Emissions Characterization Near Western Class I Visibility Areas

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ABSTRACT

The Western Regional Air Partnership (WRAP) is a collaborative effort of tribal governments, state governments, and various federal agencies to implement the recommendations of the Grand Canyon Visibility Transport Commission (GCVTC) and to develop the technical and policy tools needed by western states and tribes to comply with the U.S. Environmental Protection Agency's Regional Haze Rule. The goal of the WRAP Areas Within and Near Class I Areas Forum is to implement the GCVTC's recommendation to expand data collection, improve modeling, and implement cooperative, enforceable management plans in and near Class I areas where emissions from such areas are significant. This paper will describe geographic information systems (GIS) and other data sources and methods used to portray the dominant activities and emission sources surrounding each western Class I area. The paper will also discuss methods used to classify the area according to magnitude, trend, seasonality, and dominant type of emission source(s). The paper will show examples of maps showing the emissions and activities around each Class I area.

INTRODUCTION

The Western Regional Air Partnership (WRAP) is a collaborative effort of tribal governments, state governments, and various federal agencies to implement the recommendations of the Grand Canyon Visibility Transport Commission and to develop the technical and policy tools needed by western states and tribes to comply with the U.S. Environmental Protection Agency's (EPA) regional haze rule. To date, the WRAP has logically focused on regional sources and solutions as the first and primary way of addressing regional haze. However, there may be instances where relatively local sources of air pollution could contribute to visibility impairment, and these sources and measures for addressing them may vary widely across the region.

The WRAP established an "In and Near Forum" to address such issues. Efforts are underway to characterize emissions both "in" Class I areas and "near" Class I areas. (Class I areas include national parks and wilderness areas to which the regional haze rule is applicable). This paper summarizes the purpose and methods for conducting the "near" work. Preliminary results will be presented at the conference. Work was initiated by ENVIRON in November 2002 to characterize emissions near Western Class I Areas. The full scope of the work effort is described in the project Work Plan (ENVIRON, 2003)[1].

PURPOSE

The purpose of this project is to characterize emission sources near Class I areas, defined as the area within 50 km of the Class I area borders. Non-point sources (including mobile sources, area sources, fugitive dust, and fire emissions) are of particular interest partly because point sources are well

characterized and have been the primary focus of existing visibility regulations and partly because less is known about the magnitude, variability, and certainty of non-point source emissions, especially in the remote regions where many Class I areas are located. Many such regions are attainment areas and have not received the attention given to nonattainment areas in the development of emission inventories.

Results of this project are expected to guide future in and near work. Some Class I areas may be found to be more at risk from local sources than others and would warrant further analysis of emissions and receptor impacts. Likewise some source categories may be found to comprise relatively large portions of the "near" emissions inventory and would warrant investigation of mitigation options. Such efforts could help "close the gap" to achieving the reasonable progress required by the regional haze rule, to the extent that regional programs may fall short in some areas.

Another purpose of this project is to identify "gateway communities" for future WRAP outreach and mitigation efforts. Gateway communities are defined as relatively small towns, cities, or developments that may not only affect the visibility in nearby Class I areas but whose economic viability, character, and values are linked to such areas. Examples of gateway communities are Estes Park, CO; Jackson Hole, WY; Tusayan, AZ; Springdale, UT; and West Yellowstone, MT.

METHODS

The overall approach in characterizing emission sources near Class I areas is to:

- Cluster Class I areas into manageable and logical groups;
- Establish 50 km buffer areas around each group;
- Spatially allocate (typically county-level) area source emissions to the buffer zones using GIS software and appropriate spatial surrogates, hence obtaining quantified emission estimates for each visibility impairing pollutant;
- Map all point source emissions in and near the buffer zone;
- Survey federal, state, and local officials familiar with each Class I area to verify point source emissions and to identify trends and proposed emission-generating activities that might not be apparent in WRAP emission databases;
- Classify Class I areas according to the predominant type of nearby emissions and relative magnitude of nearby emissions, normalized by ambient monitoring data where available;
- Select a subset of Class I areas for in-depth emissions analysis;
- Perform the in-depth analyses using additional (often local) data sources and interviews; and
- Present all emissions characterization maps and other results on the WRAP Web site.

