EPA

United States
Environmental Protection
Agency

Air and Radiation

EPA420-P-04-014
April 2004
NR-014c

Geographic Allocation of State Level Nonroad Engine Population Data to the County Level

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Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

NOTICE

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Report No. NR-014c
revised April 2004

Assessment and Standards Division
EPA, Office of Transportation and Air Quality (OTAQ)

I. Purpose

The purpose of this report is to discuss the methodology and data that EPA uses in the draft NONROAD2004 model to allocate equipment populations from the national to the county level.

II. Background

The EPA has developed a national nonroad air emissions inventory model called NONROAD. This model provides a tool for EPA, States, regional air pollution organizations, and local air pollution control agencies to use in estimating pollution from nonroad vehicles and equipment for State Implementation Plans (SIPs), as required by the 1990 Clean Air Act Amendments, and other regulatory needs.

With some exceptions, the model uses national engine population or sales data from Power Systems Research (PSR), a company that tracks the sales and populations of all types of engines sold in the U.S. Since PSR also matches the engines to the equipment in which they are used, the term "equipment populations" will be used for the purpose of this report to describe the population of both nonroad equipment and the engines used to power that equipment. The EPA believes that PSR provides the most comprehensive national nonroad equipment population data currently available. PSR updates these data on a yearly basis. However, in some cases, the EPA has used population data from a source other than PSR when such a source is available and found to be more accurate than the PSR data. For some types of equipment (e.g., ATVs and snowmobiles) NONROAD uses equipment sales or population data from industry sources or state registration data.

The PSR database also geographically allocates equipment populations from the national to the county level and then aggregates the county-level populations to generate state totals. However, the methods and data that PSR uses to perform these allocations have only been explained in general terms, since PSR considers their methods to be proprietary information. Since the EPA wants the methods that it uses to allocate equipment populations in NONROAD to be fully understood by EPA and the public, we have decided to use publicly available data as much as possible to serve as factors to allocate the national PSR equipment populations to the county level. State/local users may elect to substitute their own equipment population data, where such data is well-documented and specific to local conditions, for SIP purposes. These

data may be derived from well-designed and executed surveys or other information sources. In order to be used as input data for NONROAD, these surveys or alternative sources of information should include the hours per year that the various types of equipment are used, as well as equipment populations. Using only local population data in NONROAD without the corresponding local activity data (or vice-versa) could result in distortions in the emission inventory estimates that NONROAD calculates.

III. Allocating Activity Versus Engine Population

One central feature of the NONROAD model is that it uses the same methods to allocate equipment populations, equipment activity, and equipment emissions to specific geographic areas. To the extent that a given equipment type is operated at the same power level (load factor), operating cycle, and for the same number of hours in all areas, the distribution of the population of this equipment type will match the distribution of its activity and engine emissions. In general, population, activity, and emissions will tend to track one another, since emissions are a direct function of equipment activity and the conditions that stimulate increased engine activity are likely to stimulate increased engine populations.

In reality, however, the geographic distribution of nonroad equipment may differ from the geographic distribution of emissions from these equipment. Because an equipment type's operating cycle and load factor most likely do not vary significantly by geographic area, the difference between the distribution of population and emissions depends on variations in the amount of activity. The amount of activity that each piece of nonroad equipment of a given type experiences can vary from area to area as a result of variations in local economies, weather patterns, or other local conditions. For example, agricultural equipment and residential lawnmowers may experience more use per year in areas with longer growing seasons; construction equipment is likely to be used more intensively in areas experiencing an economic boom and less intensively where the economy is not as robust.

Equipment activity may also be influenced by the age of the equipment. EPA has encountered some general information indicating that equipment activity declines as the equipment gets older. For example, older pieces of agricultural or construction equipment might be kept as spares to be used if newer equipment breaks down or if an extra piece of equipment is needed to complete a task once in awhile. Unfortunately, EPA has been unable to obtain precise quantifiable data to model this relationship for any type of nonroad equipment. EPA will continue to look for such data for the development of the nonroad portion of the MOVES Model.

Currently, the draft NONROAD2004 model is capable of handling only one activity level for each equipment type across all parts of the U.S. As a result, the model uses the same factors to allocate engine populations and their associated activity. Wherever possible, the EPA has sought indicators related to engine activity, since it is engine activity that results in emissions (except for diurnal and hot soak emissions, which are more closely related to engine populations). In some cases, however, the EPA was unable to find a suitable activity indicator

and had to rely on population-related indicators as a surrogate for engine activity. In this report, the EPA has attempted to be explicit as to whether each equipment type's geographic allocation factor is an activity-oriented indicator, a population-oriented indicator, or an indicator that is reasonable for both population and activity.

For several equipment categories, the EPA has had particular difficulty finding either activity or population indicators for several equipment categories. These categories include recreational, railway maintenance, and AC/refrigeration equipment. The EPA welcomes suggestions from the nonroad industry, state and local air quality agencies, and other interested parties concerning improved methods to allocate these equipment categories to the county level. The EPA also invites state and local air quality agencies to substitute adequately documented local data for the national default allocation estimates, in accordance with EPA guidance, for these categories and for other categories such as recreational marine engines where the national default estimates may not adequately reflect local conditions.

Through the EPA Office of Air and Radiation's (OAR) Section 103/105 Grant Program, the EPA has sought to encourage regional, state, and local air pollution organizations to develop and apply methods to collect local nonroad equipment population and activity data for categories of equipment that contribute significantly to the total nonroad emissions inventory. The EPA awarded a grant to the Northeast States Coordinated Air Use Management Association (NESCAUM) in 1999 to conduct a multi-year effort that generally includes the following:

1) performing a review and analysis of known survey methods that have been used by state and local air agencies to collect local nonroad equipment activity data,
2) choosing one of the survey methods reviewed and analyzed in part 1 or developing a new method to be included in EPA guidance to state and local air agencies, and
3) applying the chosen method to selected areas to ensure that it works properly and produces reasonable and useful results.

