Final October 2007

2006 Annual Performance & Progress Report: Air Quality in National Parks

Executive Summary

The National Park Service strives to perpetuate the best possible air quality in units of the National Park System because air pollution affects ecological health, scenic views, human health, and visitor enjoyment even at relatively low levels. Progress toward this goal is measured by examining trends for key air quality indicators, including:

- Ozone – which affects human health and native vegetation
- Visibility – which affects how well and how far visitors can see; and
- Atmospheric deposition – which affects ecological health through acidification and fertilization of soils and surface waters.

The NPS monitors one or more of these indicators in 60 park units, and there are sufficient data to assess conditions and trends in 52 of these parks. In addition, many state and local air quality monitoring stations are located near enough to other park units that the data may be considered reasonably representative of the park's air quality. In this report, we include information from deposition or ozone monitors within 10 miles of the boundary of that park. For a particulate (visibility) monitor, we required that it lie within 100 km (approximately 60 miles) of a park unit in order to be considered representative of that park. This is consistent with the Interagency Monitoring for Visual Environments (IMPROVE) program, which considers IMPROVE monitors within 100 km of a Class I area to be representative of that area for monitoring progress under the Regional Haze Rule program. Using data from nearby sites allowed us to increase the total number of park units rated considered in this analysis to 141.

In general, we consider stable or improving air quality trends a sign of success. Other objectives include that parks (1) comply with the national ambient air quality standards established by the EPA to protect human health and (2) show reasonable progress toward remedying existing visibility impairment as required by the EPA visibility protection regulations. In accordance with the Government Performance and Results Act (GPRA), the NPS has established performance goals reflecting these objectives and reports annually on progress toward air quality goals. Performance is measured by calculating the percentage of parks that meet the air quality goals. For the 2006 Annual Performance Report, data collected between 1996 and 2005 were examined.[1] As explained in more detail below, the NPS is exceeding air quality performance goals for 2006, with 86 percent of the reporting parks showing stable or improving air quality trends generally, 97 percent meeting visibility goals, and 82 percent meeting national ambient air quality standards. The target goals for 2006 were 66 percent, 88 percent, and 78 percent, respectively.

While trends are indicative of progress, the ultimate goal is clean, clear air in parks. A stable trend in air quality may not be sufficient to protect an area that is already experiencing poor quality. In this report, we also characterize current air quality conditions in the park units included in the analysis. Using an index for each type of air quality data collected (ozone concentrations, wet deposition concentrations, and visibility), park air quality is characterized as good, moderate (or cautionary), or of significant concern. With respect to visibility, 65 percent of the parks are in good or moderate condition, or are improving. Of the parks with significant visibility problems, all have stable trends. For ozone, 59 percent of the parks are in good or

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[1] The lag time in data reporting results from quality assurance and data analysis procedures.

moderate condition, or are improving. Among the 24 parks where current ozone conditions are of significant concern, all but one have a stable trend. For sulfur deposition, 60 percent of the parks are in good or moderate condition, or have an improving trend. None of the parks with a significant sulfur deposition concern have a degrading trend. Finally, with respect to nitrogen deposition, only 18 percent of the parks are in good or moderate condition, and none have an improving trend.

We expect air quality in parks to improve as regulations aimed at reducing tailpipe emissions from motor vehicles and pollution from electric-generating facilities take full effect over the next few years. In addition, States and Tribes, with assistance from regional planning organizations, are in the process of developing programs to improve visibility in national parks and wilderness areas in response to EPA regulations. Information available through the NPS air quality monitoring program has provided a foundation and impetus for pollution control programs that will benefit parks. NPS's ability to offer expert and constructive assistance and advice to regulatory and permitting agencies has stimulated collaborative efforts to find creative and cost-effective air quality management approaches.

Air Quality Goals and Trends

The NPS Strategic Plan (2003) air quality goal calls for 70 percent of reporting parks to have stable or improved air quality by 2008, with progress toward that goal measured annually through target goals. Data from visibility monitoring, gaseous air pollutant monitoring (primarily ozone), and precipitation monitoring are used to assess air quality trends; six measures are used in the calculation. Not all parks monitor all the indicators. A park is considered to have improving or stable air quality if none of the measures show a statistically significant degrading trend (denoted in red on attached figures and table). The target goal for 2006 was 66 percent, and we exceeded that goal with 86 percent of the reporting parks having stable or improving air quality in 2006 (122 out of 141 areas). Performance exceeded the goal in part because many of the park units included in this year's report are in or near urban areas, where pollution control programs have been in effect for many years. Figure 1 and Figure 2 present maps showing the overall goal status for each park and the trend for each indicator monitored, respectively. More detail on how trends are calculated appears in the Technical Appendix to this report. All referenced figures and tables follow this appendix.

Visibility Measures

For visibility, the NPS looks at the 20 percent clearest days and the 20 percent haziest days to measure visibility conditions. EPA uses these measures to assess progress toward the national goal of remedying any existing and preventing any future manmade visibility impairment in "Class I" areas. Class I areas include the largest national parks and wilderness areas.[2] They receive the highest degree of air quality protection under the Clean Air Act. This year we are able to report on 82 parks, both Class I and Class II, that have an IMPROVE monitor within 100 km and have at least 6 years of visibility data available during the period 1996-2005. All of but one of these parks recorded stable or improving trends on both the clear and hazy days. This means that 99 percent are meeting the visibility goal. On the clearest days, 35 parks are showing statistically significant improvement; these parks include Shenandoah and Acadia National Parks in the eastern U.S., and several sites in the northwest U.S., California, Colorado Plateau, the Rocky Mountain region, and Alaska. See Figure 5. On hazy days, most areas are showing stable – not improving – trends. Only three parks show statistically significant

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[2] National parks greater than 6,000 acres and national wilderness areas greater than 5,000 acres that were in existence or authorized as of August 7, 1977.

improvement (Great Smoky Mountains, Redwood, and Mount Rainier), while one park shows statistically significant worsening of visibility (Petrified Forest). See Figure 6.

Atmospheric Deposition Measures
Sulfate, nitrate, and ammonium ions in precipitation (rain and snow) are used as indicators of atmospheric deposition, because they can be directly linked to ecological effects (e.g., acidification of surface waters, nutrient enrichment that disrupts natural systems). This year we determined trends for 50 parks that had monitors inside the park or within 10 miles of the border. In 42 of those areas (84 percent), sulfate concentrations were stable, and 8 showed improvement. No area showed statistically significant deteriorating trends (see Figure 7). Trends in nitrate ion concentrations are shown in Figure 8. Nitrate ion concentrations are stable or improving in 49 parks and increasing in one park (Mount Rainier). Ammonium, like nitrate, is a form of nitrogen. Ammonium is stable in 40 areas (80 percent), with no areas showing a statistically significant decrease in concentrations. Ammonium concentrations are increasing in 10 areas, primarily in the intermountain west and Alaska. Trends in ammonium are shown in Figure 9. In total, ten parks are seeing increased nitrogen loadings: Fort Bowie, Chiricahua, Bent's Old Fort, Canyonlands, Rocky Mountain, Craters of the Moon, Minuteman Missile, Yellowstone, Glacier, and Denali. The NPS has shared information and concerns about these trends with EPA, States, Tribes, and stakeholders. As explained further below, collaborative efforts are underway to better understand the causes and effects of nitrogen loadings and to explore options for protecting ecosystem health, if necessary.

Ozone Measures
The NPS calculates ozone trends using EPA’s metric for the national ambient air quality standard (i.e., the 3-year average of the annual fourth highest daily maximum 8-hour ozone concentration). Of the 81 park units that monitor ozone or are within 10 miles of an ozone monitor outside the park, 71 units have stable or improving trends (88 percent). These trends are shown in Figure 10. In the East, where ozone concentrations in parks like Great Smoky Mountains, Mammoth Cave, and Shenandoah sometimes reach high enough levels to harm human health, the ozone trends are primarily stable over the past ten years. However, in the past few years, most eastern states implemented new pollution control programs designed to reduce nitrogen oxides – a precursor to ozone formation. If we examine the most recent years of data, an improving trend (decreasing ozone) is discernible and one that we expect to continue. Some eastern sites, including Mammoth Cave, show an improving trend over this shorter period. An improving ozone trend can also be seen at some western parks -- Big Bend, Channel Islands, and Pinnacles. On the other hand, nine parks in the West have increasing ozone levels--Canyonlands, Death Valley, Glacier, Grand Canyon, Mesa Verde, North Cascades, Petroglyph, Ross Lake, and Rocky Mountain. As with concerns about increasing nitrogen loadings in western parks, the NPS has shared information about ozone trends with regulatory agencies, and several initiatives are underway to understand causes and effects and explore management options.

The U.S. Department of the Interior Strategic Plan (2004) includes two air quality goals focused on Class I areas. One goal is measured by compliance with national ambient air quality standards, the other measures whether visibility objectives are met.

National Ambient Air Quality Standards
In 2006, 37 out of 45 NPS Class I areas with monitoring met the NAAQS for ozone, particulate matter (PM 2.5), or sulfur dioxide. Results for this goal are shown in Figures 3 and 11. Eight of the 45 parks violate one of those pollutant standards, or they are part of EPA-designated non-attainment areas for one of those pollutants. Figure 12 shows non-attainment areas along with

park units that are in those areas. Parks with ozone levels above the NAAQS (violating the standard) are: Great Smoky Mountains, Joshua Tree, Sequoia, Kings Canyon, and Yosemite National Parks. Rocky Mountain NP has monitored ozone levels below the level of the NAAQS but is part of an EPA ozone non-attainment area. Point Reyes does not have onsite ozone monitoring but is part of an EPA-designated ozone non-attainment area. Non-attainment counties in Shenandoah and Acadia National Parks were redesignated as attainment for the ozone standard and now are included with those parks meeting this goal. For PM2.5 particulate matter, no NPS Class I area with monitoring exceeds the level of the standard but the following five NPS areas are wholly or partially in EPA's PM2.5 non-attainment areas: Great Smoky Mountains, Joshua Tree, Sequoia, Kings Canyon, and Yosemite National Parks. Sulfur dioxide levels at Hawaii Volcanoes NP occasionally exceed the level of the NAAQS. Such exceedances of the standard are caused by natural volcanic, and not anthropogenic, emissions.

Visibility Objectives

The visibility objectives are met when "reasonable progress" is made toward achieving restoring natural background visibility conditions over a 60-year period, as outlined in EPA's visibility protection regulations. The definition of reasonable progress will differ for each class I area because both existing baseline visibility conditions and target natural background visibility conditions differ from area to area. Moreover, States are not required to submit plans consistent with EPA's regulations until the end of 2007. In the meantime, NPS is using a surrogate goal of "stable or improving visibility" to assess trends. As mentioned above, 97 percent (37 of 38) of Class I area parks where visibility is monitored are meeting this goal. See Figure 4.

Beginning in FY2007, air quality goals Ia3B and Ia3C will no longer be included and reported in the Department of the Interior Strategic Plan. The National Park Service will continue to monitor its progress toward meeting the air quality goal in its Strategic Plan.

Assessment of Current Air Quality Conditions

In addition to determining the trends in air quality, we are also interested in assessing the current condition of the air resources within NPS units. A stable trend in air quality may not be sufficient to protect an area that is already experiencing poor quality. To assess condition, we first used all available monitoring data over the period 2001-2005 to generate interpolations for the continental US. Monitors used included NPS, EPA, state, tribal, and local monitors. These interpolations allowed us to derive estimates of the air quality parameters at NPS units without on-site monitoring. (Since there were not sufficient monitors to generate interpolations outside the continental US, on-site monitor data were used to derive the condition category estimates for Denali and Virgin Islands.) We then used these interpolated values to determine an index for each type of air quality data collected (ozone concentrations, wet deposition concentrations, and visibility) that assigns the park to one of three condition categories:

Condition Red: Air Quality is a Significant Concern
Condition Yellow: Air Quality is in Moderate Condition
Condition Blue: Air Quality is in Good Condition

The procedures for assigning these categories are described below.

Ozone Condition

The ozone standard was used as a benchmark for rating current ozone air quality. The five-year average of the annual 4th-highest 8-hour ozone concentration was determined for each park from the interpolated values described above. If the resulting five-year average was greater than or equal to 85 ppb then Condition Red was assigned to that park. Condition Yellow for ozone was assigned to parks with average five-year 4th-highest 8-hour ozone concentrations from 68 to 84 ppb (concentrations greater than 80 percent of the standard). Condition Blue for ozone was assigned to parks with average five-year ozone concentrations less than 68 ppb (concentrations less than 80 percent of the standard).

Condition	**Ozone concentration**[3]
Red	≥ 85 ppb
Yellow	68-84 ppb
Blue	< 68 ppb

In addition to the standard, vegetation sensitivity was considered for park condition. Data show that some plant species[4] are more sensitive to ozone than humans and the ozone standard is not protective of some vegetation. Ozone injury to vegetation has been documented at a number of parks, including Great Smoky Mountains NP, Shenandoah NP, and Sequoia/Kings Canyon NPs. A risk assessment completed in 2004 rated parks at low, moderate, or high risk for ozone injury to vegetation, based on presence of sensitive plant species, ozone exposures[5], and environmental conditions, i.e., soil moisture. For this report, parks that were evaluated at high risk were moved into the next condition category (e.g., a park with an average ozone concentration of 72 ppb, but judged to be at high risk for vegetation injury would move from the category “yellow” for ozone to “red”).

Atmospheric Deposition Condition

Park scores for current condition of atmospheric deposition were based on wet deposition because dry deposition data was not available for most areas. Wet deposition was calculated by multiplying N or S concentrations in precipitation by a normalized precipitation amount.[6] Several factors were considered in rating deposition condition, including natural background deposition estimates and deposition effects on ecosystems. Estimates of natural background deposition for total deposition are approximately 0.25 kilograms per hectare per year (kg/ha/yr) in the West and 0.50 kg/ha/yr in the East for either N or S. For wet deposition only, this is roughly equivalent to 0.13 kg/ha/yr in the West and 0.25 kg/ha/yr in the East.[7] Certain sensitive ecosystems respond to levels of deposition on the order of 3 kg/ha/yr total deposition, or about 1.5 kg/ha/yr wet deposition.[8]

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[3] “Ozone concentration” represents the 4th-highest daily maximum 8-hour average ozone concentration averaged over five years.

[4] Lists of ozone sensitive species, by park, are available from NPSpecies (https://science1.nature.nps.gov/npspecies/).

[5] The ozone risk assessment for injury to vegetation was based on ozone exposures over the growing seasons from 1995-1999. The ozone exposure metrics are described in the ozone risk assessments at http://www2.nature.nps.gov/air/Pubs/ozonerisk.htm.

[6] Normalized 30-year precipitation values from the PRISM database were used to calculate deposition in order to minimize interannual variation in deposition caused by interannual fluctuations in precipitation (http://www.ocs.orst.edu/prism/).

[7] The proportion of wet to dry deposition varies by location but, in general, wet deposition is approximately one-half of total deposition.

[8] Fenn et al. 2003. BioScience 53: 404-420; Krupa 2002. Environmental Pollution 124: 179-221

Evidence is not currently available that indicates that wet deposition amounts less than 1 kg/ha/yr cause ecosystem harm. Therefore, parks with wet deposition less than 1 kg/ha/yr were considered to be in good condition for deposition; parks with from 1-3 kg/ha/yr were considered to be in moderate condition; parks with greater than 3 kg/ha/yr were considered to have a significant concern for deposition.

Deposition Condition	Wet Deposition (kg/ha/yr)
Red	> 3
Yellow	1-3
Blue	< 1

Scores for parks with ecosystems potentially sensitive to N or S[9] were adjusted up one category (e.g., a park with N deposition from 1-3 kg/ha/yr and with N-sensitive ecosystems would be assigned the deposition condition "red").

Visibility Condition

Individual park scores for visibility were based on the deviation of the current Group 50 visibility conditions from estimated Group 50 natural visibility conditions[10], where Group 50 is defined as the mean of the 40th-60th percentiles of visibility observations. Visibility in this calculation is expressed in terms of a Haze Index[11] in deciviews (dv). As the Haze Index increases, the visibility worsens. The visibility condition is expressed as

Visibility Condition = current Group 50 visibility – estimated Group 50 visibility under natural conditions.

Condition Blue was assigned to parks with a visibility condition estimate of less than two dv. Parks with visibility condition estimates ranging two to eight dv above background conditions were considered to be in moderate condition, and parks with visibility condition estimates greater than eight dv above background conditions were considered to have a significant concern. The dv ranges of these categories, while somewhat subjective, were chosen to reflect as nearly as possible the variation in visbility conditions across the monitoring network.

Air Quality Condition Maps

Table 2 gives the results of the air quality condition determinations described above. In each figure, a blue circle indicates a park assigned to the Good category for the indicated air quality parameter, a yellow circle indicates the park is assigned to the Moderate (or Caution) category, and a red circle indicates the park is assigned to the Significant Concern category. The category symbols in Table 2 are also overlaid with arrows indicating the direction of the trend (if any). The arrows represent the trends computed from data collected at individual monitors (presented in Table 1), not from the results of the data interpolations used to derive the condition estimates. A blue up arrow indicates an improving trend, a yellow double-headed horizontal arrow indicates no trend, and a red down arrow indicates a worsening trend. In the case of the nitrogen deposition and visibility trends, two trends were combined to create one

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[9] Ecosystems that are considered potentially sensitive to N or S deposition include high-elevation ecosystems in the West, upland areas in the East, areas on granitic bedrock, coastal and estuarine waters, arid ecosystems, and some grasslands.

[10] The natural visibility conditions used in this treatment are those visibility conditions that have been estimated (EPA-454/B-03-005) to exist in a given area in the absence of human-caused visibility impairment.

[11] The Haze Index is a measure of visibility derived from calculated light extinction (EPA-454/B-03-005).

trend arrow, and the less favorable trend was chosen to represent the site. For nitrogen deposition, if the trend in the concentration of one nitrogen species is degrading while the other is stable or improving, an arrow indicating a degrading trend is overlaid on the condition symbol. If the trend in one nitrogen species is stable while the other is improving, an arrow indicating a stable trend is shown. Similarly, trends in visibility on clear days and hazy days were combined and overlaid on the visibility condition symbol. If a trend in one is degrading while a trend in the other is stable or improving, an arrow indicating a degrading trend is shown for that park, and if there is one stable trend and one improving trend, a stable trend is shown. All up and down arrows represent trends that are statistically significant at the p=0.05 level.

