AirAtlas Summary Tables for I&M Parks

The Air Atlas is a mini-GIS tool available on the Internet that provides national maps and an associated look-up table with baseline values of air quality parameters for all Inventory and Monitoring (I&M) parks in the U.S. The values are based on averaged 1995-1999 data. Air Atlas was produced by the National Park Service Air Resources Division (ARD) in association with the University of Denver. Air Atlas will serve as the Air Inventory for the parks and is available on the Internet at http://www2.nature.nps.gov/ard/gas/ (see section called *Air Atlas*).

The estimated air quality values provided in the look-up table are based on the center of the polygon defining the park or multiple units of the park. Because ozone is a regional pollutant, in most cases the look-up table values are likely representative of ozone concentrations throughout the park. Greater variability may exist for other parameters, such as deposition and visibility. In the future, the full Air Atlas dataset will be available on the internet, and users of ArcView and ArcGIS will be able to obtain air quality values for multiple points in a park by entering the latitude and longitude coordinates.

Air Atlas contains a comprehensive set of air quality parameters for all I&M parks. In addition, ARD has prepared a summary table that includes a select group of air quality parameters for each I&M network. The summary version is intended to provide parks with a synopsis useful for characterizing air quality conditions. Air quality parameters selected for the summary version are described below.

Ozone Parameters

Ozone can be expressed as concentration or cumulative dose. Relevant concentration and dose parameters include:

2nd Hi 1-hr: expressed in parts per billion (ppb), this value is the 2nd highest hourly value in a year and can be compared to the former Environmental Protection Agency (EPA) human health-based standard for ozone of 125 ppb (0.12 ppm).

4th Hi 8-hr: expressed in parts per billion (ppb), this value is the average hourly value in the 4th highest 8 hour period and can be compared to the present EPA human health-based standard for ozone of 85 ppb (0.08 ppm).

8 hrs > 85 ppb: indicates how often the site would exceed the present ozone standard.

1 hr > 100 ppb: indicates how often the site experiences high ozone concentrations; high concentrations contribute to vegetation (foliar) injury in sensitive plant species.

SUM06_3Mo: The running 90-day maximum sum of the 0800-2000 hourly concentrations of ozone equal to or greater than 0.06 ppm; represents cumulative exposure dose of ozone to plants.

Ozone is one of the most widespread air pollutants. Ozone is not emitted directly from smokestacks or vehicles, but is formed when other pollutants, primarily nitrogen oxides and volatile organic compounds, react in the atmosphere in the presence of sunlight, usually during the warm summer months. In addition to harming human health, ozone is phytotoxic, and causes considerable damage to vegetation throughout the world, including agricultural crops and native plants in natural ecosystems. The Environmental Protection Agency has established an ozone standard to protect human health; however, EPA has not set a standard to protect vegetation and there is much evidence to suggest that the human health-based standard is not protective of sensitive vegetation.

Ozone enters plants through leaf stomata and oxidizes plant tissue, causing changes in biochemical and physiological processes. Both visible foliar injury (e.g., stipple and chlorosis) and growth effects (e.g., premature leaf loss, reduced photosynthesis, and reduced leaf, root, and total dry weights) can occur in sensitive plant species. In a natural ecosystem, many other factors can ameliorate or magnify the extent of ozone injury at various times and places such as soil moisture, presence of other air pollutants, insects or diseases, and other environmental stresses.

Ozone injury can be induced by a sufficiently high seasonal dose of ozone (expressed as SUM06, in ppm-hrs), high peak concentrations of ozone (expressed in ppb), or a combination of both. Ozone effects to natural vegetation have been documented throughout the country, particularly in many areas of the East and in California. For sensitive natural vegetation in the East, researchers have recommended SUM06 effects endpoints of 8-12 ppm-hrs for foliar injury and 10-15 ppm-hrs for growth effects on tree seedlings in natural forest stands. In the West (Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite NPs), researchers have found that foliar injury on ponderosa and Jeffrey pines ranges from about 15-50 percent at ozone values between 25-30 ppm-hrs. Sites with values above these endpoints may be at risk for vegetation injury if sensitive species are present. However, to adequately assess risk, other factors, including temperature and soil moisture, must be considered. In conditions of low moisture, for example, stomates may close, preventing ozone uptake. Ozone peak concentrations exceeding 100 ppb are also considered to be important in inducing injury and the number of hours in a year above 100 ppb may be significant for evaluating risk.

Atmospheric Deposition Parameters

Atmospheric deposition is the process by which airborne particles and gases are deposited to the earth's surface either through wet deposition (rain or snow), occult deposition (cloud or fog), or as a result of complex atmospheric processes such as settling, impaction, and adsorption, known as dry deposition. Although it is important to know total deposition, (i.e., the sum of wet, occult, and dry deposition) to park ecosystems, often only the wet deposition component is known, as it is the only one that is monitored routinely and extensively across the U.S. (at over 200 sites), as part of the National Atmospheric Deposition Program (NADP). Dry deposition is monitored at about 70 sites as part of the Clean Air Status and Trends Network (CASTNet). Clouds and fog may contribute significantly to total deposition at certain locations (e.g., high elevation areas and areas that experience a high frequency of clouds and fog), but monitoring cloud and fog deposition is difficult and is done at only a couple of locations in the U.S. Acids, nutrients, and toxics are the primary compounds within deposition that are of concern in park ecosystems.

Deposition can be expressed as concentration (e.g., micrograms per cubic meter or milligrams per liter) or deposition rates (e.g., kilograms per hectare per year – kg/ha/yr). Deposition rates are included in Air Atlas summaries, as these rates best characterize the amount of deposition an ecosystem experiences.

NADP dep (kg/ha/yr): pollutant ions in wet deposition from rain or snow are measured by the National Atmospheric Deposition Program (NADP) and expressed as kg/ha/yr. NADP measures a comprehensive suite of anions and cations; deposition rates of total wet sulfur (S) and total wet inorganic nitrogen (N) (ammonium plus nitrate ions) are included in the summaries.