The EPA also awarded a Section 103/105 grant to the California Air Resources Board (ARB) to conduct a lawn and garden equipment survey. This survey targets potential residential, commercial, and municipal/institutional users of lawn and garden equipment. This project includes a questionnaire about the number and type of equipment owned and used. In an attempt to develop better activity data, the ARB also is distributing data loggers to willing volunteers. A volunteer attaches the data logger to his or her equipment in order to record the time and date of when the piece of equipment is started and shut off. The results of the work performed under this grant are available in a report at the following address on the California Air Resources Board web site.

http://www.arb.ca.gov/msei/off-road/updates.htm

The EPA welcomes suggestions and comments about these efforts, as well as information about surveys of nonroad equipment that have been conducted in the past or are presently being conducted, from stakeholders and other interested parties.

IV. Methodology

The EPA decided to design NONROAD to use information related to equipment population or activity to distribute national equipment populations and their associated activity to the county level. This surrogate information constitutes a geographic allocation factor. The model can use a single allocation factor for entire categories of nonroad equipment, or it can use separate factors for one or more equipment types within a category. Mechanically, the model assumes that each piece of equipment of a given type experiences the same annual activity (i.e., hours/year). This reduces the allocation problem to one of allocating engine populations. In essence, the allocation factor serves as a surrogate for population **and** activity.

Since the NONROAD model only has the ability to allocate equipment populations from the state to the county level, the national population data for each equipment type must be processed outside of the model to obtain state-level populations used in the model. To obtain state level populations of most equipment types for input into NONROAD, the county-based allocation factors discussed in detail below are applied outside of the model to the national equipment populations to obtain county-level equipment populations, as shown in the equation below.

$$(\text{Equip. Population})_{county} = (\text{Equip. Population})_{national} \text{ x } \frac{\text{Surrogate}_{county}}{\text{Surrogate}_{national}}$$

These county-level populations are then aggregated into state totals which are input into NONROAD as the default state populations. The county-based allocation factors are also aggregated into state totals for use in the model. The model then uses the aggregated state equipment population and allocation totals to calculate the county-level equipment populations it outputs, as shown below.

$$(\text{Equip. Population})_{county} = (\text{Calculated Equip. Population})_{state} \text{ X } \frac{\text{Surrogate}_{county}}{\text{Calculated Surrogate}_{state}}$$

Due to the large amount of data that needs to be manipulated, modifying the model so that it could do all of this processing internally would increase the time it takes NONROAD to run a scenario beyond reasonable limits.

There are a few equipment types that use a modified form of the above method. As explained in more detail below in the sections covering each equipment type, snowmobiles, ATV's, offroad motorcycles, and recreational marine equipment use an equipment-specific method to allocate from national to state (done outside of the model) and then use the above method to allocate from state to county within the model.

V. Sources and Types of Data

There are three basic types of data that are potentially useful as allocation factors: human

population and its associated income and housing data, business activity, and geographic data. Most of these data are available from the U.S. Census Bureau or other federal agencies except for data concerning construction activity, which is discussed separately below. Information from the U.S. Census Bureau is especially attractive for use in the NONROAD model because census data undergo rigorous statistical analyses and quality assurance reviews.

Population Data

The U.S. Census Bureau conducts a nationwide census on a decennial basis. The census includes data on population, housing (e.g., number of homes by type, number of occupants per home), and income. The most recent census available at the time these allocations were updated occurred in 1990. The Census Bureau produces updated human population estimates on an annual basis, but does not produce an annual update for housing or income data.

Business Activity Data

The U.S. Census Bureau publishes an annual report called County Business Patterns (CBP), which tracks the number of establishments and employees for various types of businesses and industries at the national and county level using Standard Industrial Codes (SICs). NONROAD uses 1996 CBP data. EPA used County Business Pattern indicators to allocate state-level populations to the county level for the 1991 Nonroad Engine and Vehicle Emissions Study[1] (NEVES).

Geographic Data

Geographic data include factors related to an area's location or physical characteristics. Such factors include water or land surface area, weather data, and land use data. Such data are available from government agencies such as the U.S. Census Bureau, the National Oceanographic and Atmospheric Administration, and the U.S. Geological Survey.

VI. Allocation of Specific Populations of Equipment Categories/Types

The allocation indicators that the EPA has examined and selected for use in the various draft versions of the NONROAD model are discussed below. The indicators used in previous draft versions of the model and those being used in the draft NONROAD2004 model are summarized in Table 1 at the end of this report.

<u>Residential Lawn and Garden Equipment (except snowblowers)</u>

To allocate lawn and garden equipment used by private households, the EPA decided to use U.S. Census data on one and two unit housing (i.e., single family homes and duplexes) by county from the <u>USA Counties</u> database. Structures containing more than two units tend to be condominiums or apartments that use commercial lawn care services. One and two unit housing information is used as an allocation factor in the NEVES, and an analysis of this set of data during the writing of the NEVES showed that it provided a good predictor of lawn and garden equipment populations. In addition, the EPA has not been able to find an alternative type of data to use as an allocation factor for residential lawn and garden equipment that offers the high quality, the necessary county-level detail, and the predictive strength of one and two unit housing data from the U.S. Census Bureau.

The one and two unit housing data found in the <u>USA Counties</u> database and used in the June 1998 and April 1999 (Tier 2) versions of the draft model come from the 1990 census. As stated in section V, housing information is only updated during each decennial census. However, using the 1990 one and two unit housing data will cause the model to underestimate lawn and garden emissions in more urbanized parts of the country because of the continuing creation and growth of suburbs in counties that were still partially or largely rural in 1990. To address this underestimation the NONROAD model accounts for this growth by adjusting the housing data by a ratio of 1997 human population estimates to human population data by county from the 1990 Census. It should be noted that if the 1997 human population estimate for a county is less than the 1990 census value, then the 1990 single and double housing unit value for that county will remain unadjusted. In such cases, the relative longevity of most housing structures suggests that the number of one and two-unit housing sites would not decline as quickly as human population. For counties which experienced an increase in population between 1990 and 1997, the equation to adjust the housing unit data is as follows:

$$\text{1997 Adjusted Housing} = \text{1990 Housing} \times \frac{\text{1997 human population estimate}}{\text{1990 census human population}}$$

This adjustment could result in an overestimation of lawn and garden emissions to the extent that a disproportionate share of the population growth in the county is housed in multi-unit housing. Any such overestimate would be partially offset by a concomitant underestimate in the growth in commercial lawn and garden activity levels, and by the absence of any adjustment to account for the ongoing reduction in the average number of people per household.