The air quality condition results are shown graphically on maps in Figures 13-16. Results for the ozone concentration assessment are shown in Figure 13. Parks in the Significant Concern category are concentrated largely on the east and west coasts, with a few located near the Great Lakes region and eastern Texas. There is also a large number of parks falling in the Moderate category; these parks are located throughout the US. A smaller number of parks fall in the Good category, and they are located largely across the northern US, with a few on the northern coast of California, south Texas, and extreme southwestern Colorado.

Air quality conditions for N wet deposition are shown in Figure 14. Only one site, located in Utah, falls into the Good category. A few parks fall into the Moderate category; these are located in the southwestern US, Washington State, and northern Montana. The remainder of the sites, comprising the majority of the monitored parks and located throughout the US, falls into the Significant Concern category. S wet deposition conditions are shown in Figure 15. Parks in the Good and Moderate categories are located largely in the western US, along with a few in the upper Midwest. Parks in the Significant Concern category are found in the eastern US, Colorado, and Washington State.

Figure 16 shows the visibility conditions at park units. No parks fall into the Good category. Parks in the Moderate category are almost all located in the western US, with a few in the upper Midwest near the Canadian border. The vast majority of parks in the Significant Concern category are located in the eastern US, with two located in California.

Figures 17-20 show graphically the same air quality conditions and trends presented in Table 2. In each figure, an arrow is overlaid on each location symbol that shows the direction of the trend for the indicated air quality parameter. As in Table 2, a blue up-arrow indicates an improving condition, a yellow double-headed horizontal arrow indicates no trend, and a red down-arrow indicates a degrading trend.

Ozone trends are shown in Figure 17. Most trends are stable, particularly in the eastern half of the US, but a few sites indicate improving or degrading trends. Of the few degrading trends, most are found in the western US. Figures 18 and 19 show the nitrogen and sulfate trends. Nitrogen trends are all stable or degrading, with degrading trends largely in the western US. Sulfate trends are largely stable, with a few improving trends in the southwestern US and in eastern portions of the country. Visibility trends are shown in Figure 20. The vast majority of indicated trends are stable; one degrading trend is found in Arizona, and two improving trends are located in Washington state and northern California.

Information and Collaboration Produce Results

Making progress toward meeting park air quality goals is challenging because the NPS has no direct authority to control sources of pollution located outside park boundaries. In order to achieve park air quality goals, the NPS supports or helps shape federal and state air pollution control programs by sharing information about air quality conditions and trends in parks with regulatory agencies and the public. Information sharing has led to collaborative efforts with States, Tribes, EPA, the private sector, and the public aimed at protecting air quality in parks. Such efforts include:

- *Regional Haze:*
  - NPS has continued its participation in five Regional Planning Organizations (RPO's) funded by EPA to assist states and tribes in developing regional haze - visibility protection plans for national parks and wilderness areas. These RPO's are comprised of states, tribes, NPS, EPA, USFS and FWS. The RPO's were formed to address visibility impairment from a regional perspective because the pollutants responsible for regional haze can originate from sources located across broad geographic areas. The visibility protection plans are due to EPA from all 50 states in December, 2007 and will include strategies for making reasonable progress toward natural visibility conditions over the next decade, including the retrofit of older pollution sources. The NPS has been able to share air quality information and air quality modeling expertise among the RPO's, and has also provided training for state and tribal staffs. The states and tribes are required to consult with the NPS before the public hearings on the plans.
  - ARD initiated and completed the field sampling portion of the Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) Study to assess the sources and source regions of nitrogen and sulfur that affect visibility and deposition at Rocky Mountain National Park.

- *Ecosystem Protection Initiatives:*
  - The National Park Service entered into a Memorandum of Understanding (MOU) with the State of Colorado and EPA to address air pollution issues at Rocky Mountain National Park. Pursuant to the MOU, the NPS established a resource management goal ("Critical Load") for the park to guide development of a plan to address nitrogen deposition affecting sensitive park resources. The goal of 1.5 kg N/ha/yr wet deposition was subsequently endorsed by the State of Colorado and the EPA, and a proposed plan for making progress toward that goal has been developed.
  - The NPS has been encouraging the use of critical loads as indicators of ecological health and benchmarks for evaluating the effect of air pollution control programs. In cooperation with EPA, other federal land managing agencies, states and others, various approaches to developing critical loads are being examined around the country.
  - Several studies of ecological effects of air pollution have been completed in the last two years. Scientists conducting projects in Joshua Tree, Rocky Mountain, Acadia, and Great Smoky Mountains National Parks have published findings from these studies in the peer-reviewed literature or in book chapters.

- *Energy Development and New Source Review:*
  - NPS continued its participation in task forces focusing on adaptively managing environmental impacts of oil, gas, and coalbed methane energy development,

    including the Powder River Basin Air Quality Work Group (3 states, EPA, and federal land managers), the Four Corners Air Quality Task Force (4 states, several tribal nations, EPA, federal land managers), and the Federal Leadership Forum (state and regional directors from BLM, FWS, USFS, NPS, DOE and EPA in the Rocky Mountain and intermountain region).
    - Efforts are underway to improve and clarify the NPS's role in reviewing the impacts of new air pollution sources. A Memorandum of Understanding was negotiated with Pennsylvania and EPA Region 3 outlining permitting coordination procedures. The NPS, in cooperation with the Fish and Wildlife Service and US Forest Service, has been updating the Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Report. The goal of FLAG is to achieve greater consistency in the way the federal land managing agencies (NPS, FWS, and Forest Service) identify air quality related values and evaluate air pollution impacts on such values. The proposed revisions incorporate new approaches for reviewing permit applications for new pollution sources and have been presented to EPA and regional, state, local and tribal air quality agencies for review. A formal public review process will begin once NPS receives final approval from the Department of the Interior.
    - Many new conventional power plants have been proposed in the Colorado Plateau and near Everglades, Great Basin, and Theodore Roosevelt National Parks. The NPS has been collaborating with states and industry to encourage the adoption of 21st century technology, negotiating tighter pollution controls (including mercury), and securing emission offset agreements. A mitigation agreement was negotiated with the owners and operators of a proposed new power plant (Desert Rock in the Four Corners area) to offset the impact of the facility on several NPS units.
    - In all, ARD reviewed 50 new source permit applications last year for projects proposing to locate near NPS-managed areas. ARD routinely suggested that the new sources be equipped with better pollution control technology to minimize emissions, which would reduce impacts on NPS areas. In a couple cases, permit applicants agreed to mitigation measures that will more than offset emission increases with pollution reductions elsewhere in the area.
    - The Four Corners power plant, a significant contributor to visibility impairment at park units on the Colorado Plateau, succeeded in increasing the efficiency of its sulfur dioxide (SO2) emission reduction technology, resulting in an 88 percent total removal rate and more than 20,000 less tons of SO2 pollution. Discussions with the Arizona Public Service (plant operator), NPS, EPA and environmental groups resulted in a voluntary agreement to test methods for improving pollution control from 75 percent to 85 percent removal efficiency. The test program exceeded expectations, and APS has agreed to maintain an 88 percent SO2 removal rate.

- *Western Airborne Contaminants Assessment Project*
    - NPS initiated the six year long "Western Airborne Contaminants Assessment Project" (WACAP) in FY 2002 to determine the risk to ecosystems and food webs in western national parks from airborne toxic contaminants. NPS is concerned about airborne contaminants because they can pose serious health threats to wildlife and humans, as some of these compounds tend to "biomagnify" in the food chain. EPA, USGS, U.S. Forest Service, Oregon State University, and University of Washington are working with the NPS on this assessment. Results for some of the parks are starting to be published in scientific journals. A recent

publication indicated that agricultural pesticides from both international and local/regional sources are being deposited in western national parks. Parks with the highest levels of pesticides in snow are those in closest proximity to croplands and include Glacier, Rocky Mountain, and Sequoia/Kings Canyon National Parks. Other research publications by WACAP project partners at USGS, EPA, Oregon State University, University of Washington, and the US Forest Service are anticipated in the next two years, as analysis is completed on water, sediment, vegetation and fish samples from the eight national parks participating in the study.

- *Climate Change*
    - The Climate Friendly Parks Program is funded through an interagency agreement between the National Park Service and the EPA. The program encourages and enables national parks to develop both short- and long-term comprehensive strategies to reduce their greenhouse gas (GHG) emissions. The program also entails a commitment on the part of participating parks to educate the public about what actions the park is taking to mitigate emissions. A series of joint NPS-EPA workshops have been held in parks such as Hawaii Volcanoes, Rocky Mountain, and Yosemite National Parks that were aimed at creating park specific strategies for reducing GHG emissions. A Climate Friendly Parks Leadership Training workshop was also held to instruct NPS staff on the use of a computer model that estimates emissions based on park operation data inputs. A resource toolkit has also been developed to assist parks in creating and implementing their GHG emission mitigation strategies and public outreach and education programs.
    - NPS interpreters have been working in partnership with NASA and other scientists in developing climate change training materials and interpretive products such as brochures and exhibits.
    - NPS is encouraging innovative technologies and carbon offsets through its role in the permitting of new air pollution sources.

- *Night Sky*
    - The National Park Service is concerned about protecting natural lightscapes and is currently monitoring night sky conditions and considering various management actions to protect this natural resource. Night sky quality has been documented by NPS in 45 parks, with an additional 45 more to be completed in the next three years. A full-time NPS Night Sky Program Manager will be hired in FY2007.

      A new section of the Air Resource Division's web site (http://www2.nature.nps.gov/air/lightscapes/index.cfm) now includes information about natural lightscapes and light pollution - the brightness in the nighttime sky caused by artificial light. NPS is becoming well-known worldwide for science and the management of light pollution.

- *Publications*
    - NPS ARD staff scientists published 24 papers in the peer-reviewed literature on a wide range of topics (e.g., ozone, visibility, atmospheric transport of air pollutants).
    - The final version of the Yellowstone National Park 2004-2005 Winter Vehicle Emissions Study was released in late December and is available on the Air Resources Division's (ARD) web site at

http://www2.nature.nps.gov/air/Pubs/pdf/20042005YellowstoneWinterAQStudyFinal.pdf

The information, expertise and management concerns that the NPS brings to many external decision making arenas have made a difference in the past and will continue to in the future.

TECHNICAL APPENDIX
FY 2006 Annual Performance Report: Government Performance and Results Act (GPRA)
Air Quality Goals Ia3, Ia3B (DOI# PEM.1.010), and Ia3C (DOI# PEM.1.011)
Prepared by Air Resources Division
National Park Service
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The National Park Service (NPS) recently completed the FY 2006 performance assessment for the Servicewide air quality program as required by the Government Performance and Results Act (GPRA). The NPS evaluates performance based on a few air quality goals established by the NPS or the U.S. Department of the Interior (DOI).

Long Term NPS Air Quality Goal: By September 30, 2008, air quality in 70 percent of reporting parks is stable or improved (NPS Goal Ia3)

- Target goal for 2006: Air quality in 66 percent of reporting parks is stable or improved.
- Actual performance in 2006: FY 2006 assessment indicated a performance measure of 86 percent, thus exceeding our target goal. 122 of 141 reporting park areas met goal Ia3. See Figures 1 and 2 for national maps displaying overall trend as well as performance relative to the six air quality indicators.

DOI Ambient Air Quality Standards Goal: By September 30, 2006, 78 percent of reporting parks meet the national ambient air quality standards (NAAQS)(DOI Goal Ia3B - DOI #PEM1.010).

- Actual performance: For this fiscal year, 82 percent or 37 of 45 reporting NPS Class I areas met NAAQS, thus exceeding the performance goal. See also Figure 3.

DOI Visibility Goal: By September 30, 2005, 88 percent of reporting NPS Class I areas meet EPA visibility objectives. (DOI Goal Ia3C - DOI# PEM.1.011).

- Actual performance: For this fiscal year, 97 percent or 37 of 38 reporting Class I areas are currently meeting visibility goal, thus exceeding the performance goal. See also Figure 4.

NPS Goal Ia3 Performance Indicators

Determining progress toward meeting NPS Goal Ia3 requires an assessment whether park air quality is stable or improving. Assessing performance for this goal is based on a 10-year trend of three performance indicators: visibility, atmospheric deposition, and ozone. Six measures are used to assess performance under the three indicators.

Visibility: Particle measurements made at or near 82 NPS units were used to calculate the annual reconstructed atmospheric extinction in deciview for both clear and hazy days. (Extinction depends on the mass and chemical composition of the particles and is a quantitative measure of how the passage of light through the atmosphere is affected by air pollutants.)

Atmospheric Deposition: Annual precipitation-weighted means of sulfate, nitrate, and ammonium ion concentrations at or near 50 NPS areas were used to gauge air quality for this indicator. Changes in ammonium ion concentration in precipitation were included in the wet deposition indicator beginning in 2004 because ammonium contributes to total nitrogen deposition and data indicate that ammonium concentrations are increasing at a faster rate than nitrate ion concentrations alone.

Ozone: This measure was modified in FY 2004 to correspond to the new national ambient air quality standard (i.e., the 3-year average of the annual fourth highest daily maximum 8-hour ozone concentration) and has been calculated at 81 NPS units.

Significance Levels Refined: The method used to determine statistical significance of trends was modified to use a value more commonly used in the literature. In past trend reporting, we had used a significance level of 0.15, meaning there was a 15 percent chance that we could wrongly conclude that there was a trend when in fact the change was due to chance. We decided to change the significance level to 0.05, which is commonly used by many researchers. This reduces the chance that we would incorrectly conclude that there is a trend from 15 percent to 5 percent.

Calculating Progress: To calculate a servicewide percentage to compare with the air quality goal, we first performed a trend analysis for each of the above six air quality measures (2 visibility, 1 ozone, 3 acid precipitation) over a ten-year period. The FY2006 analysis used 1996-2005 data and required each site to have a minimum of at least six years of data in this 10-year period. (Year 2006 data were not used in this FY2006 analysis because all of that year's data were not available. There is typically at least a three to six month lag between the time the data are collected in the field and when they are validated and available for analysis.) Our trend time period is a sliding 10-year window and will change to 1997-2006 for next year's analysis. A sliding 10-year trend window was chosen rather than a variable length trend from a single fixed baseline year because individual parks began monitoring in different years and thus there is no individual fixed baseline year that can be applied to all parks.

A few parks operate more than one ozone, visibility, or deposition monitor. We considered data from all monitoring sites at a park and if, for example, any one of the ozone monitors at a park showed a statistically significant degrading trend, the park was considered as not meeting the goal for that measure. In past years' analyses, the same park monitoring site was used for the trend analysis, even if other park site monitoring data were available. Initially when the GPRA air quality goal reporting started, we chose to use the park monitoring site with the longest period of data collection. Monitoring at parks with multiple sites has occurred long enough for there to be more than one park monitor that can be used for trend analysis. Some park units that do not have monitors within their borders have more than one nearby monitor with sufficient data for trend analysis. Here also if one of the nearby monitors indicated a degrading trend we chose that monitor to represent the park unit in this report.

Trend Analysis Results

The results of the trend analyses for the six individual measures appear in Table 1, and trend results for all parks and indicators are represented graphically in Figure 2. For FY2006, 122 of 141, or 86 percent, of NPS parks with monitoring showed stable or improving trends. Thus, the annual air quality performance goal was met for this year.

Figure 5 through Figure 10 present maps illustrating the results of the individual trend analyses for visibility, acid deposition, and ozone. The solid blue and red arrows or boxes in these figures represent statistically significant improving or degrading trends during 1996-2005, while the hollow blue and red arrow or box symbols represent similar but not statistically significant trends with p values between 0.05 and 0.15. These last two colored symbols are included to indicate which parks had trends that would have been considered statistically significant under the procedures used in past years.

Trend calculation: A park is considered to have improving or stable air quality if none of the six measures shows a statistically significant degrading trend (denoted in Table 1 with a red box). The tabulated values include the slope or change in the measure per year and a level of statistical significance (p-value). Slopes with p values at 0.05 or less are considered statistically significant. The number of NPS areas not showing statistically significant deterioration in any of the performance indicators at the 0.05 level of significance is then divided by the total number of NPS units with monitoring to calculate a systemwide percentage which is then compared to the performance measure of the GPRA goal.

Visibility: The percent of reporting park visibility monitors showing stable or improving trends was 98 percent (81 of 82 parks) for both clear and hazy days. Acadia, Blue Ridge Parkway, and Shenandoah showed statistically significant improving visibility trends for the clearest days at eastern national park monitoring sites. (Figure 5.) Improving trends were observed on the worst days at Great Smoky Mountains, Redwood, and Mount Rainier. (Figure 6.) Statistically significant improving trends for the clearest visibility days were observed at 32 sites in the northwest U.S., California, the Colorado Plateau, Rocky Mountain areas, and Alaska. Petrified Forest reported a significantly degrading trend on the worst days.

Wet Deposition: All 50 parks with representative wet deposition monitors showed stable or improving trends for sulfate concentrations (see Figure 7). Improving trends were observed at Eisenhower, Gettysburg, Great Smoky Mountains, Natchez Trace, Buffalo National River, Guadalupe Mountains, Organ Pipe, and Mesa Verde.

Ninety eight percent of reporting park wet deposition monitors (49 of 50) showed stable or improving trends for nitrate in precipitation. (Figure 8.) Mount Rainier showed a statistically significant worsening nitrate trend. Improving trends were observed at Upper Delaware River, Delaware Water Gap, Eisenhower, Gettysburg, New River Gorge, Cumberland Gap, George Rodgers Clark, and Little Bighorn.

The spatial distribution of trends in ammonium in precipitation is shown in Figure 9. A number of parks (10 of 50 reporting), located primarily in the western portions of the country, had statistically significant worsening trends. These included Fort Bowie, Chiricahua, Bent's Old Fort, Canyonlands, Rocky Mountain, Craters of the Moon, Minuteman Missile, Yellowstone, Glacier, and Denali. The remaining 40 parks (80 percent) reported stable trends. No parks reported statistically significant improving trends in ammonium ion concentrations.

Ozone: Eighty eight percent of reporting park ozone monitors (71 of 81) indicated stable or improving trends. These trends are shown in Figure 10. With the exception of Saratoga, eastern park sites such as Great Smoky Mountains, Mammoth Cave, and Shenandoah generally did not show worsening ozone trends for the 10-year period. Improving trends were indicated at Cape Cod, Monocacy, George Rodgers Clark, Mammoth Cave, and Ocmulgee. Generally improving trends in ozone in the eastern US over the last few years have been linked by the EPA to recently implemented control strategies for nitrogen oxide emissions in the East. Ozone is formed in the atmosphere by the reaction of nitrogen oxides and volatile organic compounds in the presence of sunlight. The availability of nitrogen oxides to react with volatile organic compounds is a limiting factor in the production of ozone.