Except for the in-depth analyses, the primary sources of emissions data are the WRAP 1996 emission inventories for point sources, mobile sources (on-road and off-road), fire, and area sources.

Class I Area Groupings and Buffer Zones

There are 116 Class I areas in the WRAP region. Two of the four areas in Alaska were not included in this analysis, partly because they are extremely remote and isolated and partly because the datasets for Alaska (which officially joined the WRAP in 2002) are separate and somewhat different from the WRAP datasets developed for the lower continental region. For the same reasons, the two Alaska areas included in this analysis were only analyzed in terms of point source emissions and interviews of local officials. Further analysis of Alaska near emissions will be included in future WRAP work. Also included in this analysis is Jarbidge Wilderness Area in Nevada. Nevada is not an official member of the WRAP, but the data are readily available for this one area. Hence, a total of 116 areas

are included in the analysis. The two Class I areas in Hawaii (which is not a member of the WRAP) are not included.

Partly due to resources available for this project, but also because several Class I areas are located very near or adjacent to one another and share similar environments, the 116 Class I areas included in this study were clustered into 82 groups, many of which contain only one Class I area. These groups are shown in Figure 1. Fifty kilometer buffer zones were then established around each group using GIS software and data available on Class I area boundaries.

Spatial Allocation of Area Source Emissions

GIS software and appropriate surrogate data are used to spatially allocate the 1996 county-level WRAP area source emissions inventories to the buffer zone of each Class I group. Area sources include all non-point sources (on-road and off-road mobile, road dust, fire, and other area sources), but not biogenic or wind-blown dust emissions. Tables summarizing the area source emissions by county within the buffer zones will be developed. Emissions presented in the tables will be aggregated to the following general source categories:

- Point Sources
- Area Sources (excluding windblown dust)
    - Residential Wood Combustion
    - Other Fuel Combustion
    - Industrial Processes
    - Solvent Utilization
    - Petroleum Storage and Transport
    - Waste Disposal and Recycling
    - Agricultural Activities (except burning)
    - Prescribed Fires
    - Wildland Fires
- On-Road Mobile Sources
    - Light-duty Vehicle Emissions
    - Heavy-duty Vehicle Emissions
    - Fugitive Dust – Paved Roads
    - Fugitive Dust – Unpaved Roads
- Off-Road Mobile Sources (excluding airport and commercial marine)
    - Lawn & Garden Equipment
    - Recreational Equipment
    - Commercial and Industrial Equipment
    - Construction and Mining Equipment
    - Agricultural Equipment
    - Recreational Marine Vessels
    - Locomotives and Railroad Equipment

Spatial allocation of regional or county-level emission estimates is accomplished through the use of gridding surrogates or spatial allocation factors (SAFs) for each emission source category or groups of source categories. Spatial surrogates are typically based on the proportion of a known region-wide characteristic variable that exists within the modeling domain grid cells. Traditionally, the development of spatial gridding surrogates has been performed by a variety of methods depending on the emission source category being considered, the required spatial resolution, the geographic extent of the domain, and the particular characteristics of the geospatial data available. Spatial surrogates must define the percentage of regional or county level emissions from a particular source category that is to be allocated

to some spatial region, typically a modeling grid cell. For most area sources these percentages are based on areas of a particular land use/land cover or vegetation type, while for mobile source categories the percentages are usually based on total length of a certain road type, or transportation network.

Maps were developed that display the underlying land use/land cover (LULC), roadway, and population data within the region used for the spatial allocation of county-level emissions to the buffer zones. Examples for the Grand Canyon area are provided in Figures 2 and 3.

The spatial surrogates used for the project include:

- Agricultural land
- Forest land
- Urban land
- Water
- Total population
- Urban population
- Rural population
- Inverse population
- Housing
- Railways
- Urban primary roadways
- Urban secondary roadways
- Rural primary roadways
- Rural secondary roadways

Emissions from airports (aircraft and ground support equipment) and commercial marine vessels are not included in this analysis. Emissions from these sources are aggregated in the WRAP database at the county level; the appropriate spatial surrogate data and activity data (e.g., takeoff and landing statistics) are available for airports and seaports in the region, but use of spatial allocation using these data source cannot be done within the available WRAP resources for this project.