One and two unit housing is most properly thought of as a population allocation factor for residential lawn and garden equipment. The population of such equipment in an area should be roughly proportional to the number of single and double housing units in the area, since the average household occupying such units would have the average probability of owning any given type of lawn and garden equipment. But the amount of use such equipment experiences may vary considerably from area to area based on such variables as the average size of yards, length of growing season, and amount of rainfall. Allocation factors based on residential lawn

and garden equipment gasoline consumption, tons of yard waste removed, or the land area occupied by single and double housing units could, in principle, provide a more direct measure of activity. However, the information regarding such potential activity allocation factors are either not available, of questionable quality, or subject to confounding influences that make the potential allocation factor even less reliable than the one currently used in NONROAD. Therefore, the EPA uses one and two unit single family housing data modified by the 1997 county population estimates from the Census Bureau for the NONROAD model. EPA plans to update this allocation factor using 2000 Census data for the final release of the model. ********

Commercial Lawn and Garden Equipment (except snowblowers)

To allocate commercial lawn and garden equipment, the draft 2002 version of NONROAD uses the number of employees in landscape and horticultural services (SIC 78) from the CBP database. The 1991 NEVES study uses this factor to allocate commercial lawn and garden equipment. An analysis performed during the writing of the NEVES shows that the number of employees in landscape and horticultural services is a good predictor of commercial lawn and garden equipment populations. In addition, the EPA does not know of any other sources to adequately serve as a geographic allocation factor for commercial lawn and garden equipment.

The number of employees in landscape and horticultural services is better suited for allocating the population of commercial lawn and garden equipment than the activity associated with this type of equipment. The level of mechanization in the landscape services industry is likely to be relatively constant from county to county. By contrast, the number of hours per year that the average piece of commercial lawn and garden equipment operates is likely to vary considerably from county to county as a result of different growing seasons and rainfall patterns. Reliable information on allocation factors more directly related to activity levels, such as gallons of fuel consumed per county and year by commercial lawn and garden equipment, are not available.

One caveat for using the number of employees in landscape and horticultural services to geographically allocate commercial lawn and garden equipment populations is that this factor does not include municipal employees that perform landscape maintenance duties for schools, parks, and other properties owned and maintained by local governments. The implicit assumption used in NONROAD is that the population and activity level of such equipment is proportional to commercial lawn and garden equipment population and activity levels. The EPA welcomes comments from interested parties concerning methods or sources of data that can better account for lawn and garden equipment used by municipal landscape employees.

Snowblowers

Allocating snowblower populations and activity levels requires the use of allocation factors that account for the impact of climatic differences among regions, in addition to the factors used to allocate residential and commercial lawn and garden equipment. Put simply, snowblower populations and activity levels depend on snowfall. Snowblower populations in warm-weather states like Florida, Louisiana, and Hawaii should be zero. Snowblowers may be present in parts of states such as Texas and California because part of their territories receive snow (e.g., Texas Panhandle, Sierra Nevada Mountains in California), while snowblower populations in other parts of the state should be zero.

Due to time and resource constraints, snowblower populations at the state and county levels were set to zero in the June 1998 draft version of the model to avoid misallocation problems. However, this version of the model could calculate national annual snowblower emissions. The April 1999 (Tier 2) draft version of the model has snowblower populations assigned to states based on snowmobile registration data supplied by the International Snowmobile Manufacturer's Association (ISMA). The model then allocated the snowblowers to the county level using the same factors used to allocate other types of lawn and garden equipment.

The approach chosen by the EPA to allocate snowblowers in the NONROAD model involves estimating which counties in the U.S. receive enough snowfall to necessitate the presence and use of snowblowers. This was accomplished by overlaying a map of the U.S. from the National Oceanographic and Atmospheric Agency (NOAA) showing ranges of long-term average snowfall amounts on top of a map of U.S. counties and making an informed judgement about the minimum amount of annual snowfall requiring the use of snowblowers. The EPA has chosen a minimum snowfall limit of fifteen inches, based on discussions with a snowblower manufacturer and by the mapping process mentioned above. The same allocation factors applied to other lawn and garden equipment types (i.e., the number of single and duplex family housing units for residential snowblowers and the number of employees in landscaping and horticultural services for commercial snowblowers) will be used to determine the state snowblower population inputs to NONROAD (as discussed in Section IV: Methodology) and as inputs to the model to allocate the state snowblower population inputs to counties receiving at least 15 inches of snow. For counties that do not receive at least 15 inches of snow, the allocation factors will be set to zero so that no snowblowers will be allocated to those counties or erroneously included in the total state population.

Construction Equipment

Initially, the EPA planned to use the number of employees engaged in construction by county (CBP SIC 15) to geographically allocate construction equipment. However, early comments from some stakeholders correctly pointed out that using this indicator could lead to errors in estimating construction equipment population and activity in a county because construction employees and equipment move from project to project, often crossing county lines.

In some parts of the country, such as the Northeast, construction employees and equipment may cross state lines quite frequently. The CBP data only reflect where construction employees and establishments are headquartered, not where they work.