NADP Total S (kg/ha/yr): total sulfur from sulfate ions in wet deposition.

NADP Total N (kg/ha/yr): total inorganic nitrogen from ammonium and nitrate ions in wet deposition.

Atmospheric deposition affects ecosystems in a variety of ways, including acidification, fertilization or eutrophication, and accumulation of toxics. Acid deposition from sulfur and nitrogen compounds affects freshwater lakes, streams, and watersheds. Acid deposition effects include changes in water chemistry that affect algae, fish, submerged vegetation, and amphibian and aquatic invertebrate communities. Deposition can also cause changes in soil that affect soil microorganisms, understory plants, and trees. Excess nitrogen deposition can cause unwanted fertilization effects, leading to changes in plant community structure and diversity. In estuaries and coastal waters, nitrogen can cause algae blooms, decreases in dissolved oxygen, and loss of seagrasses (i.e., eutrophication).

All areas of the country are experiencing levels of atmospheric deposition above natural levels. The ability of ecosystems to deal with increased levels of deposition varies widely. High elevation ecosystems in the Rocky Mountains, Cascades, Sierra Nevada, southern California, and eastern U.S. are generally the most sensitive to atmospheric deposition due to their poor ability to neutralize acid deposition. Other sensitive areas include the upper Midwest, New England, and Florida, including the shallow bays and estuaries along the Atlantic and Gulf Coasts. Streams in both Shenandoah and Great Smoky Mountains NPs are experiencing chronic and episodic acidification and brook trout fisheries in Shenandoah have been affected. Rocky Mountain NP is also currently undergoing subtle changes in aquatic and terrestrial ecosystems attributable to atmospheric deposition. In some areas, excess nitrogen deposition has caused shifts in plant species composition, with native species being replaced by invasive and exotic species that are better able to utilize nitrogen.

Visibility Parameters

A number of visibility indices, or measurements, can be used to express visibility conditions. The measurement used in Air Atlas summaries is light extinction.

<u>bextClear</u>: annual average light extinction, expressed in inverse megameters, on the 20 percent clearest days

<u>bextHazy</u>: annual average light extinction, expressed in inverse megameters, on the 20 percent haziest days

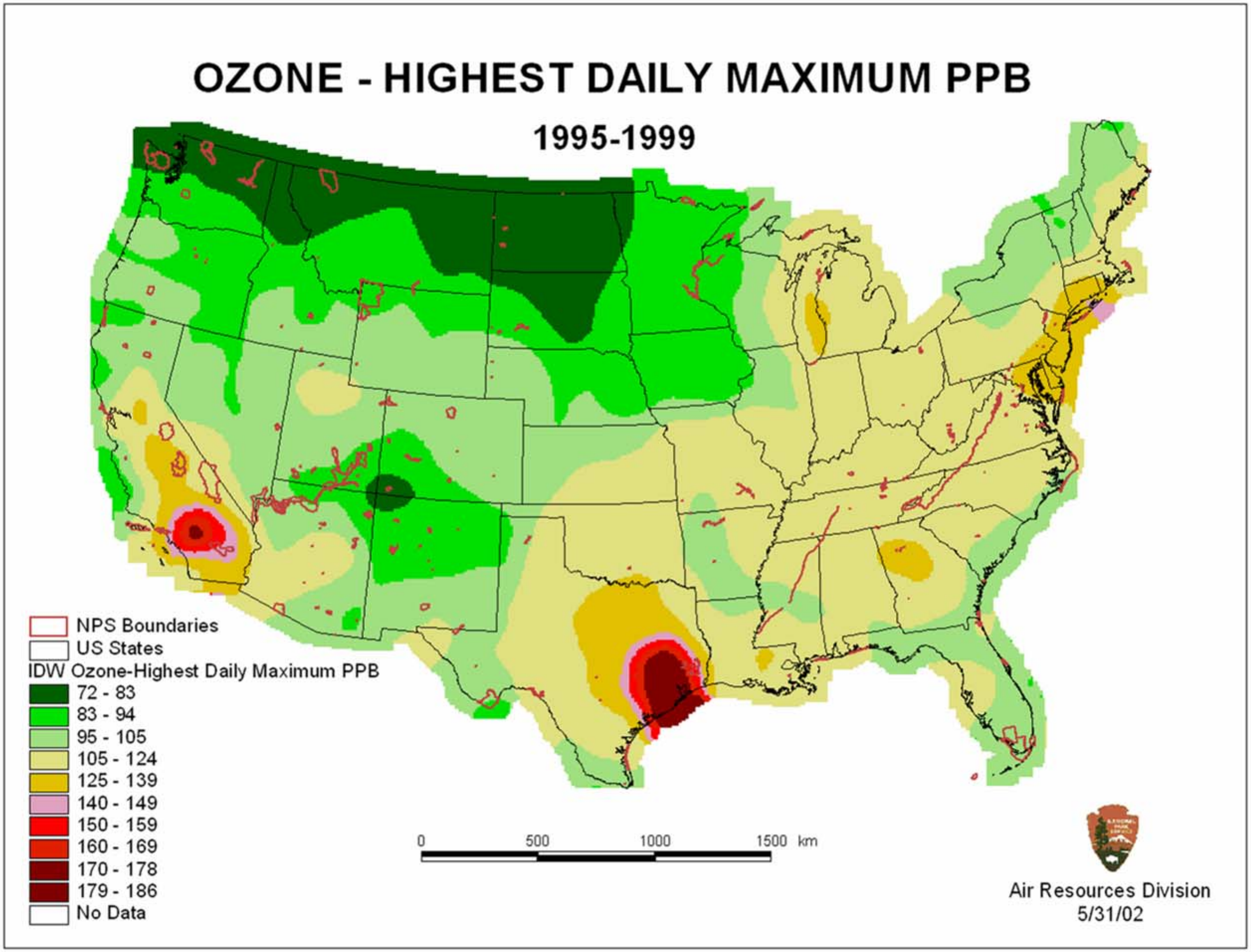
Light extinction, expressed in the form of inverse megameters (Mm^{-1}), is proportional to the amount of light lost because of scattering or absorption by particles in the air as the light travels over a million meters (one million meters = one megameter). Light extinction occurs when particles in the air scatter or absorb light; extinction generally increases as particle concentrations in the air increase.