In the west, nine sites – Canyonlands, Death Valley, Glacier, Grand Canyon, Mesa Verde, North Cascades, Petroglyph, Ross Lake, and Rocky Mountain – showed increasing ozone air pollution trends, while levels at Big Bend, Big Thicket, Channel Islands, Pinnacles, Presidio, Muir Woods, and Whiskeytown showed improving ozone trends. The trend toward increasing ozone at Intermountain West monitoring sites has been observed for several years.

Department of the Interior Strategic Plan Air Quality Goals

The National Park Service Air Resources Division reports to two servicewide air quality goals in the Department of the Interior (DOI) strategic plan. One goal, Ia3B (DOI# PEM.1.010), deals with ambient air quality standards, while the other, Ia3C (DOI# PEM.1.011) involves meeting visibility objectives in Class I areas.

Ambient Air Quality Standards: For FY2006, goal Ia3B was achieved. The goal states that by September 30, 2006, 78 percent of reporting NPS Class I areas meet national ambient air quality standards (NAAQS). For this fiscal year, 82 percent or 37 of 45 reporting NPS Class I areas met NAAQS. Eight of the 45 NPS Class I areas either have measured levels of ozone, particulate matter (PM2.5), or sulfur dioxide above the level of the NAAQS or have levels that meet the NAAQS but are included in whole or in part in EPA-designated non-attainment areas for those pollutants. (Figure 12.) NPS Class I areas with monitored ozone levels above the level of the NAAQS and in EPA non-attainment areas include Great Smoky Mountains, Joshua Tree, Sequoia, Kings Canyon, and Yosemite National Parks. Non-attainment counties in Shenandoah and Acadia National Parks were redesignated as attainment for the ozone standard and now are included with those parks meeting this goal. Rocky Mountain NP has monitored ozone levels below the level of the NAAQS but is part of an EPA ozone non-attainment area. Point Reyes does not have onsite ozone monitoring but is part of an EPA-designated ozone non-attainment area.

For PM2.5 particulate matter, no NPS Class I area with monitoring exceeds the level of the standard but the following five NPS areas are all or part in EPA's PM2.5 non-attainment areas: Great Smoky Mountains, Joshua Tree, Sequoia, Kings Canyon, and Yosemite National Parks.

Sulfur dioxide levels at Hawaii Volcanoes NP occasionally exceed the level of the NAAQS. Such exceedances of the standard are caused by natural volcanic, and not anthropogenic, emissions.

Visibility Objectives: For FY2006, the visibility goal Ia3C was also met. This goal states that by September 30, 2006, 88 percent of reporting NPS Class I areas meet visibility objectives. For FY2006, 97 percent or 37 of 38 reporting NPS Class I areas met visibility objectives. (Figure 4.) Meeting visibility objectives occurs when "reasonable progress" is made toward achieving EPA's regional haze regulation goal of restoring natural background visibility conditions over a 60-year period. The definition of reasonable progress will differ for each class I area because both existing baseline visibility conditions and target natural background visibility conditions differ from area to area.

The states are responsible for developing plans to implement the regional haze regulations and track the progress toward meeting the natural background visibility goal. States are required to assess incremental progress toward meeting that goal every five years and revise their implementation plans every 10 years to incorporate revised or new strategies to continue to make progress toward meeting the goal.

States will not submit their plans to implement regional haze regulations until 2007 or early 2008. In the absence of published visibility objectives based on approved state regional haze control plans, a surrogate visibility objective is being used by NPS for reporting under this goal. The NPS visibility objective will be that “visibility in reporting NPS Class I areas has remained stable or improved”. The surrogate visibility objective used by NPS for this DOI goal is thus a subset of the measure used for NPS air quality goal Ia3 which is applied to all parks with monitoring regardless of their air quality class designation. A reporting NPS Class I area’s visibility has remained stable or improved if the area has not experienced a statistically significant deterioration in both clear and hazy day visibility in the most recent 10-year period measured, at the 0.05 level of significance.

Beginning in FY2007, air quality goals Ia3B and Ia3C will no longer be included and reported in the Department of the Interior Strategic Plan. The National Park Service will continue to monitor its progress at meeting air quality goal Ia3 in its strategic plan.

Table 1. Individual Park 1996-2005 Trend Results

Park	Visibility				Acid Precipitation						Ozone	
	Clean Days		Dirty Days		Ammonium		Nitrate		Sulfate		Average 3-Yr 4th High 8-Hour	
	dv/yr	p-value	dv/yr	p-value	μeq/liter/yr	p-value	μeq/liter/yr	p-value	μeq/liter/yr	p-value	ppb/yr	p-value
Abraham Lincoln Birthplace	0.11	0.24	-0.15	0.18								
Acadia	-0.14	0.00	-0.08	0.11	0.07	0.46	-0.24	0.18	-0.84	0.13	0.83	0.18
Allegheny Portage Railroad											-1.00	0.05
Antietam	-0.07	0.38	-0.13	0.31								
Appalachian Trail											0.80	0.07
Arches	-0.20	0.01	-0.13	0.08								
Badlands	-0.10	0.04	-0.10	0.19								
Bandelier	-0.08	0.00	-0.04	0.36	0.29	0.18	0.12	0.46	-0.23	0.38		
Bent's Old Fort					1.07	0.01	0.07	0.43	-0.14	0.30		
Big Bend	-0.38	0.09	-0.20	0.27	-0.05	0.46	-0.24	0.13	-0.17	0.31	-0.83	0.00
Biscayne											-1.29	0.05
Big Thicket											-1.83	0.00
Black Canyon of the Gunnison	-0.14	0.01	0.01	0.54								
Blue Ridge Parkway	-0.36	0.02	0.13	0.24							0.11	0.50
Boston African American					0.13	0.31	-0.51	0.18	-0.46	0.38		
Boston Harbor Islands											-0.29	0.30
Boston					0.13	0.31	-0.51	0.18	-0.46	0.38		
Bryce Canyon	-0.14	0.01	0.08	0.24	0.55	0.28	-0.20	0.39	-0.87	0.07		
Buffalo	-0.05	0.50	0.03	0.43	-0.04	0.54	-0.25	0.18	-0.45	0.04		
Cape Cod											-1.00	0.02
Canaveral					0.01	0.54	-0.47	0.06	-0.48	0.13		
Canyonlands	-0.20	0.01	-0.13	0.08	1.35	0.03	1.16	0.39	0.06	0.50	0.33	0.04
Capitol Reef	-0.14	0.01	0.08	0.24								
Carlsbad Caverns	-0.04	0.08	0.20	0.11								
Capulin Volcano					0.13	0.23	0.06	0.50	0.08	0.50		
Cedar Breaks	-0.14	0.01	0.08	0.24								
Chamizal											-0.17	0.24
Chatahoochee River											-1.32	0.06
Chiricahua	-0.18	0.00	-0.03	0.50	2.06	0.01	0.78	0.14	0.38	0.23	0.20	0.08
Channel Islands											-2.00	0.04
Chesapeake and Ohio Canal	-0.07	0.38	-0.13	0.31							1.50	0.23
Cowpens											-1.00	0.11

Table 1 (cont.) Individual Park 1996-2005 Trend Results

Park	Visibility				Acid Precipitation						Ozone	
	Clean Days		Dirty Days		Ammonium		Nitrate		Sulfate		Average 3-Yr 4th High 8-Hour	
	dv/yr	p-value	dv/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	ppb/yr	p-value
Crater Lake	-0.20	0.00	-0.32	0.14								
Craters of the Moon					1.08	0.01	0.04	0.50	0.24	0.08	0.40	0.15
Cumberland Gap					-0.68	0.19	-1.57	0.02	-2.57	0.07	0.43	0.30
Cumberland Island	-0.07	0.30	-0.07	0.19								
Curecanti	-0.14	0.01	0.01	0.54								
Cuyahoga Valley											0.25	0.36
Denali	-0.23	0.00	0.00	0.57	0.30	0.04	0.07	0.24	0.10	0.36	0.14	0.30
Death Valley	-0.20	0.23	-0.06	0.36							0.50	0.00
Delaware Water Gap					-0.03	0.43	-0.93	0.02	-1.51	0.05		
Eisenhower					-0.46	0.28	-2.03	0.01	-2.05	0.03	0.13	0.36
Everglades					0.10	0.27	0.06	0.45	0.15	0.36		
Fort Bowie	-0.18	0.00	-0.03	0.50	2.06	0.01	0.78	0.14	0.38	0.23	0.20	0.08
Fort Caroline	-0.07	0.30	-0.07	0.19								
Fort Frederica	-0.07	0.30	-0.07	0.19								
Fort Pulaski											-0.62	0.09
Fort Sumter	-0.16	0.24	0.11	0.46								
Fort Union Trading Post	-0.20	0.36	0.23	0.50								
Frederick Law Olmsted					0.13	0.31	-0.51	0.18	-0.46	0.38		
Fredericksburg & Spotsylvania	-0.07	0.38	-0.13	0.31							-1.00	0.08
Gateway											1.00	0.23
George Rogers Clark					-0.40	0.09	-0.95	0.00	-1.30	0.09	-0.88	0.01
Gettysburg					-0.46	0.28	-2.03	0.01	-2.05	0.03	0.13	0.36
George Washington Birthplace	-0.07	0.38	-0.13	0.31								
Gila Cliff Dwellings	-0.18	0.01	-0.19	0.09	0.96	0.09	0.84	0.27	-0.50	0.20		
Glacier	-0.10	0.27	0.07	0.45	0.33	0.02	0.02	0.43	-0.13	0.08	0.83	0.02
Glen Canyon	-0.27	0.06	0.06	0.38								
Golden Gate	-0.07	0.28	0.22	0.39							0.33	0.05
Great Basin	-0.16	0.02	0.00	0.57	0.31	0.19	-0.38	0.12	-0.05	0.28	0.00	0.24
Grand Canyon	-0.27	0.06	0.06	0.38	0.31	0.28	0.34	0.28	0.04	0.50	0.33	0.00
Great Sand Dunes	0.00	0.50	0.07	0.36								
Great Smoky Mountains	-0.16	0.05	-0.27	0.01	-0.11	0.30	-0.42	0.01	-0.87	0.01	-0.14	0.43
Grand Teton	-0.18	0.01	-0.10	0.19								

Table 1 (cont.) Individual Park 1996-2005 Trend Results

Park	Visibility				Acid Precipitation						Ozone	
	Clean Days		Dirty Days		Ammonium		Nitrate		Sulfate		Average 3-Yr 4th High 8-Hour	
Park	dv/yr	p-value	dv/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	ppb/yr	p-value
Gulf Islands											-0.83	0.11
Guadalupe Mountains	-0.04	0.08	0.20	0.11	0.49	0.31	-0.23	0.38	-1.82	0.01		
George Washington Memorial Parkway	-0.07	0.38	-0.13	0.31							1.50	0.23
Harpers Ferry	-0.07	0.38	-0.13	0.31								
Home Of Franklin D Roosevelt											0.00	0.43
Illinois & Michigan Canal											0.00	0.57
Indiana Dunes					0.38	0.30	-0.23	0.30	-0.99	0.08	-0.50	0.28
Isle Royale	-0.03	0.50	-0.10	0.50	0.76	0.09	-0.03	0.36	0.40	0.09		
Jean Lafitte											-0.33	0.11
John D. Rockefeller	-0.15	0.01	-0.50	0.06								
John F Kennedy					0.13	0.31	-0.51	0.18	-0.46	0.38		
John Muir	-0.07	0.28	0.22	0.39								
Joshua Tree	-0.25	0.12	-0.10	0.19							-1.00	0.15
Keweenaw	-0.03	0.50	-0.10	0.50								
Knife River Indian Villages											-0.33	0.08
Lassen Volcanic	-0.17	0.02	-0.02	0.50							-0.57	0.15
Little Bighorn Battlefield					0.42	0.11	-0.33	0.04	-0.26	0.08		
Longfellow					0.13	0.31	-0.51	0.18	-0.46	0.38		
Mammoth Cave	0.11	0.24	-0.15	0.18							-3.67	0.00
Manassas	-0.07	0.38	-0.13	0.31							-0.25	0.43
Mesa Verde	-0.26	0.05	0.08	0.55	0.22	0.19	-0.51	0.19	-0.81	0.01	0.43	0.02
Minute Man					0.13	0.31	-0.51	0.18	-0.46	0.38	-2.00	0.36
Minuteman Missile	-0.10	0.04	-0.10	0.19	1.81	0.01	0.52	0.11	0.08	0.43		
Mississippi											0.00	0.50
Monocacy	-0.07	0.38	-0.13	0.31							-2.80	0.01
Mount Rainier	-0.09	0.04	-0.39	0.01	0.07	0.09	0.13	0.03	-0.23	0.27	0.83	0.15
Morristown											-0.75	0.05
Mount Rushmore	-0.16	0.03	-0.08	0.36								
Muir Woods	-0.07	0.28	0.22	0.39							-0.67	0.02
Natural Bridges	-0.20	0.01	-0.13	0.08								
Natchez Trace Parkway	-0.07	0.50	-0.13	0.50	-0.09	0.24	-0.27	0.08	-0.46	0.04	0.00	0.43
New River Gorge					0.26	0.19	-0.62	0.02	-0.90	0.07		

Table 1 (cont.) Individual Park 1996-2005 Trend Results

Park	Visibility				Acid Precipitation						Ozone	
	Clean Days		Dirty Days		Ammonium		Nitrate		Sulfate		Average 3-Yr 4th High 8-Hour	
	dv/yr	p-value	dv/yr	p-value	μeq/liter/yr	p-value	μeq/liter/yr	p-value	μeq/liter/yr	p-value	ppb/yr	p-value
North Cascades					-0.06	0.30	-0.06	0.43	-0.12	0.05	1.29	0.00
Ocmulgee											-4.00	0.01
Olympic					-0.02	0.27	0.05	0.20	-0.06	0.36		
Organ Pipe Cactus					-0.33	0.27	-1.18	0.14	-1.19	0.03		
Palo Alto Battlefield											0.00	0.43
Pecos	-0.08	0.00	-0.04	0.36								
Petrified Forest	-0.10	0.02	0.22	0.04								
Petersburg											-0.50	0.24
Petroglyph											1.00	0.01
Pinnacles	-0.09	0.27	-0.05	0.55							-1.00	0.00
Pictured Rocks	0.20	0.23	0.23	0.36								
Point Reyes	-0.07	0.28	0.22	0.39								
Presidio of San Francisco	-0.07	0.28	0.22	0.39							-0.33	0.02
Prince William	-0.07	0.38	-0.13	0.31							-0.50	0.24
Redwood	-0.17	0.01	-0.20	0.04								
Richmond											-0.50	0.24
Rock Creek	-0.07	0.38	-0.13	0.31							1.50	0.23
Ross Lake					-0.06	0.30	-0.06	0.43	-0.12	0.05	1.29	0.00
Rocky Mountain	-0.14	0.00	0.09	0.24	1.02	0.02	0.41	0.15	-0.13	0.36	1.00	0.01
San Antonio Missions											-0.40	0.14
Saint Croix					0.21	0.46	-0.23	0.31	-0.21	0.31	0.25	0.24
Saguaro											-0.50	0.11
Saugus Iron Works											-0.29	0.30
Santa Monica Mountains											0.75	0.36
Saratoga											1.25	0.01
Sequoia / Kings Canyon	-0.20	0.23	-0.06	0.36							-0.14	0.36
Shenandoah	-0.36	0.02	0.13	0.24	-0.03	0.54	-0.62	0.06	-0.70	0.13	-1.50	0.15
Sleeping Bear Dunes											-0.40	0.05
Sunset Crater Volcano	-0.27	0.06	0.06	0.38								
Theodore Roosevelt Island	-0.07	0.38	-0.13	0.31								
Theodore Roosevelt											0.67	0.14
Thomas Stone	-0.07	0.38	-0.13	0.31								
Timucuan	-0.07	0.30	-0.07	0.19							-0.29	0.30

Table 1 (cont.) Individual Park 1996-2005 Trend Results

	Visibility				Acid Precipitation						Ozone	
	Clean Days		Dirty Days		Ammonium		Nitrate		Sulfate		Average 3-Yr 4th High 8-Hour	
Park	dv/yr	p-value	dv/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	µeq/liter/yr	p-value	ppb/yr	p-value
Tonto	-0.15	0.02	-0.05	0.45								
Upper Delaware					-0.03	0.43	-0.93	0.02	-1.51	0.05		
Valley Forge											-1.38	0.11
Virgin Islands					0.24	0.07	-0.05	0.50	0.14	0.50		
Voyageurs	-0.04	0.50	0.10	0.50							-0.58	0.09
Washington	-0.07	0.38	-0.13	0.31							1.50	0.23
Whiskeytown	-0.17	0.02	-0.02	0.50							-1.60	0.01
Wind Cave	-0.16	0.03	-0.08	0.36								
Wolf Trap Farm Park	-0.07	0.38	-0.13	0.31								
Yellowstone	-0.15	0.01	-0.50	0.06	0.64	0.02	0.29	0.18	0.12	0.24	-0.53	0.20
Yosemite	-0.22	0.01	-0.15	0.43	0.70	0.09	0.13	0.38	0.28	0.06	0.13	0.36
Zion	-0.14	0.01	0.08	0.24								

🟦	Improving air quality trend, statistically significant (p<=0.05)	☐	Improving air quality trend, not significant (0.05<p<=0.15)
🟥	Degrading air quality trend, statistically significant (p<=0.05)	☐	Degrading air quality trend, not significant (0.05<p<=0.15)

Figure 1

FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA) Air Quality Goal Ia3 for Reporting NPS Areas