The EPA believes that the dollar value of construction offers the best means available to allocate construction equipment activity to counties. The dollar value of construction provides a good reflection of activity, since there is a proportional relationship between the dollar value of construction and the amount of construction activity in a given area. Also, using the dollar value of construction by county as an allocation factor will distribute construction equipment to where it is actually being used, as opposed to where it is headquartered. Furthermore, this indicator provides a reasonable allocation factor for construction equipment populations: competitive forces encourage construction companies to obtain the maximum return on their investments in costly pieces of construction equipment by maximizing their use as much as possible, thereby strengthening the correlation between construction activity and construction equipment population.

Data on the dollar value of construction is collected and maintained by the Census Bureau only for metropolitan statistical areas (MSAs) instead of counties. Construction valuation data by county for 1997 is available from the F.W. Dodge Company. For the June 1998 and April 1999 (Tier 2) draft versions of NONROAD, the EPA decided to use the F.W. Dodge total dollar value of construction data to allocate construction equipment populations to the county level.

Further refinements to this method have been made. The Dodge data includes the dollar value of residential, commercial, and industrial building construction, as well as road and other public works-related heavy construction. The construction of the various types of buildings accounts for a large portion of the total dollar value of construction. However, according to a survey of construction activity in Houston conducted by Environ in 1998, road and other types of heavy construction constitute a much larger share of actual equipment activity per dollar valuation compared to the construction of residential, commercial, and industrial buildings. This apparent discrepancy can be explained by the fact that, once the land is cleared and graded, heavy construction equipment is not used much in the construction of the actual building, which also usually accounts for the majority of the project's cost. The trends in the Environ survey compare favorably to a study conducted by Sierra Research in 1993 that estimated the relative activity of construction equipment based on fuel cost per project dollar valuation derived from the 1987 Census of Construction Industries.

Therefore, the EPA has weighted the various categories of the Dodge construction dollar value data based on the Environ survey of Houston construction activity. The equation to accomplish this is shown below.

$$\text{Allocation Factor}_j = (\text{SFH}_j + 3*\text{OBLDG}_j + 18.4*\text{R\&B}_j + 8.5*\text{PW}_j) / (\text{SFH} + 3*\text{OBLDG} + 18.4*\text{R\&B} + 8.5*\text{PW})$$

Where the variables are the dollar valuation for either the county (j) or national total

SFH for single/double-family housing construction,
OBLDG for other building construction,
R&B for road and bridge construction, and
PW is public works (sewer, water, and drainage) construction.

The heavier weighting given to road and other types of infrastructure construction generally tends to decrease the allocation of construction equipment to urban counties and increase the allocation of this equipment to rural counties. This stands to reason, since the road and other infrastructure systems in urban counties tend to be largely established but are still being developed in more rural counties where suburban sprawl continues to take place.

Agricultural Equipment

For this category, the EPA considered using the number of employees involved in agricultural work by county as an allocation factor (CBP SIC 78), as was used in the NEVES. However, this allocation indicator may not correlate well with either agricultural activity or agricultural equipment populations. A small number of agricultural employees in a county could cause the model to underestimate the population and activity of agricultural equipment if the predominant type of farming in that county is highly automated or relies on migrant labor that is recorded as being based in a different county. Conversely, a large number of agricultural employees in a county could cause the model to overestimate the population and emissions of agricultural equipment if the predominant type of farming is labor intensive or if migrant labor is recorded as being based in the county. Instead, the EPA chose to use the acreage of cropland harvested by county to allocate agricultural equipment populations in the June 1998 and April 1999 (Tier 2) draft versions of NONROAD. The EPA expects to use these data in the final version of NONROAD as well. This information is available from the U.S. Census Bureau's USA Counties database. It should be noted that in some cases where a county only contains a few small farms the Census Bureau does not publish crop acreage data out of a concern for confidentiality. However, agricultural equipment emissions in a county that only has a few small farms are likely to be small relative to other nonroad sources within this county and to agricultural equipment emissions in other counties within the state where farms and agricultural equipment are more numerous.

Using the amount of harvested cropland as an allocation factor provides a good predictor of agricultural equipment activity, since a proportional relationship generally exists between the amount of cropland harvested and how much equipment activity is needed to prepare the land and plant, maintain, and harvest the crops. However, the amount of cropland harvested does not necessarily provide as accurate a predictor of agricultural equipment population as it does for activity for several reasons. First, the same amount of cropland in a county can be plowed, planted and harvested by a few pieces of large equipment or several smaller ones. Second, the amount of equipment present in a county may be more dependent on the number of farms than on the amount of acreage harvested (although this source of inaccuracy in estimating populations

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may be mitigated by the presence of equipment-sharing arrangements in areas with smaller farms). Since the purpose of NONROAD is to estimate emission levels, and since emissions are more directly associated with activity levels than with equipment populations, the EPA believes that the amount of harvested cropland is an appropriate allocation factor for the draft NONROAD model.

Recreational Marine Equipment

Because the county in which the equipment is purchased, registered, and/or stored may not be the same county where the equipment is used, the geographic allocation of recreational marine equipment presents a significant challenge. An urban or suburban county where a boat is sold, registered, and/or stored may not contain a body of water that can support recreational marine traffic, or water bodies near where a boat owner lives may be overcrowded. Small and medium recreational marine craft, which constitute most of the recreational marine fleet, can be transported by trailer over a wide area, further complicating matters. Thus, sales and registration data are not sufficient to accurately allocate recreational marine equipment to the county level.

The NEVES report estimated the population of boats actually being used in each of the 24 urban nonattainment areas covered by the NEVES through the use of data from a 1991 National Marine Manufacturers Association survey of boat owners.[2] These data included where the boat owners said they primarily operated their boats, where the boats were registered, the boat owners' estimates of the amount of hours they used their boats per boating season, and their estimates of the amount of fuel their boats consumed per boating season. In general terms, the data from these surveys were used to adjust registration-based boat populations so that only the boats actually operating within the nonattainment area (as opposed to boats registered in the nonattainment area but used elsewhere) were included when calculating the recreational marine emissions for each area addressed in the NEVES. In order to check the reasonableness of the NMMA-based results, the total square miles of water surface area in a nonattainment area, the estimated square miles of water surface area needed for a typical boat to operate, and the maximum number of possible hours per boating season in each nonattainment area were used to ensure that the use of NMMA survey data did not result in a boat population estimate that exceeded the maximum number of boats that could theoretically operate during the boating season of a particular area. If the NMMA-based boat population estimate exceeded the theoretical maximum, then this population was adjusted downward.