Emissions from wildfires and prescribed wildland fires are determined for the buffer zones based on the WRAP 1996 fire databases. These databases contain fire emissions for each fire and for each day during 1996 in terms of point locations (and are therefore treated as point sources) and, in some cases as total acres burned. Because the overall extent and shape of the burn areas are not known, and because many emission records do not include the total acres burned, it is not possible to determine the areal extent of the fires within the buffer zones around each Class I area. As an alternative, the fire emissions will treated as point sources using the coordinates given in the database. Overlaying these data with the buffer zones will allow an estimate of the fire emissions within the buffer zones and the potential to impact the Class I areas. The WRAP fire databases do not include prescribed wildland fires for the state of California. For California, the databases maintained by the California Air Resources Board (ARB) are being used to estimate fire emissions within California. The ARB databases provide only total annual emissions by type of fire and by county for 1996. Therefore, estimates of prescribed wildland fire emissions for CA are estimated using procedures similar to other area sources, which are defined by county-level annual emission estimates. Estimates of the fire emissions within the buffer zones are calculated using forestland as a spatial surrogate to determine the percentage of forestland in each county within each buffer zone, and allocated this percentage of the total county-level fire emissions to the appropriate Class I Areas. As the ARB database does not include $PM_{2.5}$ or NH_3 emissions, these pollutants are estimated using appropriate scaling factors based on piled fires.

Mapping of Point Sources

In order to generate map displays of the stationary point source emissions within and near the buffer zones around each Class I area, the Arc/INFO GIS software was used with Arc Macro Language (AML) scripts. Utilizing AML scripts allowed automation of the required processing and thus maximizing resources and efficiency. The geographic extent of each map was set as a rectangular region 350 km across, centered on the Class I area group. Stationary point sources within this region were then displayed as "bubble plots" indicating the location and relative magnitude of the emission sources.

Figure 4 provides an example of a point source emissions map for NOx near the Emigrant/Hoover Wilderness/Yosemite National Park Class I Area group. Each bubble is labeled with a numeric identification code. In order to reduce the number of "bubbles" and to avoid a cumbersome "bulls-eye" effect when multiple stacks are present in the point source emission database at the same geographic coordinates, the data were first aggregated by plant, or facility. In addition, due to the relatively large number of stationary point sources, and due to certain software limitations, the facility-level point source emissions were further aggregated to 36-km grid cells. Thus, each "bubble" represents the total point source emissions within a 36-km grid cell and each label corresponds to multiple sources and/or facilities. Corresponding tables are generated such that the source names, type, location and emission rate of each pollutant shown on the map can be looked up based on the numeric identification code displayed on the map. Each entry in the table represents the facility or plant-level emissions cross-referenced with the numeric code displayed on the map. In cases where there is only a single facility within each 36-km grid cell, the "bubbles" are displayed in a different color to distinguish these from grid cell aggregated emissions.

Survey of Officials Familiar With Each Class I Area

The purpose of these surveys is to verify the point source inventories described above and to identify trends and proposed emission-generating activities that might not be apparent in WRAP emission databases. This information is also used to help classify Class I areas, select a subset of areas for in-depth analysis, and to establish contacts and identify additional information sources for use in the in-depth analysis. Interviewees were asked the following questions:

1. Please verify the location and operational status of major stationary sources listed in the attached maps and tables. Are any of the identified point sources no longer in operation? Have any of the identified point sources made any major changes that would increase or decrease emissions from 1996 levels?

2. Are there major point sources in the vicinity of the Class I area that are currently in operation but not listed in the maps and tables? Are there plans for any new major point sources in the future?

3. What are the primary emissions-generating activities within the buffer zone of the Class I area?

4. What local sources, if any, do you believe contribute to visibility impairment in the Class I area?

5. Are there any recent or expected activity changes in or near the area that could affect visibility in the area?

6. For areas that are not National Parks, can you provide any data trends on visitation to the area both in the past and expected in the future? At this point in time we are not requesting that you send us such data, only that you tell us what data you have (e.g., is it area-specific, and what years does it cover).