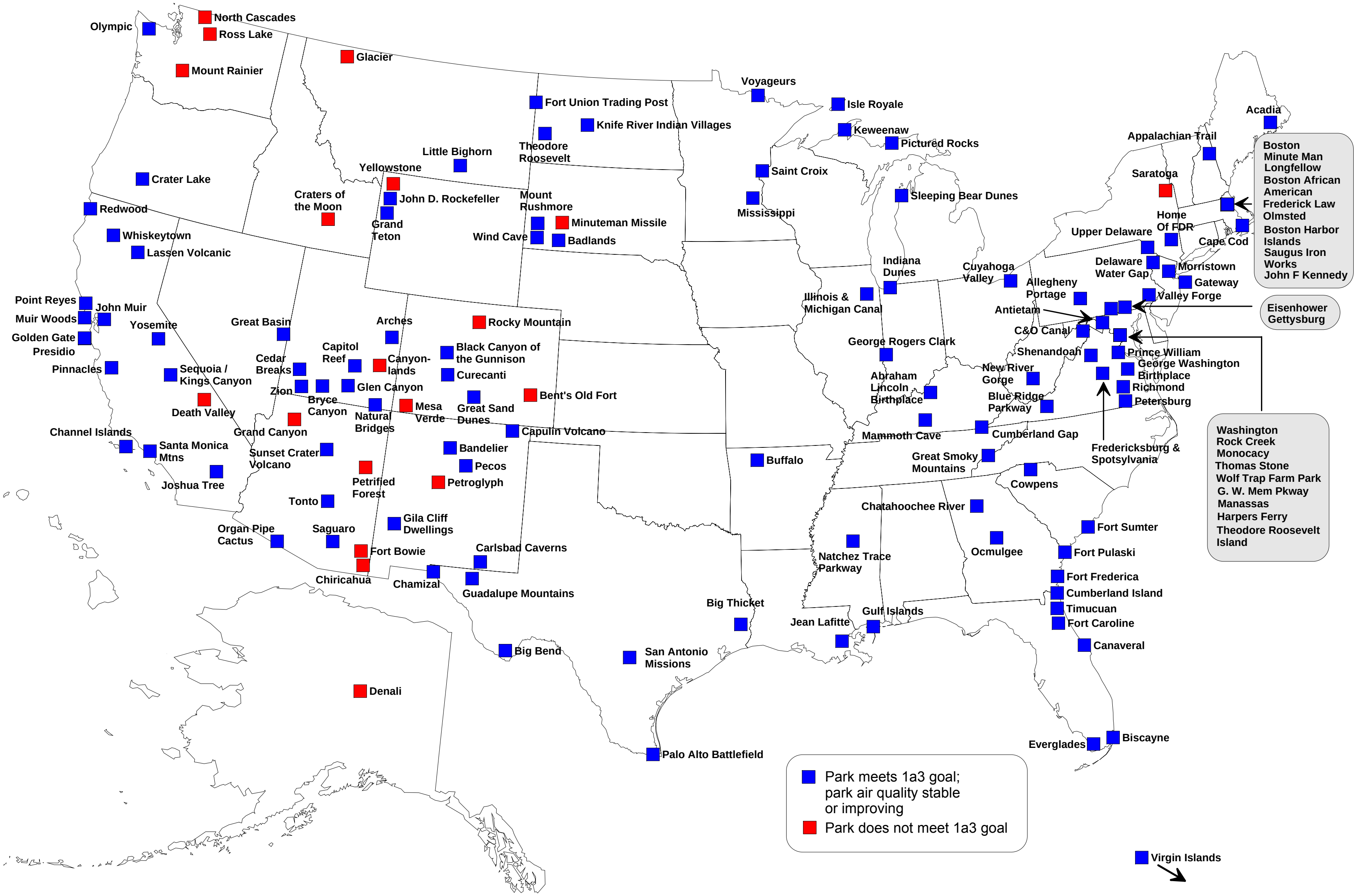


Figure 2

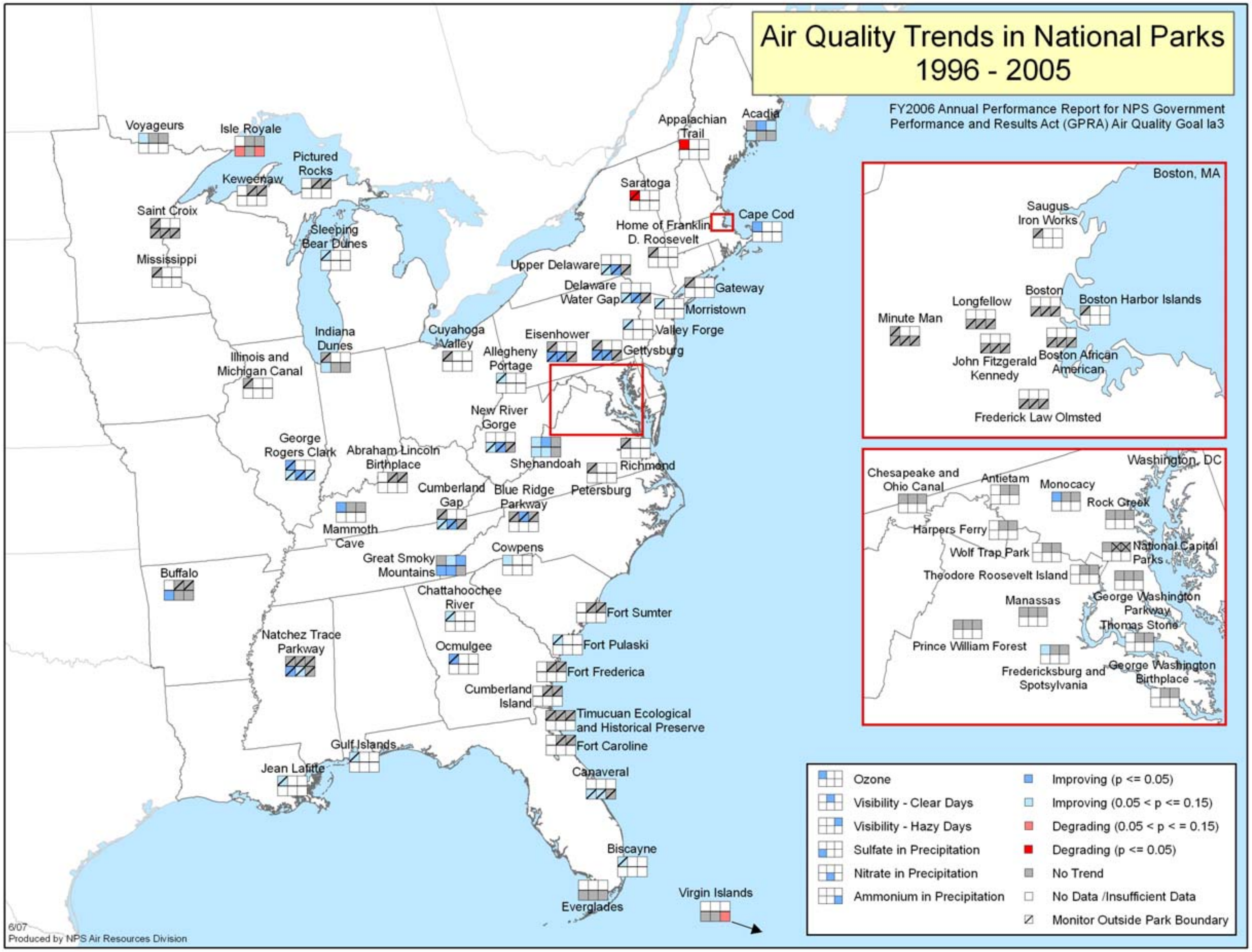

Air Quality Trends in National Parks
1996 - 2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA) Air Quality Goal Ia3
Voyageurs
Isle Royale
Keweenaw
Pictured Rocks
Saint Croix
Mississippi
Sleeping Bear Dunes
Indiana Dunes
Illinois and Michigan Canal
Cuyahoga Valley
Allegheny Portage
Eisenhower
Gettysburg
Upper Delaware
Delaware Water Gap
Morristown
Valley Forge
Gateway
Appalachian Trail
Acadia
Saratoga
Home of Franklin D. Roosevelt
Cape Cod
New River Gorge
Shenandoah
Richmond
Petersburg
George Rogers Clark
Abraham Lincoln Birthplace
Cumberland Gap
Blue Ridge Parkway
Mammoth Cave
Great Smoky Mountains
Cowpens
Buffalo
Chattahoochee River
Natchez Trace Parkway
Ocmulgee
Fort Sumter
Fort Pulaski
Fort Frederica
Cumberland Island
Timucuan Ecological and Historical Preserve
Fort Caroline
Gulf Islands
Jean Lafitte
Canaveral
Biscayne
Everglades
Virgin Islands
Boston, MA
Saugus Iron Works
Minute Man
Longfellow
Boston
Boston Harbor Islands
John Fitzgerald Kennedy
Boston African American
Frederick Law Olmsted
Washington, DC
Chesapeake and Ohio Canal
Antietam
Monocacy
Rock Creek
Harpers Ferry
Wolf Trap Park
National Capital Parks
Theodore Roosevelt Island
Manassas
George Washington Parkway
Thomas Stone
Prince William Forest
Fredericksburg and Spotsylvania
George Washington Birthplace
Ozone
Visibility - Clear Days
Visibility - Hazy Days
Sulfate in Precipitation
Nitrate in Precipitation
Ammonium in Precipitation
Improving (p <= 0.05)
Improving (0.05 < p <= 0.15)
Degrading (0.05 < p < = 0.15)
Degrading (p <= 0.05)
No Trend
No Data /Insufficient Data
Monitor Outside Park Boundary
6/07
Produced by NPS Air Resources Division

Figure 2 (cont)

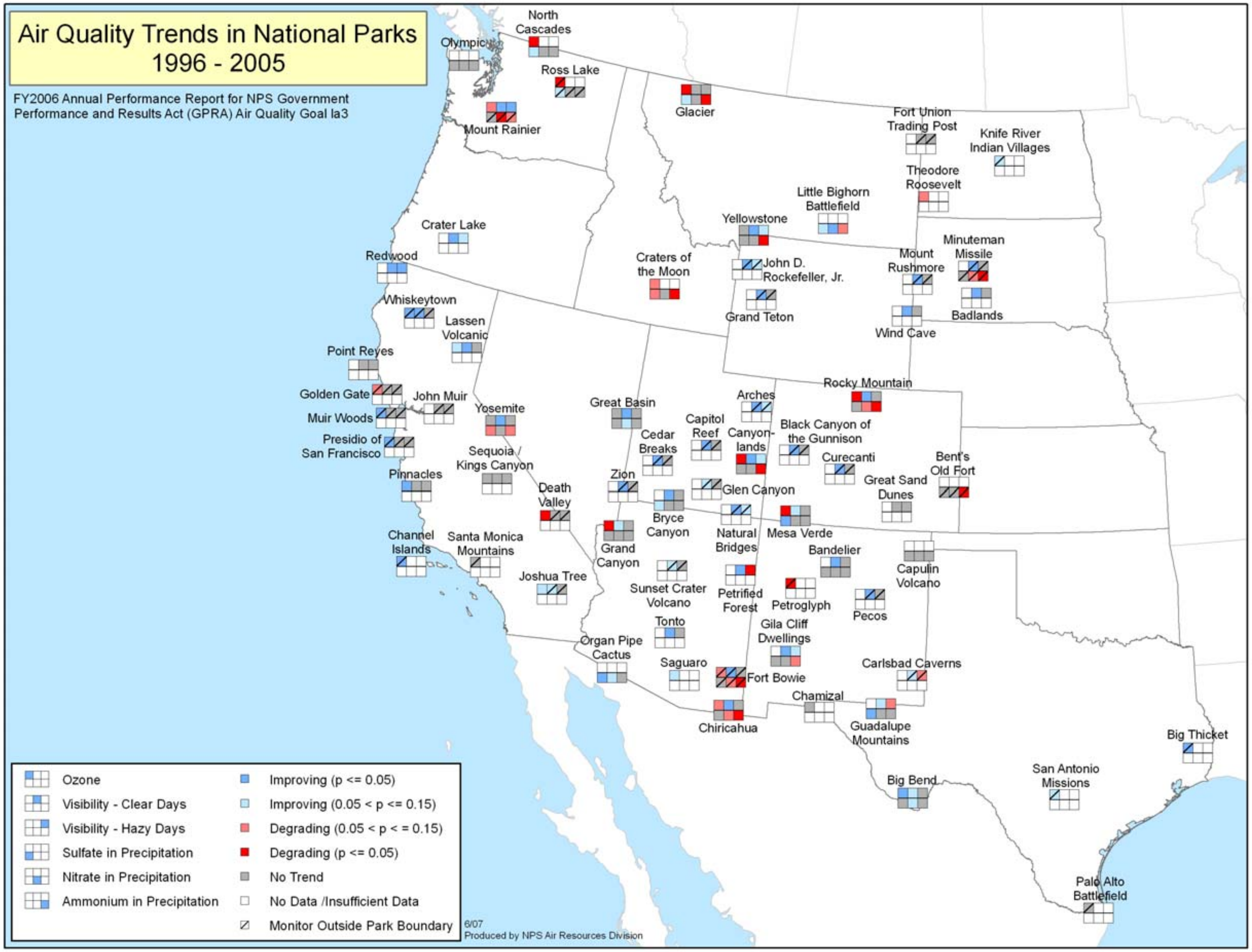
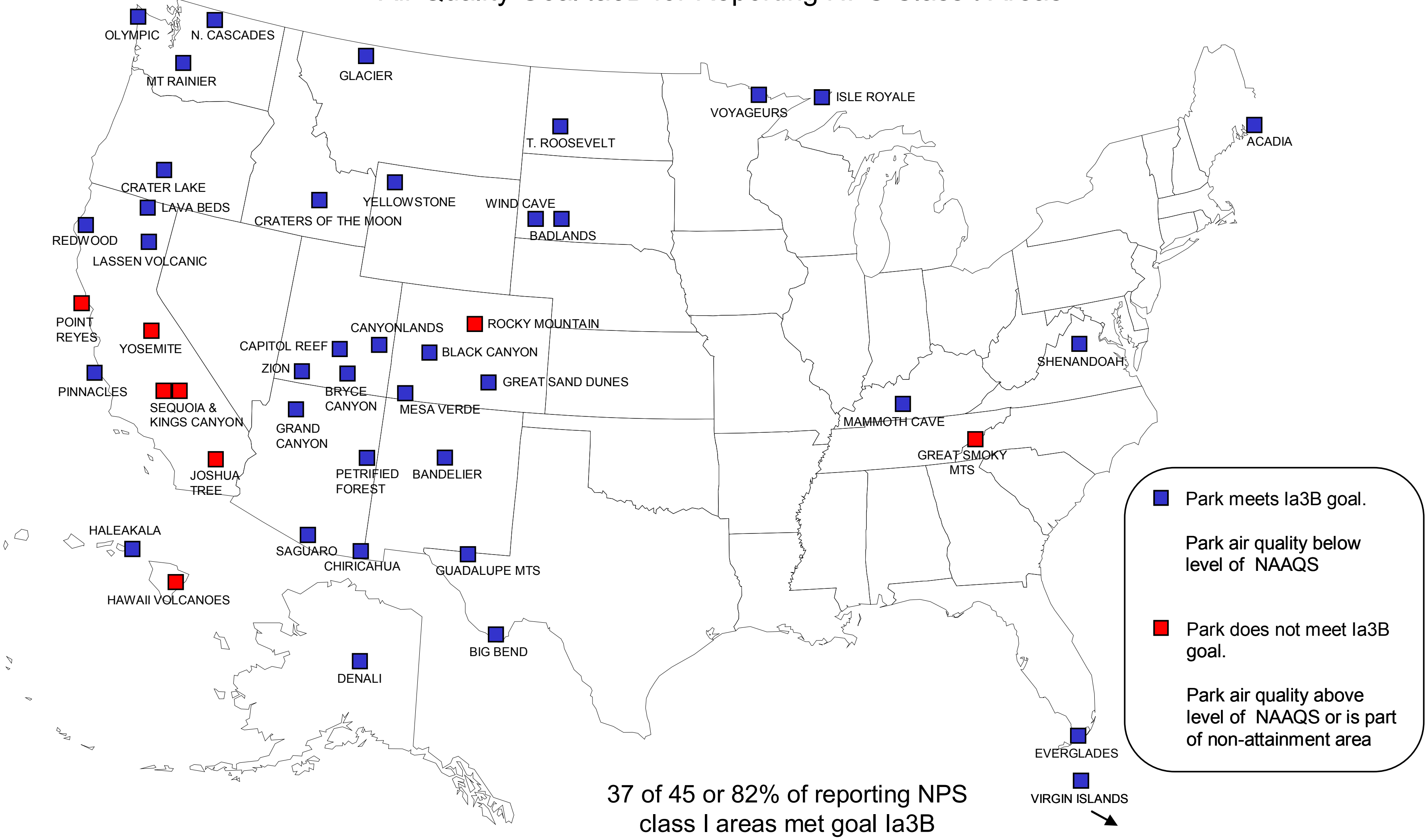


Figure 3.

FY2006 Annual Performance Report for DOI Government Performance and Results Act (GPRA) Air Quality Goal Ia3B for Reporting NPS Class I Areas



🟦 Park meets Ia3B goal.

Park air quality below level of NAAQS

🟥 Park does not meet Ia3B goal.