This method cannot be incorporated into the current design of the NONROAD model, but at least some of its elements might be adapted to allocate recreational marine equipment populations and the activity associated with them to specific counties within a state for direct input into the NONROAD model. A limitation of the NEVES method was that it focused solely on urban areas. Since most boating tends to occur outside of urban areas, it is likely that NEVES significantly underestimated recreational marine emissions in the U.S. In order to be usable for the NONROAD model, the NEVES method would have to be modified to estimate the population and accompanying activity of recreational marine equipment being used in both urban and non-urban counties. Also, new survey data would need to be collected, since much of

the 1991 NMMA survey data are most likely outdated. This would be especially true in regard to the rapid population growth and usage of personal watercraft ("jet skis"), which also would have different activity profiles from other types of boats.

The EPA decided to use water surface area data by county from the U.S. Census Bureau to allocate recreational marine populations in the June 1998 and April 1999 (Tier 2) draft releases of the NONROAD model. However, using this type of data has some limitations. Water surface area does not make a distinction between navigable bodies of water and those that are too shallow for boating or have obstructions through which boats are unable to pass. Also, water surface area does not account for convenience of location (proximity to areas of significant population) or the recreational quality of the water body (which includes such factors as its attractiveness for fishing, its visual appeal, and its water quality), both of which could be expected to affect a body of water's recreational marine activity per unit area. Another limitation is that water surface area alone does not account for access restrictions that may prevent boating or limit the number of boats permitted to operate on a given body of water. Lastly, using water surface area alone does not distinguish between the differences in usage patterns for small outboard engine-driven boats, larger inboard boats, and personal watercraft.

Even with these limitations, the EPA decided to use water surface area as a factor for the allocation of equipment populations because either the other potential approaches described above have even greater limitations or, as in the case of the NEVES approach, additional work is needed to determine the best way to adapt the approach to be compatible with NONROAD (or vice versa) and collect the data necessary to implement the approach.

Some additional work has been completed to refine the water surface area allocation method. The EPA has decided to use a 1992 gasoline consumption distribution developed by the Oak Ridge National Laboratory (ORNL) for use in its 1994 Nonhighway Gasoline Use Estimator Model to allocate the national recreational boat population to the state level. The ORNL gasoline consumption distribution is also used by the Federal Highway Administration (FHWA) to estimate annual fuel consumption for this category in states for which no gasoline tax records are available. Because the fuel consumption distribution data directly relate to activity, using this method to allocate boats to the state-level is better than using water surface area alone to allocate boating equipment populations from the national to the county level and then summing the county populations to get a state total. Using the latter method results in an over-allocation of boating equipment to some states that have a long coastline, such as Michigan. In addition, the State of Alaska received a disproportionate share of boating equipment since much of its coastline and bodies of water are either inaccessible and/or inhospitable to recreational boating.

To further refine the allocation of recreational marine equipment, the differences in how far each kind of boat (i.e., personal watercraft, outboards, inboards) tends to operate from the shore are addressed by modifying the water surface area allocation factors for each of these types. In NEVES and the earlier (June 1998 and April 1999) draft releases of NONROAD, a general assumption was made that all boats operate within one mile of the coast. For the current version of NONROAD, it will be assumed that personal watercraft and boats with outboard

engines operate no more than a quarter mile off the coast while boats with inboard engines operate up to two miles off the coast. This modification to the water surface area allocation factors attempts to at least address one aspect of the different usage patterns of these types of boats. The effect of this modification is that a greater number of larger boats with inboard engines will tend to be allocated to coastal counties while the allocation of smaller personal watercraft and boats with outboard engines will tend to shift toward waterways in inland counties.

The EPA hopes to continue to investigate ways to improve upon the water surface area allocation method currently used in the model and also explore whether there might be other methods and data available to use in NONROAD to better allocate the population of recreational marine equipment for all of the counties in the U.S. Local surveys of recreational boating activity focusing on things such as marina and boat ramp usage offer the most accurate means to assess boat populations and activity at the county level. One early stakeholder comment suggested using data on boating violations and accidents to allocate recreational marine equipment. Surveys better capture the actual activity on local lakes, rivers, and other waterways, as well as account for boats registered in one county but used in another. If States, regional air organizations, and local air pollution control districts have such types of data, then the EPA is interested in learning about them. Furthermore, EPA encourages state, regional, and local air organizations to use these local data in the NONROAD model for county-level boat populations, subject to appropriate guidance.

Recreational Equipment (except for snowmobiles and golf carts)

The allocation of recreational equipment, such as all terrain vehicles (ATVs) shares the same challenge as the allocation of recreational boats, namely where the equipment is registered, purchased, serviced, and stored is usually not the location where the equipment is actually used. Because of convenience, people tend to purchase recreational equipment, like other products, near where they live. Hence, most recreational equipment is purchased in urban and suburban areas, where the majority of the U.S. population lives, and this equipment also is registered, stored and serviced in these areas. However, there are relatively few places in urban and suburban areas where it is possible and legal to operate recreational equipment. Generally speaking, recreational equipment usage tends to be concentrated in rural and semi-rural areas near a metropolitan area; such areas are conveniently accessible to the owners of most of the recreational equipment, have more area that is attractive for recreational equipment use, and tend to impose fewer restrictions on recreational equipment use than more densely populated areas. Thus far, however, the EPA has not found an adequate allocation factor that can be used with the current allocation method contained in the model (discussed in Section III, Methodology) to reflect this population/activity distribution pattern.