Extinction can be measured directly, with a transmissometer and nephelometer, or it can be calculated from representative aerosol measurements. Air Atlas extinction estimates, so-called "reconstructed" estimates, are calculated from aerosol measurements. Total extinction is the sum of the individual extinctions caused by gases, particles, and air molecules in the atmosphere. Relative humidity, as well as particle concentrations, is considered in the equation, as relative humidity increases the extinction efficiency of certain particles.

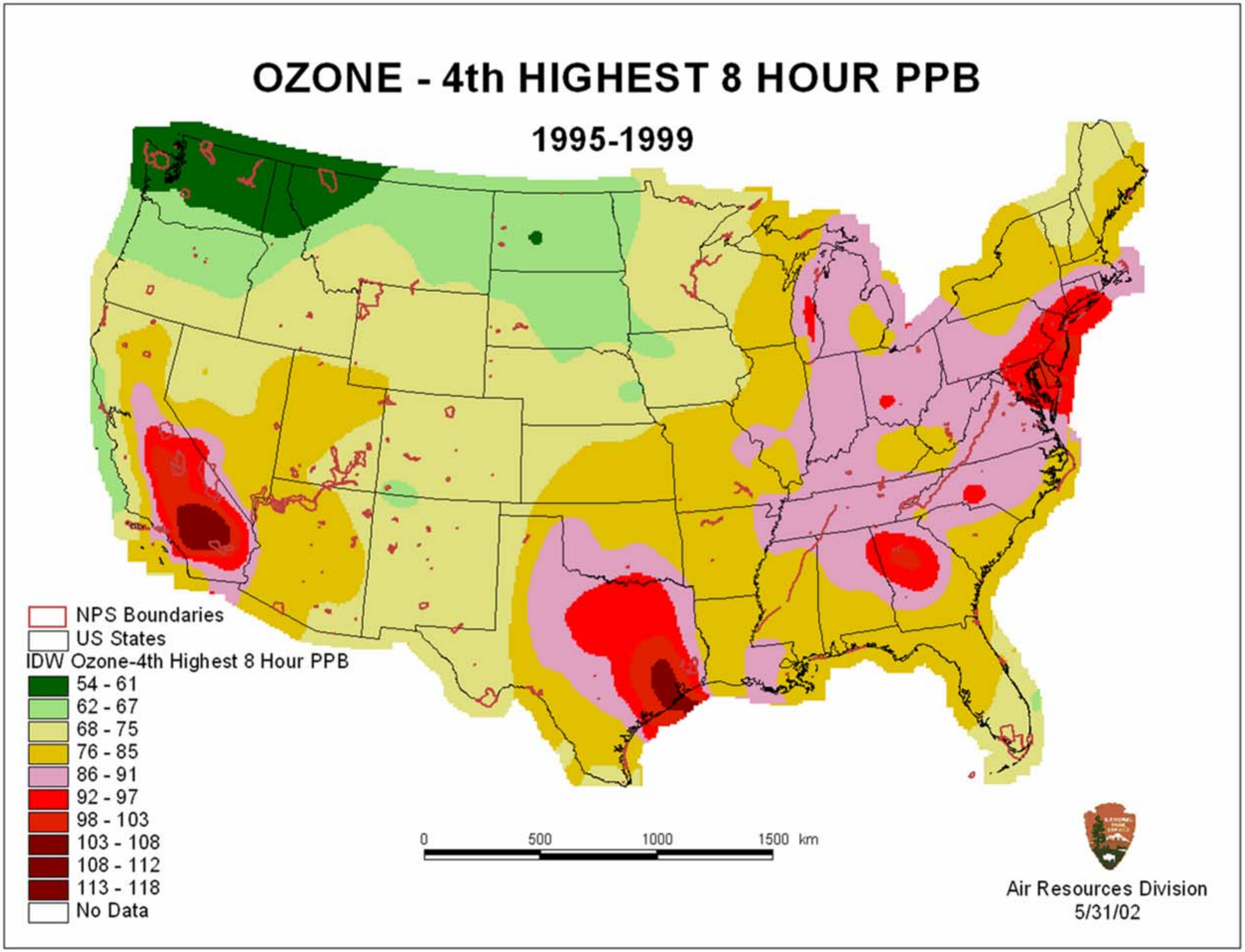
Light extinction is averaged for the 20 percent clearest and the 20 percent haziest days in an area. The Environmental Protection Agency's 1999 Regional Haze Regulations require that reasonable progress be made to restore visibility to natural background conditions within 60 years. States are to establish goals for each Class I area to improve visibility on the haziest days (defined as the 20 percent haziest day) and ensure no degradation occurs on the clearest days (defined as the 20 percent clearest days). Emissions reductions that benefit visibility in Class I areas are also expected to benefit visibility in all other areas.