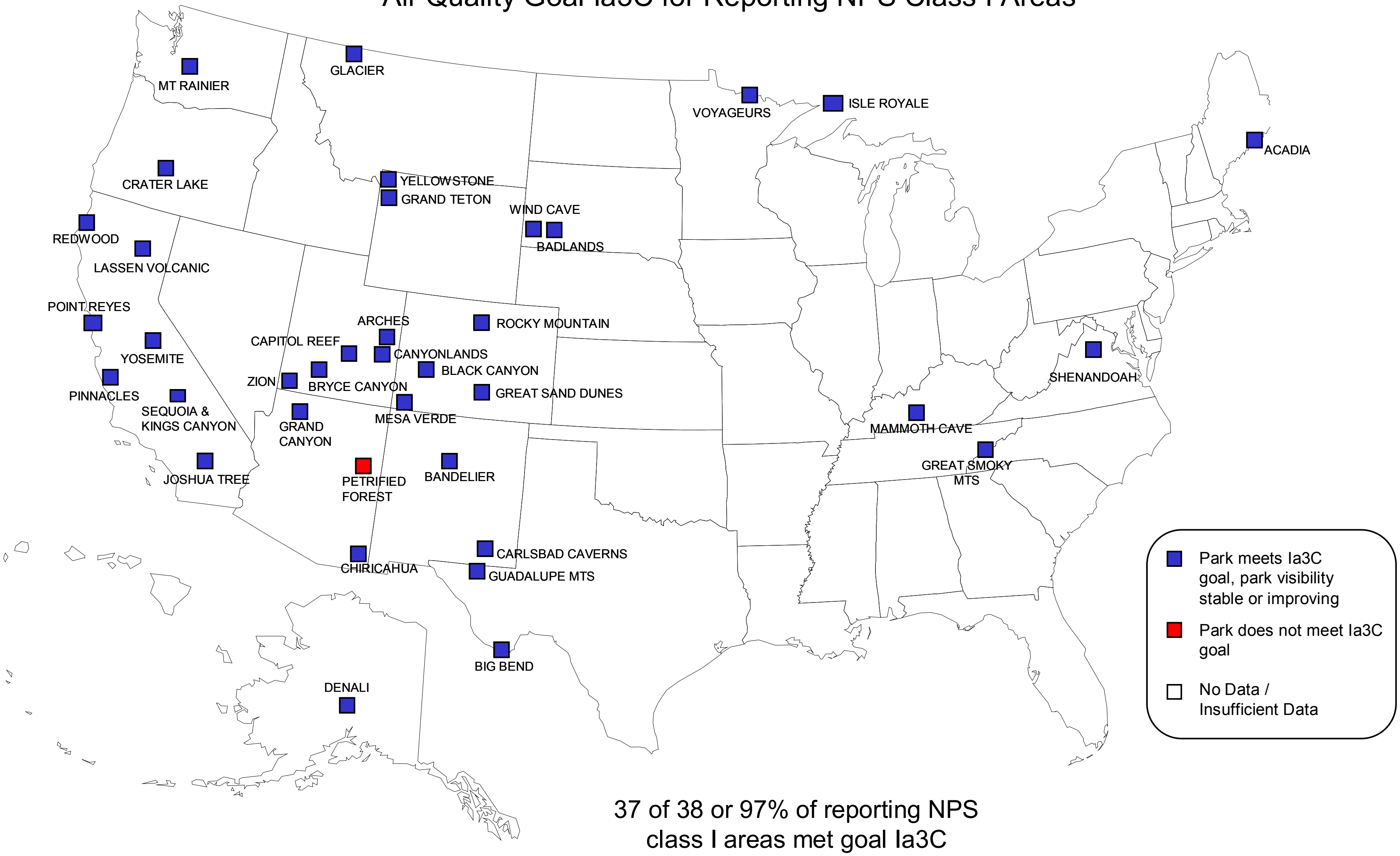
Park air quality above level of NAAQS or is part of non-attainment area

37 of 45 or 82% of reporting NPS class I areas met goal Ia3B

06/13/2007

Figure 4

FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA) Air Quality Goal Ia3C for Reporting NPS Class I Areas



37 of 38 or 97% of reporting NPS class I areas met goal Ia3C

Figure 5

Trends in Haze Index (Deciview) on Clearest Days, 1996-2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

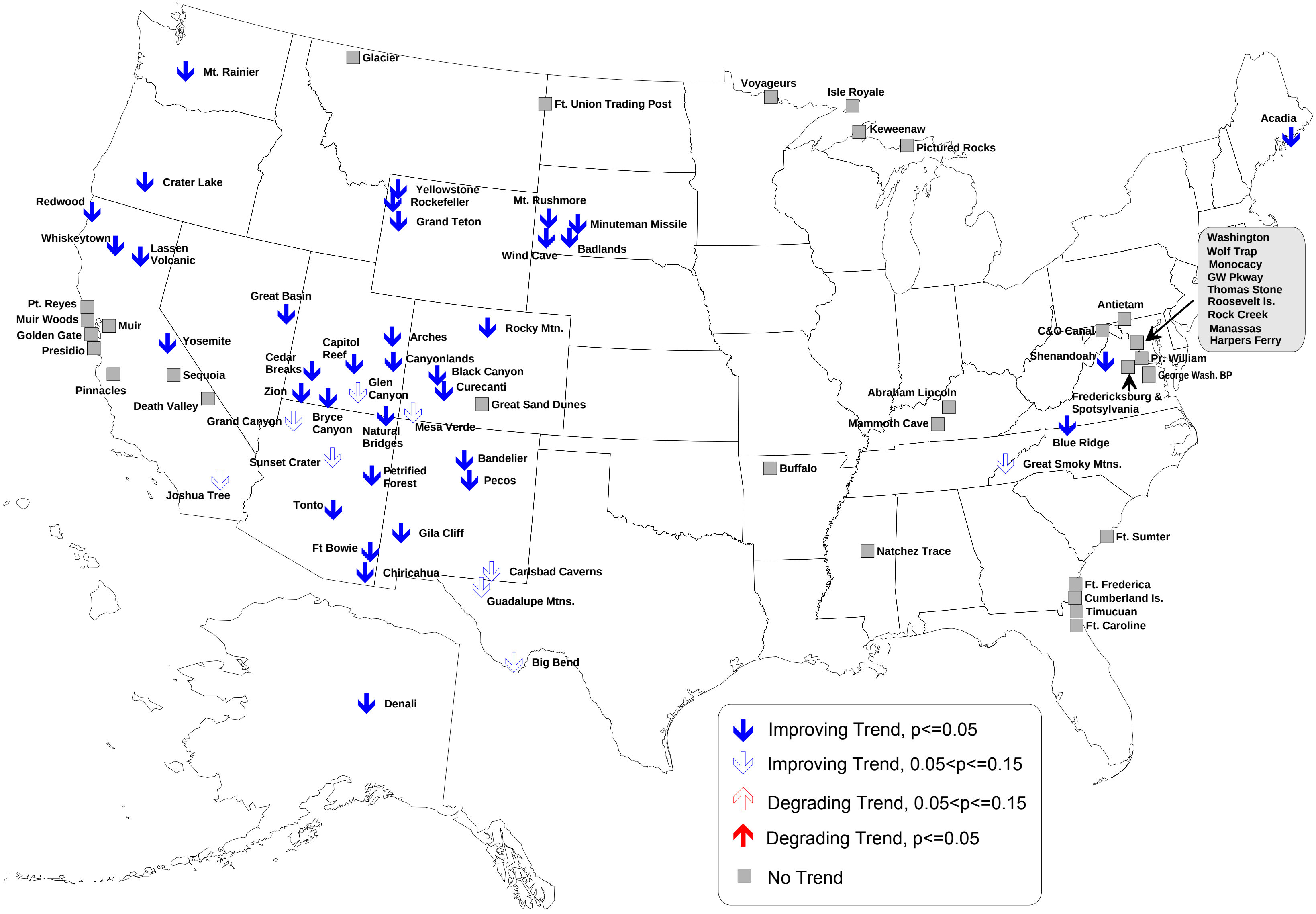


Figure 6

Trends in Haze Index (Deciview) on Haziest Days, 1996-2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

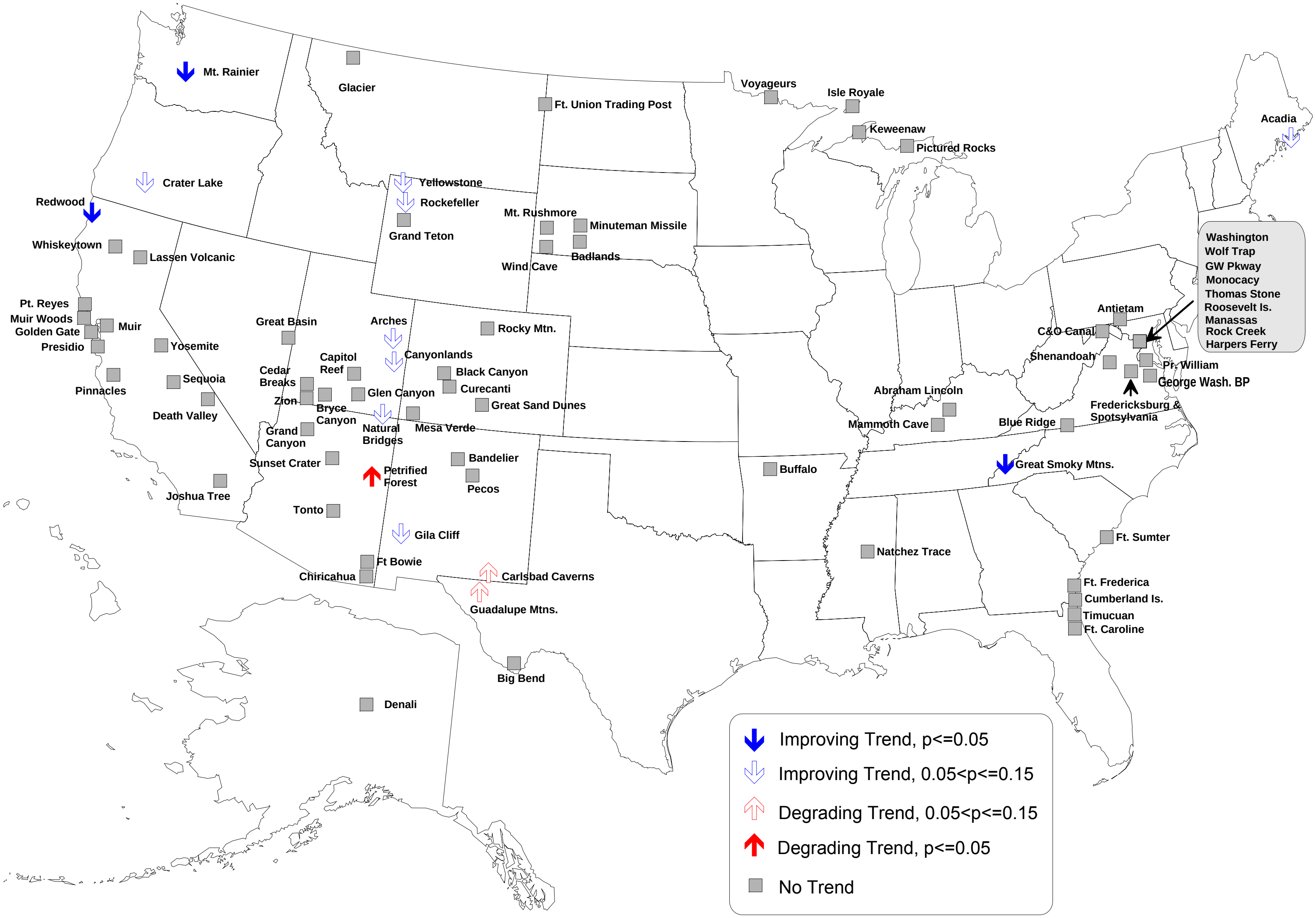


Figure 7

Trends in SO4 Concentrations in Precipitation, 1996-2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

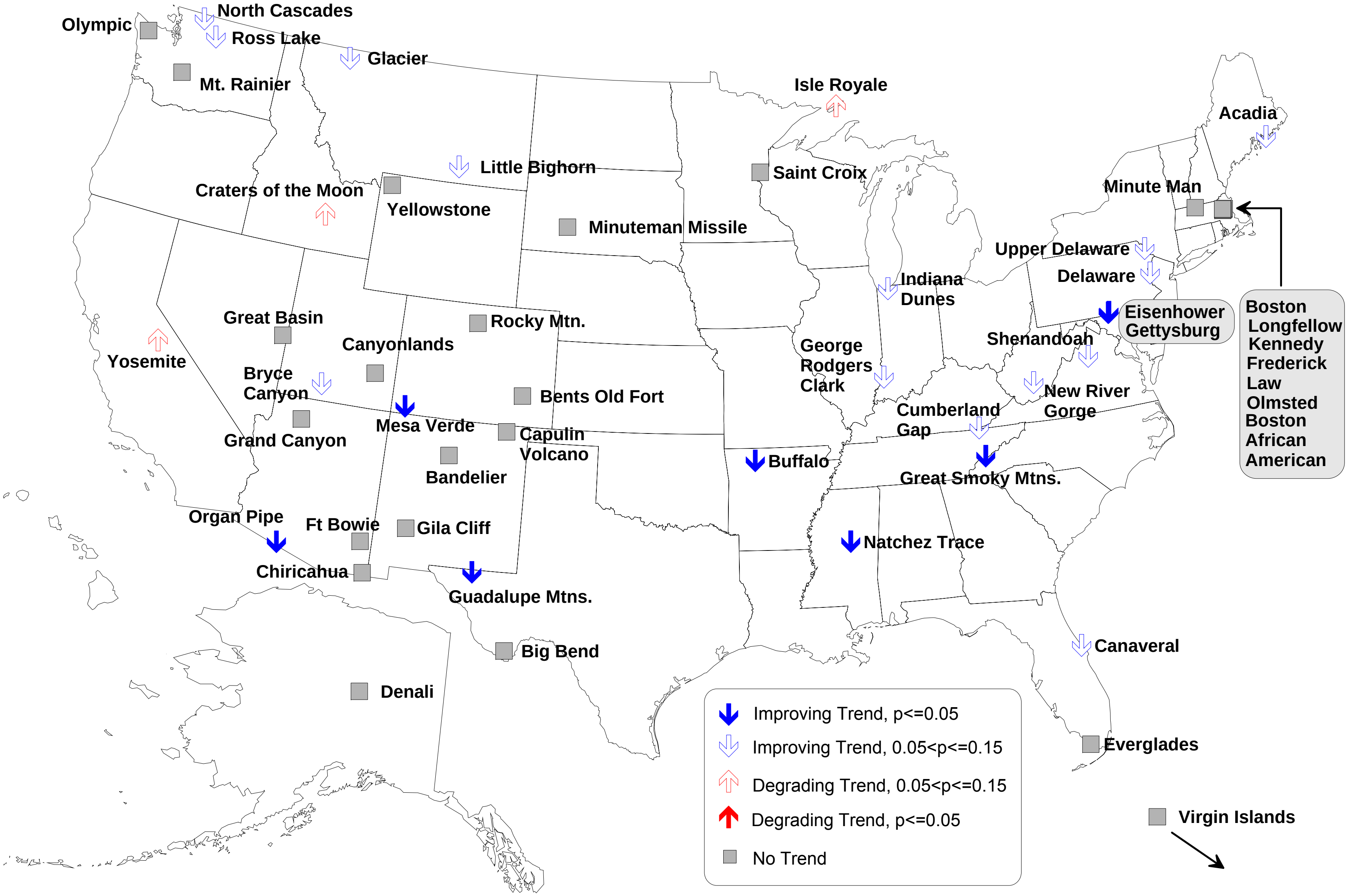


Figure 8

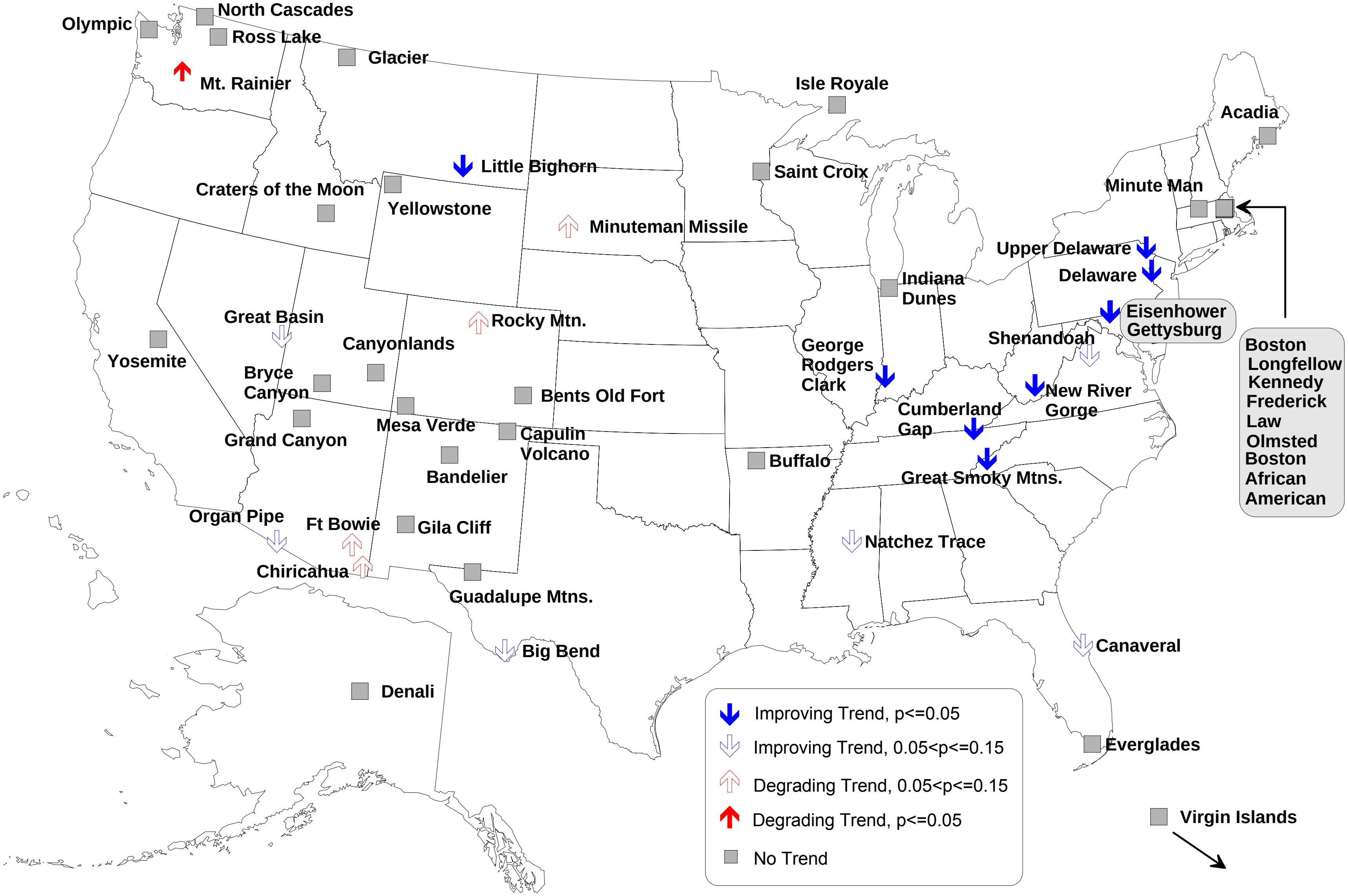

Trends in NO3 Concentrations in Precipitation, 1996-2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

Figure 9

Trends in NH4 Concentrations in Precipitation, 1996-2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