The NEVES report used CBP data set SIC 557 (number of motorcycle establishments) to allocate recreational equipment to the county level. However, this data is not available for one or more counties in some States. The NEVES report also used SIC 55 (number of employees in auto dealerships and service stations), of which SIC 557 is a subset. Neither of these data sets

provide a reasonable allocation factor for recreational equipment because most motorcycle establishments, auto dealerships and service stations are located in urban and suburban areas instead of rural and semi-rural areas where most recreational equipment activity occurs.

Registration data also exist for ATVs in most States, but there may be some cases where these data are not available or up to date. Sales data also are available from PSR or manufacturers. However, using registration or sales data as allocation factors presents the same drawback as using the CBP data: the location of population does not correlate well with the location of recreational equipment activity outside of heavily urbanized or suburbanized areas.

The EPA has considered using the simple alternative approach of allocating recreational equipment population and activity based on the inverse of population or population density (i.e., the higher the population or population density of a county, the less recreational equipment activity is allocated to that county). The EPA has also considered allocating activity based on the amount of non-urbanized land area per county within a State. While these approaches would reduce the risk of overestimating urban activity, they would tend to overestimate activity in remote rural areas, such as the North Slope of Alaska, Michigan's Upper Peninsula, the Mojave Desert, or the Texas Panhandle. Yet another approach would use employment or Gross Domestic Product (GDP) economic activity directly associated with recreational equipment usage to allocate recreational equipment. However, the EPA has been unable to locate these data at the county level. The CBP database does not include recreational equipment GDP data, and the Bureau of Economic Analysis (BEA) only tracks GDP data down to the state level.

Given these problems, the EPA chose to use the number of camps and recreational vehicle park establishments (CBP SIC 7030) in the June 1998 and April 1999 (Tier 2) draft versions of NONROAD. CBP SIC 7030 includes sporting and recreational camps, trailer parks, and campsites. The data subset from CBP SIC 7030 containing the number of establishments offers better coverage of the U.S. than the subset containing the number of camp and recreational vehicle park employees. The data subset containing the number of employees appears to be missing information for areas known to contain national and state parks, near which camps and recreational vehicle parks are likely to be located. The EPA acknowledges that this approach may not adequately account for recreational equipment being used on private and public lands that are not associated with and/or adjacent to camps and recreational vehicle parks. In addition, using the number of camps and recreational vehicle parks as an allocation factor is only loosely correlated to the level of recreational equipment activity occurring in a county. At the present time, however, the EPA is not aware of other allocation methods that are both practical and reasonably accurate to allocate from state to county population and activity.

For the April 2000 draft version of NONROAD, the EPA was able to use state population estimates obtained from the Motorcycle Industry Council (MIC) for offroad motorcycles and ATV's to allocate population and activity of these vehicles from national to state levels. This method resulted in allocation factors that were not greatly different from those used in the earlier draft versions of NONROAD. This hybrid method of allocating from national to state levels using state population estimates, and allocating from state to county levels according to number

of RV parks is also used for the NONROAD model. The EPA welcomes suggestions of alternative methods and requests reviewers and stakeholders with such suggestions to share them with the team.

Golf Carts

Golf carts have a different pattern of usage from other types of equipment in the recreational category. Unlike ATVs or snowmobiles, golf carts are predominantly used in a central location (golf courses), which is usually within or close to an urban/suburban area. The EPA initially planned to use public golf course employees (CBP SIC 7992) as an allocation factor for this equipment type. However, the EPA has discovered that these data are incomplete for many counties in the U.S. For example, no employees of golf courses are reported for the state of Colorado. The EPA decided to use this factor as a temporary place holder in the June 1998 draft version of NONROAD. For the April 1999 (Tier 2) version of the model, the EPA switched to using the number of golf courses by county for allocating golf carts.

Using the number of golf courses to allocate golf carts and their emissions to the county level does not provide a precise reflection of golf cart population or activity. Like the allocation factor presently being used to allocate the other types of recreational equipment (the number of camps and recreational vehicle parks), the relationship between the number of golf courses on the one hand and the population and activity level of golf carts and on the other is a loose one. The population and activity of golf carts at a given golf course depends on the size, popularity, and type of course. A large, popular, 36-hole championship golf course will have more golf carts that are used more intensively than a small, less intensively used 9 hole course. The location of a golf course also affects golf cart activity. A golf course adjacent to an urban area or in a suburban area will tend to have more players than one located in a rural area, resulting in higher golf cart activity at the urban or suburban course. An additional complication is that many golf courses use electrically powered carts instead of carts using gasoline-powered engines. However, the EPA does not know of any nationally applicable allocation factors that account for these influences. Therefore, the EPA plans to continue using the number of golf courses as an allocation factor in the NONROAD model. However, if available, the use of local activity and population data may be the best alternative. The EPA welcomes comments from stakeholders and other interested reviewers concerning the existence of better factors or methods to allocate golf carts from the state level to the county level, as well as sources of local data on golf cart activity and/or population.

Snowmobiles

The allocation of snowmobile activity presents the same challenges as for other recreational equipment (except for golf carts), but it is additionally complicated by the need to take snowfall into account. For the June 1998 draft version of the model, time and resource constraints did not allow the EPA to properly address how to properly allocate snowmobiles. As a result, the EPA set state and county snowmobile populations to zero for this first version of the draft model, but it could calculate national snowmobile emissions. For the April 1999 (Tier 2) draft version of the model, the EPA decided to use registration data of snowmobiles for national and state populations. Using these data avoids allocating snowmobiles to states without significant or any snowfall. There are some states that do not require snowmobiles to be registered, such as Connecticut, but data were not available to estimate snowmobile populations in these states. The same allocation factor used for other types of recreational equipment, the number of camps and recreational vehicle park establishments, is used to allocate snowmobile populations to the county level in the April 1999 (Tier 2) version of NONROAD. However, the EPA realizes that the use of this allocation factor is still inadequate to allocate snowmobiles to the county level, since snowmobiles need to be restricted to rural counties within a state that receive frequent snowfall that results in significant and persistent snow coverage.