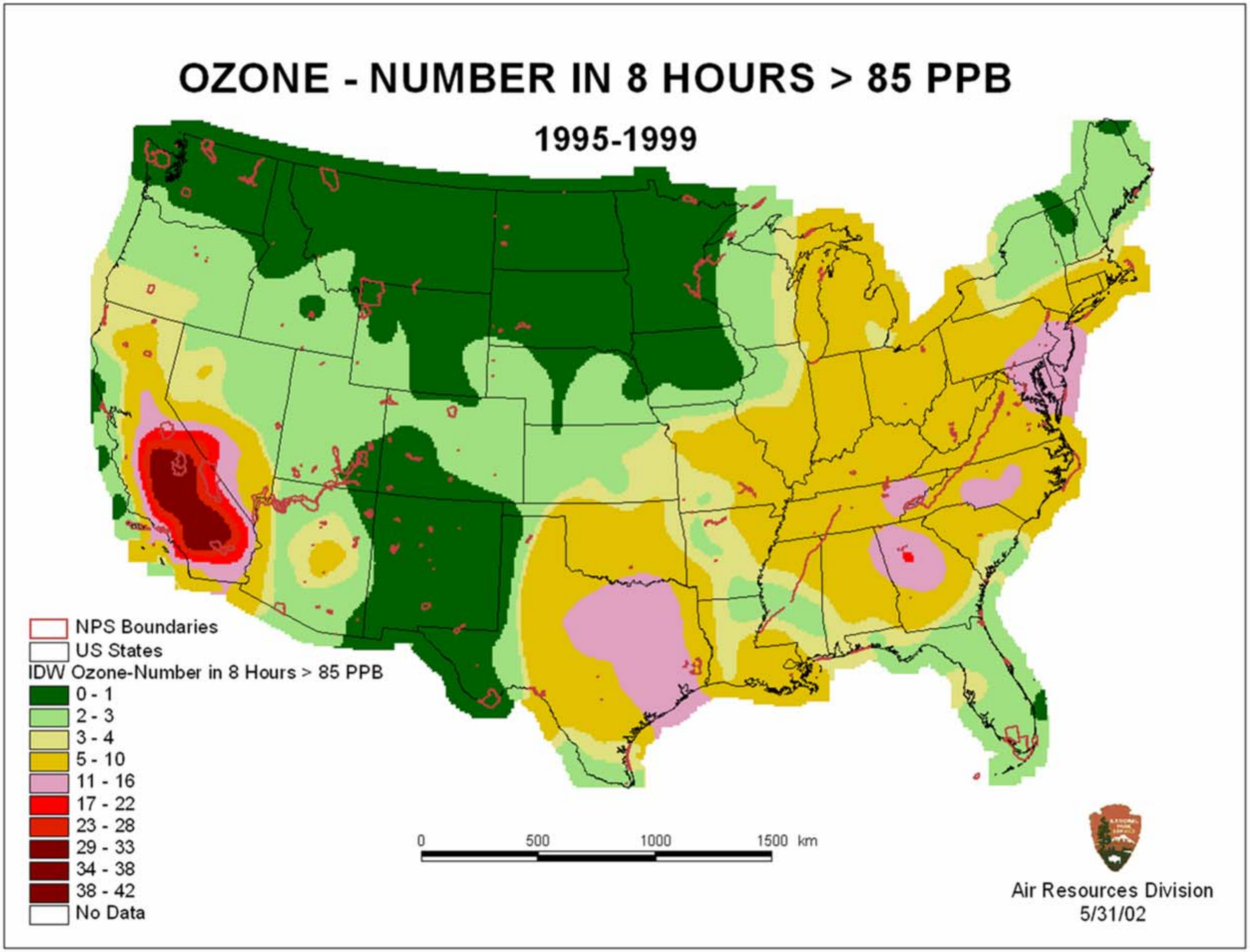
Visual range (VR) is another index used to describe visibility. Because VR is not particularly useful for assessing the quality of scenic vistas (clarity, color), light extinction is used in Air Atlas. However, VR is sometimes useful for describing visibility to the general public. VR is expressed as length; extinction is expressed as 1/length. The relationship between VR and extinction is:

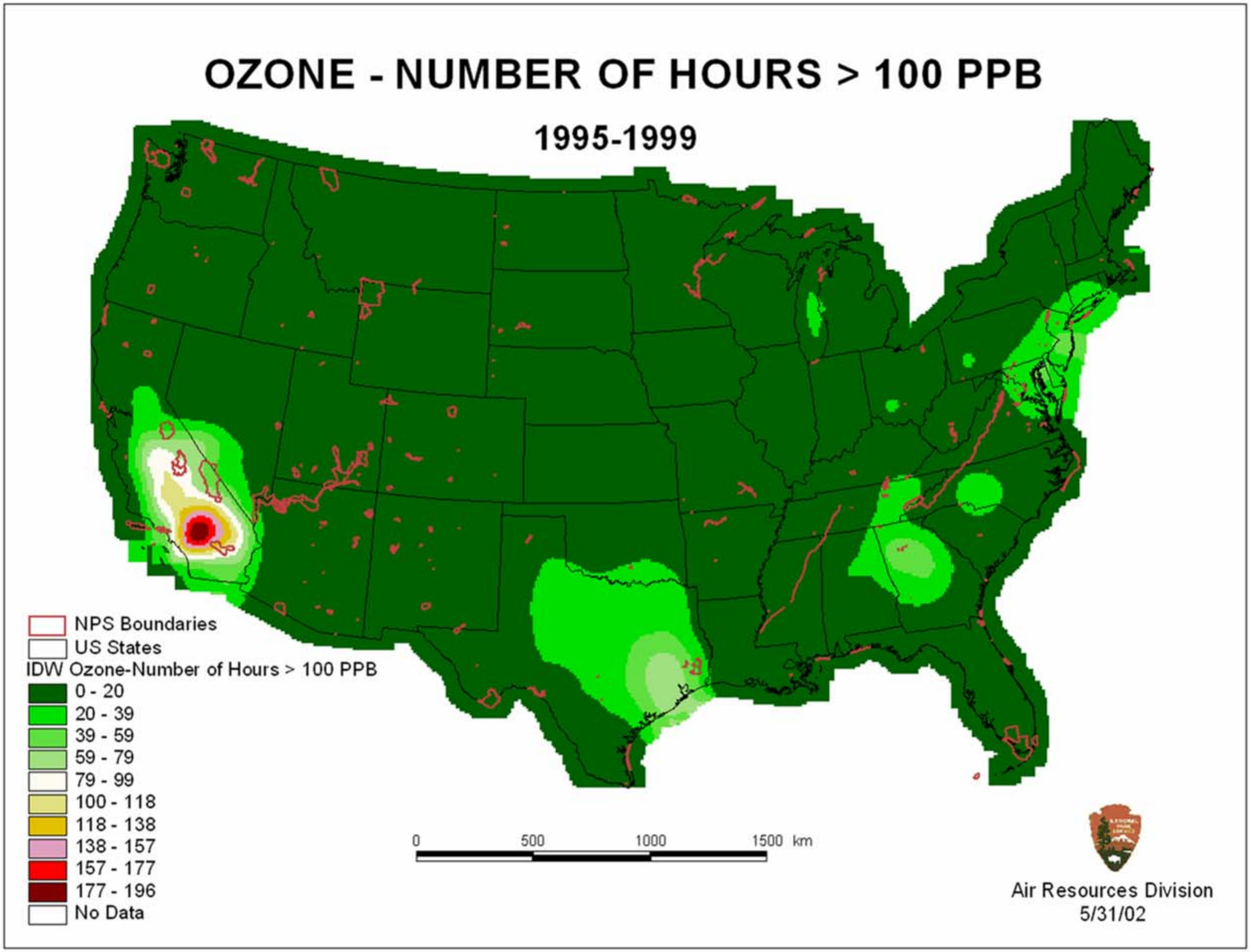
$$\mathrm{VR} = \frac{3.912}{\mathrm{bext}(\mathrm{km}^{-1})} = \frac{3912}{\mathrm{bext}(\mathrm{Mm}^{-1})}$$