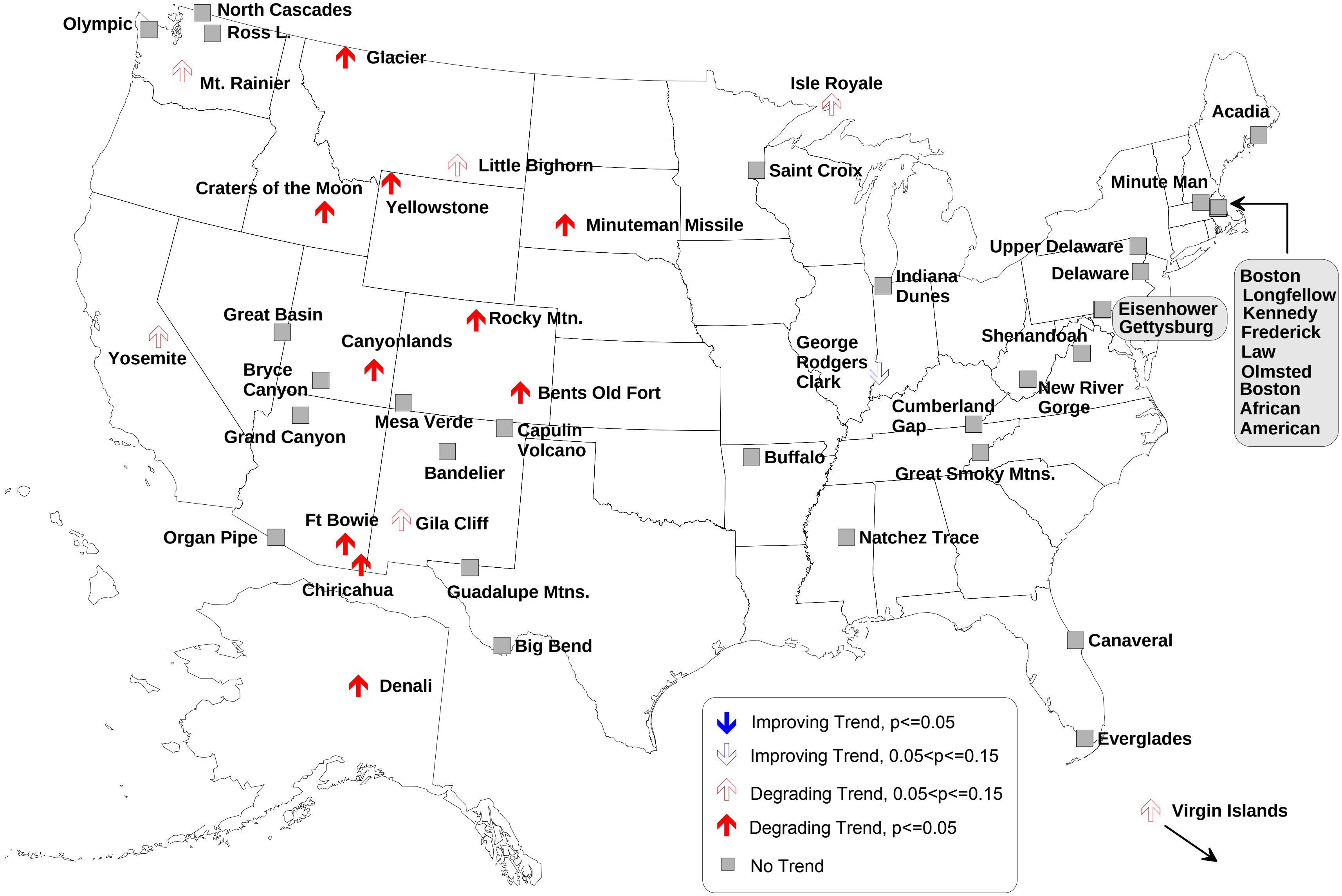


Figure 10

Trends in 3-Year Average 4th Highest 8-Hour Ozone Concentrations, 1996-2005
FY2006 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3

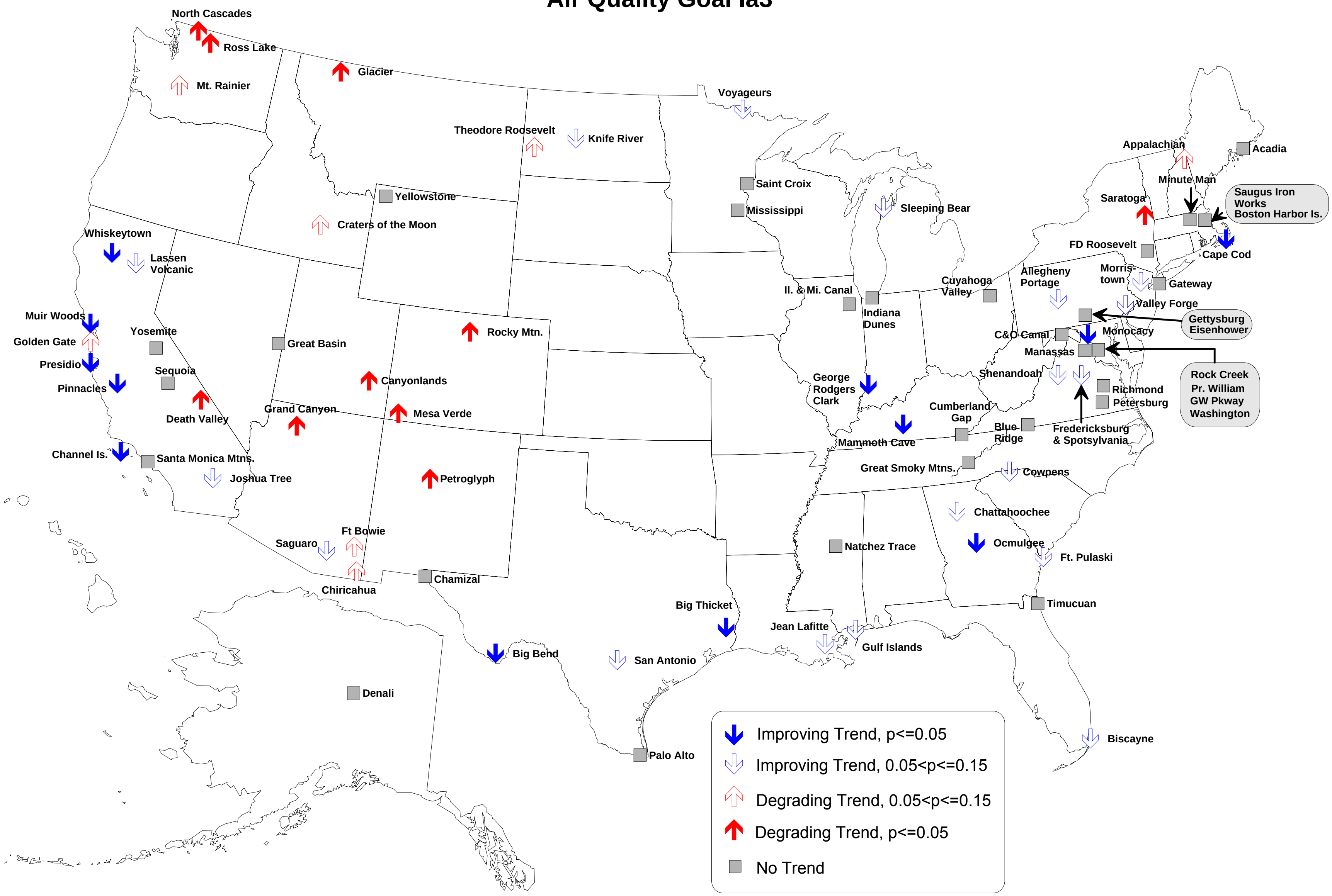
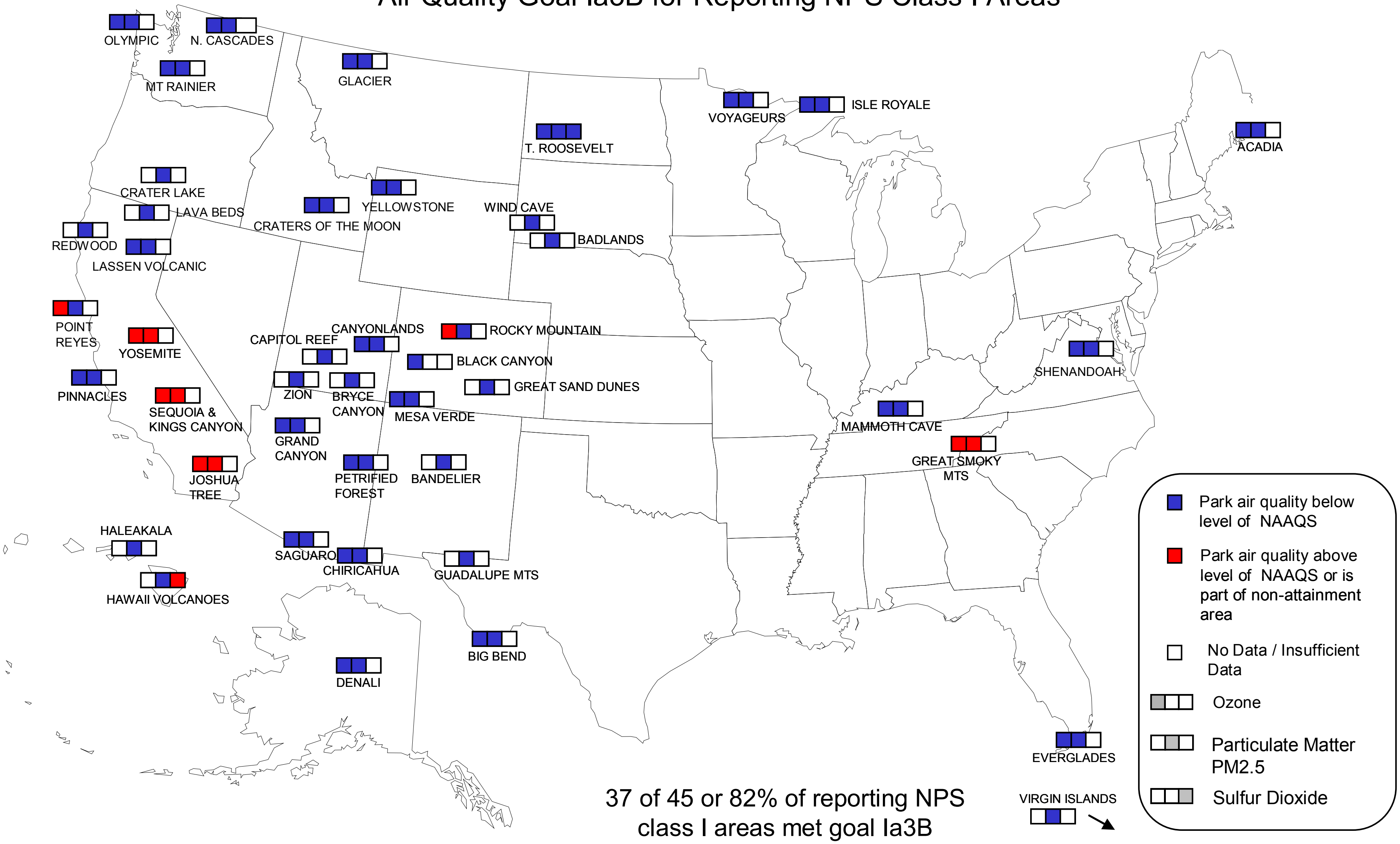


Figure 11

FY2006 Annual Performance Report for DOI Government Performance and Results Act (GPRA) Air Quality Goal Ia3B for Reporting NPS Class I Areas



06/13/2007

Figure 12

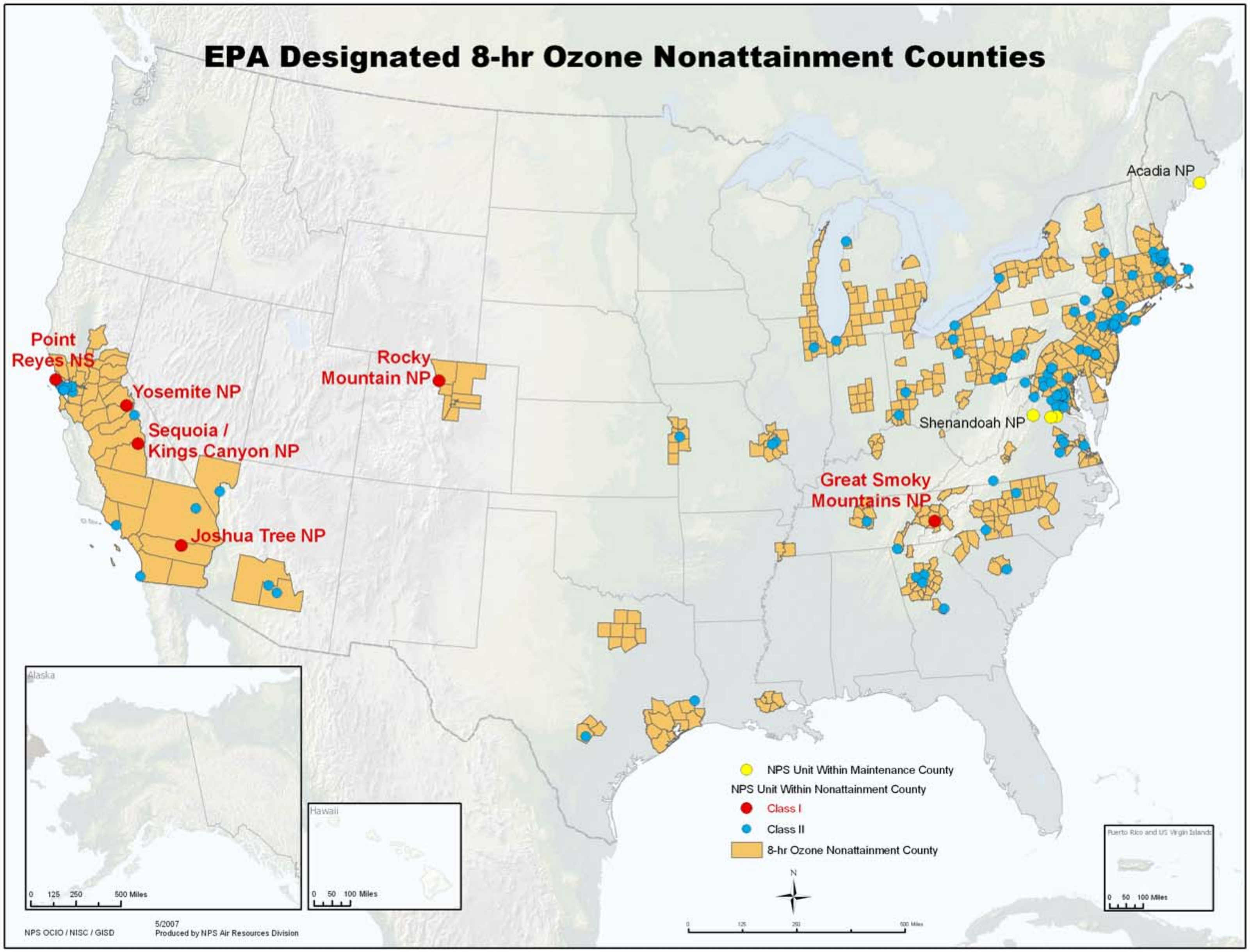

EPA Designated 8-hr Ozone Nonattainment Counties
Point Reyes NS
Yosemite NP
Sequoia / Kings Canyon NP
Joshua Tree NP
Rocky Mountain NP
Great Smoky Mountains NP
Shenandoah NP
Acadia NP
Alaska
0 125 250 500 Miles
Hawaii
0 50 100 Miles
NPS Unit Within Maintenance County
NPS Unit Within Nonattainment County
Class I
Class II
8-hr Ozone Nonattainment County
N
0 125 250 500 Miles
Puerto Rico and US Virgin Islands
0 50 100 Miles
NPS OCIO / NISC / GISD
5/2007
Produced by NPS Air Resources Division

Table 2. Air Quality Condition and Trends Scorecard for 141 Parks (1996-2005)

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Abraham Lincoln Birthplace	🔴⇔			
Acadia	🟡⇔	🔴⇔	🔴⇔	🟡⇔
Allegheny Portage Railroad				🟡⇔
Antietam	🔴⇔			
Arches	🟡⇔			
Badlands	🟡⇔			
Bandelier	🟡⇔	🟡⇔	🔵⇔	
Bent's Old Fort		🟡⇓	🔵⇔	
Big Bend	🟡⇔	🔴⇔	🟡⇔	🔵⇑
Big Thicket				🔴⇑
Biscayne				🔵⇔
Black Canyon of the Gunnison	🟡⇔			
Blue Ridge Parkway	🔴⇔			🟡⇔
Boston		🔴⇔	🔴⇔	
Boston African American		🔴⇔	🔴⇔	
Boston Harbor Islands				🟡⇔
Bryce Canyon	🟡⇔	🟡⇔	🔵⇔	
Buffalo	🔴⇔	🔴⇔	🔴⇑	
Canaveral		🔴⇔	🔴⇔	
Canyonlands	🟡⇔	🔵⇓	🔵⇔	🟡⇓
Cape Cod				🔴⇑
Capitol Reef	🟡⇔			
Capulin Volcano		🟡⇔	🟡⇔	
Carlsbad Caverns	🟡⇔			
Catoctin Mountain		🔴⇔	🔴⇑	
Cedar Breaks	🟡⇔			

Table 2 (cont). Air Quality Condition and Trends Scorecard for 141 Parks (1996-2005)

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Chamizal				🟡⇔
Channel Islands				🟡⇧
Chatahoochee River				🔴⇔
Chesapeake and Ohio Canal	🔴⇔			🔴⇔
Chiricahua	🟡⇔	🔴⇩	🟡⇔	🟡⇔
Cowpens				🔴⇔
Crater Lake	🟡⇔			
Craters of the Moon		🔴⇩	🔵⇔	🔵⇔
Cumberland Gap		🔴⇔	🔴⇔	🟡⇔
Cumberland Island	🔴⇔			
Curecanti	🟡⇔			
Cuyahoga Valley				🔴⇔
Death Valley	🟡⇔			🔴⇩
Delaware Water Gap		🔴⇔	🔴⇔	
Denali	🔵⇔	🔵⇩	🔵⇔	🔵⇔
Eisenhower		🔴⇔	🔴⇧	🔴⇔
Everglades		🔴⇔	🔴⇔	
Fort Bowie	🟡⇔	🟡⇩	🟡⇔	🟡⇔
Fort Caroline	🔴⇔			
Fort Frederica	🔴⇔			
Fort Pulaski				🟡⇔
Fort Sumter	🔴⇔			
Fort Union Trading Post	🟡⇔			
Frederick Law Olmsted		🔴⇔	🔴⇔	
Fredericksburg & Spotsylvania	🔴⇔			🔴⇔
Gateway				🔴⇔
George Rogers Clark		🔴⇔	🔴⇔	🟡⇧
George Washington Birthplace	🔴⇔			
George Washington Memorial Parkway	🔴⇔			🔴⇔