7. Are there any air quality studies (monitoring or modeling) that have been planned or recently completed?

Classification of Class I Areas

Classification schemes are used to help summarize the diversity of near emissions across the WRAP region and to help select areas for in-depth analysis. Tables and/or maps are used to show the areas, for example, with the highest emissions for each pollutant, and areas with the highest proportion of emissions for each of the major source category.

Ratios of emissions to monitored visibility are also evaluated, using visibility data from the IMPROVE monitoring network. Such ratios are used to identify areas most at risk to nearby emissions. For example, 18 annual tons of PM emissions may be more significant near a clean area than a relatively hazy one.

Selection of Class I Areas for In-Depth Analysis

A subset of the groups will be selected for more detailed analysis. The criteria to be used for selecting this subset will include the following:

- Magnitude of local emissions sources. Priority should be given to areas with relatively high local emissions, with the exception noted below.
- Proximity of major urban areas. Areas near large cities (e.g., San Gorgonio) should be avoided since such areas are often subject to existing emission control plans and would require substantial resources for in-depth analysis.
- Availability of IMPROVE data. Such data could help identify sources and trends.
- Availability of WRAP and NPS in-park micro inventories. Such inventories would add considerable value to the in-depth analysis of nearby activities.
- Local population change. Substantial increases would indicate a growing risk from nearby sources and a warning sign for air quality managers.
- Proximity of gateway communities. Analysis of areas with gateway communities would assist the Forum in its other activities.
- Interview results. The interviews may reveal issues or trends not evident in project databases, or may verify such issues or trends.
- Ratio of emissions to monitored visibility. High ratios indicate a higher susceptibility to local impacts.
- Diversity of local emissions. Areas with relatively high local emissions of more than one pollutant and/or areas with an even distribution of local source categories may produce more interesting results.
- Prevalence of wind-blown fugitive dust. This inventory is currently under development, so areas dominated by wind-blown dust may not benefit much from closer inspection.
- Decisions also need to be made whether Class I areas with local fire emissions should be included.

In-Depth Analysis

The in-depth analysis includes additional interviews with local officials to provide better characterization of the impacts of local emissions and changes in local emissions over the years. Local officials are also asked about any significant seasonal variation in activity. For some national parks, in-park emission micro-inventories have been developed and are used as reference to better understand

near-park emissions. The IMPROVE data for the Class I areas are analyzed in more detail over more years and correlations between the trends in the IMPROVE aerosol concentrations and changes in local sources identified are be assessed. Recent local GIS data (LULC, transportation networks, etc) and population data are requested from local agencies that may aide in the characterization and in-depth analysis. To the extent feasible, consistency is maintained across the subset of Class I areas to facilitate comparison. However, by the nature of this task, there a variety of different types of information available for each Class I area.

RESULTS

The analyses of the emissions data and results of the interviews, as well as the in-depth analysis, are ongoing. These results will be disseminated at a later date.

SUMMARY

Emission sources "near" Class I Areas throughout the Western states are being characterized with respect to their potential impact on visibility and regional haze. The "near" Class I Area regions are defined as a 50 km buffer zone around the boundaries of each Class I Area or groups of Class I Areas. Stationary point and area sources from the WRAP 1996 emission inventory are being used in the characterization. County-level area source are spatially allocated to the buffer zones using appropriate spatial surrogate data (i.e., land use/land cover, roadways, population). Stationary point sources are aggregated first by plant/facility then by 36-km grid cell to minimize resources and to overcome certain software limitations. Annual emissions of the NOx, VOC, SO2, PM10, PM2.5 and NH3 are considered in the analysis.

Federal, state and local officials were interviewed to verify point source emissions near each Class I Area group and to identify trends and proposed emission-generating activities that might not be reflected in the WRAP 1996 emission databases. Based on the characterization of emission sources and an analysis of the results of the interview process, a subset of Class I Areas will be selected to conduct further in-depth analyses. The ultimate goal of the characterization is to identify possible "gateway communities" for future WRAP outreach and mitigation efforts. Included among future WRAP efforts is a need to repeat the analysis with the WRAP 2002 emission inventory when available.