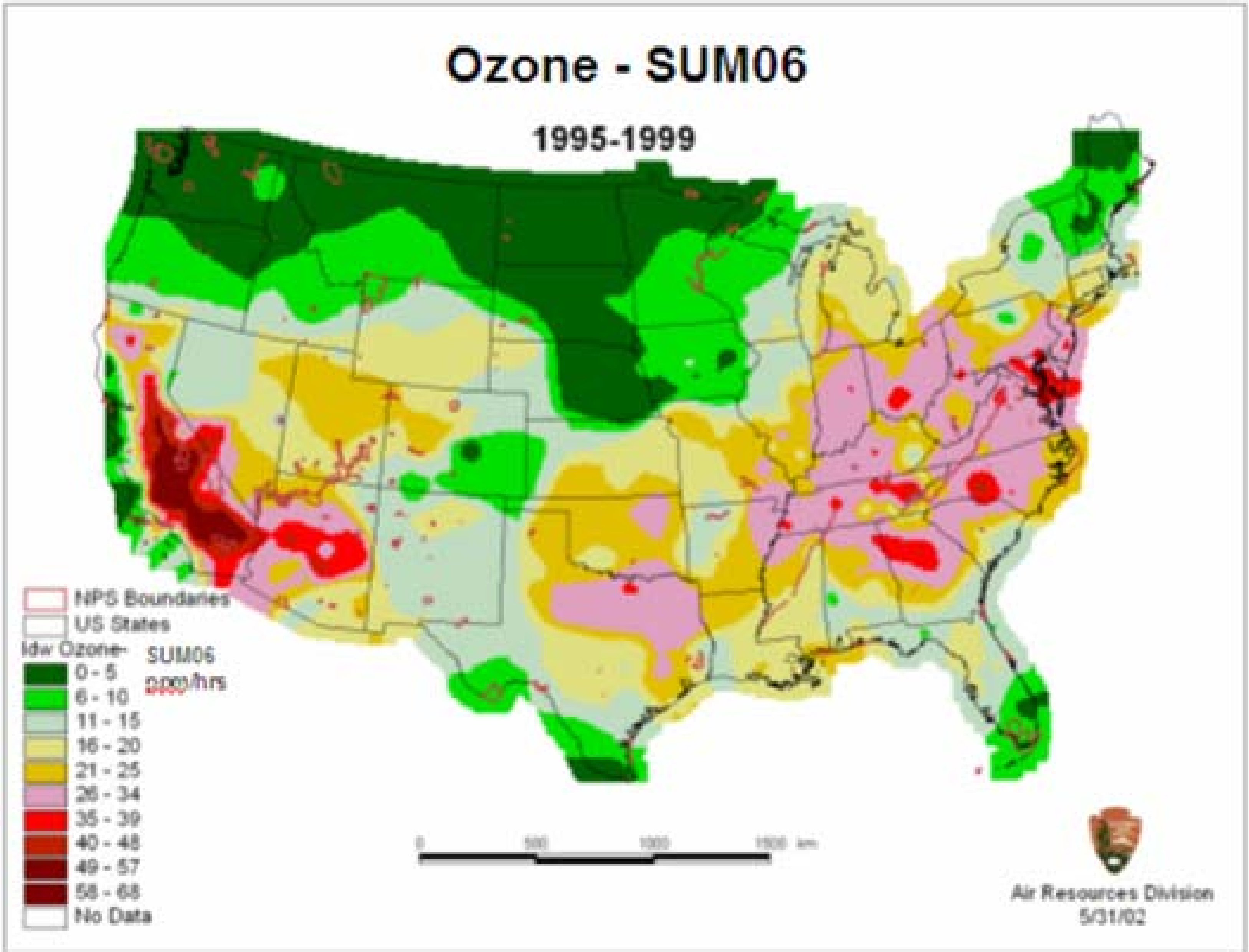


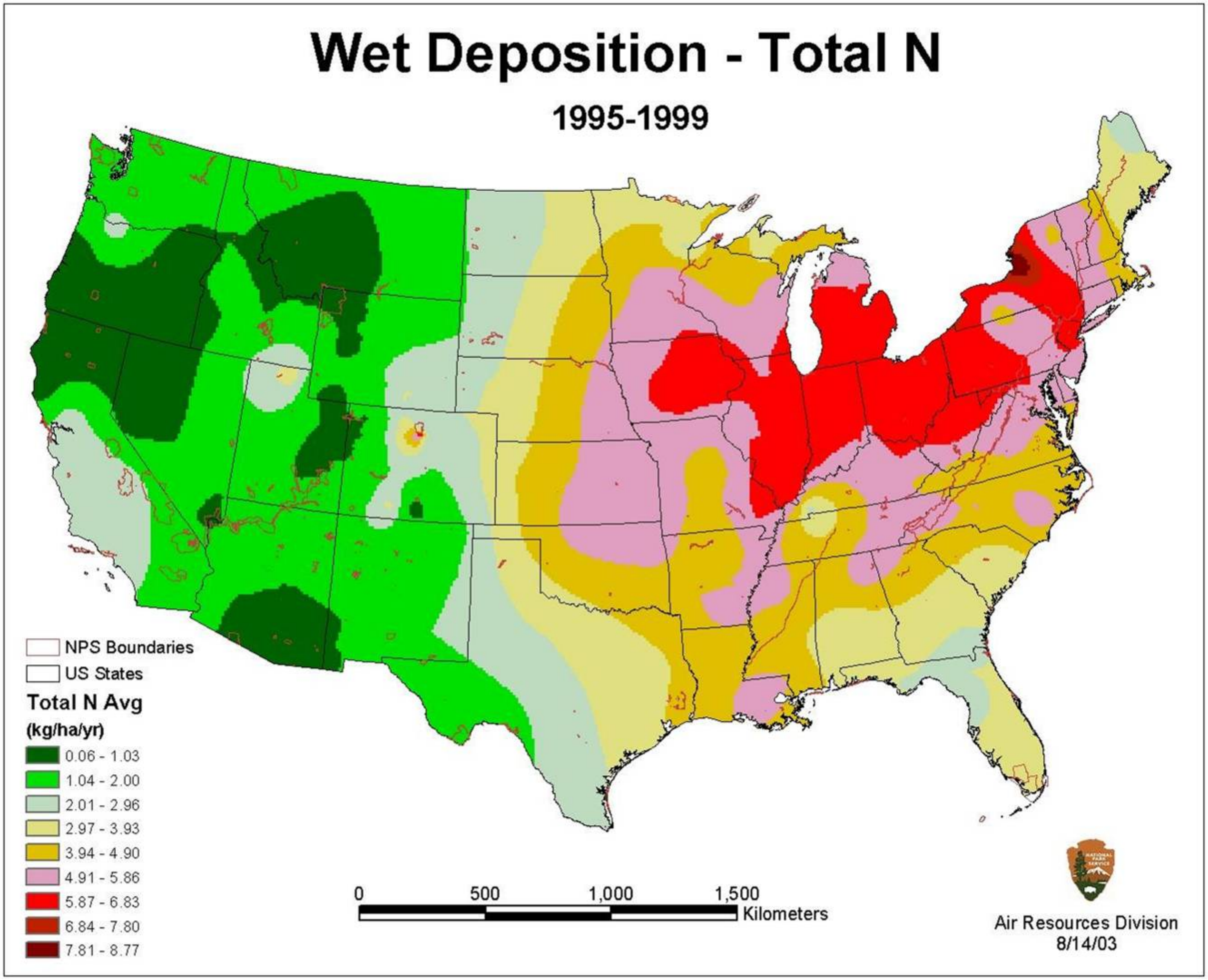
OZONE - HIGHEST DAILY MAXIMUM PPB
1995-1999
NPS Boundaries
US States
IDW Ozone-Highest Daily Maximum PPB
72 - 83
83 - 94
95 - 105
105 - 124
125 - 139
140 - 149
150 - 159
160 - 169
170 - 178
179 - 186
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02


OZONE - 4th HIGHEST 8 HOUR PPB
1995-1999
NPS Boundaries
US States
IDW Ozone-4th Highest 8 Hour PPB
54 - 61
62 - 67
68 - 75
76 - 85
86 - 91
92 - 97
98 - 103
103 - 108
108 - 112
113 - 118
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02


OZONE - NUMBER IN 8 HOURS > 85 PPB
1995-1999
NPS Boundaries
US States
IDW Ozone-Number in 8 Hours > 85 PPB
0 - 1
2 - 3
3 - 4
5 - 10
11 - 16
17 - 22
23 - 28
29 - 33
34 - 38
38 - 42
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02


OZONE - NUMBER OF HOURS > 100 PPB
1995-1999
NPS Boundaries
US States
IDW Ozone-Number of Hours > 100 PPB
0 - 20
20 - 39
39 - 59
59 - 79
79 - 99
100 - 118
118 - 138
138 - 157
157 - 177
177 - 196
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02