Snowmobile trail mileage by county presents an apparently logical method to allocate snowmobiles, since they are only located where the annual snowfall would support snowmobile use and the amount of activity would be reflected by how many miles of trails a county would have. Most states where snowmobiles are used have trail maps, but these maps vary significantly in quality and may or may not be scaled accurately. In addition, the EPA found that states with snowmobile trails do not keep track of the mileage of these trails by county. Trail mileage also does not necessarily provide an accurate reflection of activity, since it does not capture how intensively a given trail is used, and it does not account for off-trail snowmobiling.

In the draft NONROAD2002 model, the state snowmobile registration data used in the April 1999 (Tier 2) draft version was updated and an attempt made to account for unregistered snowmobiles, since anecdotal information suggests that these may account for a significant portion of total snowmobile emissions. To allocate snowmobiles from the state level to counties with sufficient snowfall, the model uses a minimal average annual snowfall limit of forty inches and the allocation factors for counties receiving less than forty inches of snow have been set to zero, similar to the method used for snowblowers (discussed above). The annual average snowfall data are available from NOAA. The model uses inverse human population as the county allocation factor to ensure that snowmobiles are allocated to rural counties where snowmobile trails would be located. Additionally, counties that are considered to be urban are excluded completely from the snowmobile allocation. An exception to the use of inverse human population and exclusion of urban counties has been made for Alaska, since using inverse human population would allocate snowmobiles to the numerous areas of Alaska that are uninhabited and inaccessible. Since most of the populated parts of Alaska are largely rural to begin with, human population is directly used in conjunction with snowfall data. This approach has been maintained in current version of NONROAD.

Airport Ground Support Equipment

For the June 1998, April 1999 (Tier 2), and 2002 draft versions of NONROAD, the EPA decided to use the number of people employed in air transportation by county (CBP SIC 4500) to allocate ground support equipment. However, this indicator may include employees that are not directly connected to aircraft operations, such as airline reservation staff and ticket agents. Using this factor may lead to an overestimation of aircraft ground support equipment population and activity in a county, especially in counties that either have airports with one or more airline "hubs" or that do not have a commercial airport but have branch ticket offices for various airlines. EPA plans to develop a better method for allocating ground support equipment for the final version of the model.

Light Commercial and Industrial Equipment

For light commercial and industrial equipment, the EPA chose to use the same indicators as those used in the 1991 NEVES report in the June 1998 and April 1999 (Tier 2) draft versions of the model. For light commercial equipment, the EPA decided to use the number of wholesale establishments by county (CBP SIC 50). For industrial equipment, the EPA chose to use the number of employees in manufacturing (CBP SIC 20). Analyses done for the NEVES report showed that these indicators provided reasonable predictors of light commercial and industrial equipment populations. Because these types of equipment are expected to remain close to a fixed central base of operations, as opposed to types of equipment that tend to move around a wide area (e.g., construction equipment), one would expect that the number of establishments and employees would be good factors with which to allocate light commercial and industrial equipment populations, respectively. The EPA acknowledges that the number of establishments may not be a good indicator of activity, which is a function of the size of the average establishment and the mix of establishment types in addition to the absolute number of establishments. The current version of the NONROAD model uses these same allocation factors. The EPA requests comment on possible sources of alternative activity-related allocation factors such as the dollar value of commercial, wholesale, or industrial output, including their advantages and disadvantages relative to the number of employees and establishments and their availability on a county-by-county basis for the entire U.S.

Logging Equipment

For logging equipment, the EPA chose to use the number of employees in logging (CBP SIC 2410) combined with the number of employees in saw and planing mills (CBP SIC 2420) for the June 1998 And April 1999 (Tier 2) draft versions of NONROAD. However, the number of employees in saw and planing mills allocated logging equipment populations to unlikely places such as Southern California and various urban areas in Texas. For the final version of NONROAD, the EPA plans to use only the number of employees in logging operations to allocate logging equipment. The number of logging employees should provide a good reflection of logging equipment activity. Generally speaking, each employee most likely uses one piece of

equipment at a time. Economic pressures would discourage logging companies from having expensive logging equipment sit idle for long periods of time, which suggests that the number of employees in logging operations can also serve as an allocation factor for logging equipment populations. The current version of NONROAD uses this allocation factor as well. The EPA requests comment on potentially more reliable activity and population allocation factors, such as the number of acres of forest harvested per county, and on possible sources of data for those alternatives.

Oil Field, Underground Mining, Railroad Maintenance, and AC/Refrigeration Equipment

To allocate oil field equipment population and activity, the EPA decided to use the number of employees in oil and gas extraction operations (CBP SIC 1300) for the June 1998 draft version of NONROAD. For the April 1999 (Tier 2) draft version of the model, the EPA decided to continue using this factor. The draft 2002 version of NONROAD also uses this factor. To allocate underground mining equipment population and activity in the June 1998 draft version of NONROAD, the EPA decided to use the number of employees engaged in metal mining (CBP SIC 1000), and the April 1999 (Tier 2) version also contains this factor. However, the EPA no longer believes that this indicator represents underground mining operations because most metal mining is now performed above ground through the excavation of large open pits. As a result, the EPA has decided to use CBP employment data on coal mines (CBP SIC 1200) to allocate underground mining equipment in the model. Employment data provide reasonable allocation factors for oil field and underground mining equipment activity because a proportional relationship between the number of employees and the amount of equipment they use is likely to exist for both of these categories. Furthermore, economic incentives to avoid leaving expensive equipment idle suggests that activity and equipment populations will be closely correlated. Finally, these types of equipment tend to not move around (unlike construction equipment, for example), so the location of activity for oil field and underground mining equipment usually coincides with the location where the employees are based. A production-based allocation factor, such as gallons of oil pumped or tons of coal mined, might be an even better allocation factor, but the EPA has been unable to find these types of activity-related data at the county level.