REFERENCE

1. ENVIRON. Characterization of Emission Sources Near Class I Areas in the WRAP Region, Final Work Plan. Prepared for Western Governors' Association. Prepared by ENVIRON International Corporation. January 2003.

Figure 1. Class I Areas in the Western Continental US with 50-km buffer zones.

Figure 2. Land Use/Land Cover (LULC) display for the Grand Canyon National Park.

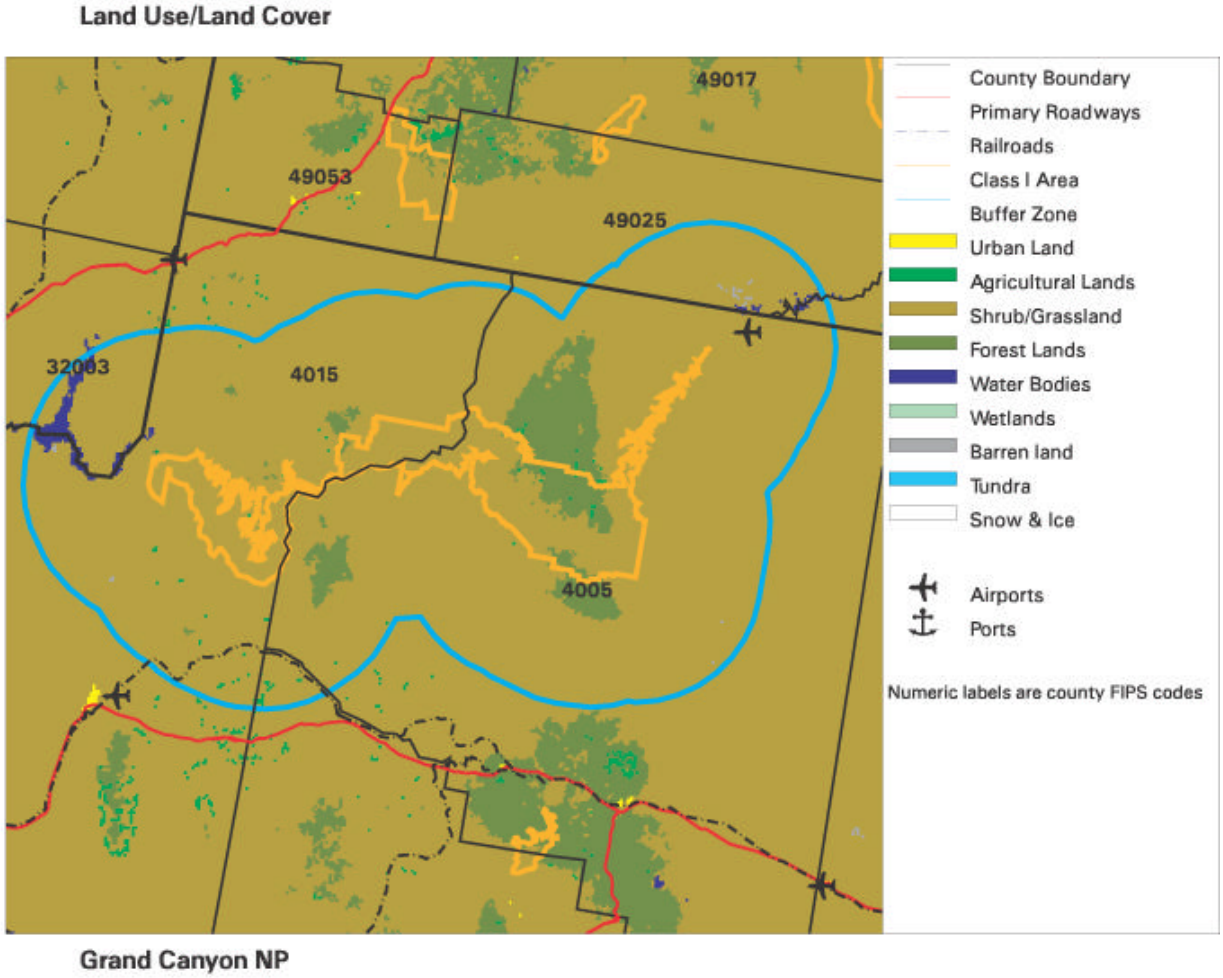


Figure 3. Population density display for the Grand Canyon National Park.