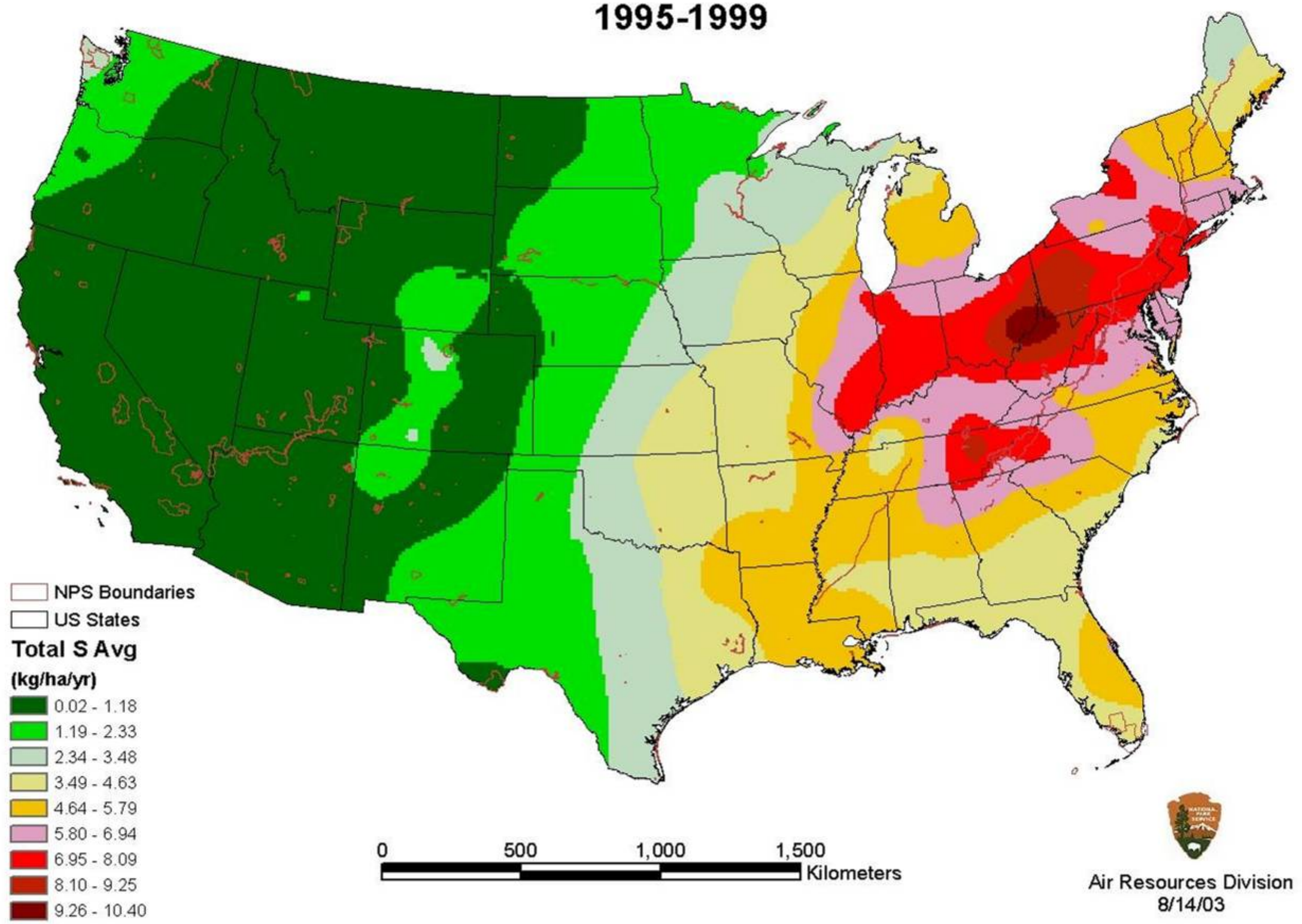

Ozone - SUM06
1995-1999
NPS Boundaries
US States
Idw Ozone- SUM06
ppm/hrs
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 34
35 - 39
40 - 48
49 - 57
58 - 68
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02