Table 2 (cont). Air Quality Condition and Trends Scorecard for 141 Parks (1996-2005)

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Gettysburg		🔴⇔	🔴⇧	🔴⇔
Gila Cliff Dwellings	🟡⇔	🟡⇔	🟡⇔	
Glacier	🟡⇔	🔴⇩	🟡⇔	🔵⇩
Glen Canyon	🟡⇔			
Golden Gate	🟡⇔			🔵⇔
Grand Canyon	🟡⇔	🟡⇔	🔵⇔	🟡⇩
Grand Teton	🟡⇔			
Great Basin	🟡⇔	🟡⇔	🔵⇔	🟡⇔
Great Sand Dunes	🟡⇔			
Great Smoky Mountains	🔴⇔	🔴⇔	🔴⇧	🔴⇔
Guadalupe Mountains	🟡⇔	🔴⇔	🟡⇧	
Gulf Islands				🟡⇔
Harpers Ferry	🔴⇔			
Home Of Franklin D Roosevelt				🔴⇔
Illinois & Michigan Canal				🟡⇔
Indiana Dunes		🔴⇔	🔴⇔	🔴⇔
Isle Royale	🟡⇔	🔴⇔	🟡⇔	
Jean Lafitte				🟡⇔
John D. Rockefeller	🟡⇔			
John F Kennedy		🔴⇔	🔴⇔	
John Muir	🟡⇔			
Joshua Tree	🔴⇔			🔴⇔
Keweenaw	🟡⇔			
Knife River Indian Villages				🔵⇔
Lassen Volcanic	🟡⇔			🟡⇔
Little Bighorn Battlefield		🟡⇔	🔵⇔	
Longfellow		🔴⇔	🔴⇔	
Mammoth Cave	🔴⇔			🟡⇧
Manassas	🔴⇔			🔴⇔

Table 2 (cont). Air Quality Condition and Trends Scorecard for 141 Parks (1996-2005)

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Mesa Verde	🟡⇔	🔴⇔	🔵⇧	🔵⇩
Minute Man		🔴⇔	🔴⇔	🟡⇔
Minuteman Missile	🟡⇔	🔴⇩	🟡⇔	
Mississippi				🟡⇔
Monocacy	🔴⇔			🔴⇧
Morristown				🔴⇔
Mount Rainier	🟡⇧	🔴⇩	🔴⇔	🔵⇔
Mount Rushmore	🟡⇔			
Muir Woods	🟡⇔			🔵⇧
Natchez Trace Parkway	🔴⇔	🔴⇔	🔴⇧	🟡⇔
Natural Bridges	🟡⇔			
New River Gorge		🔴⇔	🔴⇔	
North Cascades		🔴⇔	🔴⇔	🔵⇩
Ocmulgee				🔴⇧
Olympic		🔴⇔	🔴⇔	
Organ Pipe Cactus		🔴⇔	🔵⇧	
Palo Alto Battlefield				🔵⇔
Pecos	🟡⇔			
Petersburg				🟡⇔
Petrified Forest	🟡⇩			
Petroglyph				🟡⇩
Pictured Rocks	🟡⇔			
Pinnacles	🟡⇔			🔴⇧
Point Reyes	🟡⇔			
Presidio of San Francisco	🟡⇔			🔵⇧
Prince William	🔴⇔			🔴⇔
Redwood	🟡⇧			
Richmond				🟡⇔
Rock Creek	🔴⇔			🔴⇔

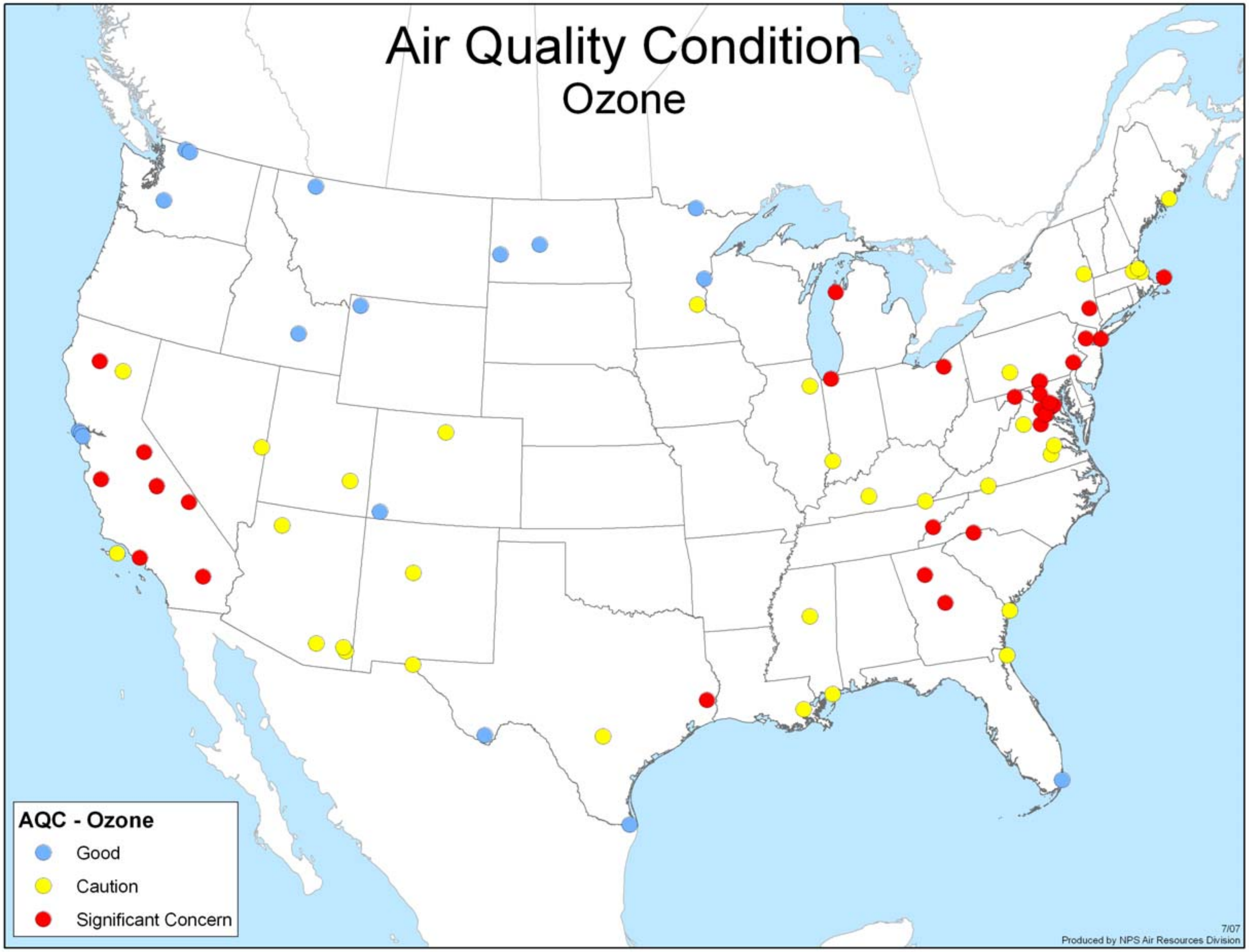
Table 2 (cont). Air Quality Condition and Trends Scorecard for 141 Parks (1996-2005)

Park	Condition and Trend Symbol			
	Visibility	Nitrogen Deposition	Sulfur Deposition	Ozone
Rocky Mountain	🟡⇔	🔴⇩	🔴⇔	🟡⇩
Ross Lake		🟡⇔	🟡⇔	🔵⇩
Saguaro				🟡⇔
Saint Croix		🔴⇔	🟡⇔	🔵⇔
San Antonio Missions				🟡⇔
Santa Monica Mountains				🔴⇔
Saratoga				🟡⇩
Saugus Iron Works				🟡⇔
Sequoia / Kings Canyon	🔴⇔			🔴⇔
Shenandoah	🔴⇔	🔴⇔	🔴⇔	🟡⇔
Sleeping Bear Dunes				🔴⇔
Sunset Crater Volcano	🟡⇔			
Theodore Roosevelt				🔵⇔
Theodore Roosevelt Island	🔴⇔			
Thomas Stone	🔴⇔			
Timucuan	🔴⇔			🟡⇔
Tonto	🟡⇔			
Upper Delaware		🔴⇔	🔴⇔	
Valley Forge				🔴⇔
Virgin Islands		🔵⇔	🔵⇔	
Voyageurs	🟡⇔			🔵⇔
Washington	🔴⇔			🔴⇔
Whiskeytown	🟡⇔			🔴⇧
Wind Cave	🟡⇔			
Wolf Trap Farm Park	🔴⇔			
Yellowstone	🟡⇔	🔴⇩	🟡⇔	🔵⇔
Yosemite	🟡⇔	🔴⇔	🟡⇔	🔴⇔
Zion	🟡⇔			

Table 2 (cont). Symbol Legend.

Condition		Trend	
🔵	Good	⬆	Improving
🟡	Moderate (Caution)	⇔	No Trend
🔴	Significant Concern	⬇	Degrading

Figure 13



Air Quality Condition
Ozone
AQC - Ozone
Good
Caution
Significant Concern
7/07
Produced by NPS Air Resources Division

Figure 14

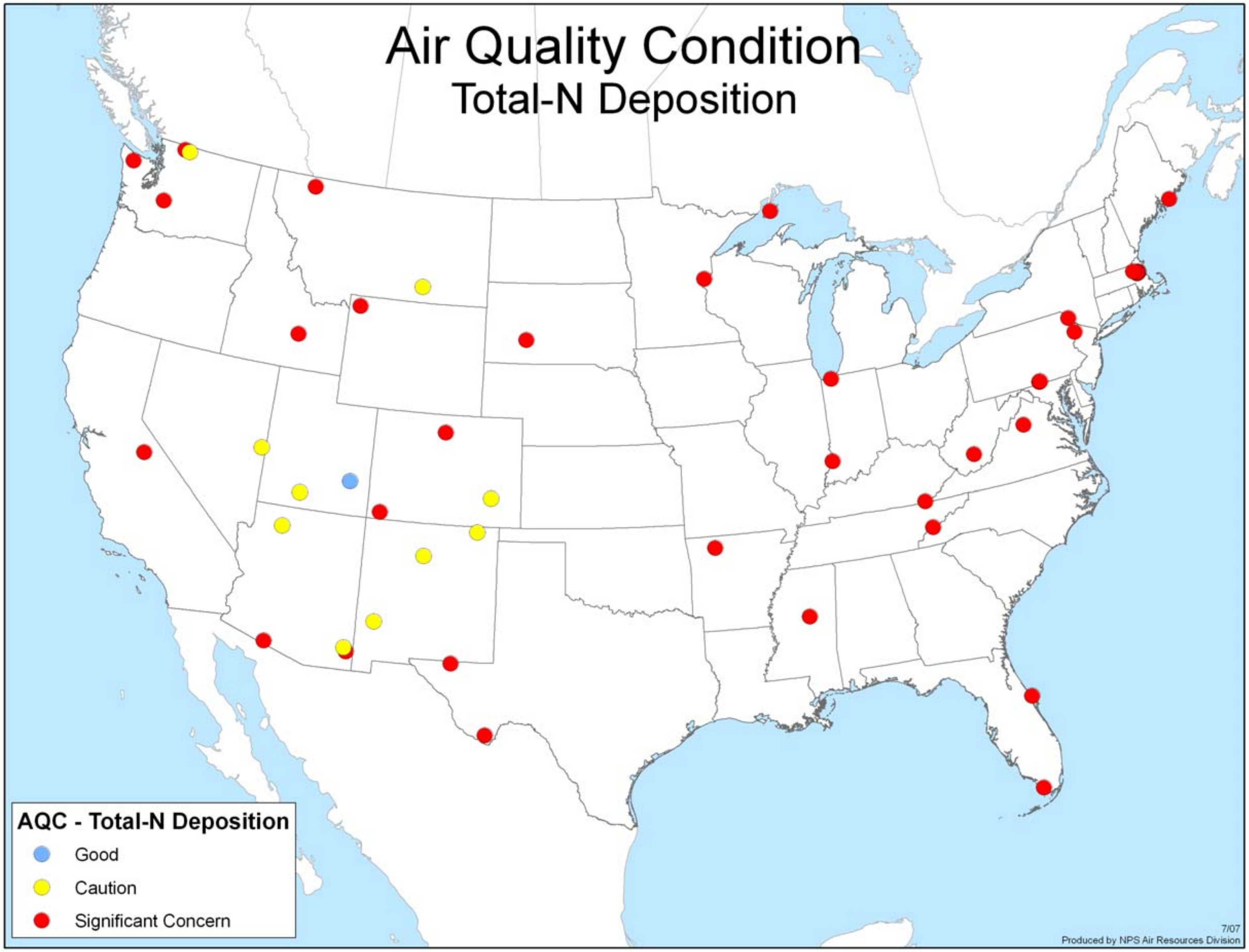

Air Quality Condition
Total-N Deposition
AQC - Total-N Deposition
Good
Caution
Significant Concern
7/07
Produced by NPS Air Resources Division

Figure 15

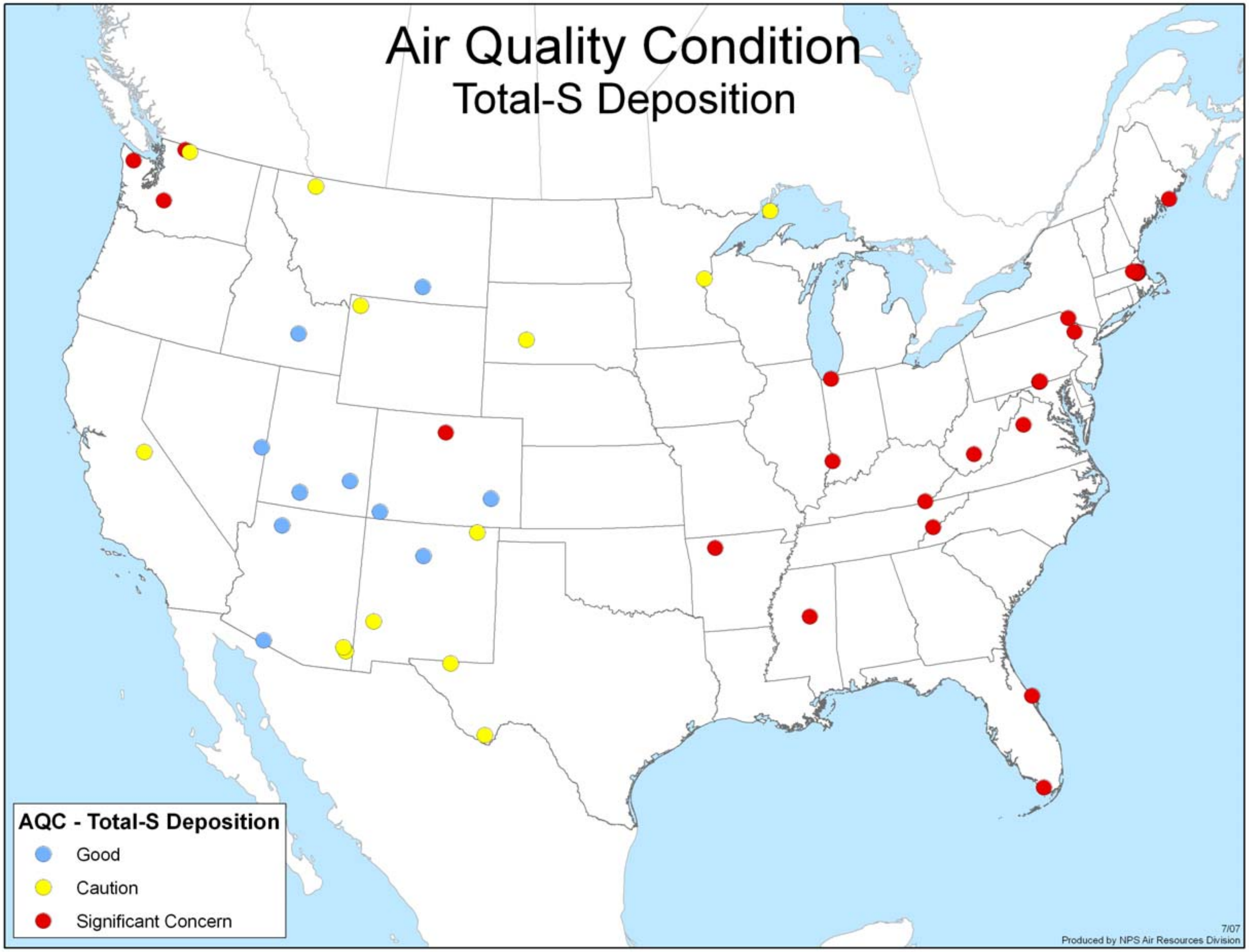

Air Quality Condition
Total-S Deposition
AQC - Total-S Deposition
● Good
● Caution
● Significant Concern
7/07
Produced by NPS Air Resources Division