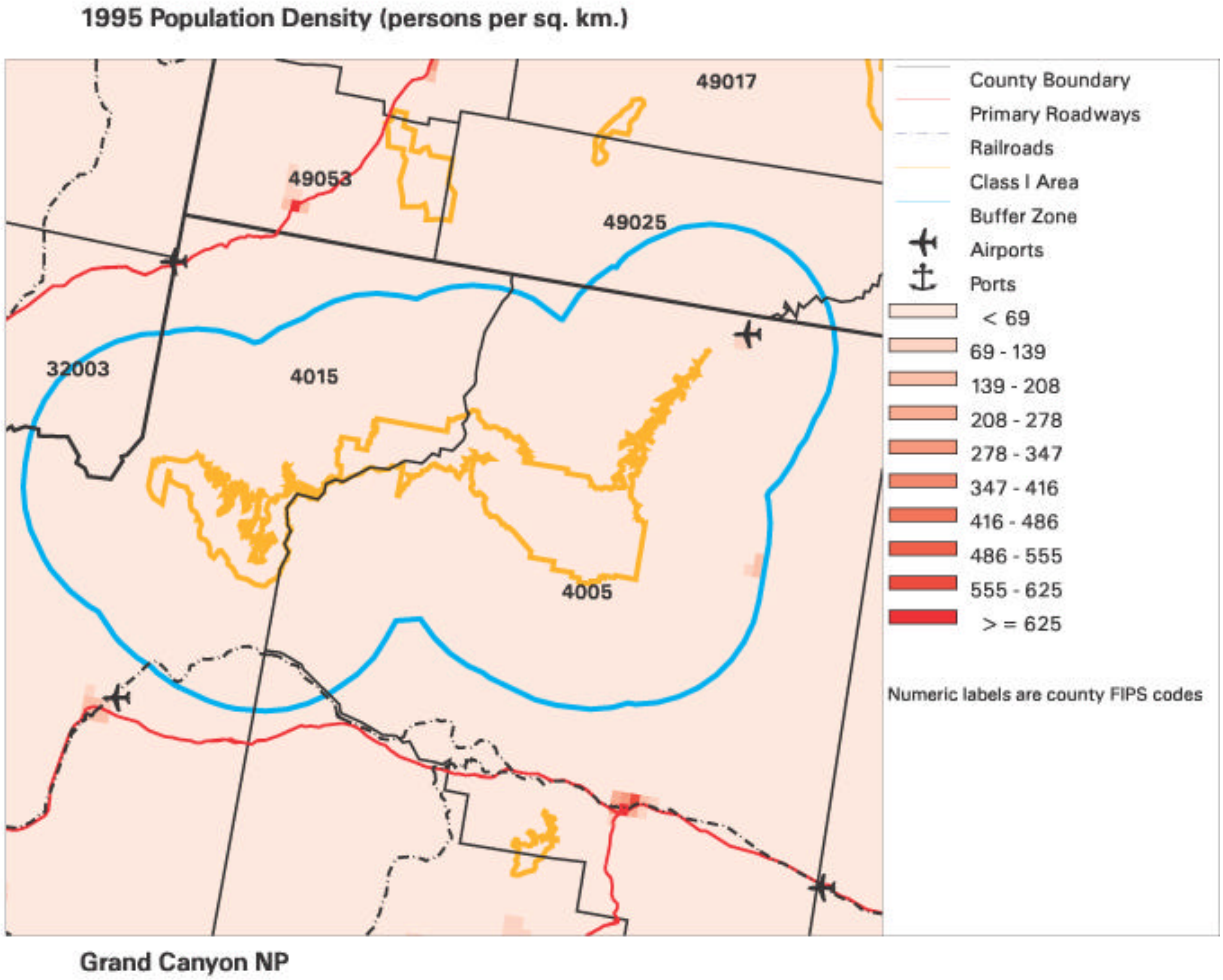
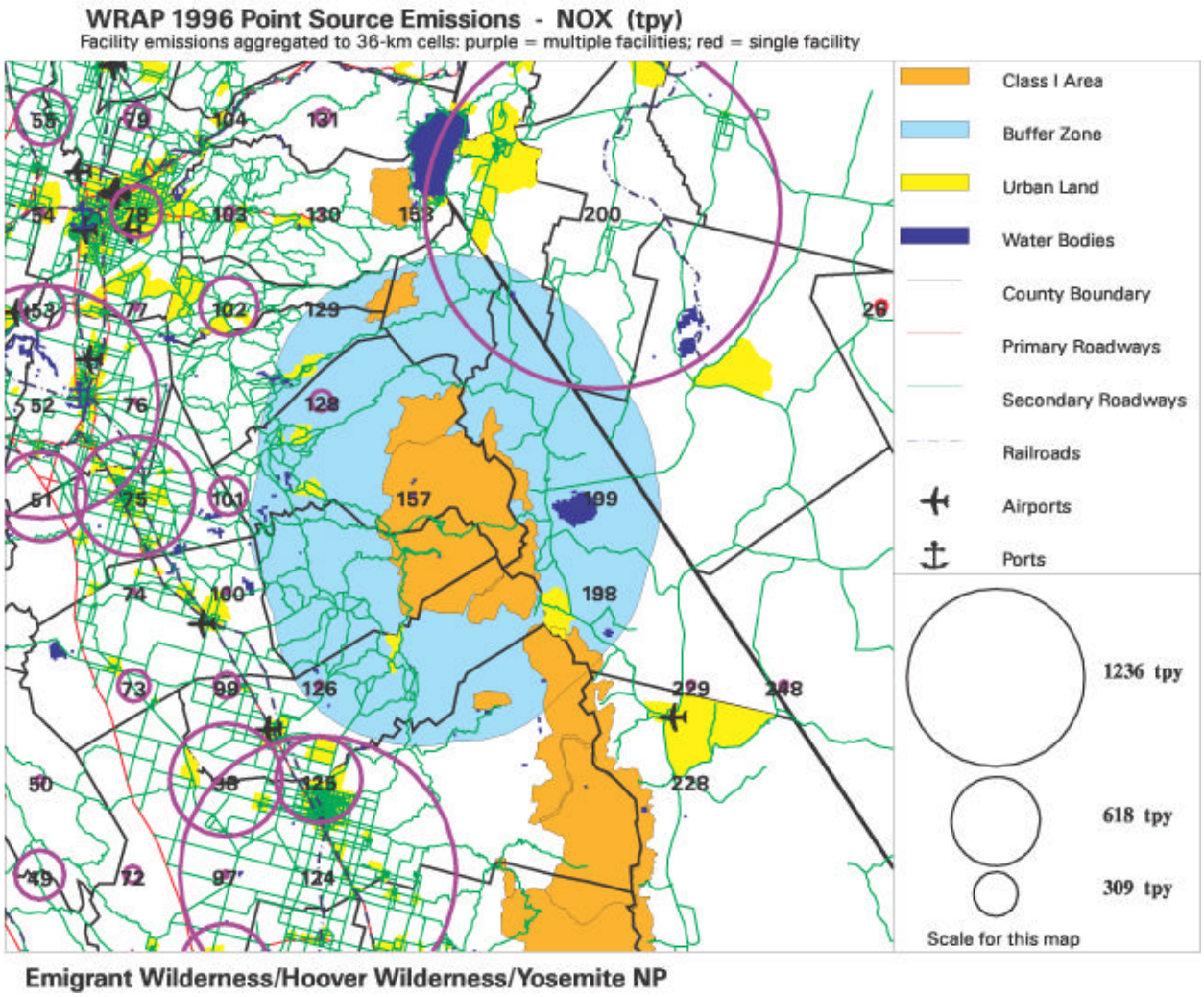


Figure 4. NOx point source emissions map for the Emigrant/Hoover Wilderness/Yosemite National Park.



KEYWORDS

Class I Areas
emission inventories
GIS
regional haze
spatial surrogates
visibility impairment