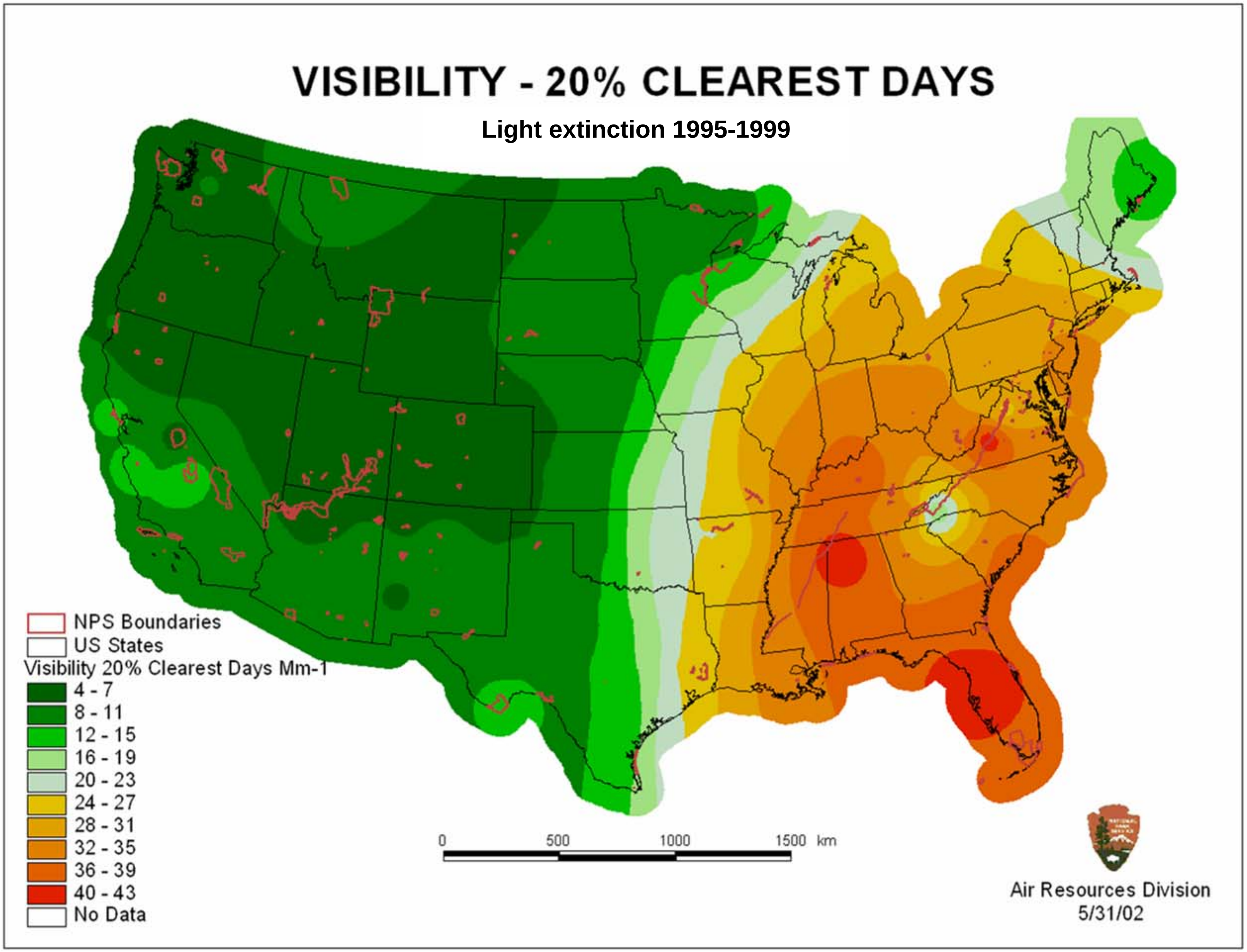


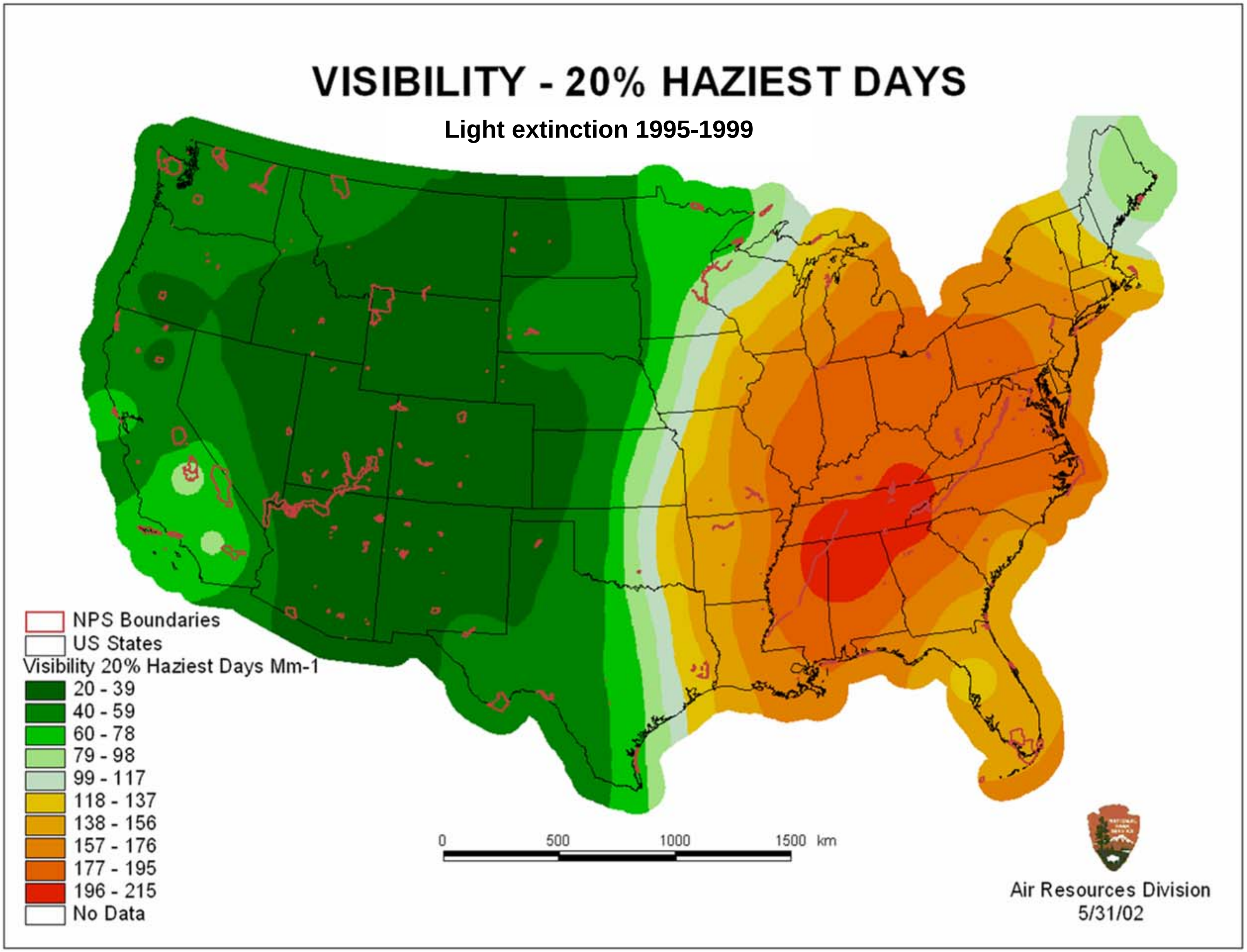
Wet Deposition - Total N
1995-1999
NPS Boundaries
US States
Total N Avg
(kg/ha/yr)
0.06 - 1.03
1.04 - 2.00
2.01 - 2.96
2.97 - 3.93
3.94 - 4.90
4.91 - 5.86
5.87 - 6.83
6.84 - 7.80
7.81 - 8.77
0
500
1,000
1,500
Kilometers
Air Resources Division
8/14/03

Wet Deposition - Total S

1995-1999




VISIBILITY - 20% CLEAREST DAYS
Light extinction 1995-1999
NPS Boundaries
US States
Visibility 20% Clearest Days Mm-1
4 - 7
8 - 11
12 - 15
16 - 19
20 - 23
24 - 27
28 - 31
32 - 35
36 - 39
40 - 43
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02


VISIBILITY - 20% HAZIEST DAYS
Light extinction 1995-1999
NPS Boundaries
US States
Visibility 20% Haziest Days Mm-1
20 - 39
40 - 59
60 - 78
79 - 98
99 - 117
118 - 137
138 - 156
157 - 176
177 - 195
196 - 215
No Data
0
500
1000
1500 km
Air Resources Division
5/31/02