Figure 16

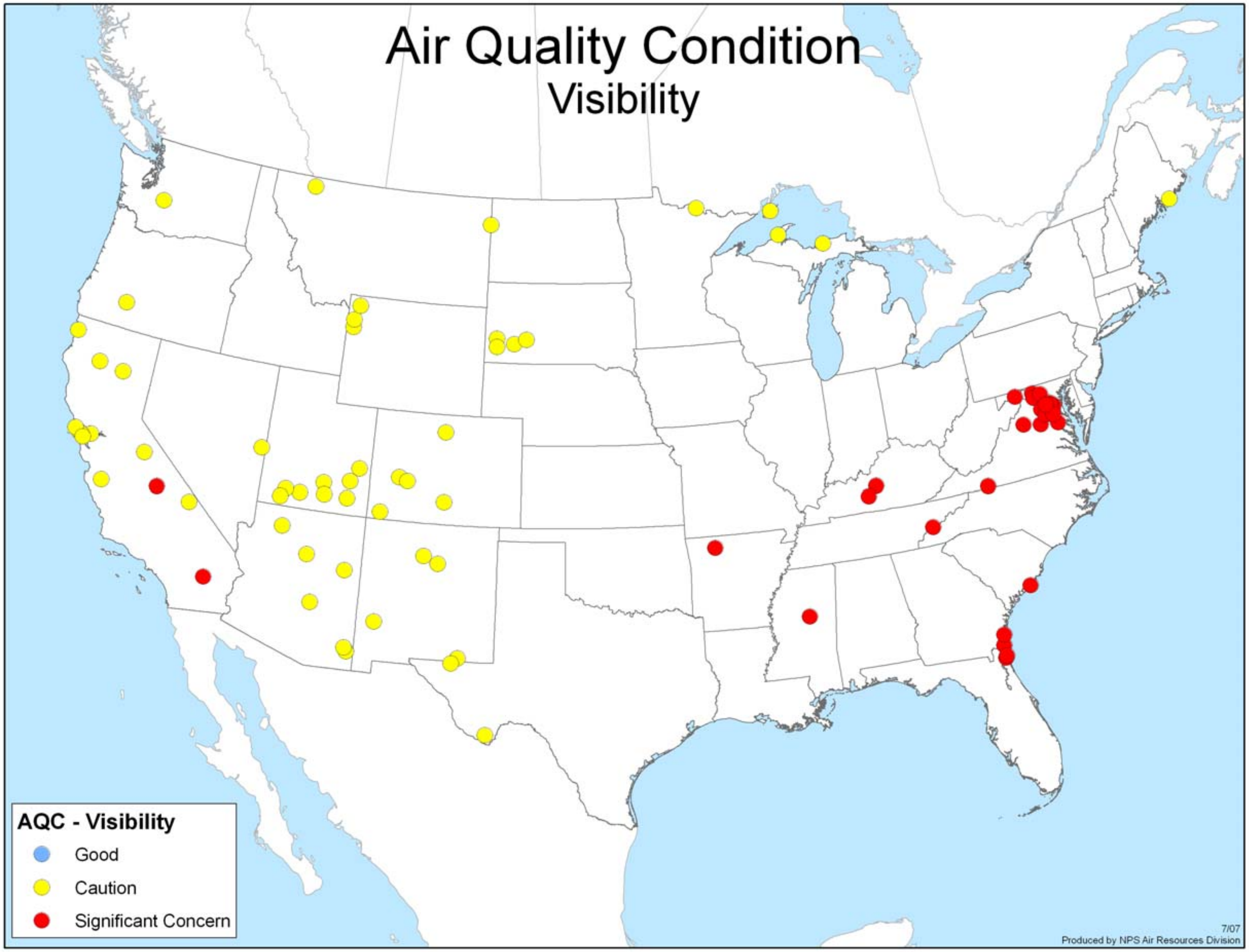

Air Quality Condition
Visibility
AQC - Visibility
● Good
● Caution
● Significant Concern
7/07
Produced by NPS Air Resources Division

Figure 17

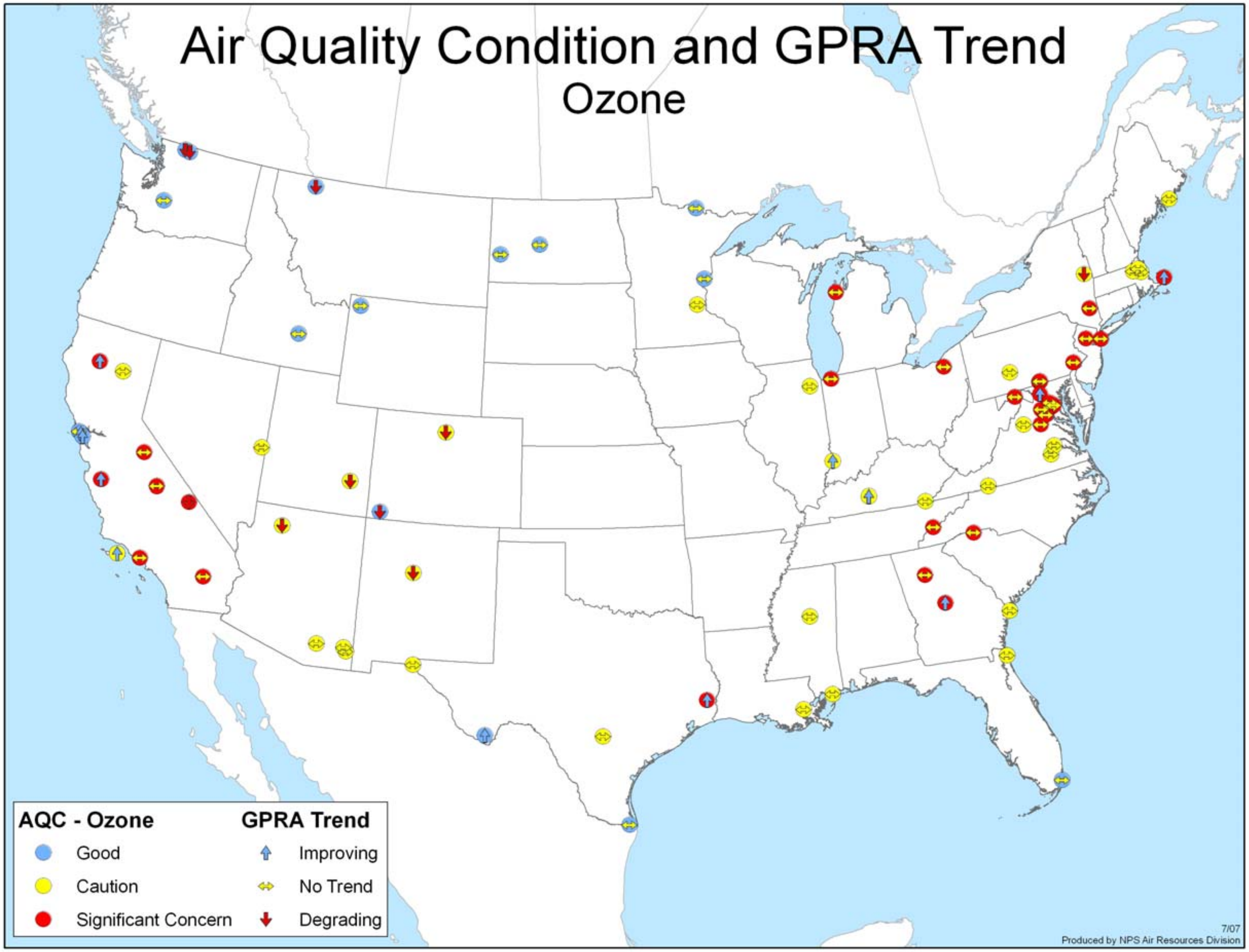

Air Quality Condition and GPRA Trend
Ozone
AQC - Ozone
Good
Caution
Significant Concern
GPRA Trend
Improving
No Trend
Degrading
7/07
Produced by NPS Air Resources Division

Figure 18

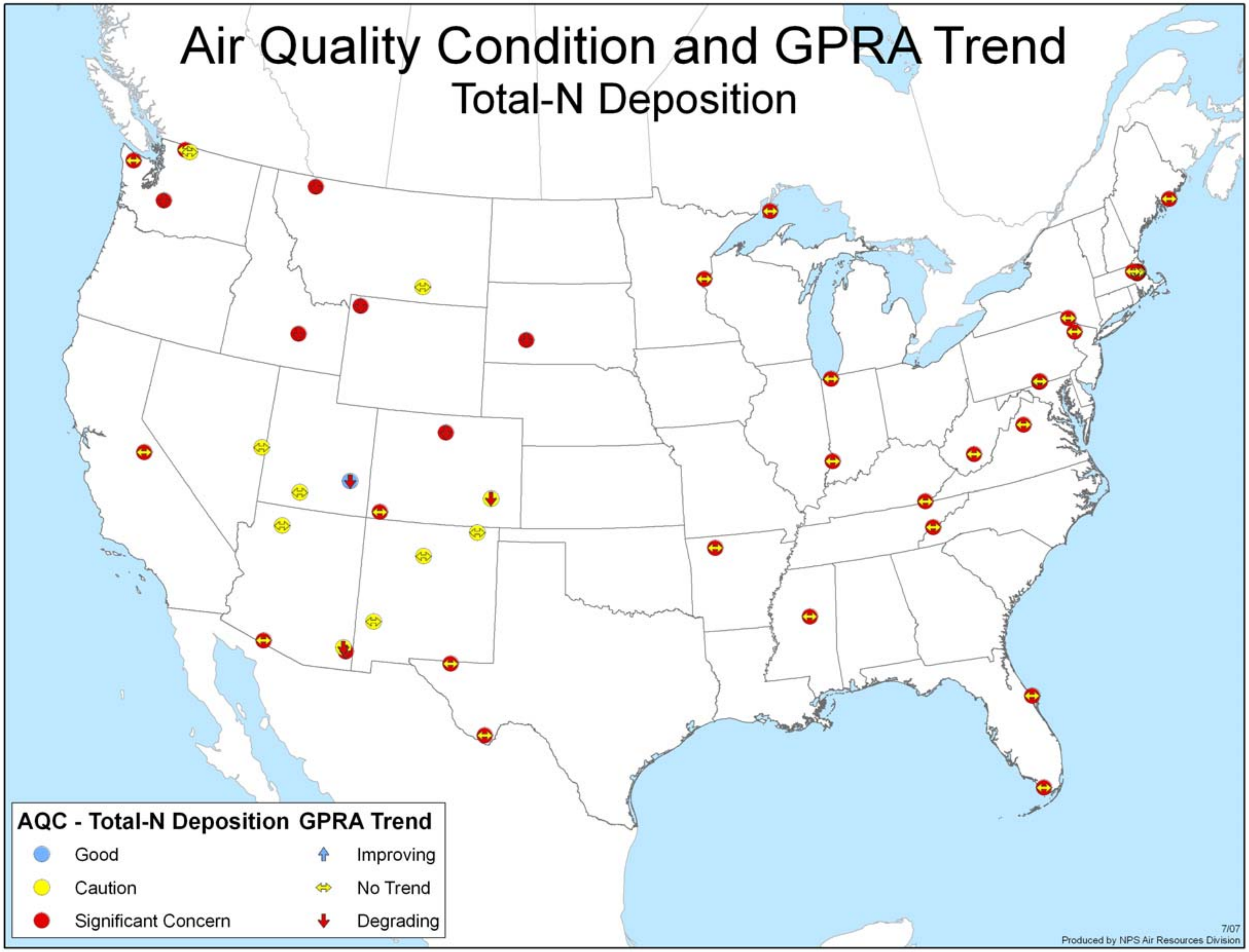

Air Quality Condition and GPRA Trend
Total-N Deposition
AQC - Total-N Deposition
● Good
● Caution
● Significant Concern
GPRA Trend
⇧ Improving
⇔ No Trend
⇩ Degrading
7/07
Produced by NPS Air Resources Division

Figure 19

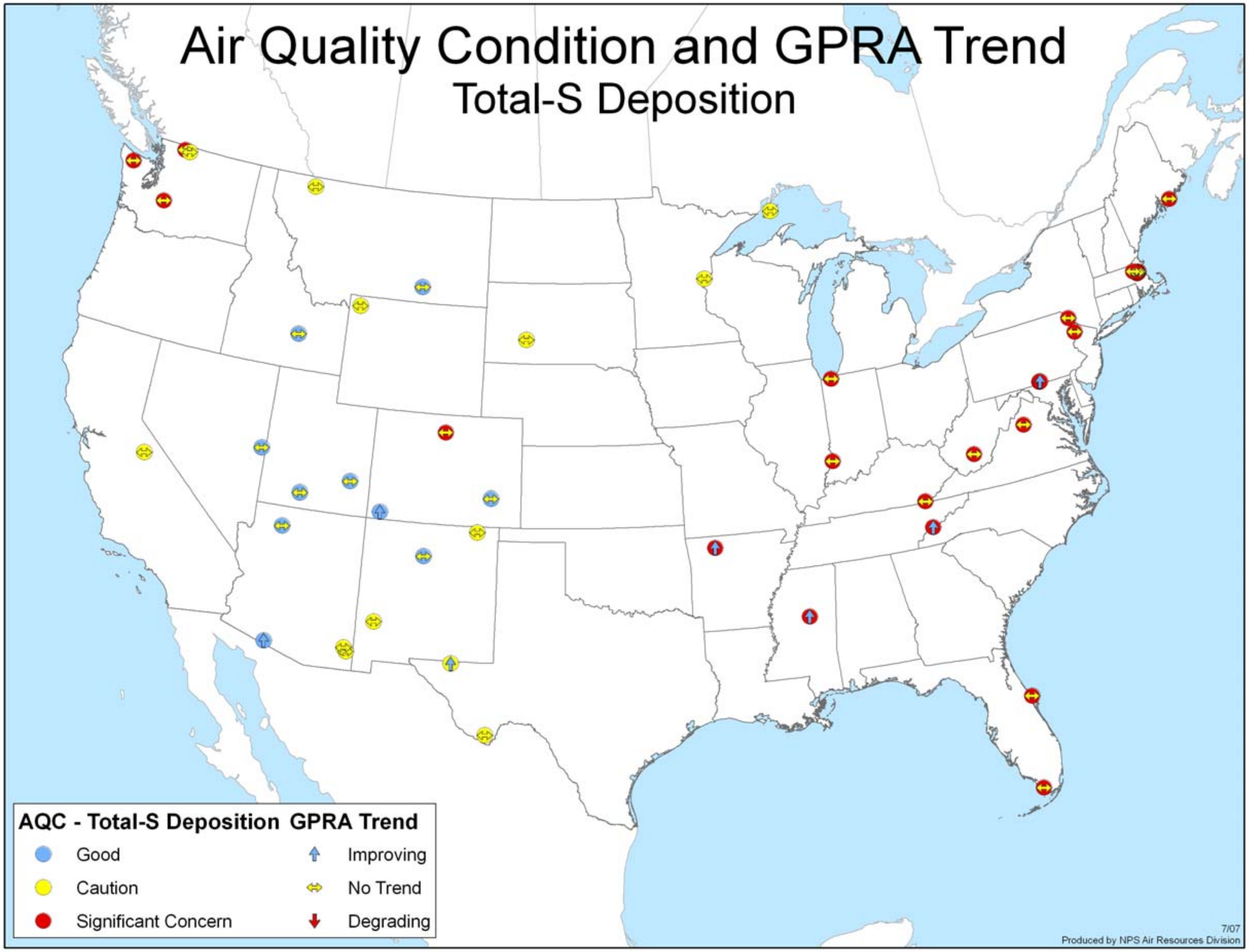
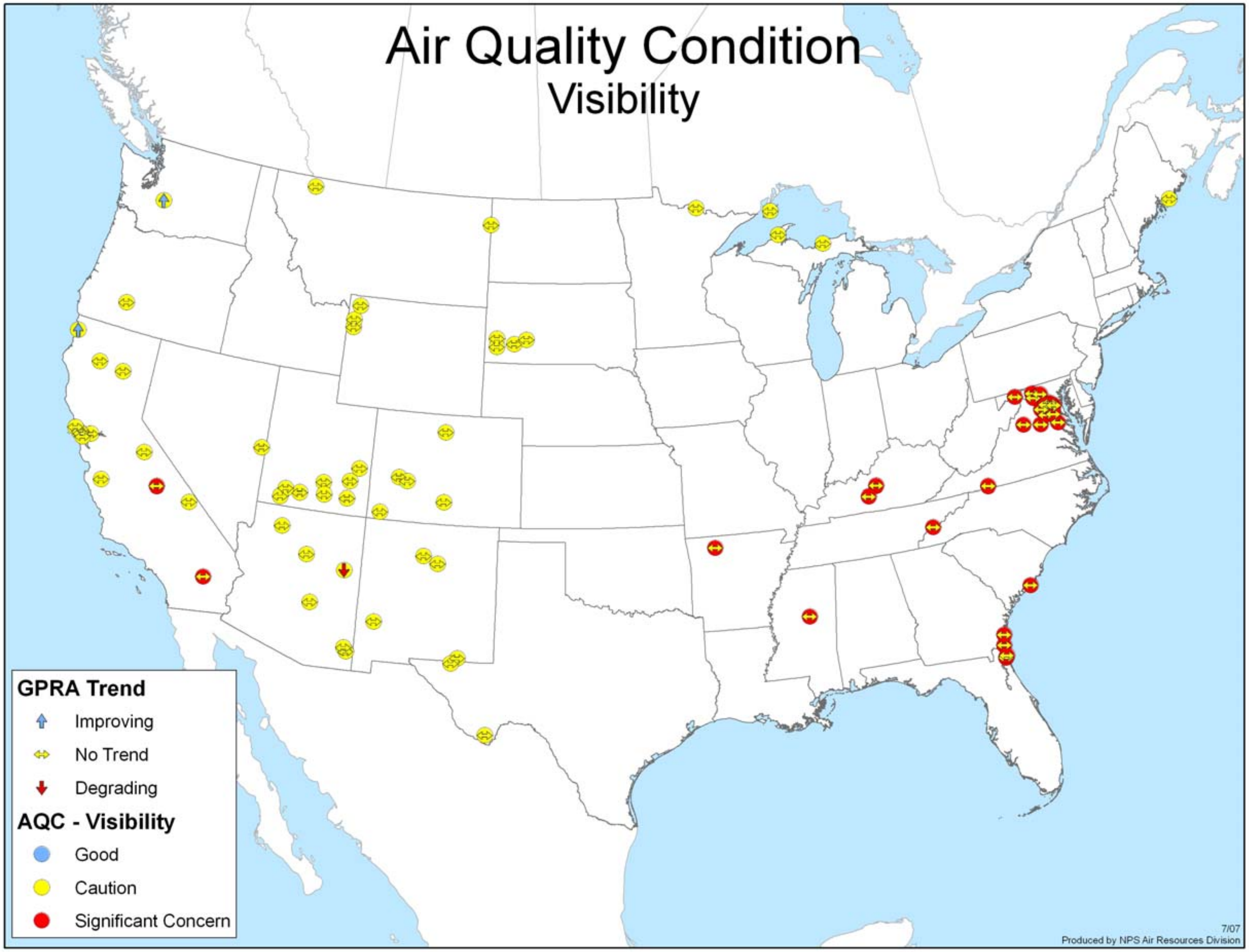

Air Quality Condition and GPRA Trend
Total-S Deposition
AQC - Total-S Deposition
● Good
● Caution
● Significant Concern
GPRA Trend
↑ Improving
⇔ No Trend
↓ Degrading
7/07
Produced by NPS Air Resources Division

Figure 20


Air Quality Condition
Visibility
GPRA Trend
Improving
No Trend
Degrading
AQC - Visibility
Good
Caution
Significant Concern
7/07
Produced by NPS Air Resources Division