To allocate railroad maintenance equipment populations, no applicable CBP SIC exists and no other reasonable alternatives have been found. The EPA is investigating the possibility of using railroad track mileage for the final version of NONROAD, if such data are available by county. The EPA has also been unable to find a targeted allocation factor for air conditioning/refrigeration units used on trucking trailers to keep food cold and fresh while it is transported to restaurants and markets. In the absence of an allocation factor that is more directly related to such activity, the EPA decided to use human population as the allocation factor for railroad maintenance and AC/refrigeration equipment in the June 1998 and April 1999 (Tier 2) versions of the draft NONROAD model. The model also uses human population for these equipment categories.

The EPA acknowledges that human population is unlikely to correspond well to the location and usage of railroad maintenance equipment. The EPA requests comments and ideas

for a better allocation factor for this category of equipment. However, unless a better factor is found, the EPA will continue to use human population to allocate railroad maintenance equipment. Human population may be a sufficiently reliable indicator of AC/refrigeration unit populations and activity levels, since the number of units being used to transport food into or within a given county is likely to be directly related to the size of the population in the county. The EPA welcomes comments concerning better allocation factors for these equipment categories.

Table 1

NONROAD Surrogate Allocation Factors

Nonroad Equipment Category	Allocation Factor June 1998 Draft Version	Allocation Factor April 1999 Draft Tier 2 Version	Allocation Factor 2002 Draft Version
Lawn and Garden Residential	Number of single and double (duplex) family housing units from 1990 Census by county.	Number of single and double (duplex) family housing units from 1990 Census by county adjusted by 1997 county human population estimates from U.S. Census Bureau.	Same as April 1999 draft version.
Lawn and Garden Commercial	Number of employees in landscape and horticultural services, County Bus. Patterns (CBP), Standard Industrial Code (SIC)78.	Same as June 1998 draft version.	Same as June 1998 draft version.
Residential Snowblowers	Snowblowers set to zero pending implementation of proper allocation based on snowfall.	Populations allocated to states based on snowmobile registration data by state, then allocated to counties using same factor as residential lawn and garden.	Same as residential lawn and garden, but allocation factors for counties with snowfall less than 15 inches set to zero.
Commercial Snowblowers	Snowblowers set to zero pending implementation of proper allocation based on snowfall.	Populations allocated to states based on snowmobile registration data by state, then allocated to counties using same factor as commercial lawn and garden	Same as commercial lawn and garden, but allocation factors for counties with snowfall less than 15 inches set to zero.
Construction	Total dollar value of construction by county.	Same as June 1998	Categories (e.g., housing, commercial buildings, public works construction) of F.W. Dodge construction dollar value data weighted by 1998 Environ survey of construction equipment activity in Houston, TX and then totaled.
Agricultural	Harvested cropland (U.S. Census Bureau, USA Counties database).	Same as June 1998 draft version.	Same as June 1998 draft version.

Nonroad Equipment Category	Allocation Factor June 1998 Draft Version	Allocation Factor April 1999 Draft Tier 2 Version	Allocation Factor 2002 Draft Version
Recreational Marine	Ratio of county water surface area to total national water surface area.	Same as June 1998 draft version.	Population will be allocated to states using ORNL fuel consumption distribution. Allocation to counties using water surface area with different operating limits from shore for personal watercraft, outboards, and inboards.
Recreational (except snowmobiles and golf carts)	Number of camps and recreational vehicle park establishments (CBP SIC 7030).	Number of camps and recreational vehicle park establishments (CBP SIC 7030).	State motorcycle/ATV population estimates from MIC for national to state allocation and number of camps and recreational vehicle park establishments (CBP SIC 7030) for state to county allocation.
Snowmobiles	Snowmobiles set to zero pending implementation of proper allocation based on snowfall.	Populations allocated to states based on ISMA snowmobile registration data by state, then allocated to counties using the same factor as other recreational equipment, the number of RV park/camp establishments .	Registration data from ISMA to be used for state populations. Will allocate to counties using snowfall limit of 40 inches and inverse human population. For Alaska, will use direct human population.
Golf Carts	Number of public golf course employees (CBP SIC 7992).	Number of public golf courses (CBP SIC 7992).	Same as April 1999 draft version.
Aircraft Ground Support Equipment	Number of employees in air transportation (CBP SIC 4500).	Same as June 1998 draft version.	Revised to be based on FAA number of landings and takeoffs (LTOs) of commercial aircraft.
Light Commercial	Number of wholesale establishments (CBP SIC 50).	Same as June 1998 draft version.	Same as June 1998 draft version.
Industrial	Number of employees in manufacturing (CBP SIC 20)	Same as June 1998 draft version.	Same as June 1998 draft version.

Nonroad Equipment Category	Allocation Factor June 1998 Draft Version	Allocation Factor April 1999 Draft Tier 2 Version	Allocation Factor 2002 Draft Version
Logging	Number of employees in logging plus saw and planing mills (CBP SIC 2410 and 2420).	Same as June 1998 draft version.	Number of employees in logging (CBP SIC 2410).
Oil Field Equipment	Number of employees engaged in oil and gas extraction (CBP SIC 1300).	Same as June 1998 draft version.	Same as June 1998 draft version.
Railroad Maintenance Equipment	1990 human population.	1990 and 1996 human population.	Might be revised using different allocation factor for final version, pending review.
Underground Mining Equipment	Number of employees engaged in metals mining(CBP SIC 1000).	Same as June 1998 draft version.	Number of Employees in coal mining (CBP SIC 1200).
AC/Refrigeration Equipment	1990 human population.	1990 and 1996 human population	Will update with latest human population data available.

Endnotes

1. Environmental Protection Agency, Office of Air and Radiation. <u>Nonroad Engine and Vehicle Emission Study</u>, 21A-2001, November 1991.

2. Irwin Broh & Associates, Inc., <u>NMMA Boat Usage Survey</u>, prepared for the National Marine Manufacturers Association, Des Plaines, IL, August 1991.