant to this analysis, the ISMA predicted that the total population of snowmobiles will decrease in future years, as sales of newer models are not anticipated to outweigh the scrappage of older models placed in service in the late 1970s and early 1980s.

Recreational Marine

As indicated in Table II-1, PSR checks their sales data for outboard motors, personal watercraft, and powerboats against data compiled by the National Marine Manufacturing Association (NMMA). As part of the regulatory impact analysis for the *Control of Air Pollution Emission Standards for New Nonroad Spark-Ignition Marine Engines*, EPA estimated the in-service population of outboards, personal watercraft, and sterndrive/inboard engines for 1990 to 2051 (EPA, 1996). Nationwide in-use populations for these three classes of engines, along with average annual hours of use, were obtained from NMMA. 1996 populations estimated for outboards and personal watercraft are compared with 1996 PSR estimates below.

Table III-4. Comparison of Recreational Marine Equipment Population Estimates

Recreational Marine Equipment	1996 In-Service Population	
	EPA	PSR
Outboards	8,619,722	7,116,244
Personal Watercraft	1,026,387	815, 614
Sterndrive/Inboards	2,567,067	2,040, 503

PSR does not have a sterndrive/inboard category, although they have a category for powerboats. PSR's 1996 population for powerboats are presented in Table III-4 to compare with sterndrive/inboard populations.

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D. Conclusions

In their *PartsLink* data base, PSR makes critical distinctions in engine populations that are important for accurately quantifying emissions from nonroad engines (e.g., fuel type, engine type, horsepower). There is no other more comprehensive data base that addresses all types of nonroad equipment on a national level. The main limitation with the PSR nonroad populations are associated with the lack of geographic detail. PSR acknowledges that in order to serve their main clients (equipment manufacturers and suppliers), the precision of county level populations is not their main priority. As such, accounting more accurately for regional variations (either at a county, State, or a broader geographical region) is an area that EPA may wish to investigate further. Another issue that warrants further analysis is the incorporation of use/equipment age correlations into the scrappage model for nonroad populations.

CHAPTER IV
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